Investigation of Multi Band Microstrip Line Fed Antenna using DGS Technique for WLAN/WiMAX Applications

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ABSTRACT

A multiband planar monopole antenna fed by microstrip line feed with Defected Ground Structure (DGS) is presented for simultaneously satisfying wireless local area network (WLAN) and worldwide interoperability for microwave access (WiMAX) applications. The proposed antenna consists of a rectangular microstrip patch with rectangular slit, including the circular defect etched on the ground plane forming DGS structure. The soft nature of the DGS facilitates improvement in the performance of microstrip antennas. The simulated -10 dB bandwidth for return loss is from 2.9-3.77 GHz, 3.91-6.36, covering the WLAN: 5.15–5.35 and 5.725–5.85 GHz and WiMAX: 3.3–3.8 and 5.25–5.85 GHz bands. The design and optimization of DGS structures along with the parametric study were carried out using IE3D ZELAND which is based on method of moment.

Keywords

Microstrip Antenna, WLAN, Wi-MAX, Microstrip feed, DGS (Defected Ground Structure)

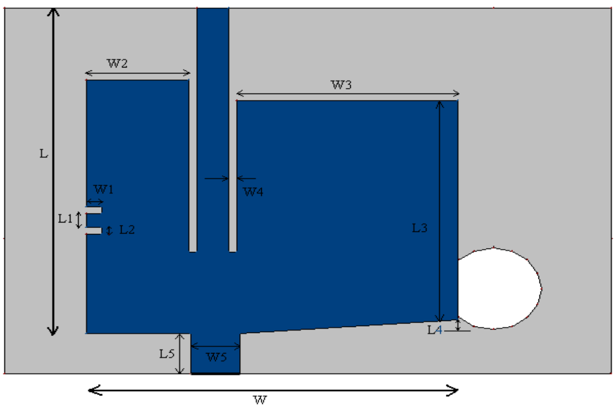
1. INTRODUCTION

Recently, there are rapid developments in wireless communications, and in order to satisfy the IEEE 802.11 WLAN/WiMAX standards, the printed monopole antennas are required. These printed monopole antennas are very suitable to be integrated on the circuit board of a communication device, leading to the attractive features of occupying very small volume of the system and decreasing the fabrication cost of the final product. With the use of this kind of printed monopole antennas, a concealed antenna for the system can be obtained; that is, there are no protruded portions in appearance for the antenna [1]. For short- and long-range applications, many antenna designs suitable for wireless local area network (WLAN: 2.4–2.483, 5.15–5.35, and 5.725–5.85 GHz) and worldwide interoperability for microwave access (WiMAX: 2.5–2.69, 3.3–3.8, and 5.25–5.85 GHz) operation have been studied [2-6]. The simplest way to implementing planar forms of the antenna is using the microstrip feeding technology. Microstrip antenna in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side of the substrate [3]. Recently several interesting designs of the slot antennas with diverse geometric configurations for the bandwidth enhancement and the size reduction functions have been widely studied[4]. Size reduction and bandwidth enhancement are becoming major design considerations for practical applications of micro strip antennas. For this reason, studies to achieve compact and broadband operations of micro strip antennas have greatly increase [5]. Defected Ground Structure is one of the methods which is used for this purpose. The defect in a ground is one of the unique techniques to reduce the antenna size. So design the antenna with the defected ground structure, the antenna size is reduced for a particular frequency as compared to the antenna size without the defect in the ground.

DGS is realized by etching the ground plane with a certain lattice shape which disturbs the current distribution of the antenna. Many shapes of DGS have been studied such as concentric ring, circle, spiral, dumbbells, elliptical and U, V slots. DGS gives an extra degree of freedom in microwave circuit design and can be used for a wide range of applications. Meanwhile, for antenna applications, DGS is mainly applied to the feeding technique. The concept of Defected Ground Structures (DGS) evolved in recent years primarily from the studies of Photonic Band Gap (PBG) structures in electromagnetics. DGS refers to some compact geometries known as a unit cell etched out as a single defect or in a periodic configuration with a small period number on the ground plane of a microwave printed circuit board [6]
In this research work, DGS antenna design satisfies WLAN/WiMAX standard. The proposed monopole antenna consists of rectangular microstrip patch with rectangular slits and the circular defect etched on the ground plane forming DGS. The details of the proposed antenna design are presented and discussed in next section.

2. ANTENNA GEOMETRY

The geometry and dimensions of the proposed antenna for Multi-band WiMAX/WLAN operations is shown in Fig.1. The antenna is excited by the microstrip line feed and is printed on the FR4 substrate with a thickness of 1.6 mm and relative permittivity of 4.4. FR4 means flame retardant and type 4 indicates woven glass reinforced epoxy resin. The total size of the proposed rectangular microstrip patch is 24 mm x 23 mm. Rectangular shape patch is loaded with rectangular slits which results better return loss. To reduce the size of conventional antenna and improves resonance peak of the return losses the ground is loaded with circular defect. The ways that slot are loaded into the ground change the resonant frequency due to the disturbance caused to mean current paths of any resonant frequency.



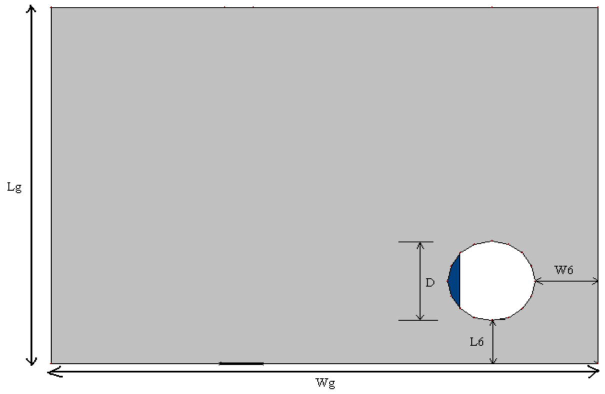


Fig.1. Geometry of proposed Antenna

Table 1. Parameter of the Proposed Multiband Antenna

Parameter	Size(mm)	Parameter	Size(mm)
L	24	W	23
L_g	27	W_g	37.5
L_1	1	W_1	1
L_2	0.5	W_2	6.325
L_3	16.2	W_3	13.7
L_4	1	W_4	0.5
L_5	3	W_5	3
L6	3.275	W_6	4.3
D	6		

The effect of the structure of the ground plane on antenna performance is also investigated by mounting the proposed antenna structure on a defected ground structure(DGS) plane. The DGS plane constitutes of an etched circular shape defect having diameter 6 mm which are arranged as shown in Figure.1. There are two major advantages associated with using DGS plane. First, such structures provide broad and wider bandwidth with enhanced gain and higher radiation efficiency. Second, these structures forbid the propagation of electromagnetic waves in a certain frequency band. Therefore, they can be used to block surface waves that usually corrupt antenna performance at a certain frequency band.

To obtain the optimal parameters of the proposed antenna for WLAN/WiMAX application, IE3D, full-wave commercial EM software, is used. Thus, the proposed antenna design can provide a wide bandwidth while retaining stable performance via the optimized geometrical parameters.

3. SIMULATED RESULTS AND DISCUSSIONS

The parametric study results and simulated return loss for the proposed antenna are obtained. Simulated return loss of the optimized proposed antenna is shown in Fig 2. The simulated result has a -10 dB impedance bandwidth 0.87GHz in the band of 2.9-3.77 GHz and 2.45 GHz in the working band of 3.91-6.36GHz which cover both lower and upper bands of WLAN/WiMAX. The proposed monopole antenna has a broader bandwidth covering the required bandwidths of the IEEE 802.11 WLAN standard in the band at 5.2 GHz (5.15- 5.35 GHz) and 5.8 GHz (5.72-5.82 GHz) and WIMAX standard in the band at 3.5 GHz (3.4-3.69 GHz) and 5.5 GHz (5.25-5.85 GHz).

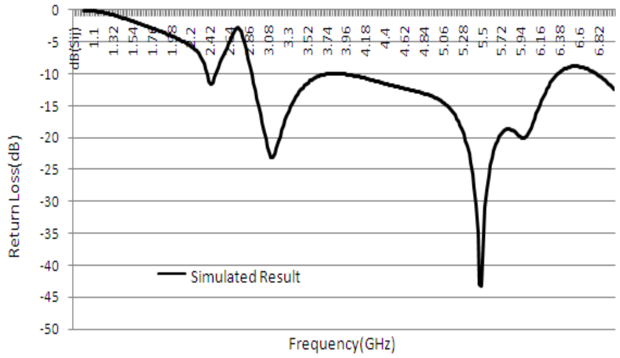


Fig.2. Return loss of proposed multiband antenna

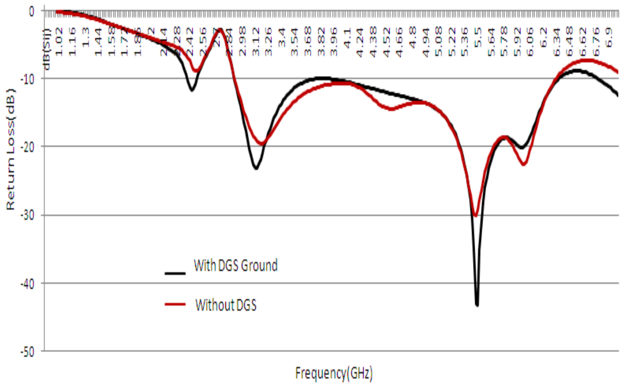
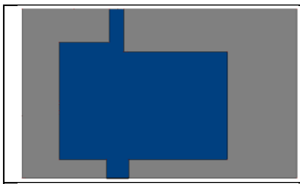
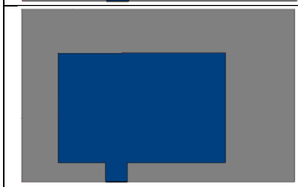
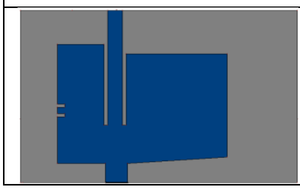


Fig.3. Return loss of proposed antenna (a)witout DGS (b)with DGS

Table 2. Geometry of Antenna 1, Antenna 2 and Antenna 3

	Antenna 1
	Antenna 2
	Antenna 3 (proposed)

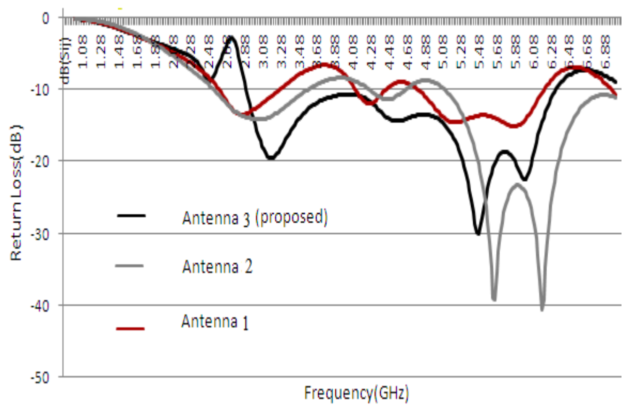


Fig.4. Parametric comparison of return loss of antenna

Furthermore, to investigate in detail the behavior of the proposed antenna, it is observed that, the simulated return loss of patch antenna with DGS ground plane is better than corresponding return loss of the patch antenna with the conventional ground plane proposed antenna. Figure.3, compares the simulated return loss versus frequency of the proposed antenna with DGS ground plane with the defect loading. Also, the figure shows that most of the constructed shape with slot loading gives reasonable bandwidth and antenna is resonate at 5.48 GHz at -43dB. These configuration give the antenna the capability to be used for different applications. For a specific application one can decide the required resonant frequencies applicable for that application.

From the simulation result shown in Figure3. it can be seen that, by adding a circular defect etched in the ground plane, considerably the return losses are improved .The resonance peak improved from -30dB to -43dB at resonance frequency 5.48 GHz and at 3.12GHz, resonance peak improved from -19dB to -22dB, which satistisfying the IEEE standard. But the bandwidth is decreased from 3.46GHz to 3.32GHz. The antenna gain has also improved from 3.12717dBi to 3.15822 dBi at 3.12GHz and the antenna efficiency increased from 98.6949% to 99.5021% at 3.12GHz. This result demonstrates the ability of the DGS ground plane to enhance the gain and radiation efficiency of the antenna. This clearly reveals that by using DGS much better return loss can be obtained. Overall the radiation efficiency og antenna is 100%

Effects of rectangular slits of key structure parameters on the antenna is also presented in Fig. 4. Antenna1, without rectangular slits cover only upper band of WiMAX/WLAN in the band of 2.6-3.25GHz, 4.11-4.44GHz, 4.81-6.2GHz with 2.37GHz bandwidth. Whereas, Antenna 2 is the primitive structure of proposed antenna which work in the band 2.54-3.55 GHz, 5.1-6.91 GHz with 2.82 GHz bandwidth which also cover only upper bands of the WiMAX/WLAN. But compare with antenna 1, the bandwidth is increased from 2.37 to 2.82 GHz. Proposed Antenna 3 with rectangular slits working in the band 2.9-6.33GHz with 3.43GHz bandwidth which covers both upper and lower bands of WiMAX/WLAN applications. Compare with antenna 1, bandwidth is increased from 2.37GHz to 3.43 GHz i.e 1.06 GHz. Referring to these results, the antenna can satisfy not only the WLAN bands of 5.2/5.8 GHz, but also the WiMAX band of 3.5/5.5 GHz with rectangular slits

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3.1 Current Distribution

We also simulate the surface current distribution for the resonant frequencies at 3.12GHz and 5.48GHz respectively. The resonant current shown in Fig. 5(a) flows along rectangular slits of the patch at frequency 3.12GHz and a current flow along the microstrip feed line at frequency 5.48GHz shown in Fig5(b). circular defect on ground disturbs the current distribution, resulting in a controlled excitation and propagation of the electromagnetic waves via the substrate layer and change the resonance peak .

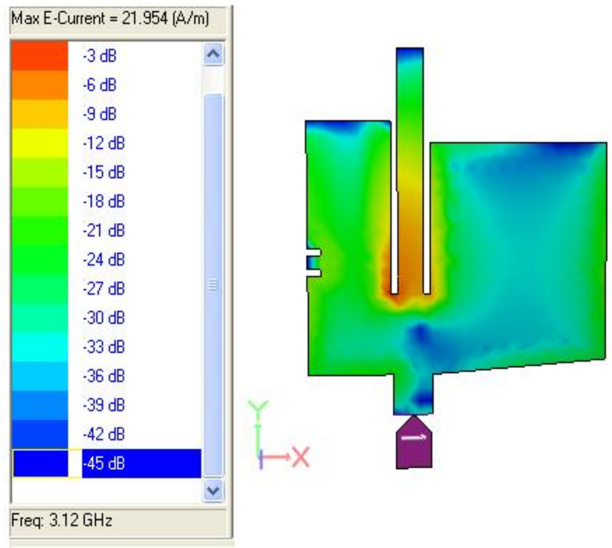

Fig.5(a). Current distribution of proposed antenna at 3.12 GHz

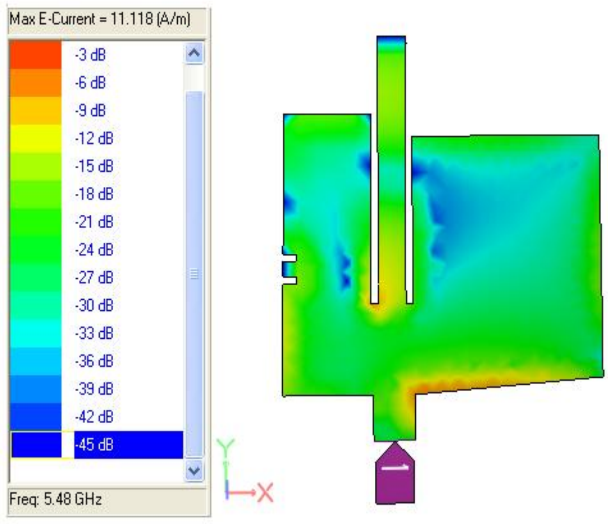

Fig.5(b). Current distribution of proposed antenna at 5.48 GHz

3.2 Voltage Standing Wave Ratio (VSWR)

There should be a maximum power transfer between the transmitter and the antenna to perform efficiently. The VSWR plot for CPW feed antenna is shown in Figure.6 Ideally, VSWR must lie in the range of 1-2 which has been achieved for the frequency 3.12 and 5.48GHz, near the operating frequency value.

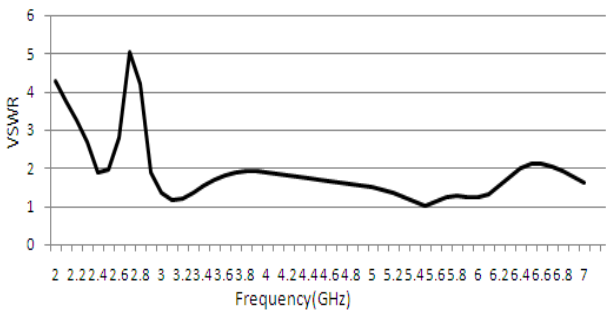

Fig.6. VSWR of proposed antenna

3.3 Radiation pattern

The simulated 2D radiation pattern for elevation and azimuthal plane is shown in Fig.7(a) and 7(b) respectively and 3D radiation pattern respectively is shown in Fig.8. Radiation pattern presents the graphical representation of radiation properties of antenna as a function of space co-ordinates. E-plane patterns at 90 degree are shown, which satisfies the condition of radiation pattern of a microstrip antenna, which is same as that for a monopole antenna. Similarly H-plane patterns for 90 degree forms an omni-directional pattern. These patterns are desirable for WLAN/WiMAX applications.

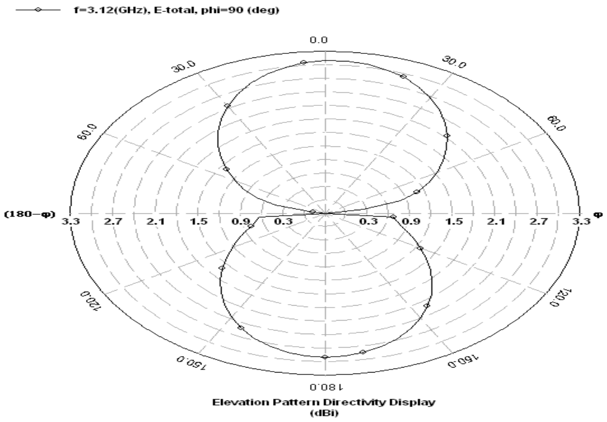

Fig.7(a). Elevation radiation pattern at 90 degree at 3.12 GHz

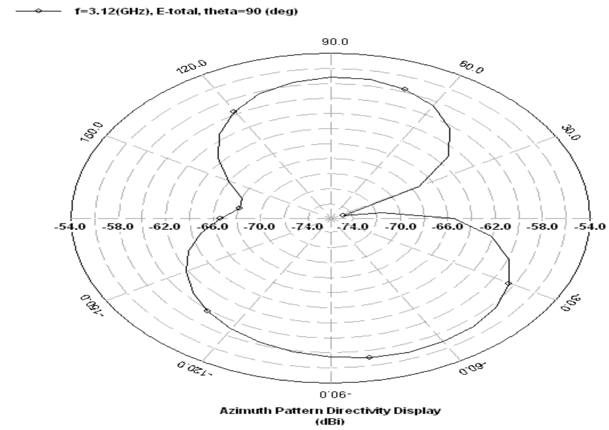

Fig.7(b). Azimuthal radiation pattern at 90 degree at 3.12 GHz

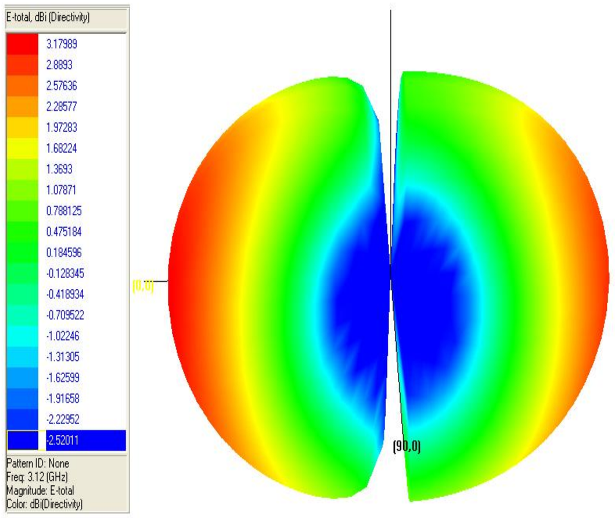

Fig 8: 3-Dimensional Pattern of Proposed Antenna at 3.12 GHz

4. CONCLUSION

A microstrip patch antenna suitable for WLAN/ WiMAX applications is proposed. The proposed monopole antenna consists of microstrip patch fed by microstrip line. To reduce the size of conventional antenna and widen its bandwidth or improves the return losses, the ground plane is etched with circular shape slot. The circular shape defect with diameter 6 mm etched on the ground plane as DGS. The simulated result has a impedance bandwidth which cover lower bands and upper bands of WLAN/WiMAX. Effects of varying dimensions of key structure parameters on the antenna and various parameters like VSWR, current distribution, radiation pattern and their performance are also studied. The parametric studies show significant effects on the impedance bandwidth of the proposed antenna. Moreover, the proposed antenna has several advantages, such as small size, excellent radiation patterns, good efficiency. These characteristics are very attractive for some wireless communication systems.

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