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Design and Fabrication of DGS Microstrip Patch Antenna for S, C & X Band Applications

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Abstract: ***The design and simulation of defected ground structure microstrip patch antenna for Worldwide Interoperability for Microwave Access (WiMAX) and Wireless Local Area Network (WLAN) applications are additionally testing as the antenna ought to be little in size, light in weight, easy to manufacture, minimal effort, and simplicity of joining in such gadgets. The target of this work is to plan and creation of an antenna which will be appropriate for WiMAX and WLAN applications with improved gain and optimized bandwidth. WiMAX depend on gauges, for example, IEEE 802.16, intended to work between 2-11 GHz and spreads S, C and X microwave recurrence groups. Metropolitan Area Network (MAN) conventions are in the 2.3 GHz, 2.5 GHz, 3.5 GHz and 5.8 GHz ranges. A planar antenna with imperfect ground plane is proposed and manufactured, 3.5/5.5 GHz WiMAX band, 5.2/5.8 GHz WLAN band, 4/6 GHz satellite correspondence, and different remote correspondence applications. This structure canvassed two groups in which it is extending from 3.34-8.72 GHz implies a band of 5.38 GHz with impedance BW 89.22%. The resonating frequencies are 3.92 GHz and 7.88 GHz with return loss - 35.59 dB and - 31.99 dB, VSWR 1.03 and 1.05 and gain 9.46 dB and 0.14 dB respectively. The second band covers 9.22-13.06 GHz implies a band of 3.84 GHz with impedance BW 34.47%. This resounds at 10.58 GHz with return loss - 55.52 dB, VSWR 1.00 and gain is 7.09 dB. The deliberate outcomes are in great concurrence with reproduced consequences of the proposed antenna.***

Index Terms**: *Microstrip Patch Antenna (MPA), Dielectric constant, Defective Ground Structure (DGS), WiMAX, WLAN, Return loss, VSWR, Gain and Radiation pattern.***

I. INTRODUCTION

The substantial burden of mobile communication systems is clearly reflected in past decade and present market expansion ventures at global canvas. This expansion of discerning inflation in population demands is of utmost importance to be handled. Owing to the paucity of modern-day cellular conversation systems, antenna is of vital importance. If we consider each industrial and army purposes wideband, multiband and low-profile antennas are exceptional demand for modern-day wireless communication system. As antennas are one of the most vital parts of a mobile system the evolution of antenna has been obvious: smaller, light-weight and most importantly high quality [1][2][3]. The rapid development of wireless technology research platforms deciphers that verbal exchange is incomplete barring a perception of the operative condition of antenna [3]. Piecing of metal strip or chip and dielectric layer (substrate) over a ground plane results in the development of microstrip; a pioneer invention by Bob Munson in 1972 (but earlier worked by Den champs go back to 1953)[1]. They are mostly used at microwave frequencies [1] [2]. The wide range of application of microstrip antennas have emerge as very popular in current many years due to their skinny planar profile which can be integrated into the surfaces of customer products, aircraft and missiles based on ease of fabrication with the use of printed circuit methods [1]. After approval of commercial use of Ultra Wide Band by Federal Communication Commission, UWB has become a great point of interest in present research area [4][5]. Several researchers have faced the challenges such as reducing the antenna size, increasing bandwidth and minimizing interference. But now a day many research works have been proposed for ultra wide band antenna [6][7][8]. Most available wireless communication systems are placed at overlapping frequency bandwidth to that of UWB systems. This results in causing interference to the structures *viz* (i) IEEE 802.11a in USA (5.150-5.350 GHz and 5.725-5.825 GHz) and (ii) World Interoperability for Microwave Access (WiMAX) (3.400-3.690 GHz and 5.250-5.825 GHz) [5] [10]. In case, the most challenging part is the designing of UWB antennas by restricting the interference between UWB structures and present narrow band wireless communication system by frequency notched band. Overcoming the limitations provided by UWB, Wide band Microchip Antennas (MPAs): a round shaped Defected Ground Structure (DGS) are of prime importance for wireless systems applications [2][5].

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II. DESIGNING AND STRUCTURAL CONFIRMATIONS OF ANTENNA

The standard dimensions of the proposed antenna are 20 × 25 × 1.6 mm^3. A 50 Ω impedance microstrip line feeds the antenna. The proposed shape is fabricated on a FR-4 substrate with $\varepsilon_r = 4.4$, $\mu_r = 1$ with a loss tangent of 0.02 which is proven in figure 1. The precise geometry of the proposed antenna with the exact parameters is confirmed in table 1.

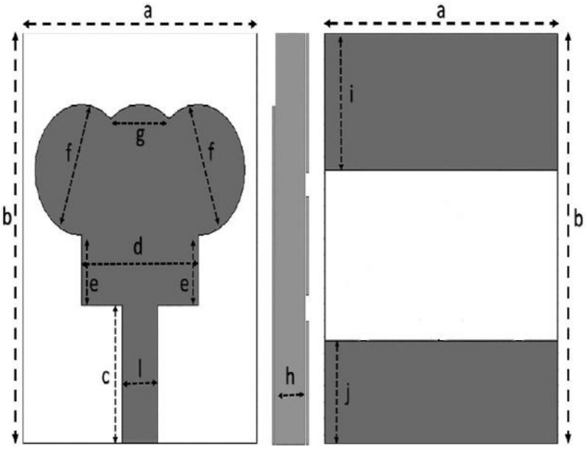

Figure 1: Structure of proposed antenna

Table 1: Parametric values of proposed antenna

a	b	c	d	e	f	g	h	i	j	k
20	25	8.3	10	4.1	8	8	1.6	8.33	6.25	3

In this study, a combination of circular-rectangular patch antenna incurring 50-Ω microstrip feed and semi ground plane is designed. Analysis and optimization of proposed antenna design was enabled by utilizing Ansoft HFSS. Fabrication is performed on FR-4 epoxy substrate; with supporting validation by simulation platforms.

The breadth and the size of the substrate is denoted as “a” and “b” respectively. In accordance, width and the size of the microstrip line are denoted via “l” and “c” respectively Thickness of the substrate (FR-4) is denoted via “h.” “f” is the diameter of the circular patch it is the top section of the square patch, the width of the patch is denoted by using “d”. Diameter of the center round patch is denoted via “g”. The dimension of the defect on the ground plane is denoted via “i” and “j” respectively. The proposed antenna has been excited with lumped port. Copper is used in the designing of feed line, rectangular patch as nicely as round patch. The top and bottom view of fabricated proposed antenna is shown in figure 2 and 3 respectively.

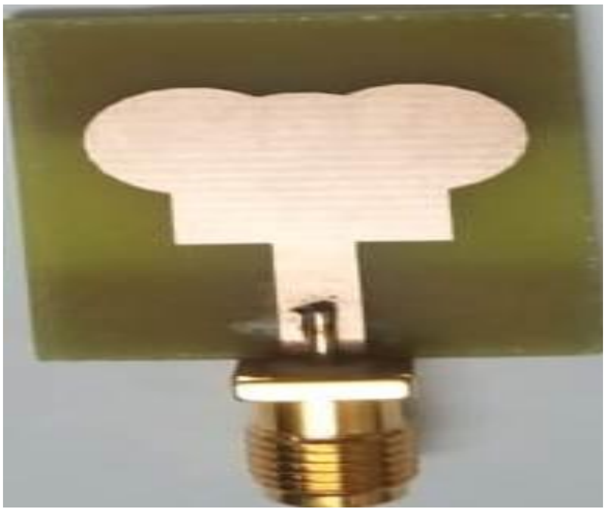

Figure 2: Top view of fabricated antenna

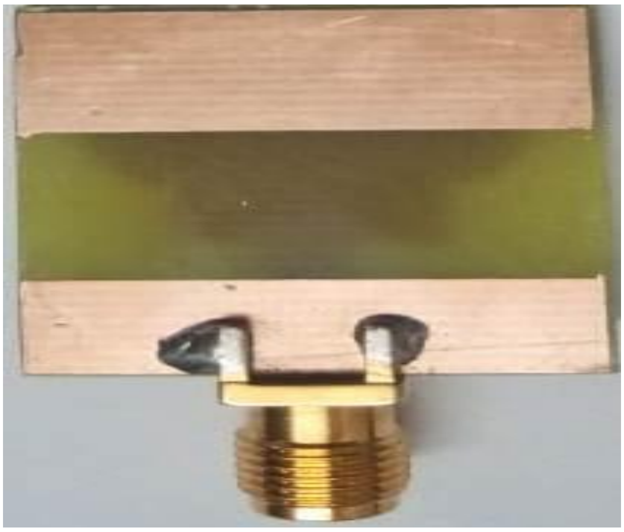

Figure 3: Bottom view of fabricated Antenna

Measurement of proposed antenna using Vector Network Analyzer (Agilent N5247A: A.09.90.02) in anechoic Chamber is shown figure 4.

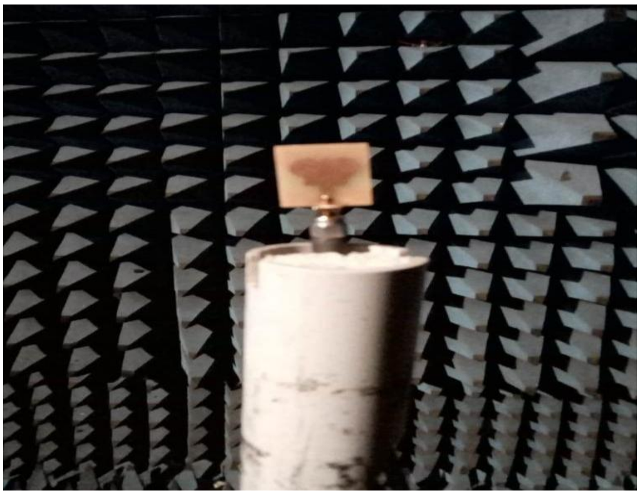

Figure 4: Measurement of fabricated antenna

III. RESULT AND DISCUSSION

The proposed antenna is fabricated on a commercially accessible inexpensive (FR-4) substrate with $\varepsilon_r = 4.4$, $\mu_r = 1$ and the loss tangent of 0.02. The optimization of the proposed antenna was performed with the use of Vector Network Analyzer (Agilent) with a 50 Ω SMA connector to the microstrip feed line in an anechoic Chamber. There are more than one frequency bands is found. The graph covers from 3.34-8.72 GHz skill a band of 5.38 GHz skill BW proportion is 89.22% which is lies in the S band (2-4 GHz) and C band (4-8 GHz). The second band covers 9.22-13.06 GHz skill a band of 3.84 GHz impedance BW proportion is 34.47% which lies in X (8-12 GHz) bands, small resonance shifts at the center order frequencies effects due to the compact measurement of the shape and owing to the reality that the dimension of the SMA connector is comparably large. They can be regarded as fabrication tolerances.

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Figure 5 indicates the assessment of the simulated and measured return loss versus frequency of the proposed antenna. The simulated return loss of the proposed antenna are -35.59 dB and -31.99 dB with resonating frequencies 3.92 GHz and 7.88 GHz for the first band and -55.52 dB with resonating frequency 10.58 GHz for the second band. The simulated result is in precise settlement with the measured ones, which is validating the simulation method.

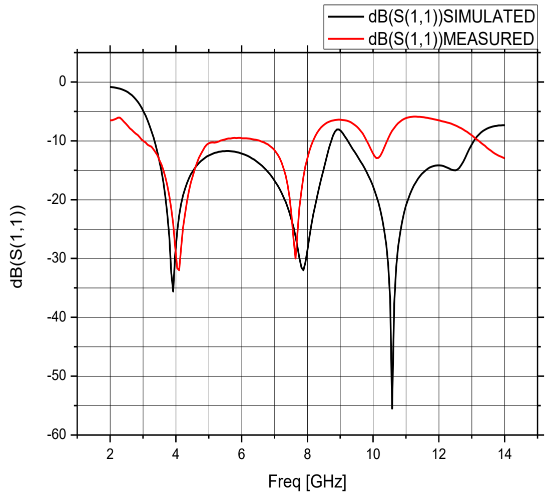

Figure 5: Comparison of simulated and measured return loss of the proposed antenna

Now simulated and measured outcomes of VSWR v/s frequency of proposed antenna. The simulated value of VSWR is 1.0338, 1.0515 and 1.0034 at 3.92 GHz, 7.88 GHz and 10.58 GHz respectively [Figure 6].

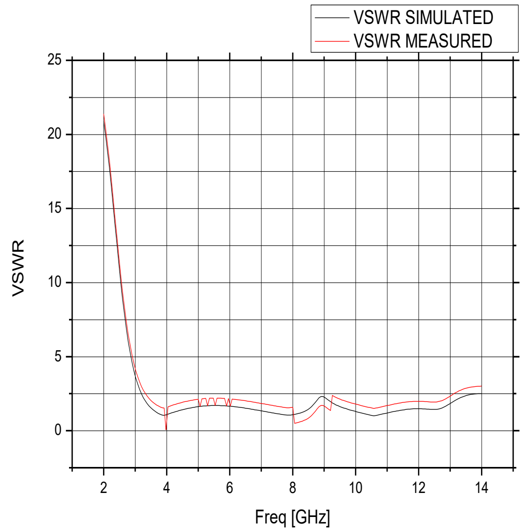

Figure 6: Comparison of simulated and measured VSWR of the proposed antenna

Figure 7 shows the simulated and measured gain versus frequency of the proposed antenna. Simulated results are in affirmative agreement with the measured ones. Observed from the gain versus frequency curve, that as frequency increases, gain of the proposed antenna increases, this is validated, as a gain of an antenna is directly proportional to frequency. The maximum gain of the proposed antenna is 9.46 dB, 0.14 dB and 7.09 dB at resonant frequency 3.92 GHz, 7.88 GHz and 10.58 GHz respectively.

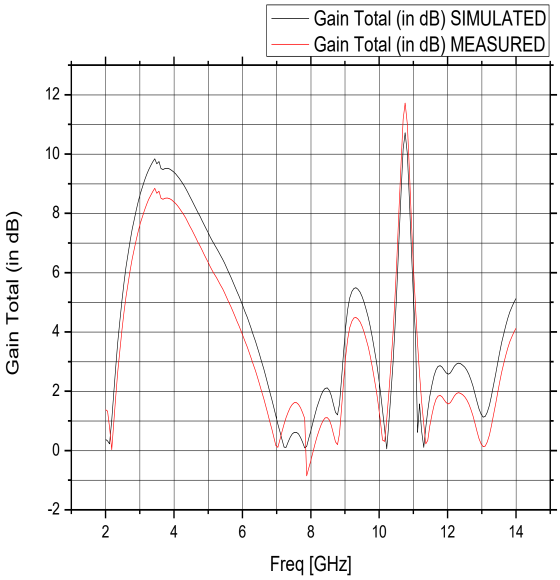

Figure 7: Comparison of simulated and measured Gain of the proposed antenna

For higher understandings of our work, a comparative evaluation of simulated and measured outcomes is proven in desk 2. In this desk we can find the frequency ranges (bands), bandwidth percent (BW), resonant frequencies (RF), return loss (RL), VSWR and gain.

Table 2: Comparative analysis of simulated and measured results of proposed antenna

Antenna Parameters	Results					
	Simulated			Measured		
Bands (in GHz)	3.34-8.72	9.22-13.06		3.02-8.12		9.8-10.4
BW (%)	89.22	34.47		91.56		5.94
RF (in GHz)	3.92	7.88	10.58	4.1	7.64	10.1
RL (in dB)	35.59	31.99	55.52	32	29.96	12.92
VSWR	1.0338	1.0515	1.0034	1.6585	1.6023	1.7416
Gain (in dB)	9.46	0.14	7.09	8.26	1.55	0.35

The Radiation mechanisms of simulated outcomes are proven in figure 8 to 10 for distinct angles. In which Radiation Pattern 1 for Phi = 0° & 90° at 3.92 GHz is proven in Figure 8, Radiation Pattern 2 for Phi = 0° & 90° at 7.88 GHz is proven in figure 9, Radiation Pattern 3 for Phi = 0° & 90° at 10.58 GHz is proven in figure 10.

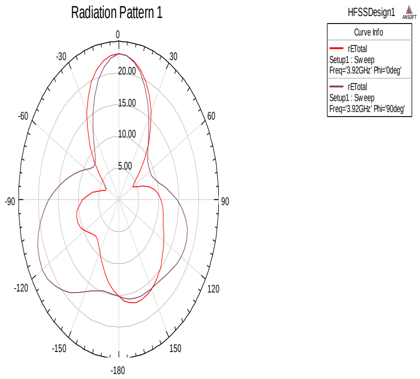

Figure 8: Radiation Pattern 1 for Phi = 0° & 90° at 3.92GHz

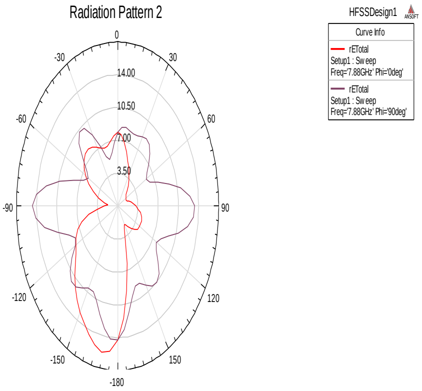

Figure 9: Radiation Pattern 2 for Phi = 0° & 90° at 7.88GHz

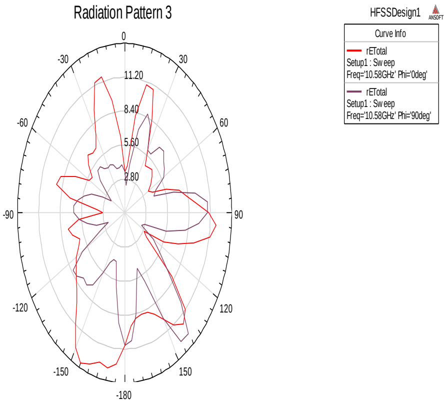

Figure 10: Radiation Pattern 3 for Phi = 0° & 90° at 10.58GHz

IV. CONCLUSION

The simulation is performed by means of the software program Ansoft HFSS v.15.0. The simulated outcomes are validated with measured results. The antenna is fabricated on FR-4 epoxy substrate with copper patch, ranges from 3.34-8.72 GHz (impedance BW is 89.22%) and the second band ranging from 9.22-13.06 GHz (impedance BW is 34.47%) which lies in the S (2-4 GHz), C (4-8 GHz) and X (8-12 GHz) bands. This result validates that graph is appropriate for the WiMAX, WLAN etc. of S-band, Long Distance Radio Telecommunication applications of C-band and Satellite, RADAR, Space Communication, Molecular Rotational Spectroscopy of X-band. For the first band the resonating frequencies are 3.92 GHz and 7.88 GHz with return loss -35.59 dB and -31.99 dB, VSWR 1.0338 and 1.0515 and achieve 9.46 dB and 0.14 dB respectively and for the second band it resonates at 10.58 GHz with return loss -55.52 dB, VSWR 1.0034 and gain is 7.09 dB. Conclusively, due to optimized bandwidth and expected gain in the proposed design of antenna made it peer quality wireless communication gadget. Such above-stated properties of antenna add on the priority of the design over others with 3.5/5.5 GHz WiMAX band, 5.2/5.8 GHz WLAN band, 4/6 GHz and render it appropriate for different wireless communication system functions of S, C & X band. An array in number of elements supports the increase in applicability of design for higher gain.

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