Effect of Different Shapes of DGS on Characteristics of Rectangular Microstrip Patch Antenna

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Abstract— The design of Microstrip antennas mainly got focus due to need of multiband, larger gain and low profile antennas to support multiple wireless applications. Main advantage of microstrip antennas is small profile design which enhance their application in the micro communication devices. The overall characteristics of such antennas can be further modified and improved by two techniques: Introducing defect in ground plane and adding layers to the conducting surface. This paper presents the changes in the above characteristics of micostrip patch antenna due to different shapes of defects introduced in the ground plane. The antenna in this presented in this paper is simulated on FR4 substrate with dielectric constant of 4.4 and simulated for results using HFSS software. By changing shapes of the defects the corresponding changes in the characteristics have been noted for 2.4GHz of resonant frequency.

Key words: Microstrip Patch Antenna; Defected Ground Structure

I. INTRODUCTION

To enhance the performance of antenna especially the bandwidth, Defected Ground Structure is a newly introduced revolutionary technique in the field of microstrip antennas. Defect in the ground plane means to remove out some part of the ground plane.

Basically DGS causes to disturb the shield current distribution in the ground plane.Changes of the characteristics of transmission line such as capacitance and inductance results because of disturbance in the shield current distribution. The effective resultant is that improved bandwidth for the antenna. DGS is periodic or non-periodic cascaded defect in ground of a planar transmission line achieved by etching process. This paper will show the effective comparison between antenna characteristics for U-shaped DGS, E-shaped, Double E-Shaped and Modified E-Shaped DGS of ground plane.

II. DESIGN CALCULATIONS FOR MICROSTRIP PATCH

A. Design Requirements

The patch antenna has been designed for achieving following requirements.

- Resonant frequency(f_r) = 2.45Ghz
- Dielecrtric constant(εr) = 4.4
- Bandwidth(Bw) >250Mhz
- Return loss > -10dB
- 1<VSWR>2

B. Antenna Geometry

1) Width of Patch

$$W = \frac{c}{2fr\sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

W = 38.22mm

2) Effective Dielectric Constant

$$\varepsilon reff = \frac{(\varepsilon r+1)}{2} + \frac{(\varepsilon r-1)}{2}(1+12\frac{h}{w})^{\frac{-1}{2}} \quad (2)$$

$\varepsilon reff$ = 3.999

Then calculate the effective length.

3) Effective Length

$$Leff = \frac{C}{2*Fr*\sqrt{(\varepsilon reff)}} \quad (3)$$

$Leff$ = 30.55mm

4) Delta Length

$$\Delta L = 0.412h \frac{(\varepsilon reff+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{w}{h}+0.8\right)} \quad (4)$$

ΔL = 747.7µm

5) Actual Length

With the effective length and delta length now calculate the actual length patch:

L = Leff–(2*ΔL) (5)

L= 28.4mm

6) Ground Plane

The width and length ground plane can be calculated by the following equations:

Wg = 6*h +W = 66mm(6)

Lg= 6*h + L = 58mm(7)

7) Feed Point

Feed point =(L/4)=28/4=7mm (8)

Feed Width=(377/(sqrt(εr)*(w/t+2)))=2.84 (9)

III. SIMULATION SOFTWARE

ANSOFT HFSS is used to simulate all the designs presented in the paper. It is one of the most precise antenna simulation software on the market. Modeling of the patch antenna using the calculated geometrical dimension is done prior.

HFSS offers a dynamic selection of geometrical shapes which builds really helpful tool while drawing 3-D models. The three different ground planes are designed by using Boolean and subtraction operation available in the HFSS.

IV. DESIGN MODELS

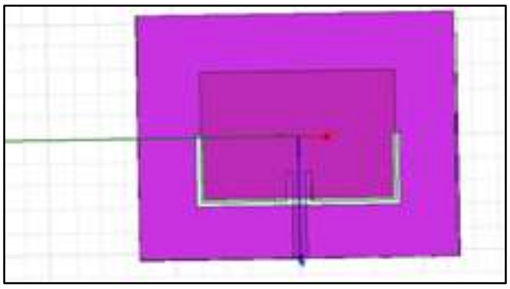

Fig. 1: Design Model1: U-shaped DGS

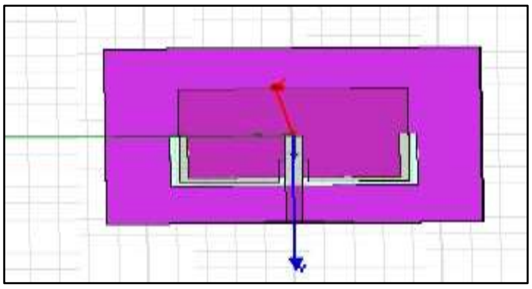

Fig. 2: Design Model2: E-shaped DGS

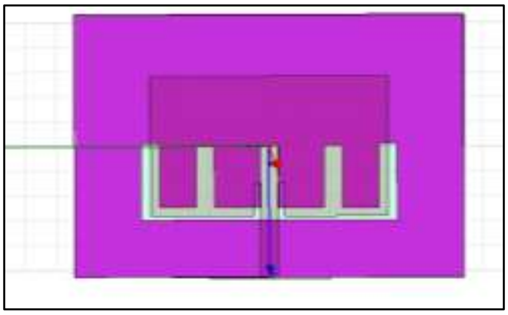

Fig. 3: Design Model3: Double E-shaped DGS

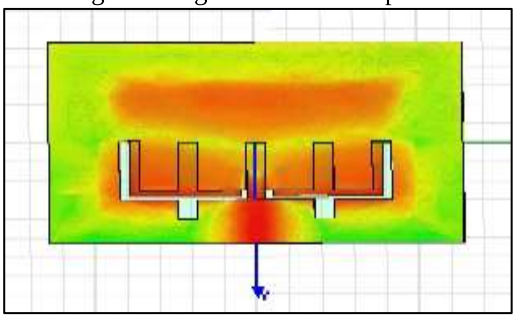

Fig.4 Design Model4: Modified Double E-shaped DGS

Model number one in Fig.1 shows microstrip patch antenna with U-DGS meaning the white U-shaped part of the conducting ground surface is subtracted for the plane ground.

Model number two shown by Fig.2 is same patch antenna but with E-shaped modified ground plane. Model number three and four in Fig.3 and Fig.4 shows the Double E-shaped and modified Double E-shaped defected structure respectively for the same patch geometry.

V. RESULTS OF SIMULATION

A. Return Loss

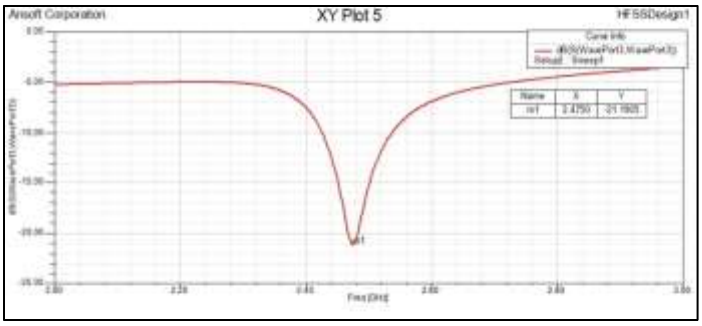

Fig. 5: Return loss Model 1 (U-shaped DGS)

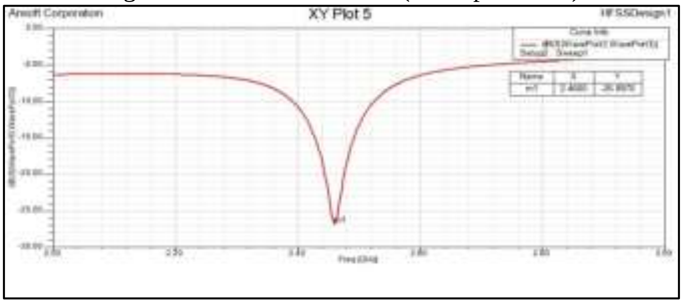

Fig. 6: Return loss for Model2 (E-shaped DGS)

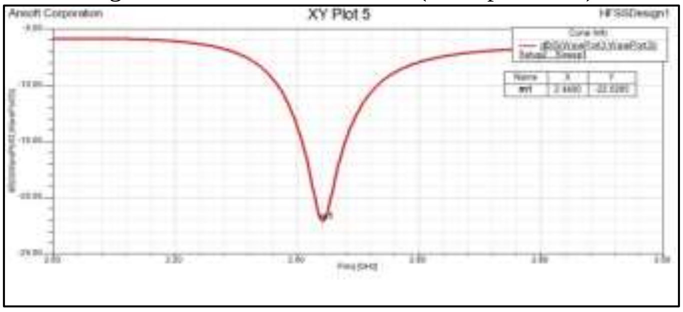

Fig. 7: Return loss for Model3 (Modified E-shaped DGS)

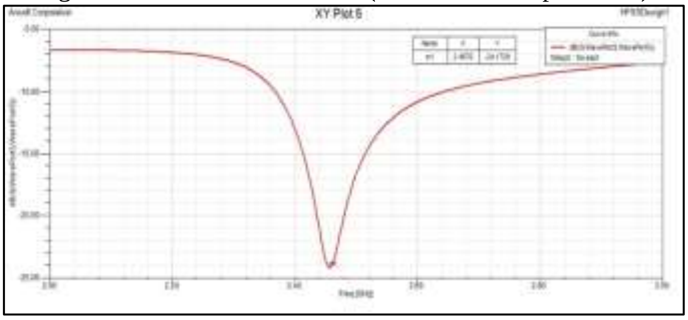

Fig. 8: Return loss for Model4 (Modified Double E-shaped DGS)

B. VSWR

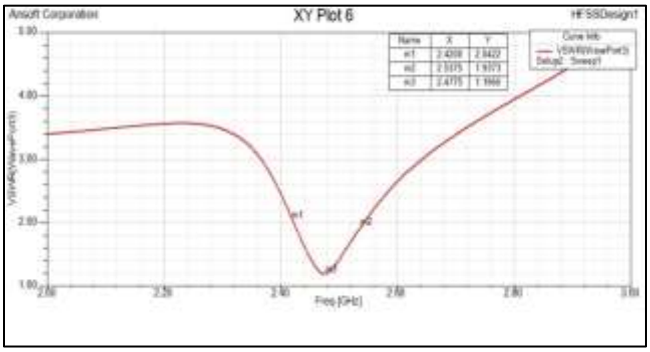

Fig. 9: VSWR for Model1 (U-shaped DGS)

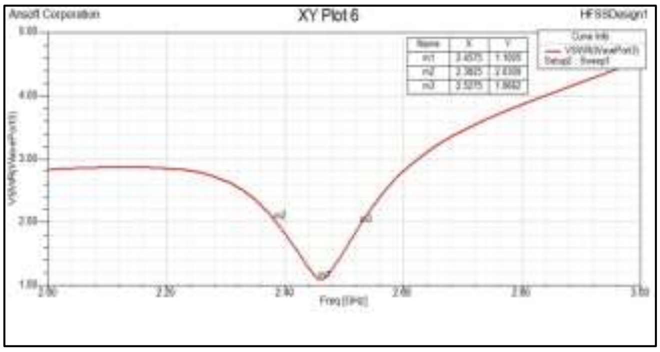

Fig. 10: VSWR for Model2 (E-shaped DGS)

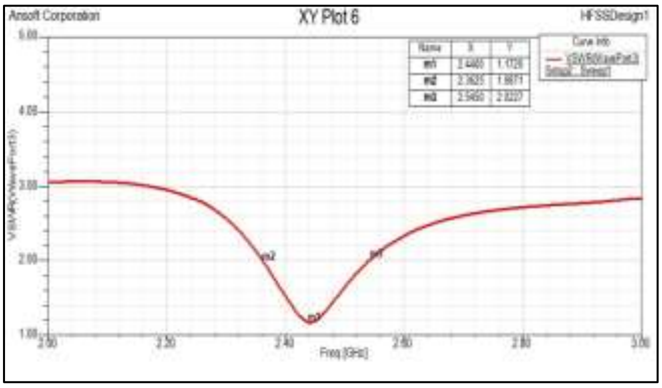

Fig. 11: VSWR for Model3 (Double E-shaped DGS)

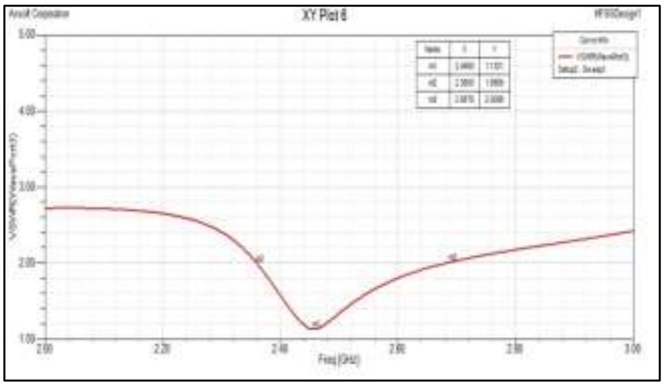

Fig. 12: VSWR for Model4 (Modified Double E-shaped DGS)

C. Directivity

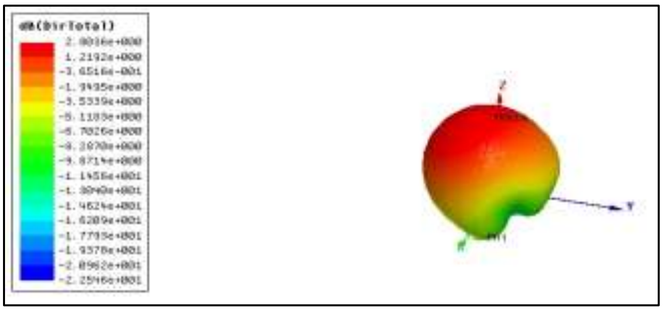

Fig. 13: Directivity of Model1 (U-shaped DGS)

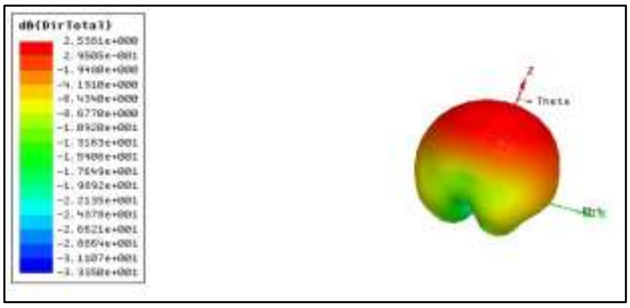

Fig. 14: Directivity of Model2 (E-shaped DGS)

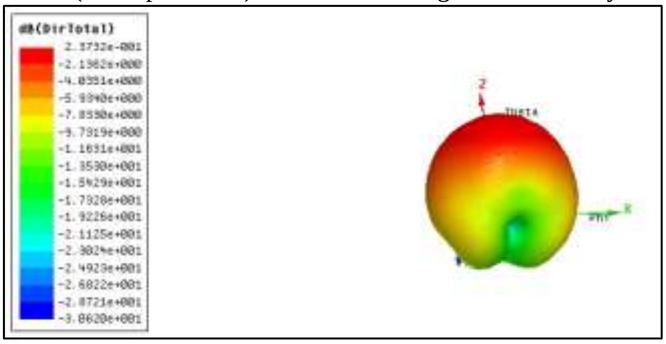

Fig. 15: Directivity of Model3 (Double E-shaped DGS)

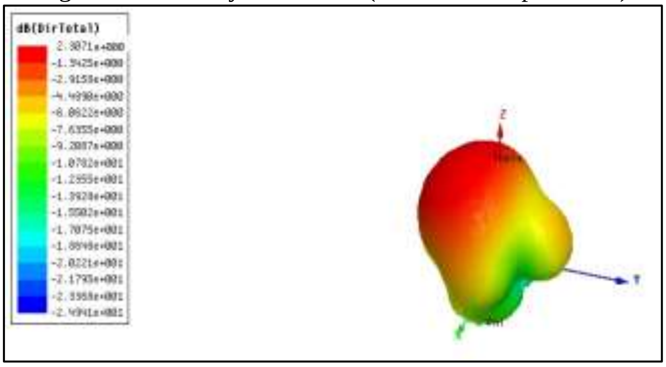

Fig. 16: Directivity of Model4 (Modified Double E-shaped DGS)

VI. Conclusion and Result Analysis

It would have been a big advantage to know the Ansoft HFSS simulation software beforehand as a lot of measurements could have been applied. Microstrip antennas and their theory get much more complex as you want to create more efficiency and wider bandwidth.

With DGS the parameters of simple rectangular microstrip patch antenna such as Bandwidth,return loss and VSWR has been improved as compared with the four models andalso there is small amount of reduction in directivity. There is 24% of improvement observed in bandwidth in a comparison of U-shaped DGS and E-shapedDGS structure. Same is about 163% is observed in Modified double E-shaped DGS. Thus it can be concludedthat with a proper DGS structure the bandwidth can be improved with much narrowed directivity.

All the four designs have shown the VSWR ratio within the standard range of 1 to 2. E-shaped DGS has shown the nearest value to 1 i.e. 1.10 compared to the other three. The Return loss criteria are most satisfying with the E-shaped DGS.A slight variation is seen in directivity with the four shapes. Directivity goes decreasing in the decibel scale from model1 to model4.

Design type	**Result Analysis**			
	Bandwidth(Mhz)	**Return loss(dB)**	**VSWR**	**Directivity (dB)**
U-shaped DGS	117	-21.90	1.19	2.80
E-shaped DGS	145	-26.88	1.10	2.53
Double E-shaped DGS	183	-22.01	1.71	2.37
Modified Double E-shaped DGS	308	-24.17	1.13	2.30

Table 1: Result Analysis

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