Dual Band Microstrip Antenna for Improved Gain and Reduced Return Loss with Rectangular Slots and DGS

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Abstract: In this paper a new design of microstrip antenna is presented. A rectangular microstrip patch antenna designed with strip line feed. Rectangular slots employed on patch for resonating in two frequencies at 2.4GHz and 3.5 GHz. To improve the working efficiency of proposed antenna, a Defected Ground Structure is used. FR4 epoxy material is used as substrate of height 1.6 mm with relative permittivity of 4.4. The proposed antenna has the dimensions of 50 x50 x 1.6mm^3. The proposed antenna is designed at two resonance frequencies of 2.4GHz and 3.5 GHz for Bluetooth devices, Wi-Fi, public wireless hot spots and WiMax.

Keywords: Microstrip Antenna, Bandwidth, Radiation Pattern, Return Loss (RL)

I. INTRODUCTION

Modern area especially in the field of communications is considered to be age of technology. The present day wireless communication systems shows increased affinity towards antennas with multiband operations. Due to advancements in the technology, the systems become reduced in size and hence the antenna in results has also been reduced in size to transmit and receive signals with high directive properties. Microstrip patch antennas are prominent to their features like compactness, durability, conformability, low-profile, low cost for the hardware fabrication and compatibility. However, the microstrip antenna has narrow bandwidth characteristics. One way to widen the bandwidth of antenna is to deploy defects in the ground plane and slots in the patch. Slot cuts in the patch are helped to achieve multiple frequency bands and improve the impedance bandwidth improvement. Defected ground structure is used to improve the bandwidth. Antenna performance parameters like gain, efficiency and directivity can be improved by deploying the defected structures in the ground plane of an antenna. The strip line feeding technique is used for better input impedance matching. Hence the antenna can effectively radiate the power which is fed by the source. Two frequency bands at 2.4GHz and 3.5GHz are choose for various applications like Bluetooth Devices, IEEE 802.15.4 based wireless data networks, public wireless hotspots and WiMax. The proposed antenna is stimulated using ANSOFT HFSS V13. The dual band antenna characteristics are evaluated on the basis of the parameters such as return loss, VSWR and Gain. This paper is organised as follows: In the section II, the design evolution of antenna is presented, Section III summarizes the simulation reports and discussions, and Section IV concludes the paper.

II.PROPOSED ANTENNA DESIGN

This section explains the design evolution of the proposed dual band antenna with slots and DGS. A basic square patch antenna has been initially designed having dimensions 40mm x 29.04mm x 1.6mm as shown in Fig1. A 50Ω microstrip feed line is used. The following Equations are used to design the proposed antenna.
The width of the patch (W)

$$W = \frac{C}{2f_0\sqrt{\frac{\epsilon_r+1}{2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (1)$$

Where,
C is velocity of light
f_0 is Resonant Frequency
ε_r is Relative Dielectric Constant
Effective dielectric constant (ε_{eff})

$$\epsilon_{eff} = \frac{\epsilon_r+1}{2} + \frac{\epsilon_r-1}{2}\sqrt{1+12\frac{h}{W}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (2)$$

h is height of the substrate
Effective length (L_{eff})

$$L_{eff} = \frac{c}{2f_0\sqrt{\epsilon_{eff}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Length Extension (ΔL)

$$\Delta L = 0.412h \frac{(\epsilon_{eff}+0.3)(\frac{W}{h}+0.264)}{(\epsilon_{eff}-0.258)(\frac{W}{h}+0.8)} \ldots\ldots\ldots\ldots\ldots (4)$$

Actual length of patch (L):

$$L = L_{eff} - 2\Delta L \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

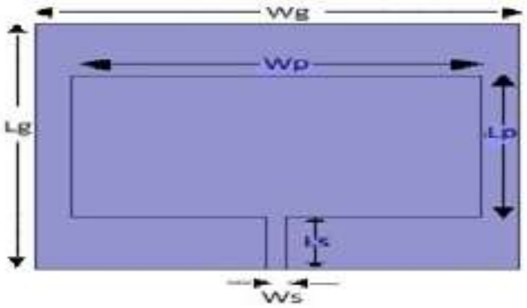

Figure 1: Top View of Conventional Antenna

To progress the performance of the depicted antenna model, two rectangular slots are placed in the patch having dimensions 1.67mm x 0.8mm as shown in Fig2. These slots improve the gain and the return loss performance.

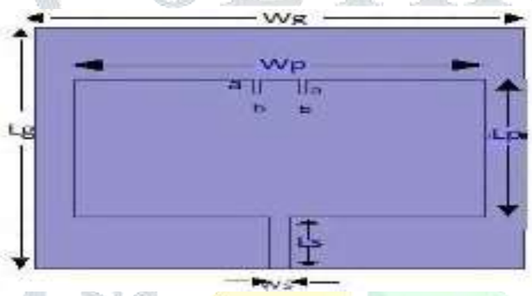

Figure 2: Top View of antenna with Rectangular slot

One more attempt were made to improve the gain and return loss at the upper resonance frequency, two rectangular slots are placed on the ground plane having dimensions 4mm x 1.5mm as shown in Fig3. Defects on the ground plane thus will disturb the current distribution which changes the flow of current depending upon the shape and dimensions of the defect introduced. The rectangular DGS resulting in improved return loss and gain.

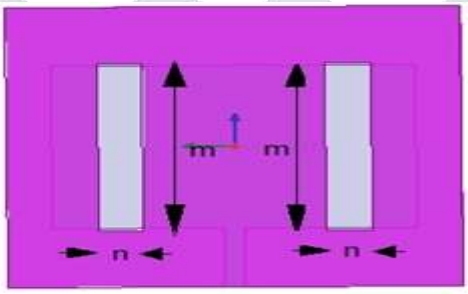

Figure 3: Bottom View of Antenna with slots and DGS

Table 1: Dimensions of the proposed antenna

Parameter	Dimension (mm)
Width of the Ground (Wg)	50
Length of the Ground (Lg)	50
Width of the Patch (Wp)	40
Length of the Patch (Lp)	29.04
Width of the strip (Ws)	2.2
Width of the Strip (Ls)	11
Width of the rectangular slot on patch (a)	1
Length of the rectangular slot on patch (b)	4

Width of the rectangular DGS on Ground (n)	5
Length of the rectangular DGS on Ground (m)	30

III.SIMULATION RESULTS

Simulations are carried out in HFSS V 13. Return loss for conventional, slot and slot with DGS MSA are shown in Fig 4. For conventional antenna the return loss at 2.4GHz and 3.53GHz is -17.75dB and -11.59dB respectively, Return losses are better in slot and slot with DGS antennas than conventional antenna MSA.

Figure 4: Return Loss response for three different antennas.

VSWR for conventional, slot and slot with DGS MSA are shown in Fig 5. VSWR at 2.3GHz and 3.53GHz is below 2, which clear that the proposed antenna having better impedance matching.

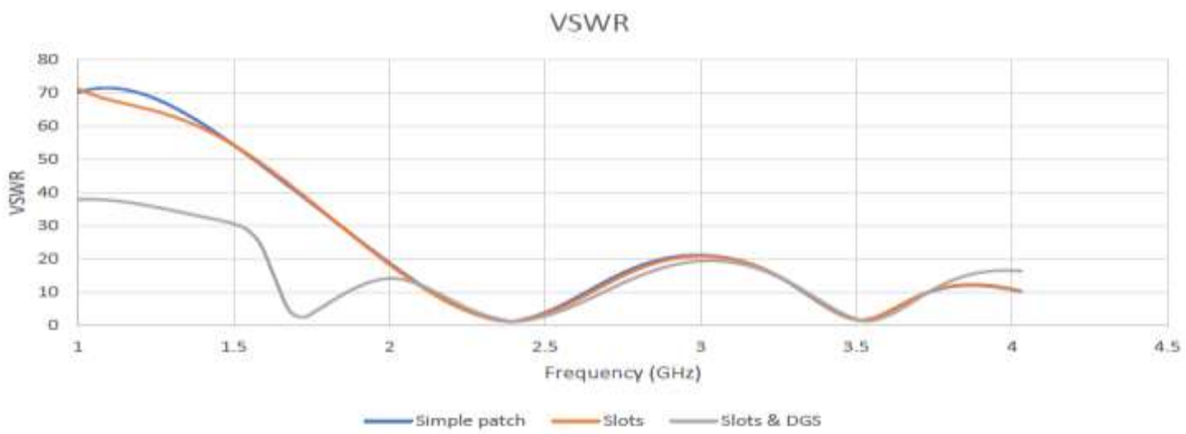

Figure 5: VSWR response for three different antennas.

Fig 6, Fig 7 & Fig 8 shows the gain plots for conventional, slot and slot with DGS MSA. From these results, it is clear that the gain is improved from 2.66dB to 3.13dB by introducing the slots and DGS.

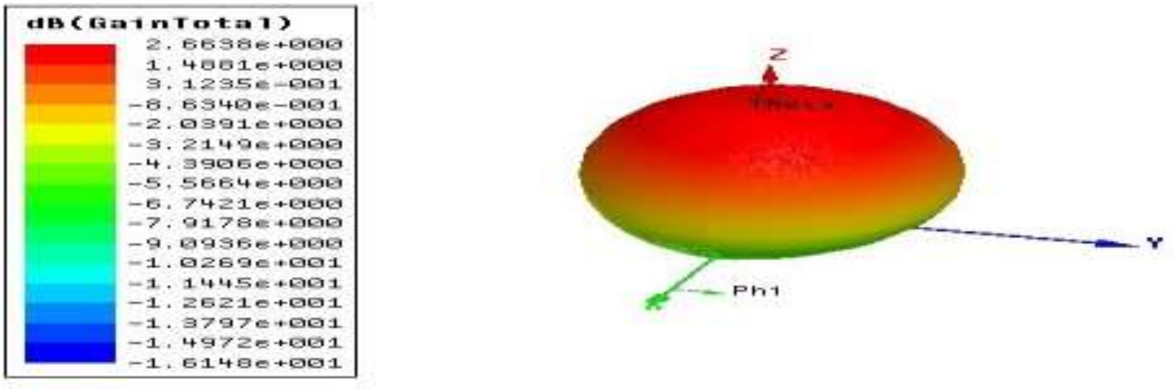

Figure 6: Gain plot for a conventional microstrip antenna

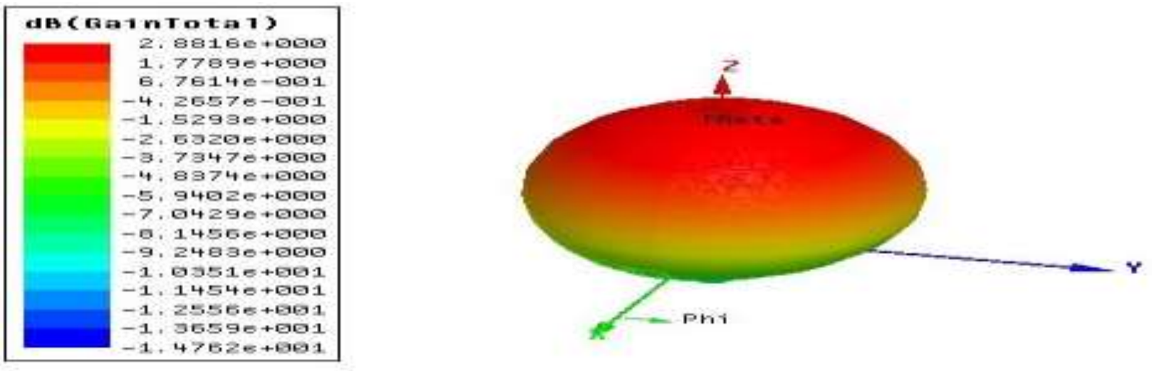

Figure 7: Gain plot for a microstrip antenna with slots on patch

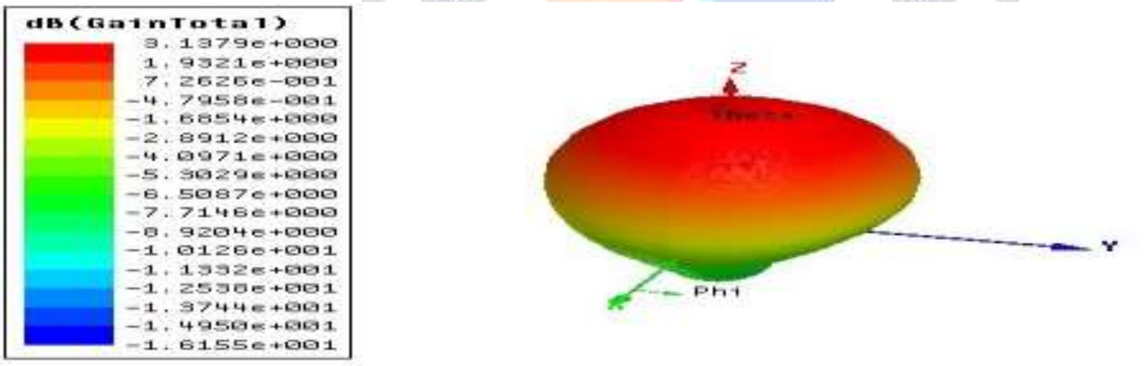

Figure 8: Gain plot for a microstrip antenna with slots and DGS.

Table 2: Simulated Results

Parameter	Conventional Antenna		MSA with Slots		MSA with Slots & DGS	
	2.4GHz	3.5GHz	2.4GHz	3.5GHz	2.4GHz	3.5GHz
Return Loss	-17.75dB	-11.59 dB	-1-89 dB	-11.81 dB	-22.63 dB	-20.97 dB
VSWR	1.29	1.71	1.25	1.68	1.15	1.19
GAIN	2.66 dB	2.66 dB	2.88 dB	2.88 dB	3.13 dB	3.13 dB
Bandwidth	120MHz	50 MHz	140 MHz	80 MHz	120 MHz	80 MHz

Table 2 represents the comparative results of conventional, slot and slot with DGS microstrip antennas. From the above table 2, it is clear that the performance parameters of antenna with slots and DGS are better than conventional and only slot antennas.

IV.CONCLUSION

A dual band microstrip antenna with rectangular slots and DGS for WiFi and WiMax is presented in this paper to improve the return loss and gain of the antenna. The simulation results proven that the impedance bandwidth of 120MHz (2.35GHz-2.47GHz) and 80MHz (3.5GHz-3.58GHz) is obtained after deploying the slots and DGS in rectangular shape. The return loss levels are reduced from –17.75dB to -22.63 dB at 2.4GHz and from -11.59dB to -20.97dB at 3.53GHz. The defected ground structure not only helps in achieving the multiband operation but it also helps to improve the performance of an antenna with respect to its gain and bandwidth. The proposed antenna can be used in many applications such as Bluetooth Devices, wireless data networks, public wireless hotspots and WiMax.

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