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# Efficient Microstrip Fed Rectangular Patch Antenna with DGS for WLAN & WiMAX Applications

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## Abstract

**In this paper a monopole antenna for WLAN and WiMAX frequencies is proposed. The given antenna is composed of a rectangular patch monopole antenna having an E-shaped slot with two backward slits on the substrate and a defected ground plane. The antenna exhibits single band, which creates an impedance bandwidth of 2 GHz for the working band of 4-6 GHz. The various characteristic parameters like S-parameters, gain, current distribution, and radiation pattern are studied. The proposed antenna is suitable for IEEE 802.11 WLAN standards in the bands 5.2/5.8 GHz and WiMAX standards in the bands at 5.5 GHz. Microstrip feeding technique is used. The compact size antenna using DGS technique is simulated using IE3D software.**

## Introduction

The main aim of next generation wireless communication system is high speed networking service for multimedia communication. Microstrip antennas attracts many microwave and wireless communication systems due to their various advantages like light weight, easy fabrication, low cost etc but still due to their limited input impedance and bandwidth they are not used in modern microwave systems. Miniaturization of antenna, bandwidth improvement, high input impedance and gain efficiency are the main requirements to enhance the performance of an antenna [1-2]. The need for wireless broadband communications has increased rapidly in recent years demanding quality of service, security, handover, and increased throughput for the wireless local area networks (WLANs- 5.150 GHz–5.350 GHz)[2]. One can use DGS technique to achieve this band in a compact system. DGS is analyzed in terms of its superior properties, which enables the designers to easily realize much kind of wireless devices which are impossible to achieve with the standard applications [3-5]. DGS unit in a two-element microstrip array that suppresses surface waves which leads to an exceptionally high isolation between array elements. The defect in a ground is one of the unique techniques to reduce the antenna size and to increase the bandwidth, hence thereby increasing the performance of an antenna. DGS offers dual band gaps characteristic yielding a high order matching network for bandwidth enhancement. So designing an antenna with the defected ground structure technique, the antenna size is reduced for a particular frequency as compared to the antenna size without the defect in the ground. A shape defected on a ground plane disturbs the shielded current distribution depending on the shape and dimension of the defect [6]. The disturbance at the shielded current distribution will influence the input impedance and the current flow of the antenna. It can also control the excitation and electromagnetic waves propagating through the substrate layer [7]. This technique is cost effective because it is more convenient for a certain design to operate with a single antenna than multiple antennas [8].

Here a rectangular microstrip line fed patch antenna with defected ground structure is presented. The objective is to design a reduced-size wideband Microstrip antenna, the design idea was taken from broadband antennas to make the antenna work in a large band of frequencies. So defected ground structure technique is chosen and also rectangular shape is chosen because it has high input impedance. It was, thus, possible to reduce the size of patch, thereby reducing the size of Microstrip antenna with increased bandwidth, only due to using defected ground structure. In this design a double layer substrate antenna design with microstrip feeding technology has been used to achieve multi-band operation for various wireless applications covering upper band of WLAN applications. The proposed antenna design is basically composed of H-shaped defect with corner upwards into the ground plane with rectangular patch having E-shaped slot. The parametric study is performed to understand the characteristics of the proposed antenna.

## Antenna geometry and Design

The glass epoxy substrate with height 1.6mm and the dielectric constant is 4.4 is used. The diagram of the proposed antenna with its geometric dimensions is shown in Figure 1. A rectangular patch with E-shaped slot having two parallel slits in the backward direction forms the substrate of the planar antenna and a defected ground is formed by inserting H-shaped defect with corners upwards into its ground plane. The patch is fed by a microstrip feed line and is designed on a low cost durable 1.6 mm-thick FR4 substrate, with relative permittivity 4.4 and with overall dimensions of 45.4 mm X 45.4 mm X 1.6 mm. Figure 1 shows the geometry of proposed antenna. In which (a) part presents the complete geometry and (b) part presents the back view that is ground of the microstrip patch antenna.

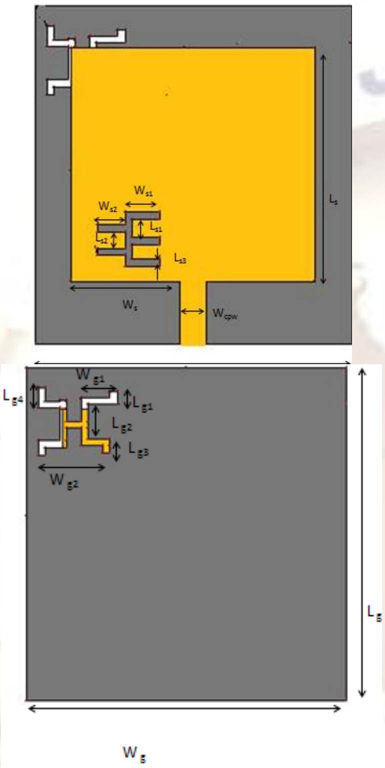

**Figure 1: (a) Geometry of proposed triple band antenna (b) Back View**

The proposed antenna has a double layer metallic structure, one side forms the substrate and back side is the ground of antenna. In this technique, a conducting strip is connected directly to the edge of the microstrip patch. The conducting strip is much smaller in width as compared to the width of the patch. This kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide planar structure.

The optimized geometric parameters of the proposed antenna are given in table 1:

**Table 1 Specifications of the Proposed Antenna**

| *Parameter* | *Specification* | *Parameter* | *Specification* |
|---|---|---|---|
| $L_s$ | 34.7 mm | $L_{s1}$ | 3mm |
| $W_s$ | 35mm | $L_{s2}$ | 3 mm |
| $L_g$ | 45.4 mm | $L_{s3}$ | 1mm |
| $W_g$ | 45.4mm | $W_{s1}$ | 4mm |
| $W_{s2}$ | 4mm | $L_{g1}$ | 3 mm |
| $L_{g3}$ | 1mm | $L_{g2}$ | 4 mm |
| $W_{g1}$ | 4mm | $W_{g2}$ | 7 mm |
| $L_{g4}$ | 3 mm | | |

The main radiating element of the antenna, which is etched on the ground plane, is H-Shaped defect with corner in upward direction, which makes the antenna to achieve better impedance. The E-shaped defect having two parallel slits in the backward direction in the rectangular patch substrate also affects the impedance performance and the resonant frequencies of the antenna to some extent. The antenna is simulated using IE3D simulator. The effects of the key structure parameters on the antenna performances are also analyzed and presented.

## Results and Discussions

The simulated return loss and parametric study results for the proposed monopole antenna are obtained. Simulated return loss of the optimized proposed antenna is shown in Figure 2.

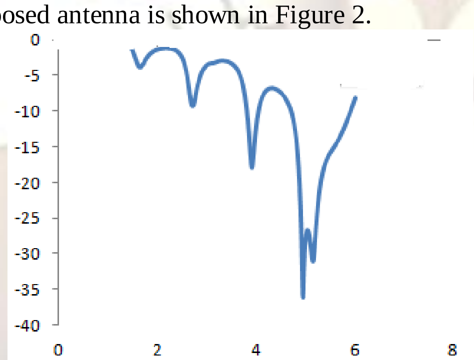


**Figure 2: Return Loss of Proposed Antenna**

From the simulated results, it is clear that this defect in the ground plane of monopole antenna provides different resonances and better impedance matching which creates impedance bandwidth of 2 GHz for the working bands of 4-6 GHz centered at 5.4 GHz. Obviously, the proposed antenna has very broader bandwidth which covers the required bandwidths of IEEE 802.11 WLAN standards in the bands 5.2/5.8 GHz and WiMAX standards in the bands at 5.5 GHz.

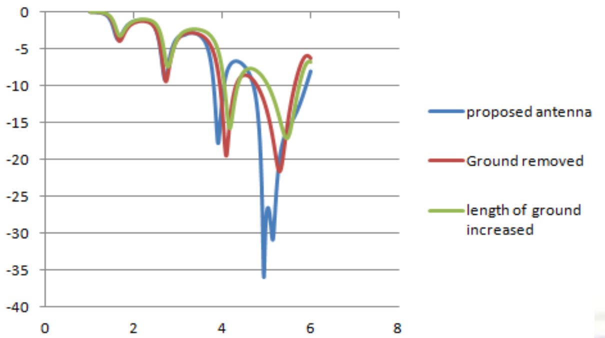


**Figure 3 Parametric comparison of return loss of antenna**

A parametric study is performed and it demonstrates that the following parameters influence on the performance of the proposed antenna in terms of bandwidth. The parametric study is carried out by simulating the antenna with one geometry parameter slightly changed from the reference design while all the other parameters are fixed. The parametric study showing the case when defect from the ground plane is removed. It clearly reduces the bandwidth and also no wireless standard band is covered. Also when length of ground plane is increased then again its bandwidth gets reduced. Hence in any way DGS is only responsible for bandwidth enhancement and size miniaturization.

Gain of proposed Antenna:

Figure 4 shows the gain of proposed geometry. The antenna has a maximum gain of about 4.11dBi at 3.14 GHz frequency with small gain variations in the operating bandwidth.

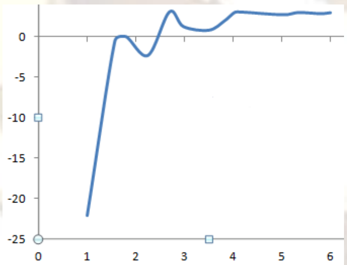

**Figure 4: Gain of proposed triple band Antenna**

3.2 Current Distribution of proposed Antenna:

The formation of the upper frequency resonances can be explained by observing the surface currents on the conductors of the antenna at 5.7 GHz, as shown in Figure 5. Due to the addition of slots in the ground plane it can be seen that there is a strong concentration of currents on the lower edge of the disc, around the feed line and H-shaped slot, along the top edge of the ground plane, along the E-shaped defect in the substrate. The maximum current is present at the bottom of feed line.

This helps in achieving miniaturization and upper resonating bands.

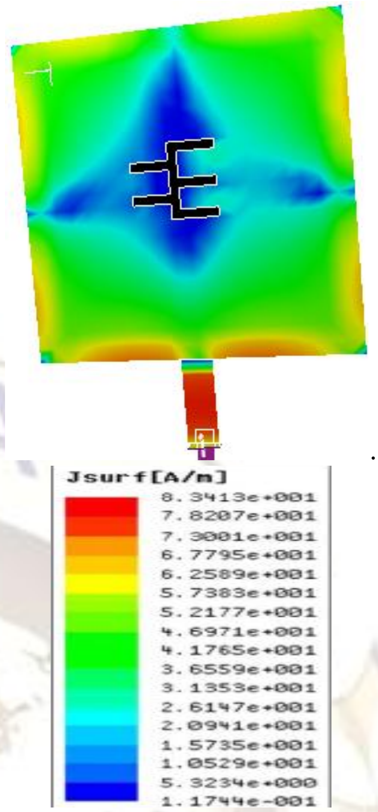


**Figure 5: Current distribution of proposed antenna at 5.7 GHz.**

3.3 Antenna Efficiency of proposed geometry

Figure 6 shows the antenna efficiency. Simulation studies indicate that the maximum antenna radiation efficiency is approximately 82% at 4.9 GHZ as shown in figure 5.

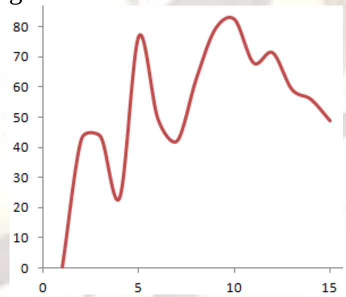

**Figure 6: Efficiency of proposed triple band Antenna**

Radiation efficiency tells how much of the input power accepted by an antenna (Pin) it converts to radiated power. Radiation efficiency can also be expressed as the ratio of the unloaded quality factor to the radiation quality factor of the antenna.

## Conclusion

A compact monopole rectangular patch microstrip fed antenna suitable for WLAN/ WiMAX applications is proposed. Using H-shaped defect on ground plane antenna, a resonant mode having excellent impedance performance is achieved. Effects of varying dimensions of key structure parameters on the antenna and various parameters like gain, current distribution, radiation pattern and their performance are also studied. The parametric studies show significant effects on the impedance bandwidth of the proposed antenna. Gain performance of the antenna is acceptable at all the frequency bands. Moreover, the proposed antenna has several advantages, such as small size, excellent radiation patterns, and higher gains and good efficiency. These characteristics are very attractive for some wireless communication systems.

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