

# Rectangular Patch Antenna Performances Improvement Employing Slotted Rectangular shaped for WLAN Applications

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## Abstract

This paper describes the effect of inserting a rectangular shape defected ground structure (DGS) into the ground plane of the conventional rectangular microstrip patch antenna (CRMPA). The performances of the CRMPA are characterized by varying the dimensions of the rectangular slot (RS-DGS) and also by locating the RS-DGS at specific position. Simulation results have verified that the CRMPA including RS-DGS had improved the CRMPA without RS-DGS. The return loss (RL) enhances approximately of 100 %, and gain improvement of 0.8 dB.

*Keywords:* Conventional Rectangular Microstrip Patch Antenna (CRMPA), Rectangular Slot Defected Groud Structure (RS-DGS), Return Loss (RL), Gain, Radiation pattern.

## 1. Introduction

Recently, there has been a growing demand of microwave, and wireless communication systems in various applications resulting in an interest to improve antenna performances. Modern communication systems and instruments such as Wireless local area networks (WLAN), mobile handsets require lightweight, small size and low cost. The selection of microstrip antenna technology can fulfill these requirements [1]. WLAN in the 2.4 GHz band (2.4-2.483 GHz) has made rapid progress and several IEEE standards are available namely 802.11a, b, g and j [1]. Various design techniques using defected ground structure (DGS) in the patch antenna have been suggested in previous publications [2-4]. DGS is realized by etching a defect in the ground plane of planar circuits and antennas. This defect disturbs the shield current distribution in the ground plane and modifies a transmission line such as line capacitance and inductance characteristics [5]. Accordingly, a DGS is able to provide a wide band-stop characteristic in some frequency bands with a reduced number of unit cells. Due to their excellent pass and rejection frequency band characteristics [5], DGS

circuits are widely used in various active and passive microwave and millimeter-wave devices [6].

The purpose of this work is to enhance conventional rectangular microstrip patch antenna (CRMPA) performances operating at 2.4 GHz frequency band for WLAN applications using Rectangular Slot (RS) in the ground plane named RS-DGS. Configurations using RS-DGS located at different positions in the bottom of the substrate are considered and assessment of the new rectangular microstrip patch antennas performances achieved.

## 2. Antenna Design

A CRMPA is designed on a dielectric layer RO4003C substrate which has a relative permittivity and thickness of 1.524 mm. As shown in Figure 2.a, the patch antenna has a length (L) of 30 mm and a width (w) of 21 mm and its resonant frequency is 2.40 GHz. The resonant frequency, also called the center frequency, is selected as the one at which the return loss is minimum. An etched RS-DGS with different length values and a fixed width (3.5 mm) is then inserted into the ground plane of the original CRMPA shown in figure 1 (Ant.1) at different positions as shown in figure 2.a (Ant.2), figure 2.b (Ant.3) and figure 2.c (Ant.4).

In Figure 2, the RS-DGS is drawn with dash lines to indicate that it is located on the bottom of the substrate. Except the insertion of a rectangular shape slot to the ground plane, no other modification has been performed to the antenna patch and the feeding system.

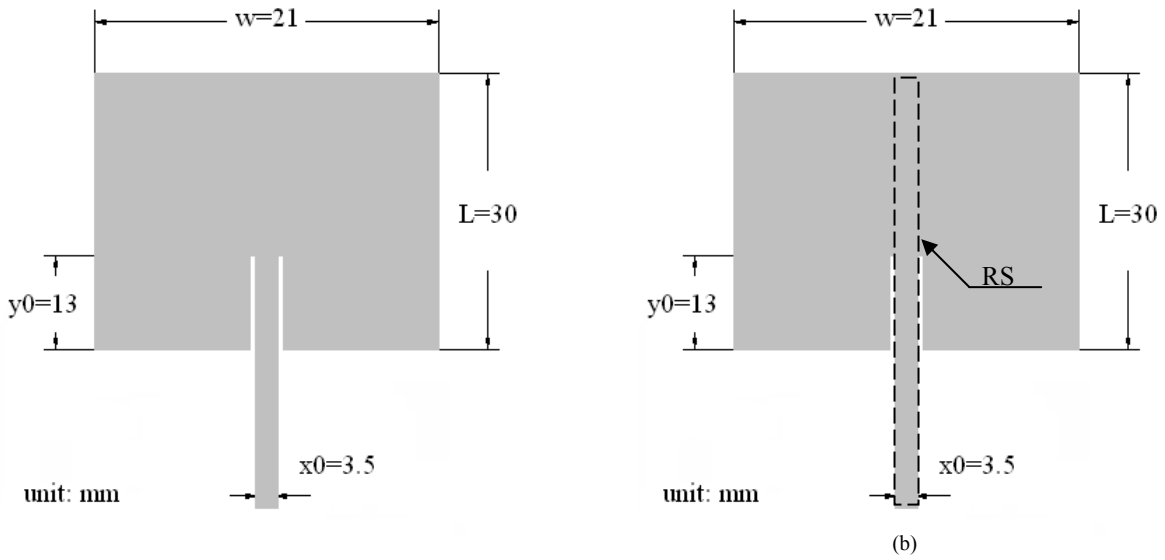


Fig. 1 Conventional Rectangular microstrip patch antenna (Ant. 1)

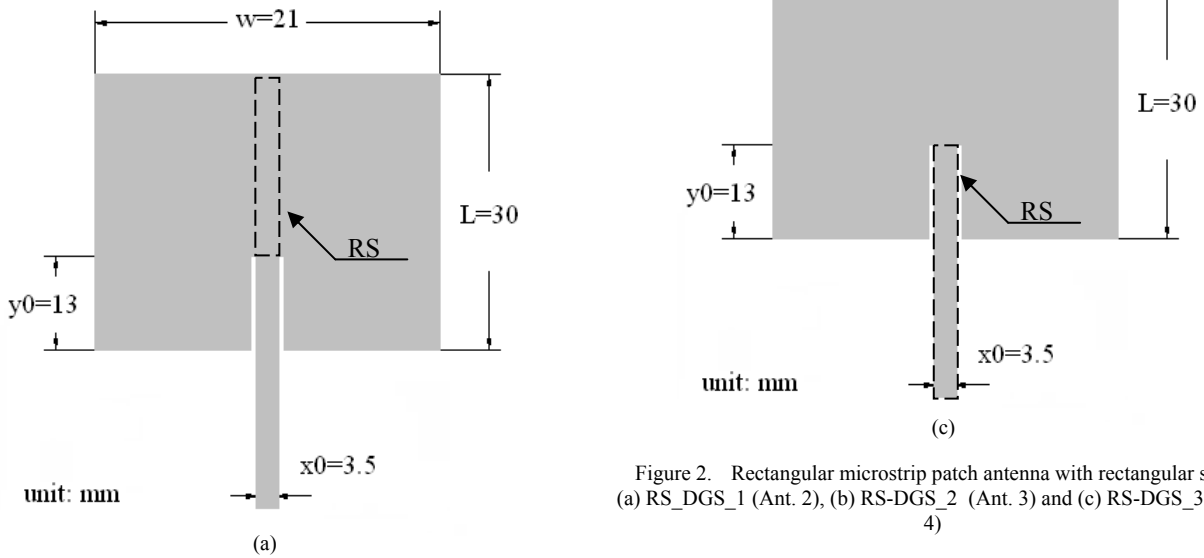


Figure 2. Rectangular microstrip patch antenna with rectangular slot (a) RS\_DGS\_1 (Ant. 2), (b) RS-DGS\_2 (Ant. 3) and (c) RS-DGS\_3 (Ant. 4)

The design and simulation are carried out over four RMPA types; CRMPA and the new modified model antenna by including RS-DGS located at different positions as shown in Figure 2a (Ant. 1), Figure 2b (Ant. 2), Figure 2c (Ant. 3) and, Figure 2d (Ant. 4). The simulations are carried out with IE3D from Zeland software which is based on the method of moments. The software is available in the microwave laboratory of UCL –Belgium.

With a specific resonant frequency ( $f_0$ ) and a characteristic impedance ( $Z_c$ ), the width ( $W$ ), length ( $L$ ) and the Feeding position of CRMSA are expressed as follows [7-8]:

$$W = \frac{c}{2f_0 \sqrt{\frac{\epsilon_r + 1}{2}}} \quad (1)$$

$$L = L_c - 2\Delta L \quad (2)$$

$$y_0 = \frac{L}{\pi} \times \sqrt{\arccos\left(\frac{R_{in}}{R_c}\right)} \quad (3)$$

where,

$$\Delta L = 0,412.h \cdot \frac{(\epsilon_e + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\epsilon_e - 0.258)\left(\frac{W}{h} + 0.8\right)} \quad (4)$$

$$L_e = \frac{\lambda}{2} = \frac{\lambda_0}{2\sqrt{\epsilon_e}} = \frac{c}{2f_0\sqrt{\epsilon_e}} \quad (5)$$

$R_{in}$ ,  $L_e$  and  $\Delta L$  are, respectively, the input impedance, the effective and the extended lengths.

### 3. Results and discussion

Figure 3 shows the simulation result of the return loss (RL) of the CRMPA and the structures with inserted RS-DGS at different positions. This figure shows return losses of -15.72 dB, -14.99 dB, -26.92 dB and -31.87 dB at the resonant frequency of 2.4 GHz and respectively the CRMPA, Ant.2, Ant.3 and Ant. 4.

The simulation carried out with the structure with an RS-DGS implemented in the antenna (Ant.2) shows no significant difference as compared to the CRMPA except a slight shift up of the resonant frequency as illustrated in Figure 3. However, significant improvements are performed when the RS-DGS is implemented as shown in Figure 2.b (Ant. 3) and Figure 2.c (Ant. 4).

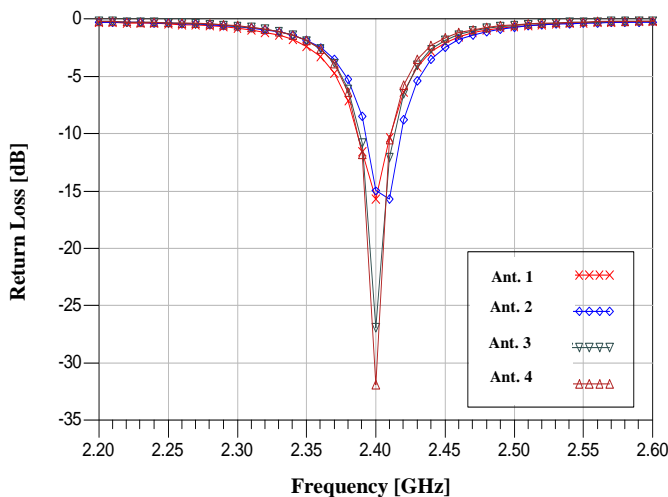


Fig. 3 Return Loss of the CRMPA and the antennas with RS-DGS

Another parameter, namely the gain, is also simulated and the results illustrated in Figure 4. This figure shows a gain

of 5.1 dB for the CRMPA and the insertion of RS-DGS's produces a gain of 5.9 dB for both Ant. 3 and Ant. 4 that is an improvement of 0.8 dB with respect to the antenna without RS-DGS. The gain enhancement justifies the impedance matching of the RL which makes in evidence an enhancement of the antenna efficiency.

Afterward, radiation patterns of the CRMPA in the E and H plane for both with and without RS-DGS are shown in Figure 5 and Figure 6 respectively. The CRMPA radiation patterns are simulated at a frequency of 2.4 GHz. It is observed from these figures that the antennas with RS-DGS have slightly higher lobe level due to the existence of the etched structure in the ground plane acting as a slot antenna resulting in a field distribution.

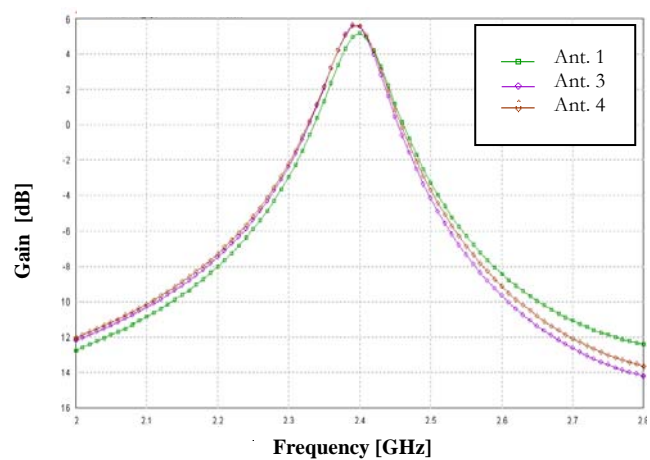


Fig.4 Gains of the CRMPA and the antennas with RS-DGS

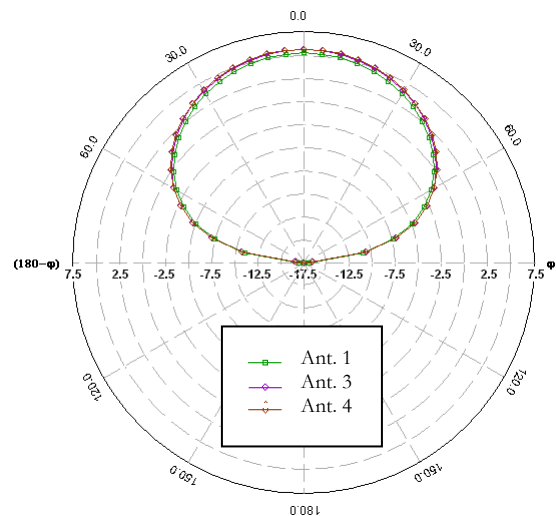


Fig. 5 E-plane radiation patterns of the CRMPA and the antennas with RS-DGS

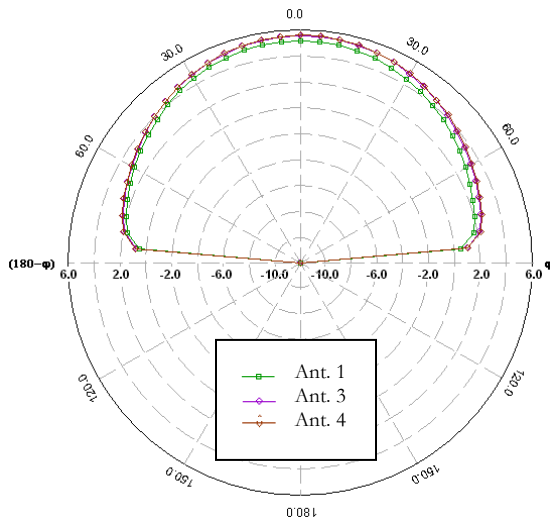


Fig. 6 H-plane radiation patterns of the CRMPA and the antennas with RS-DGS.

Table 1 summarizes the obtained simulation features of the designed antennas.

Table 1: The obtained simulations features

Antennas types	Resonance Freq. [GHz]	Material	RL [dB]	Gain [dB]
Ant. 1 : CRMPA	2.4	RO4003C $\epsilon_r = 3.4$ H=1.524 mm	-15.72	5.1
Ant. 3 : CRMPA with RS-DGS	2.4	RO4003C $\epsilon_r = 3.4$ H=1.524 mm	-26.92	5.9
Ant. 4 : CRMPA with RS-DGS	2.4	RO4003C $\epsilon_r = 3.4$ H=1.524 mm	-31.87	5.9

#### 4. Conclusions

A simple technique to improve conventional rectangular microstrip patch antenna (CRMPA) characteristics by adding an etched rectangular slot in the ground plane (RS-DGS) is presented in this paper. Simulation results have shown that inserting RS-DGS improves the antenna performances. For the considered CRMPA, the results show a 100 % enhancement of the return loss and a 0.8 dB improvement of the gain for the configurations named Ant. 3 and Ant. 4. A further work focusing on the effect of the RS-DGS position and parameters is essential to end up with an antenna configuration with optimal performances.

Moreover, an investigation of various shapes of DGSs is also planned.

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