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# Rectangular Slotted Patch Antenna for 5-6GHz Applications

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***Abstract*- A novel miniature wideband rectangular patch antenna is designed for wireless local area network (WLANs) applications and operating for 5-6 GHz ISM band, and wideband applications. The proposed antenna gives a bandwidth of 4.84 to 6.56 GHz for S11<-10dB. The antenna has the dimensions of 20 mm by 15 mm by 0.8 mm on FR4 substrate. Rectangular slot and step have been used for bandwidth improvement.**

***Index Terms*- Wideband antenna, WLANs, ISM band, microstrip patch antenna.**

## I. INTRODUCTION

The rapid growth of wireless communications has necessitated that antennas for portable devices be low profile, packaged, and wide-band to allow operation at multiple frequency bands, eliminating the need for separate antennas for each application. Miniature antennas are well desired for wireless communications systems. The most popular among miniature antenna choice is the microstrip patch antenna [1].

The future generation wireless networks require systems with broad-band capabilities in high-mobility environments [2], to satisfy several applications as personal communications, home, car, and office networking. The wireless communication market has been greatly expanded and the demands of Industrial, Scientific, and Medical (ISM) band are increasing.

The antenna is the basic element on these communication systems, it is a key component in system performance and size, and it has to simultaneously satisfy three classes of requirements [3]:

i) Geometrical characteristics (small size, light weight, adaptability to actual platform, and nonobstructive to the user), ii) Electrical performance (wide bandwidth, radiation properties, high efficiency, reconfigurability, and suitability for diversity), and iii) Manufacturing constraints (low cost, reliability, packaging capabilities).
Antenna's performance must also not be degraded by environment as human body, and the design must respect the radiation safety standards.

Wireless communications continues to enjoy exponential growth in the cellular telephony, wireless Internet, and wireless home networking arenas. Wireless networks include wireless local area network (WLAN) for which the IEEE 802.11 group has the responsibility for setting the standards [4]. The most significant technology exists in the ISM bands: 2.4–2.4835 GHz and 5.15–5.825 GHz [5].

The current fastest and robust WLANs operate in the 5–6 GHz band (e.g., IEEE 802.11a [6]), which can provide reliable high-speed connectivity between notebook computers, PCs, personal organizers and other wireless digital appliances [7].

In this paper, we proposed a novel miniature wideband rectangular patch antenna for 5 to 6GHz applications. The proposed antenna can operate from 4.8 to 6.6 GHz making it suitable for wideband applications. The frequency band of this antenna covers the entire 5.15-5.825 GHz ISM band. This small printed monopole antenna can be used in the biomedical engineering

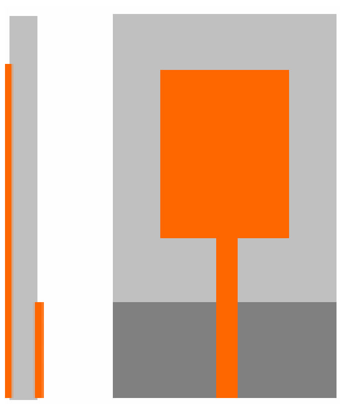
domain, and to be mounted on the medical devices.
The proposed antenna design and performances are analysed by using Ansoft High Frequency Structure Simulator (HFSS) [8] and CST Microwave Studio [9].

## II. ANTENNA DESIGN AND SIMULATED RESULTS

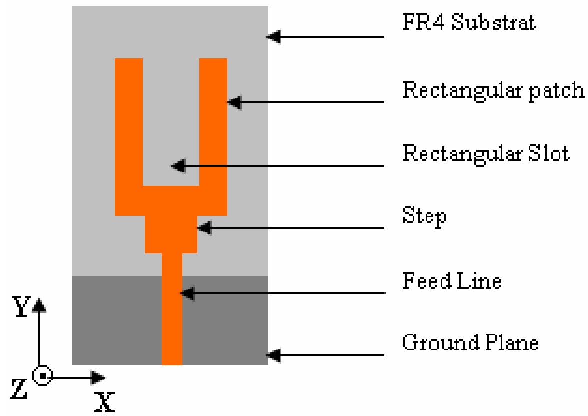
### *A. Geometry of Antenna*

The geometry of the proposed antenna is showed in Fig.1. It consists of a printed rectangular patch antenna on FR4 substrate of thickness 0.8 mm and a relative permittivity 4.4. The substrate has a length of L=20 mm and the width of W=15 mm. The dimensions of the partial conducting ground plane are 15mm×7 mm. The excitation is launched through a 50 Ohm microstrip feed line, which has the length 8mm and the width 1.5mm.

In this paper, rectangular slot on the radiator element and rectangular step have been used for bandwidth improvement, in order to cover the entire 5-6GHz band, and make the antenna suitable for 5 to 6 GHz applications.
The dimensions of all part of the proposed antenna are given in table.1.



(a) Without step, without slot




(b) With step, with slot

Fig.1. Geometry of the proposed antenna

| | |
|---|---|
| FR4 Subsrate (X, Y, Z) | 15mm×20mm×0.8 mm |
| Rectangular Patch (X, Y) | 7mm×8 mm |
| Rectangular Slot (X, Y) | 3mm×6 mm |
| Step (X, Y) | 3mm×2 mm |
| Feed Line (X, Y) | 1.5mm×8 mm |
| Ground Plane (X, Y) | 15mm×7 mm |

Table 1: Dimensions of all part of the proposed antenna

### *B. Criteria Design*

Fig.2 shows the simulated return loss for differnt cases of antenna's geometry (without slot, without step), (witout slot, with step) and (with slot, with step).

For the first case, the antenna operates from 3.1 to 5.5 GHz, this bandwidth covers the lower part of the UWB as defined by FCC. In the Second case, adding rectangular step allows to widen the operational bandwidth by enhancing upper frequency. The proposed antenna operates from 3.4 to 6 GHz. In the Third case, rectangular slot on the patch antenna allows to shift the frequency band in the direction of the higher frequencies. This enhances the lower and the upper frequency, thus the antenna operates from 4.8 to 6.5GHz, which covers well the entire 5-6GHz band.

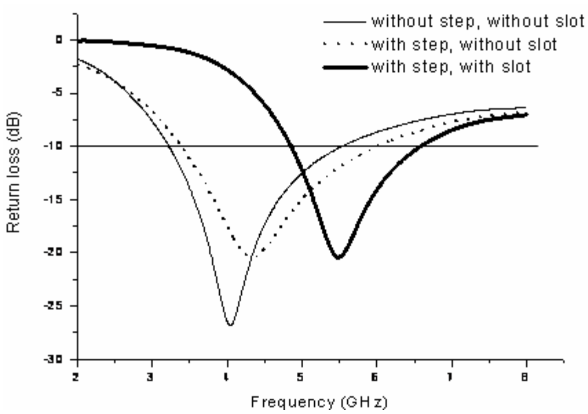



Fig.2. Simulated (CST) return loss for different cases of antenna's geometry

Fig. 3 shows the simulated return loss of the rectangular slotted patch antenna (Fig.1-b). It is found that the proposed antenna gives a bandwidth for S11<-10dB, of 4.8 to 6.2 GHz. (HFSS) and 4.8 to 6.5 GHz (CST), which covers the entire 5-6 GHz band. Good agreement is obtained between HFSS and CST results.

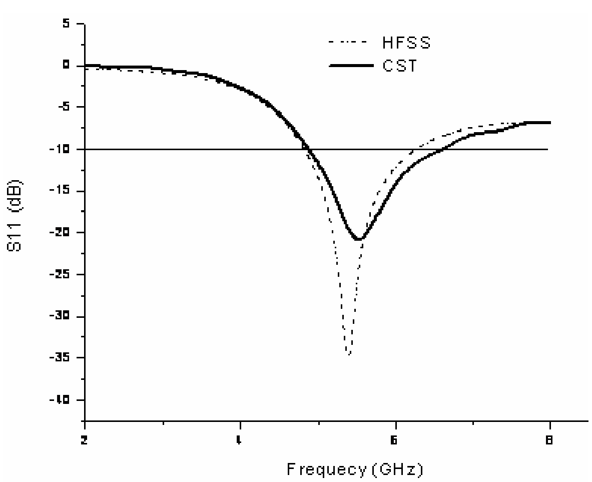



Fig.3. Simulated return loss (HFSS & CST)

The designed antenna satisfies the voltage standing wave ratio requirement of loss than 2.0 in the frequency range between 5-6 GHz as shown in Fig. 4.

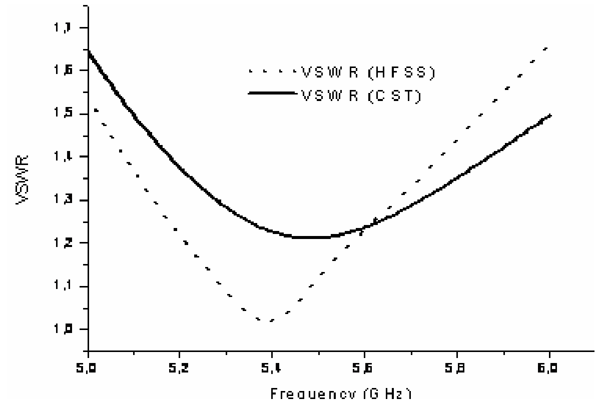



Fig.4. Simulated VSWR for the proposed antenna

For planar monopole antennas, the impedance bandwidth is considerably affected by some parameters such as the dimension of the radiator element, the ground plane size. In this paper, we study the effects of the length and the width of the rectangular step, and length of partial ground plane. This can be proved by investigating the return loss of this wideband antenna.

*B.1. Effects of the step length*

The return loss was simulated for different step length (Fig. 5). It was seen that the lower-edge frequency is not affected, but the upper frequency increases by increasing the step length. The optimized step length is Lstep=2mm.

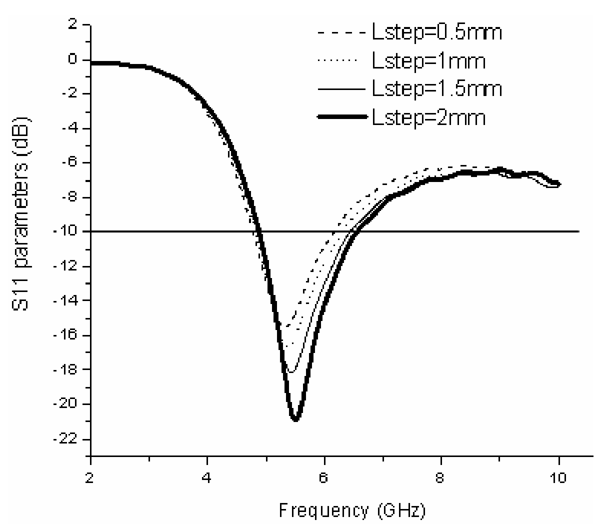



Fig.5. Simulated return loss for the different values of step length

*B.2. Effects of the step width*

Fig.6 illustrates the return loss for different values of step width. It is seen that the bandwidth is heavily dependent on the width of the rectangular step. In this paper, we choose Wstep=3mm to have an operational bandwidth that covers 5-6 GHz band.

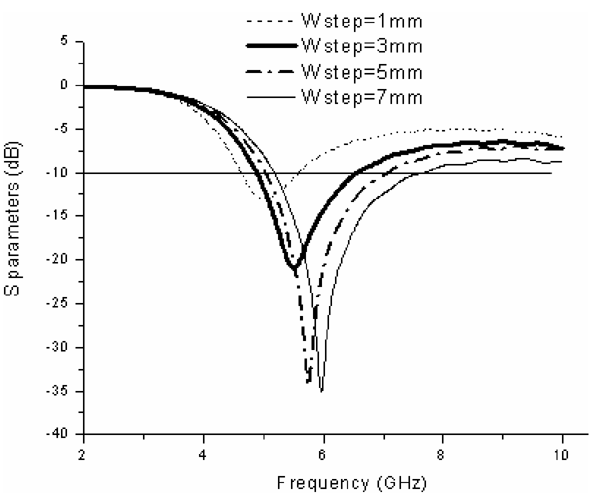



Fig.6. Simulated return loss for the different values of step width

*B.3. Effects of the ground plane length*

Fig.7 shows the variation of return loss with respect to the ground plane size (length). It is found that the lower and the upper-edge frequency will increase when the ground plane length increases, thus the bandwidth shifts towards higher frequencies. Using the optimized parameters above, the ground plane length is chosen to be equal to 7mm.

*C. Simulated Radiation pattern of the proposed antenna*

Figures 8-10 plot the simulated radiation patterns at 5.2, 5.5 and 5.8 GHz. Similarly to the conventional monopole antenna, the radiation patterns of the proposed antenna are nearly omnidirectional over the operating bandwidth

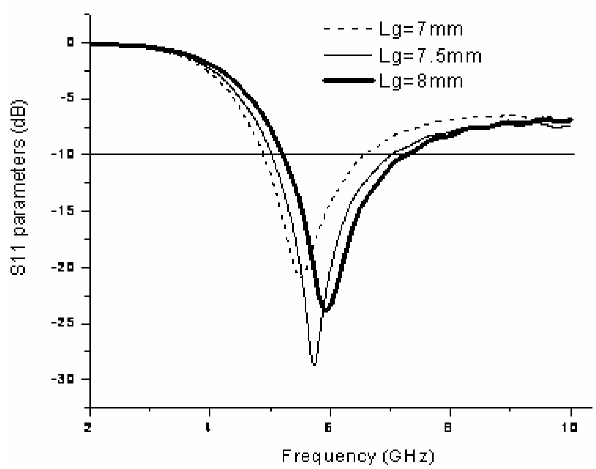



Fig.7. Simulated return loss for the different values of ground plane length

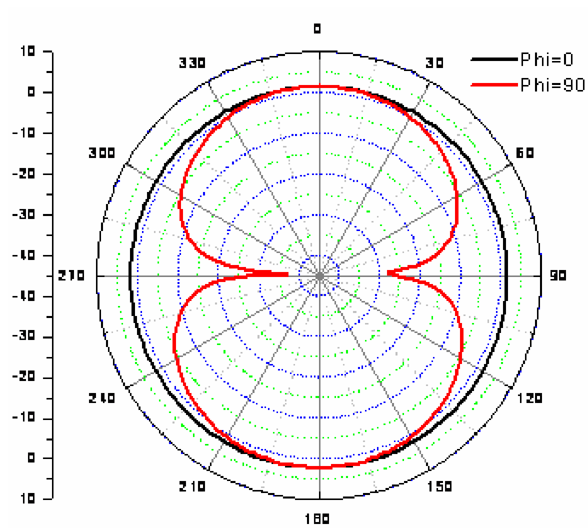



Fig.8. Radiation pattern at 5.2 GHz

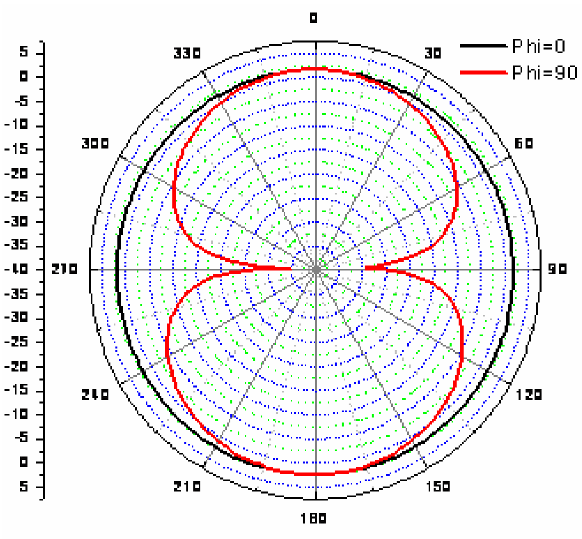



Fig.9. Radiation pattern at 5.5 GHz

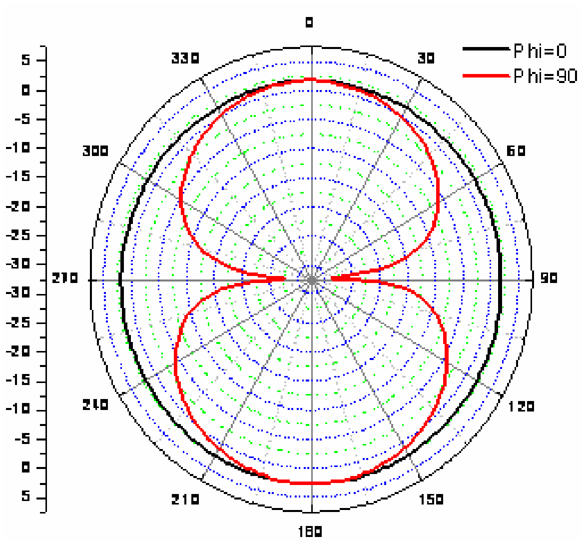



Fig.10. Radiation pattern at 5.8 GHz

The maximum gain over the frequency range is shown in Fig.11. The proposed antenna design, with good gain, is highly suitable for 5 to 6 GHz applications.

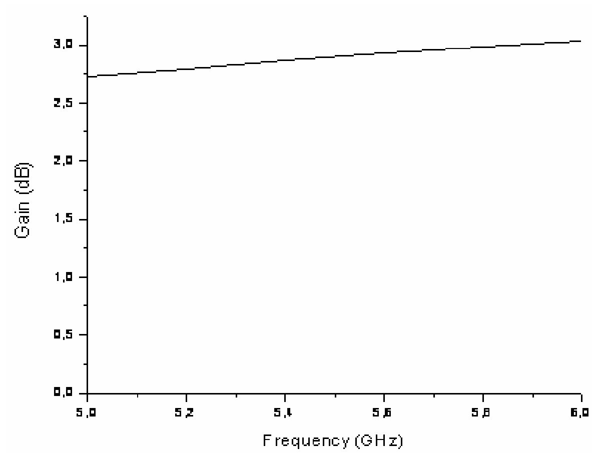



Fig.11. The Gain (dB) of the antenna over the 5-6 GHz band

## III. CONCLUSION

It is shown that the introduction of a rectangular step and a rectangular slot in the radiator element can be used to improve the impedance characteristics for the printed rectangular planar monopole antenna. The simulations results obtained by HFSS simulator and CST microwave studio show good agreement. The proposed rectangular slotted patch antenna can be good candidate for 5 to 6 GHz applications, and wideband applications, due to it's miniature size, and its good performances. The frequency range obtained for VSWR < 2 is 4.8- 6.5 GHz. The radiation pattern and maximum gain over the operating band of the antenna are given.

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