DESIGN OF SLOT ANTENNA WITH DEFECTED GROUND STRUCTURE FOR WIMAX APPLICATION

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Abstract: It is presented a slotted Micro strip patch antenna for WIMAX Wireless application. Embedding slots with Defected Ground Structure (DGS) technique improves overall performance of an antenna at 5.66GHz in this proposed design. The Computer Simulation technology (CST) simulator which can simulate electromagnetic signals is used for the design. The size of this antenna is 72.54×72.54mm^2. The proposed prototype antenna is well suitable for WIMAX application. The antenna parameters like Bandwidth, Radiation Efficiency, Gain and Directivity have been increased.

Keywords— WIMAX, DGS, Square slot, CST Software.

1. INTRODUCTION

Microstrip patch antenna is a kind of radio wave antenna with a low profile which is embedded on a flat surface. It is a conformal and a planar structure, compactness, low profile, directive with high transmission efficiency and ease of integration with microwave circuit and portable communication equipment. A major factor for recent advancement in Microstrip patch antenna is the current evolution in electronic field miniaturization brought about by improvement in large scale integration. For improved antenna performance, a thick dielectric substrate is desirable since this provides improved efficiency, larger bandwidth and better radiation.

With this added advantage we are implementing slots. The slot antenna is simply an opening cut in a sheet of conductor which is energized in some appropriate manner, such as via a coaxial cable or waveguide. The slot antenna makes use of the fact that energy is radiated when a high frequency fields exist across a narrow slot in a conducting plane. The shape, size of the slot and the frequency determines the radiation pattern. Slot antennas are usually used at Ultra High Frequency (UHF) and microwave frequencies. The introduction of slots in our design enhances bandwidth and gain of an antenna. In this proposed work we made DGS for enhancing antenna parameters for WIMAX Wireless application. The geometrical slot embedded on the ground plane of microwave circuit is known as Defected Ground It is integrated into the ground plane with planar transmission line (i.e.) Microstrip line. It is embedded etching off a basic cut in the ground. The use of DGS in our design improves antenna parameters and radiation characteristics and also it reduces mutual coupling between adjacent element and cross polarization.

WIMAX- Worldwide Interoperability for Microwave Access. It is a family of Wireless Broadband Communication Standard based on IEEE 802.16. WIMAX is an advanced technology based on a standard designed to meet the need for very high speed wide area internet access with low cost. The main aim of WIMAX is to provide business and consumer broadband service on the scale of MAN. The speed of WIMAX transmission is 70 mbps. It provides portable mobile broadband connection across cities and countries through various devices. WIMAX provides compatibility and interoperability of devices. Comparing with Wi-Fi, WIMAX supports further transmission distance and high data rate. The use of both Defected Ground Structure (DGS) and slot enhance the antenna parameters such as Bandwidth, Radiation Efficiency, Gain, and Directivity for WIMAX application at 5.66GHz. Nowadays, DGS has been widely used for enhancing Microstrip patch antenna. Bandwidth enhancement rectangular monopole antenna is reported in [1]. Multiband patch antenna is proposed with the partial ground plane for improving bandwidth [2]. U shape patch antenna and impact on the ground plane is discussed in [3]. Several techniques for improving bandwidth in antennas are stated in [4] to [6].

In this paper, combinations of two methods such as slot and DGS has been proposed to increase the parameters of the antenna. Great improvements in antenna parameters are achieved at 5.66 GHz. The enhancement in bandwidth is achieved by 33%, radiation efficiency by 75.82% and antenna gain and directivity by 6.01 and 8.42 respectively. The paper proceeds as Section II discussing the structure of the design. The results are analyzed in Section III, and finally, Section IV will conclude the work.

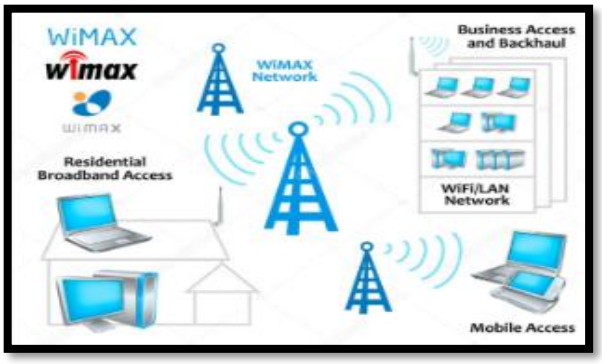


Fig. 1.Block diagram of WIMAX communication System

2. ANTENNA DESIGN

The structure of antenna design is simulated by CST (Computer Simulation Technology) software. Fig.1 indicates the layout and dimension of the designed antenna on FR4 lossy substrate. The thickness is 1.6mm. Dielectric constant of 4.3 and Loss tangent of 0.035. The dimension of the antenna is 72.54 x 72.54mm^2. The dimension of the patch is 36.27 x 36.27mm^2. The layout of the design consists of a two square slots embedded in the square patch and DGS in the ground plane.

TABLE I.COMPARISON OF THE SIZE AND BANDWIDTH OF PROPOSED ANTENNA WITH THE OTHER REFERENCES.

Reference	**Size(mm^2)**	***Bandwidth(MHz)***
[7]	58 × 66	302
[8]	31 × 28.5	223
[9]	45 × 26	90
Proposed	72.54 ×72.54	330

TABLE II.DESIGN PARAMETERS OF THE PROPOSED ANTENNA

Parameters	**Symbol**	**Value unit *(mm^2)***
Substrate	(L×W)	72.54 x 72.54
Ground Plane	(Lg×Wg)	72.54 x 72.54
DGS	(Ld×Wd)	25 × 5.4
Feed line width	Wf	2.932
Height	H	1.6
Permittivity	Ɛr	4.93
Tan δ	Δ	0.035
Gap	Fi	4.8
Patch	(Wp×Lp)	36.27 x 36.27
slot	Ws	7

In this design process of slot antenna the parameters such as resonance frequency, dielectric constant and thickness of the substrate are fundamental.

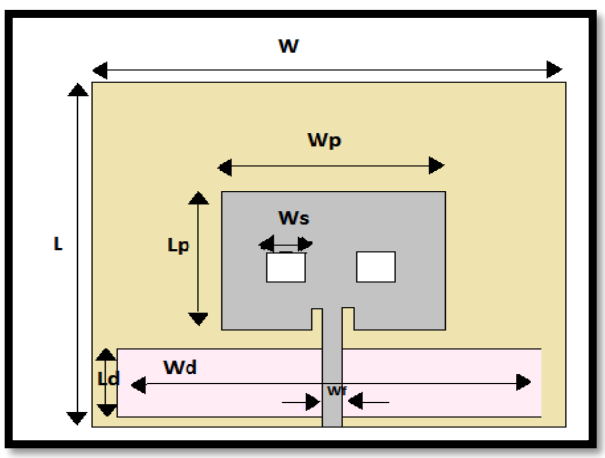


Fig. 2. Design layout of the proposed antenna

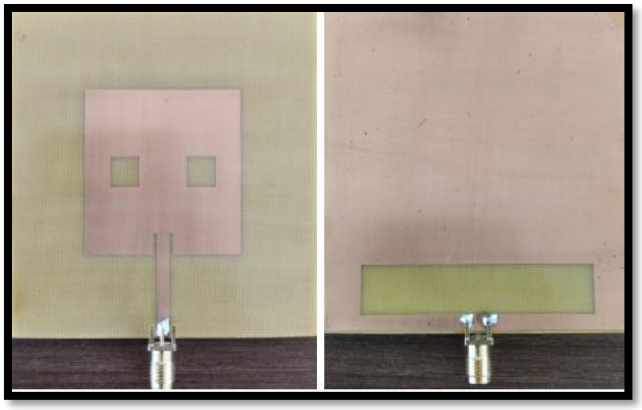
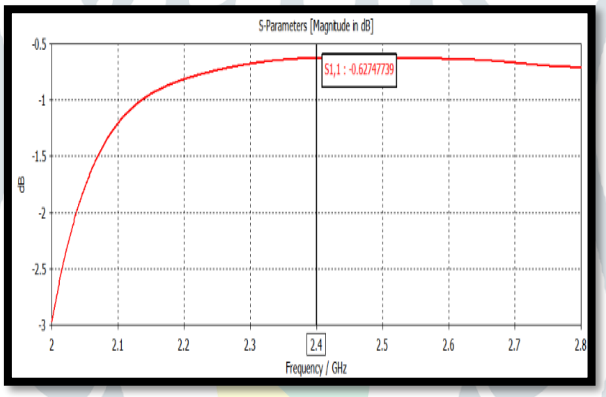


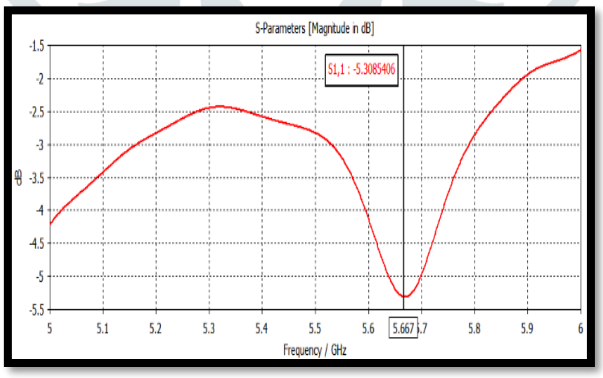
Fig. 3. Proposed antenna prototype :Front view; Back view

3. SIMULATED RESULTS AND DISSCUSSION

This design implementation has been completed by using CST microwave studio simulator version 2019. Both single slot square antenna without DGS and two slot square antennas with DGS have been simulated for the required frequency. Embedded square slot in the patch and rectangular slot in the ground plane named DGS have been implemented. The rectangular slot embedded on the ground plane is illustrated in Fig. 2.



(a)



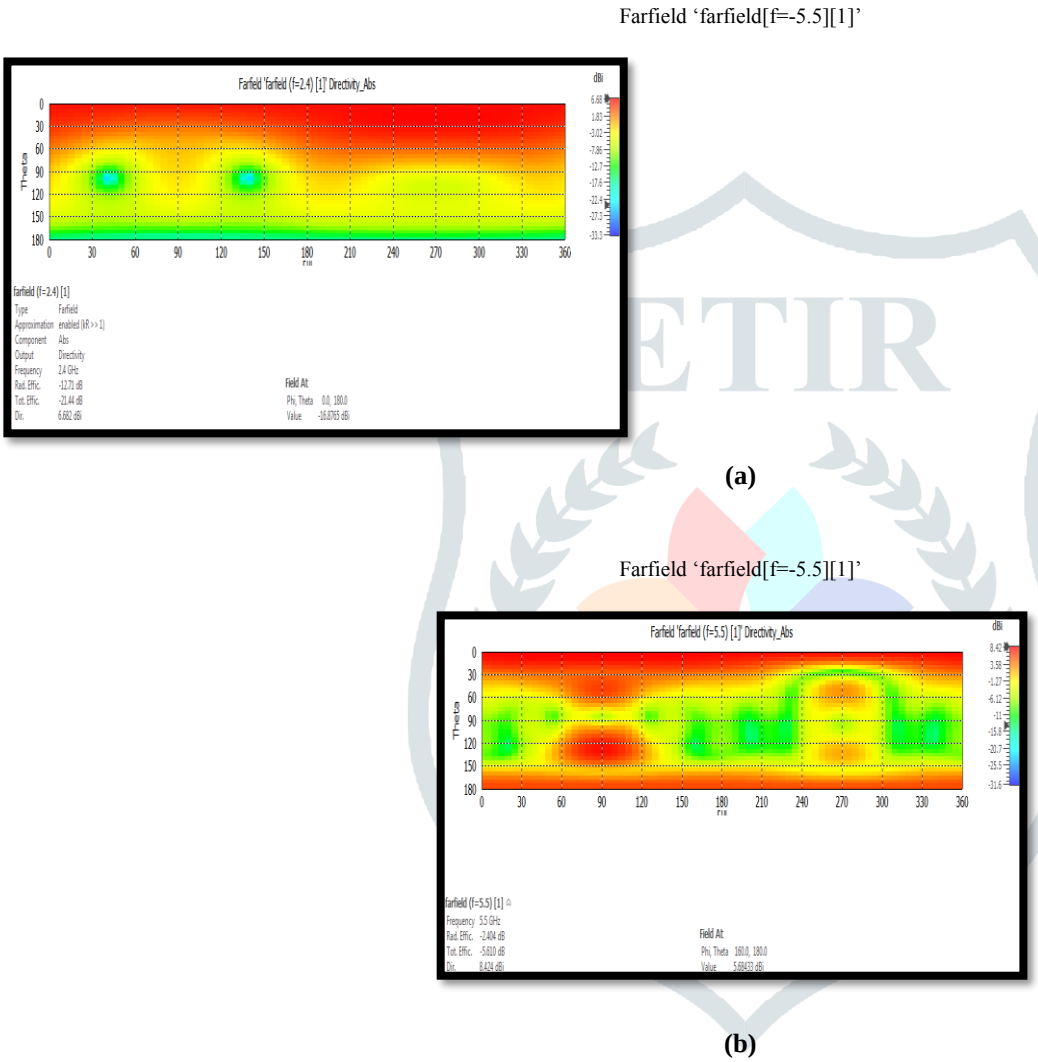
(b)

Fig. 4. Simulated return loss of the proposed antenna : (a) Without DGS; (b) with DGS

The objective is to enhance the antenna parameters such as reflection coefficient, bandwidth, radiation efficiency, gain and directivity. Fig.2 illustrates the proposed antenna prototype. Fig.3. demonstrates the performance contrast of return loss of with and without DGS antenna. The value obtained for the reflection coefficient is -5.30. The concept of DGS is to improve the features of Microstrip patch antenna operating at microwave frequency.

TABLE III. ANTENNA PARAMETER RESULTS

Simulation	Return Loss (dB)	Directivity	BW%	Rad.Efficiency%
Antenna without DGS	-0.62	6.682	27%	23.14%
Antenna with DGS	-5.30	8.41	33%	75.82%



Farfield 'farfield[f=-5.5][1]'

(a)

Farfield 'farfield[f=-5.5][1]'

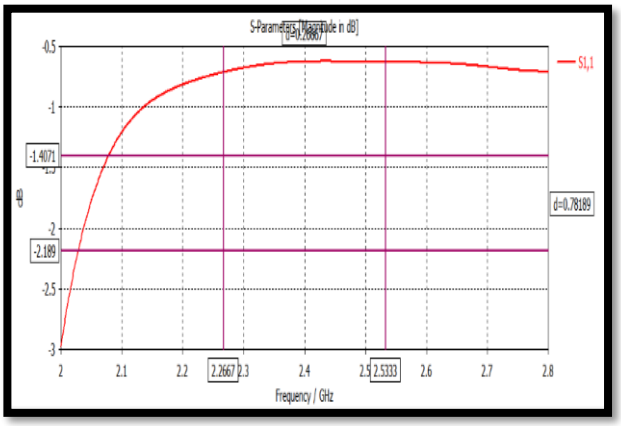
(b)

Fig.5. Simulated 2D radiation pattern for the proposed antenna :(a) antenna without DGS; (b) antenna with DGS

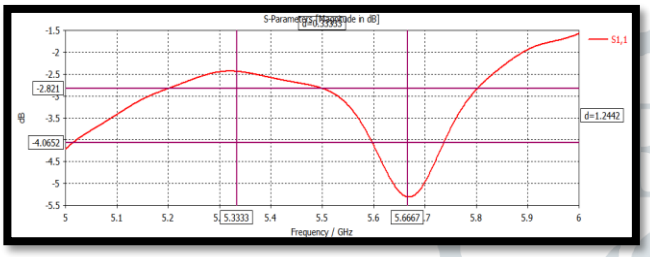
The radiation pattern is a characteristic which helps to comprehend the designed antennas behavior. It is a mathematical function or a graphical represents of radiation properties of an antenna as a function of space coordinates. Fig. 5.represents the 2D radiation pattern of with and without DGS antenna. Radiation pattern is broadside and omnidirectional. The conventional antenna has a radiation efficiency of 55.15%. After improving the ground plane, 76.31% of radiation efficiency is obtained.

In this proposed design it can be observed that bandwidth is improved by 33%. The proposed antenna with DGS has a maximum gain and directivity of 6.01 and 8.42 respectively.Fig.8. illustrates the 3D Gain and Directivity of the proposed antenna.

The importance of using DGS is to mainly improve bandwidth and radiation efficiency of square slot antenna. The implementation of both with and without DGS antenna is experimentally verified to confirm the design concept. The results from Vector Network Analyzer (VNA) are also verified. Compared to the simulated and measured results from VNA only slight difference occurs due to printing errors and dielectric losses. It can be that our proposed antenna is miniaturized and represents a significant and good adaptation. From obtained results, the antenna parameters improved.

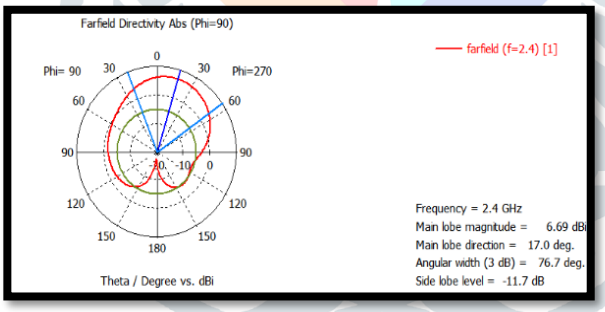


(a)

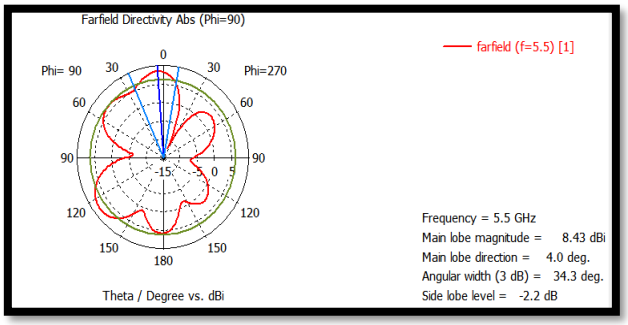


(b)

6. Simulated and the measured reflection coefficient of the proposed antenna: (a) without DGS; (b) with DGS

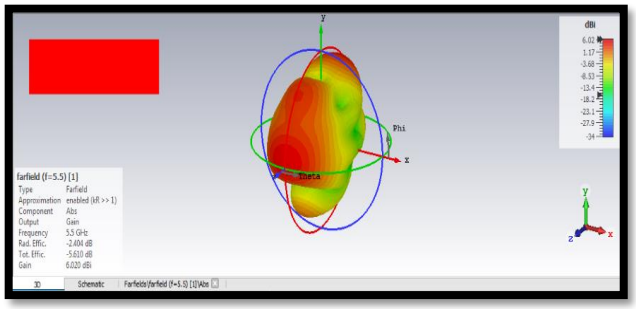


(a)

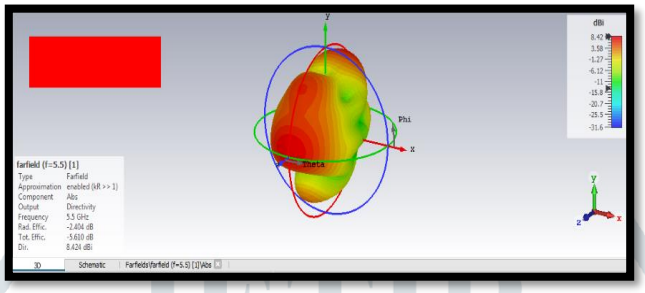


(b)

Fig. 7. Simulated Polar plot for the proposed antenna:(a) antenna without DGS; (b) antenna with DGS



(a)



(b)

Fig. 8. Simulated 3D Gain and directivity for the proposed antenna :(a) antenna Gain; (b) antenna Directivity

TABLE IV. COMPARISION OF SIMULATED AND MEASURED RESULTS

Result	Parameters	Frequency (GHz)	Return Loss(dB)	Impedance (Ω)
Simulation	S_{11}	5.667	-33.4	50
Hardware	S_{11}	5.659	-29.94	47.2-j0.7

Fig. 9. Measurement of hardware result using Network Analyzer

4.CONCLUSION

A slotted microstrip patch antenna with defected groud structure is simulated and fabricated. We made slot for enhancing antenna parameters for WIMAX wireless application. The antenna parameters are interested such as bandwidth is achieved by 33%, radiation efficiency by 75.82%, gain and directivity by 6.01 and 8.42 respectively. WIMAX system is used for high speed data transmission. WIMAX is intended to provide broadband connectivity to mobile devices.

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