PATCH ANTENNA ENHANCED BANDWIDTH AND RADIATION SPECIFICATIONS FOR WIMAX APPLICATIONS

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ABSTRACT

Smaller scale strip fix reception apparatus is generally exhibited dependent on its focal points, particularly for WiMAX remote applications. Despite the fact that, lessening the receiving wire estimate is a recognized point of radio wire improvement, the reception apparatus execution altogether drops for a little radio wire. In this paper, two openings on a minimized square ring and surrendered ground structure (DGS) are exhibited for transfer speed upgrade and radiation productivity at 5.5 GHz. At the point when the DGS and spaces are implanted in the structure of the planned reception apparatus, two noteworthy upgrades are accomplished. Upgraded impedance data transfer capacities with |S11|< - 10 dB run from 5.041 to 5.88 GHz (15.25%) and the radiation proficiency of 80.8% by stacking DGS over regular fix recieving wire are accomplished. The two reception apparatuses with/without DGS accomplish great far-field radiation designs inside the working recurrence band at 5.5 GHz. CST microwave studio is utilized for mimicking the structure. The physical receiving wire design is imprinted on FR4 substrate. The proposed arrangement has a scaled down size of 25 × 25 mm2. The created radio wire is tried to approve the proposed plan. Accordingly results acquired from reenactments and estimations demonstrate great assention. The proposed model can be viewed as a reasonable possibility for WiMAX remote applications.

Keywords—Bandwidth enhancement; square ring; DGS; Wimax; miniaturized; patch antenna.

I. INTRODUCTION

Nowadays, a low profile microstrip antenna is broadly utilized, which provides several advantages

Such as; easiness of manufacture, low cost, compactness, and integral with devices. In this manner, many researchers favored a microstrip patch antenna for numerous wireless communication applications [1].While miniaturizing the antenna size is an attractive target for the researchers, the antenna performance significantly drops such as; gain, bandwidth, and radiation efficiency . Therefore, enhance the bandwidth of a compact antenna is considered a challenging topic. Recently, many articles have been represented improving the bandwidth of microstrip patch antenna. Enhancing 50% of bandwidth accomplished by introducing a square slot in the ground plane [2]. This has created a great motivation for antenna specialists to design smaller than the normally printed antenna that can suitable numerous communication systems such as; Wireless Local Area Network (WLAN), and Worldwide Interoperability for Microwave Access (WiMAX).The federal communication commission (FCC) indicated cut frequencies at 2.5, 3.5, and 5.5 GHz for WiMAX systems [3].

However, the microstrip patch antennas experience various drawbacks contrasted with regular unprinted antennas. There are some disadvantages like; low gain, narrow bandwidth, and low surface wave excitation, which reduces radiation efficiency. To rectify narrow bandwidth, numerous methods can be utilized. For example, a thicker substrate with a low dielectric constant and ferrite structure gives broad bandwidth, but the first method leads to increase the size of antenna. On conducting feeding method like proximity can be utilized to enhance the bandwidth. It is hard to print and multi-resonator stack, however the drawback of resulting great thickness prototype [4].

Currently, defected ground structures (DGSs) have been widely utilized for improving microstrip patch antennas. These structures are acknowledged by etching off a basic cut shape in the antenna's ground plane [5]. At this point, various microstrip antennas with various configurations have been tentatively considered for both reducing the size and enhance the bandwidth for wireless application. Bandwidth enhancement using a single slot in heptagonal microstrip patch antenna is presented in [6]. Multi-band patch antenna is proposed with the partial ground plane for improving bandwidth [7].Mobile bandwidth enhancement techniques are reported over the wireless medium [8]. Bandwidth enhancement printed rectangular monopole antenna is reported in [9]. U-shape patch antenna and impact the ground plane dimensions are discussed in [10-13] for bandwidth enhancement. Several techniques for improving bandwidth in antennas are stated [15-19].DGS is simple to outline and manufacture. In addition, its equivalent circuit is easy to recognize, for these reasons, realizing both a broad bandwidth and higher radiation efficiency of the compact antenna printed on the conventional substrate material (FR4) is identified a challenging task for the researchers.

In this paper, the combinations of two methods are proposed to increase the impedance bandwidth and the radiation efficiency of the patch antenna. Embedding slots in square ring patch and DGS technique are proposed. Great improvements of bandwidth and radiation efficiency are achieved at 5.5 GHz for WiMAX Application. The enhancement is achieved in the overall antenna bandwidth by 65.25% and radiation efficiency by 30.6% higher than the conventional square ring antenna with DGS. The antenna is fabricated and examined to verify the proposed design, the proposed antenna configuration and analyzed results are deliberated in the following sections. The paper proceeds as Section II discussed the structure of the design. The results are analyzed in Section III, and finally, Section IV will conclude the work.

II. ANTENNA DESIGN

The physical structure of the antenna design with DGS is simulated by using CST microwave studio. Fig.1 demonstrates the physical layout and dimensions of the proposed antenna on FR4 substrate, which has a thickness of 1.6mm, the relative dielectric constant of 4.3, and loss tangent of 0.025. The proposed configuration has a minimized size of 25 × 25mm2.The configuration antenna physical layout contains a square patch with the square shaped slot of (lag=1.6mm) is inserted at the focal point of the patch. The defected ground structure characteristic is applied to antenna size compactness. Further study indicated that the slot on the ground plane increases the impedance matching and the bandwidth of the mode. Table I and Table II are shown a correlation of size and bandwidth of the proposed antenna with other references.

TABLE I

COMPARISON OF SIZE AND BANDWIDTH OF THE PROPOSED ANTENNA WITH OTHER REFERENCES

Reference	Size(mm^2)	*Bandwidth(MHz)*
[1]	58 × 66	302
[9]	33 × 25	700
[10]	31 × 28.5	223
[11]	55.6 × 42.84	320
[12]	45 × 26	90
Proposed	25 × 25	839

TABLE II

DESIGN PARAMETERS OF THE PROPOSED ANTENNA

Parameters	Symbol	Value unit (mm^2)
Substrate	(L×W)	25 × 25
Ground Plane	(Lg×Wg)	25 × 25
DGS	(Ld×Wd)	20 × 4.50
Feed length	Lf	10.50
Height	h	1.6
Permittivity	εr	4.3
Tan δ	δ	0.025
Gap	x	1
Distance	R	4.65
Ring slot	Wr	1.6
Feed line width	Wf	1.2

In the typical design process of square ring antenna, three parameters are fundamental, for example as resonance frequency fr, Dielectric constant of the substrate, εr and thickness of substrate.

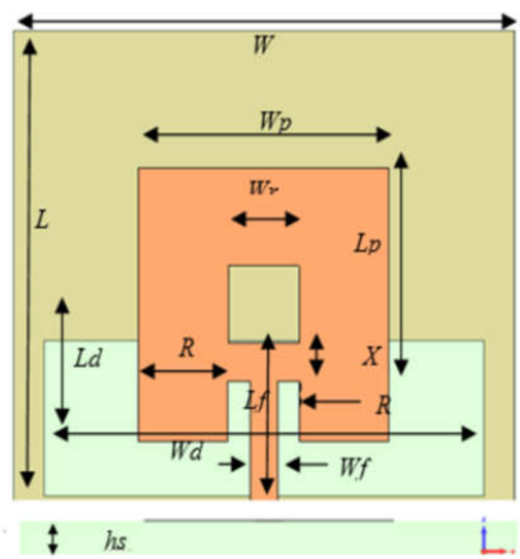


Fig.1. Design layout of the proposed antenna

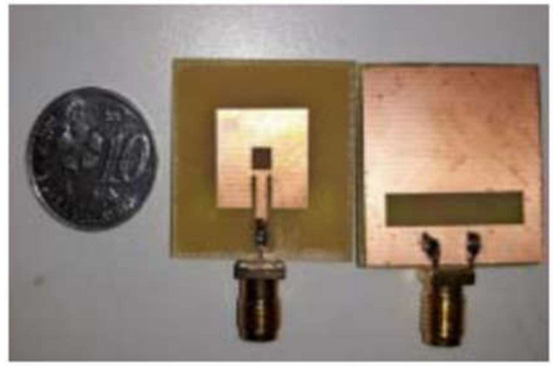


Fig. 2. Proposed antenna prototype: Front view; Back view In order to achieve the desired resonant frequency, the following mathematical approach is applied [14]:.

$$W_O = \frac{C}{2fr}\sqrt{\frac{2}{\varepsilon_r + 1}} \qquad (1)$$

Where Wo, c, εr, and fr are the width of the patch, speed of light, permittivity of the substrate, and desired operating frequency, respectively.

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(\frac{1}{\sqrt{1 + \frac{12h}{w}}}\right) \qquad (2)$$

where εreff and h are the effective permittivity and height of the substrate.

$$L_{eff} = \frac{C}{2fr\sqrt{\varepsilon_{reff}}} \qquad (3)$$

Leff and εreff are the effective length of patch and the effective permittivity.

$$\Delta L = 0.412h\frac{(\varepsilon_{reff} + 0.3)(\frac{w}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{w}{h} + 0.8)} \qquad (4)$$

ΔL is the length extension while L0 is the actual length of the patch.

$$L_O = L_{eff} - 2\Delta l \qquad (5)$$

$$Z_O = Z_{in}cos^2\left(\frac{\pi d}{L_O}\right) \qquad (6)$$

Zo and Zin are characteristics impedance, Zin input impedance d = inset depth/notch depth/gap depth.

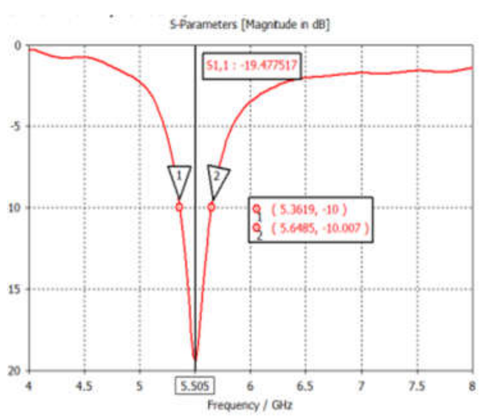
The full ground plane, as well as the substrate, is 6 times larger than the height of the dielectric substrate plus the used length or width. The ground plane can now be calculated as:

$$W_g = 6h + w \qquad (8)$$

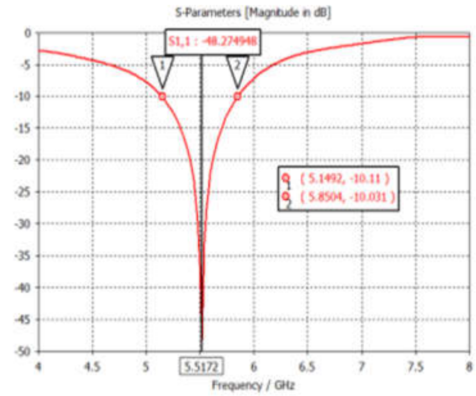
$$L_g = 6h + L \qquad (9)$$

III. ANTENNA DESIGN

The implementation of configuration has been completed and improved by using commercial electromagnetic software, which is called CST Microwave Studio simulator package version 2015. Both the conventional square ring antenna and square ring antenna with defected ground structure have been configured and simulated for the desired frequency. Square slot and rectangular slot are embedded in the patch and ground plane for additionally enhancing the impedance bandwidth and radiation efficiency. The rectangular slot embedded on the ground plane is illustrated in Fig.1. The objective is to enhance the reflection coefficient performance with the end goal that optimum loss is less than -10 dB. It can be observed that the presentation of this slot enhances impedance bandwidth from 5.04 MHz to 5.88 MHz as shown in Fig.3 (b). Therefore, the performance contrast of the antenna with and without DGS is shown in Fig.3. It can be observed that the bandwidth is improved by 15.5%.



(a)



(b)

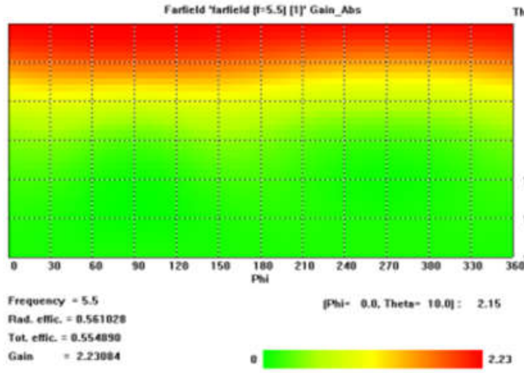
Fig.3. simulated reflection coefficient of the proposed antenna: (a) Without DGS; (b) with DGS

The value of utilizing DGS as ground plane for improving the radiation efficiency of printed square slot element has been assessed. It was demonstrated that for single slots, the position of back square ring patch realizes just a peripheral change to the radiation efficiency due to the strong excitation of the plate. However, the conventional antenna has a radiation efficiency of 56.1 %.After improving the ground plane, 80.8% of radiation efficiency is obtained as shown in Fig. 4.

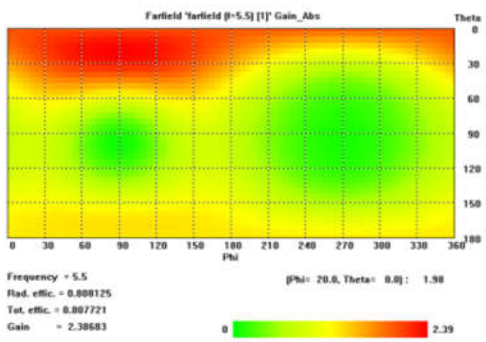
TABLE III

ANTENNA RETURN LOSS AND VSWR

Simulation	Return Loss (dB)	VSWR	BW%	Rad.Efficiency%
Antenna without DGS	-19.48	1.24	5.3%	56.1%
Antenna with DGS	-48.27	1.03	15.25%	80.8%



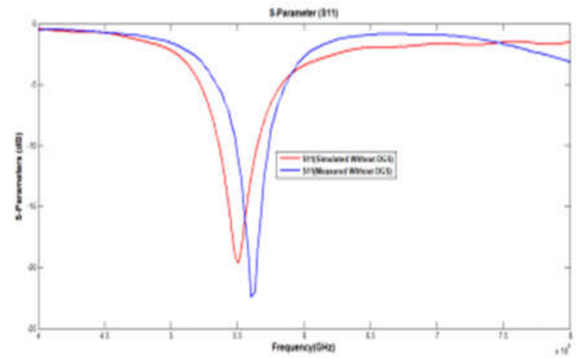
(a)



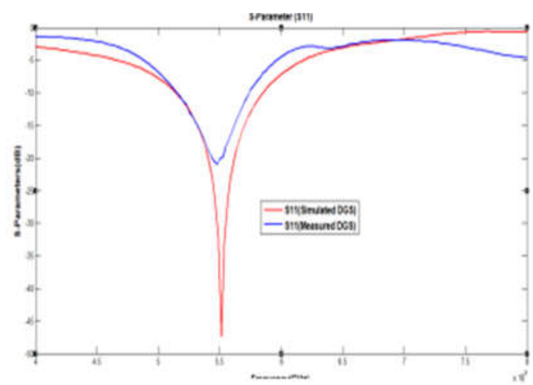
(b)

Fig.4. Simulated 2D radiation pattern for the proposed antenna: (a) antenna without DGS; (b) antenna with DGS

The performances of both antennas with and without DGS are experimentally performed to confirm the design concept. Also, the measurement results from Vector Network Analyzer (VNA) are validated with simulation. The simulation results together with the measurements scatter parameters are compared in Fig 5. Although there slightly differences are the present, good agreements are observed. The operating bandwidth works over a range from 5.15 to 5.73 MHz with reflection coefficient less than -10 dB. The characterization of the antenna is completed concerning the simulation and the measured VSWR data as shown in Fig 6, which clearly shows VSWR <2 across the range. Among the simulated and measured results, the slight difference is noted, which is attributed to the factors such as the effect of SMA plug, printing errors and dielectric losses. The radiation patterns of the proposed antennas are shown in Fig.6.It is observed that, for the conventional antenna, the radiation pattern is broadsided as shown in Fig.6 (a) and Omni-directional for the antenna with DGS as shown in Fig.6 (b).In this case, it can be observed the antenna with DGS has a maximum gain of 5.87 dBi compared with conventional square MSA (5.99dBi) at 5.5 GHz.

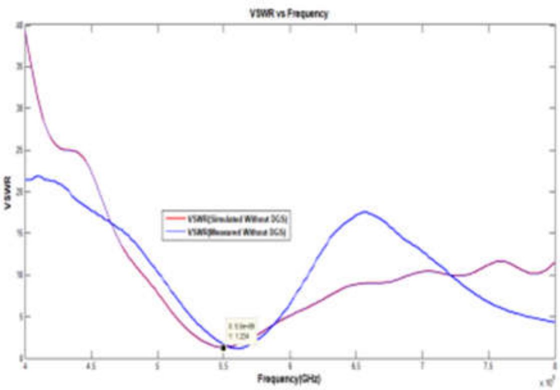


(a)

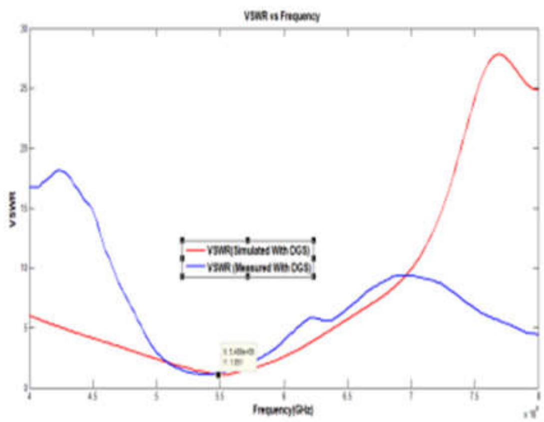


(b)

Fig.5. Simulated and the measured reflection coefficient of the proposed antenna: (a) without DGS; (b) with DGS

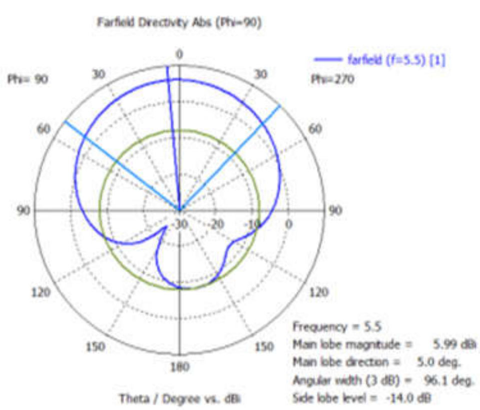


(a)

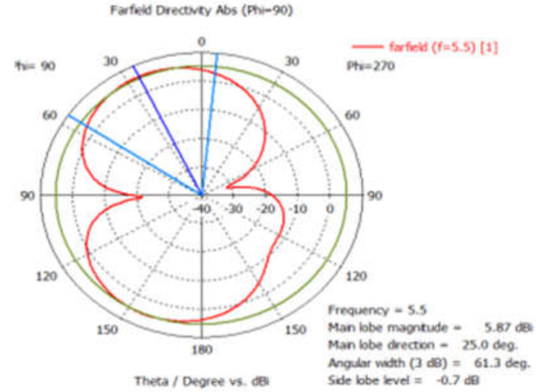


(b)

Fig.6. Comparison simulated and measured VSWR of the proposed antenna: (a) without DGS; (b) with DGS.



(a)



(b)

Fig.7. Simulated 2D radiation pattern for the proposed antenna: (a) antenna without DGS; (b) antenna with DGS

TABLE IV

ANTENNA RETURN LOSS AND VSWR

Measurement	**Bandwidth (MHz)**	**VSWR**
Antenna without DGS	230	1.23
Antenna with DGS	550	1.26

Fig.8. Measurement set-up for square ring antenna

IV. CONCLUSION

A conservative of square ring patch radiator dependent on composite fix reception apparatus with DGS has been proposed. The structure is manufactured utilizing a FR4dielectric substrate with generally speaking radio wire measurement of 25 × 25 mm2. The transfer speed of the proposed radio wire is upgraded from 5.3% to 15.25% over customary fix reception apparatus structures the equivalent resounding recurrence. From the examination, the radiation productivity and transmission capacity are expanded by 30.6% and 65.25%, individually. The estimation uncovers great assention over recreated results to make it appropriate for WiMAX application.

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