Design of Compact Symmetric slotted Triple Band Microstrip Patch Antenna using DGS

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Abstract: A compact slotted patch antenna with the Defected Ground Structure (DGS) is proposed in this paper. The concept of DGS and slotted patch are integrated to get the multiple frequency bands, compact size, enhanced bandwidth, and gain. The antenna is designed on a low loss tangent substrate material Rogers RT/duroid 5870 with dielectric constant 2.2 and thickness 0.8 mm, dimensions of the patch are 14 mm X 20 mm, the antenna is excited by using the microstrip line feeding. The antenna is designed and simulated using ANSYS HFSS 18.0v at triple bands 2.5/4.9/7.0 GHz. Enhanced output characteristics are gain of 2.5/3.75/5dB, return loss -22/-35/-19dB, VSWR of 1.2/0.8/1.6dB and impedance bandwidth 300MHz/270MHz/690MHz at 2.5/4.9/7GHz .

Index Terms: ANSYS HFSS 18.0v, Defected Ground Structure, Microstrip line feed, symmetric slotted patch.

I.INTRODUCTION

In all modern Hi-tech products wireless communication plays an important role. In the next generation for better communication need to decrease the size of the antenna for the high data rate of wireless network and also to improve the compatibility. Now a days there dual, triple or multi band operation had a craze because they have ability to provide multiple functions in a single device.

Microstrip patch antenna is widely preferred in many applications, It features such as low-profile nature; patch antennas can be fabricated using printed circuit technology which results in low cost, low weight with conformal shapes which makes easy to integrate with microwave integrated circuits. One of the most popular type of microstrip patch antenna is rectangular patch antennas [1]. Several methods have been proposed recently like slots on the patch with different shapes [2-4], management of dielectric substrates [5] or Defected Ground Structure (DGS) which consist etching of a simple shape in the ground plane, or sometimes by a complicated shape for the better performance. [6-7].

To get the characteristics such as radiated fields, impedance bandwidth and efficiency, the antenna should be excited. There are four techniques [8] used to excite the microstrip patch antenna. In this paper, the antenna is excited by using microstrip line feeding because it is easy to design and provides the good matching of the input impedance [9].The simulation of results is performed using finite element method (FEM) software "High Frequency Structure Simulator" HFSS 18.0v [10].

In this paper, section II explains the design of a compact triple band microstrip patch antenna using DGS. In section III antenna simulation results that are conducted on the antennas broadband impedance bandwidth, return loss, VSWR, radiation pattern and gain are discussed. Section IV proposed design is concluded.

II. ANTENNA DESIGN

This section describes the design process and performance features of proposed antenna. The design analysis is based on the flowchart shown in Fig 1.

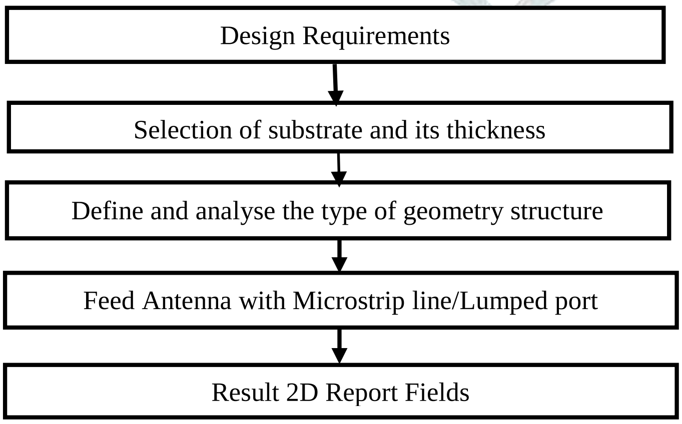

Figure 1 Flowchart for designing an antenna

Table 1: Selection of specifications

Specifications	**Selection**
Triple Band frequencies (f_c)	*2.5/4.9/7.0 GHZ*
Substrate Material	*Rogers RT/duroid 5870*
Dielectric Constant (ϵ_r)	*2.33*
Substrate Height (*h*)	*0.8 mm*

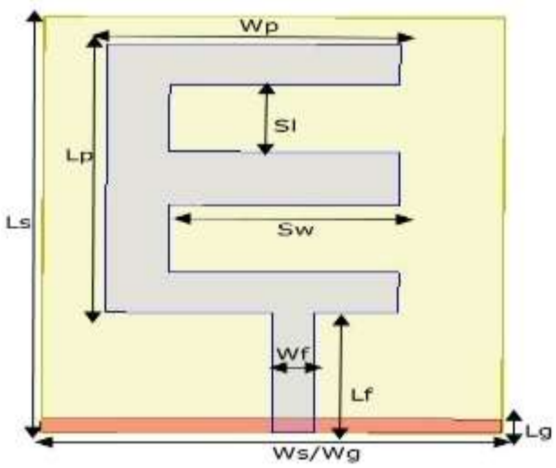

Figure 2 The geometry of the proposed antenna with labels

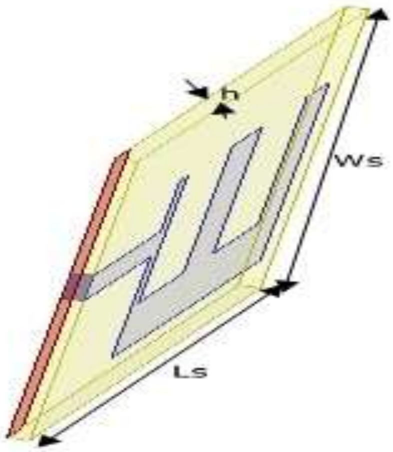

Figure 3. The geometry of proposed antenna side view

The overall geometry of the proposed antenna is shown in Fig 2 and geometry of proposed antenna side view is shown in Fig.3.The final optimized geometry is designed and simulated with the software ANSYS HFSS 18.0v. Triple band frequency is achieved using a symmetry slotted cut on conducting patch and DGS of the partial rectangle shape cut on the ground plane.

To calculate the dimensions of the rectangular patch microstrip antenna, certain parameters selection is defined from the parameters listed in Table 1.

The proposed antenna has one radiating patch which occupies a length (Lp) of 20 mm and width (Wp) of 14 mm.

Fields at the edges of the patch undergo fringing which radiates the antenna, to increase the radiation, technique of Slotting is used on the patch. A Symmetric rectangular slot loaded on the conducting patch element with the overall geometry dimensions are illustrated in table 2.

Parameters	Dimensions in mm
Ls	*31*
Ws/Wg	*22*
Lg	*2*
Lp	*20*
Wp	*14*
Lf	*9*
Wf	*2*
Sl	*11*
Sw	*6*

Table 2 Dimensions of the designed antenna

Slotting Increases the fringing effect and gives the better radiation and shift of frequency. The effect of slot keeping other parameters fixed achieve the resonance frequency falls from 3GHz to triple bands 2.5/4.9/7GHz as shown in Fig.4 which indirectly reduces the size of the antenna.

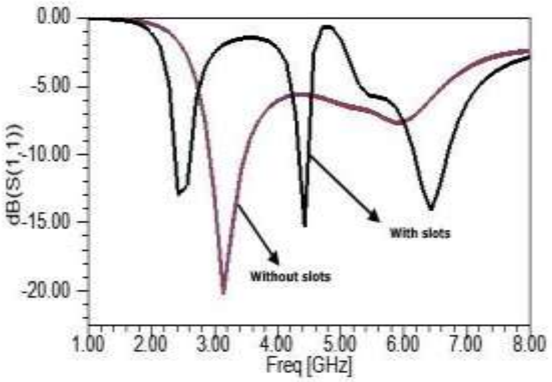

Figure 4 The simulated return loss of the defected ground plane width by parameters variation from Lg=2mm and 14mm.

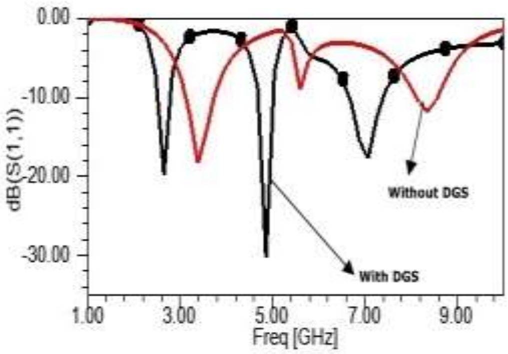

Figure 5 The simulated return loss of the defected ground plane width by parameters variation from Lg=2mm and 14mm

The effect of varying the ground length by keeping all parameters constant achieve best results Fig.5 reveals the result of output characteristics with and without using DGS, with an decrease in substrate length Lg from 14mm to 2mm bandwidth increases and losses decreases. The parametric optimetrics of the different values drawn conclusion that, defected ground dimensions of length Lg=2mm and width Wg=22mm gives the enhanced output characteristics.

Launching the power to and from the antenna is done by exciting the antenna by feeding which indirectly will determine the achievable bandwidth, radiated fields, and efficiency of the overall antenna. The proposed antenna is fed by microstrip line feed, to correctly match the input impedance of the antenna, the input impedance of the antenna is matched by adjusting the width of the patch or changing the insert feed position. Experimental iterations are done to choose the feed width and feed position for 50Ω matching. The optimized position of feed obtained at feed position p=10mm from the origin, with feed line length Lf =9mm and optimized feed width Wf=2mm.

III. RESULTS AND DISCUSSION

The proposed antenna was designed and simulated using ANSYS HFSS 18.0v.By practical analysis -10dB return loss is sufficient that gives 10% Reflection and 90% power into the antenna and -20dB return loss gives 1% Reflection, 99% power into the antenna. The return loss of simulated result obtained for the triple band design is -22/-35/-19dB as shown in Fig.6 at 2.5/4.9/7GHz.

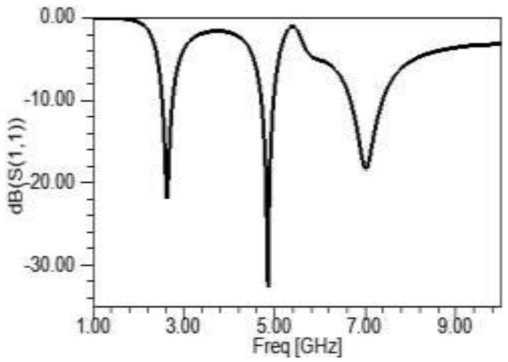

Figure 6 Simulated Return loss Vs Frequency of the proposed antenna at 2.5/4.9/7GHz.

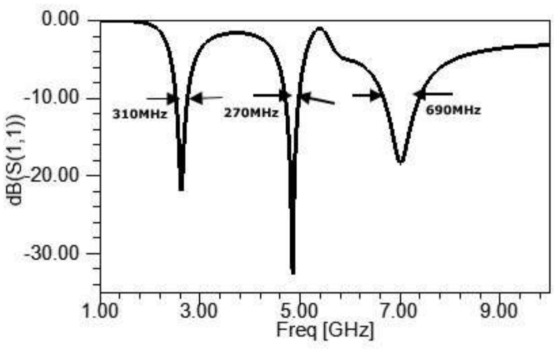

Figure 7 Simulated bandwidth of the proposed antenna at 2.5/4.9/7GHz.

The bandwidth of antenna specifies the range of frequencies over which the antenna satisfies the gain, radiation pattern, VSWR, return loss etc. The proposed antenna given 300MHz/270MHz/690MHz of impedance bandwidth at 2.5/4.9/7GHz as shown in Fig.7.

VSWR specification commonly adopted at 2:1, which means that the range of frequencies over which the VSWR is less than 2, is chosen for operation. For the practical antennas, the VSWR must be less than 2 that gives 90% of the power that must be radiated into space and only 10% of the power is reflected. So, the value of VSWR can be seen to be within 1 to 2 in the operating range. The simulation results of design are shown in Fig.8 for VSWR at frequency 2.5/4.9/7GHz is 1.2/0.8/1.6dB.

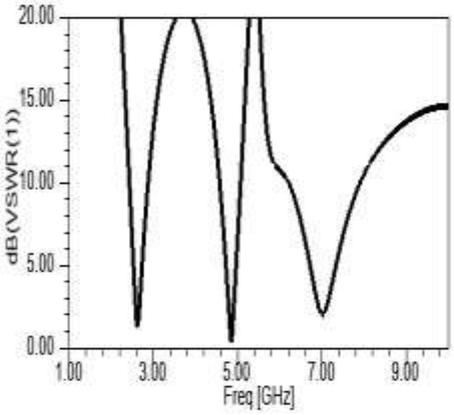

Figure 8 Simulated VSWR Vs Frequency of the proposed antenna at 2.5/4.9/7GHz.

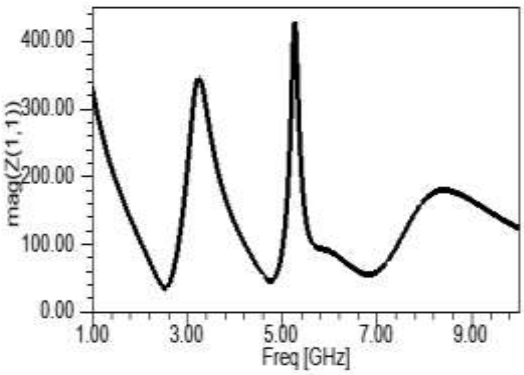

Figure 9 Simulated magnitude of impedance Vs Frequency of the proposed antenna at 2.5/4.9/7GHz.

Better transmission and reception of the signal is achieved when the antenna gives the impedance matching. Fig.9 shows the impedance at required frequency 2.5/4.9/7GHz matched to approximately 50Ω.

The radiation characteristics which are function of angular position and radial distribution from the antenna, 3D polar E-field polar plot is shown in Fig.10, Fig.11 and Fig.12 for the frequencies 2.5/4.9/7GHz the observed gain is 2.5/3.75/5Db.

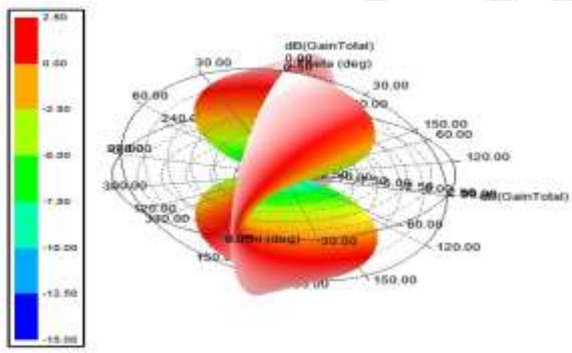

Figure 10 Simulated 3D polar plot for the gain at frequency 2.5GHz

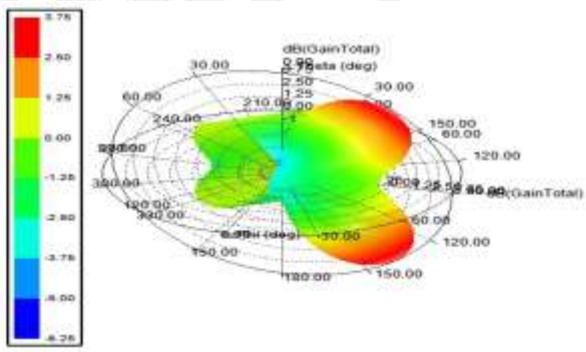

Figure 11 Simulated 3D polar plot for the gain at frequency 4.9 GHz

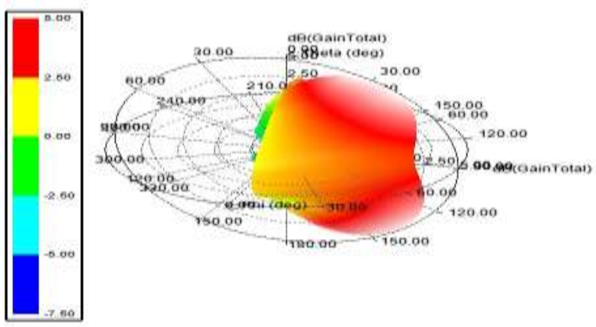

Figure 12 Simulated 3D polar plot for the gain at frequency 7 GHz.

IV. CONCULSION

The proposed antenna is compact in size with the dimension 14 X 20 X 0.8 mm^3.For designing the proposed antenna microstrip patch antenna is proposed firstly and then two rectangular symmetric slotting is designed we got three bands 2.5/4.9/7GHz but with less efficient output characteristics by introducing the Defected Ground Structure the output characteristics are enhanced with gain 2.5/3.75/5dB, return loss -22/-35/-19dB, VSWR of 1.2/0.8/1.6dB and impedance bandwidth 300MHz/270MHz/690MHz at 2.5/4.9/7GHz.All the are used for radiolocation (CHT Global 4G LTE Hotspot , Point to Point Device , Wireless USB Mini-Card UWB Transmitter Modules).In future, proposed antenna can be converting into reconfigurable antenna using RF switches. So that single antenna can be used for multiple frequencies.

V. ACKNOWLEDGEMENT

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