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A Dual Ultra Wide Band Slotted Antenna for C and X Bands Application

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Abstract—In this paper, a novel compact dual-band microstrip antenna operating at two different bands, namely, C-band and X-band is presented and analyzed. The dual ultra wide band is realized by cutting two triangular slots on the right and on the left sides of the patch and a rectangular slot on the top side of the patch. The antenna structure is optimized and simulated using commercial software. The excitation is launched through a 50 Ohms microstrip-line. According to simulation and measured results the proposed antenna can provide two separated impedance bandwidths of 500 MHz centered at 7 GHz and 2 GHz centered at 10.7 GHz and stable radiation patterns.

1. INTRODUCTION

Recent wireless communication systems require low profile, light weight, high gain, and simple antenna structure to ensure reliability, mobility, and high efficiency characteristics. Most of these requirements are satisfied through microstrip antenna technology. However, the most important challenge in microstrip antenna design is to increase the bandwidth and gain [1]. Concurrent dual-band patch antennas were introduced to operate at different frequencies simultaneously [2, 3] to provide several advantages, especially, low complexity, low cost, low power consumption, and small size systems. Furthermore, there are rapid developments in several areas of RF and microwave technologies such as wireless and mobile communications and microwave imaging in order to meet the requirements of different applications such as synthetic aperture radar (SAR), shuttle imaging radar, remote sensing radars, and other wireless communication systems operating at L, C and X bands [4].

Several techniques can be used to achieve multi-band performances such as multilayer stacked patch, multi resonator, multi slots loaded antennas. For instance, the most popular technique for obtaining a dual-frequency behavior is to introduce slots loading to a single patch [5, 6].

In this paper, we present a novel and simple compact dual-band microstrip antenna. To achieve two bands, we introduce two shapes of slots, triangular and rectangular, on the top layer of the patch using a partial ground plane [15].

This dual-band antenna is a good candidate for both C and X wide-bands wireless applications due to the simplicity of its structure, ease of fabrication and high gain and efficiency [7–11].

Its operating frequency range corresponds to both 6.8–7.3 GHz and 9.7–11.7 GHz bands, making it suitable for several wireless applications [7–11].

The proposed antenna design and performances are analyzed and optimized using commercial Computer Simulation Technology simulator software (CST Microwave Studio) [10]. A prototype of this antenna was fabricated using FR4 substrate with a thickness of 1.5 mm and relative permittivity of 4.4. Detail of the investigations based on measurements of the proposed antenna is described in the following paragraph.

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2. ANTENNA DESIGN

2.1. Antenna Geometry

The performances of microstrip antennas depend mainly on their geometry, dimensions and on the dielectric substrate characteristics [13]. Depending on the dimensions, the operating frequency, radiation efficiency, directivity, return loss and other related parameters are also influenced. Theoretically, the length of the slot function is chiefly determined by the expression [12–14]:

$$L_{slot} = \frac{c}{2f\sqrt{\varepsilon_{eff}}} \tag{1}$$

where

$$\varepsilon_{eff} = \frac{\varepsilon_r + 1}{2} \tag{2}$$

As shown in Figure 1, the proposed rectangular patch antenna contains a rectangular slot, on the top side which has the following dimensions 20 mm × 5 mm and other two parallel triangular slots on right and left sides. These slots are introduced to optimize the dual-band operation of this antenna.

Using CST Microwave studio, which is a commercial simulator based on Finite integration (FIT) Method, the feed line is matched to 50 Ω, where the length and width are calculated and found to be 8 mm, and 1.3 mm, respectively.

The substrate has a length of $L = 21$ mm and width of $W = 30$ mm. The truncated ground plane has a length of $L_b = 8$ mm and width of $W_b = 30$ mm. The geometrical parameters of the slots antenna are presented in Table 1.

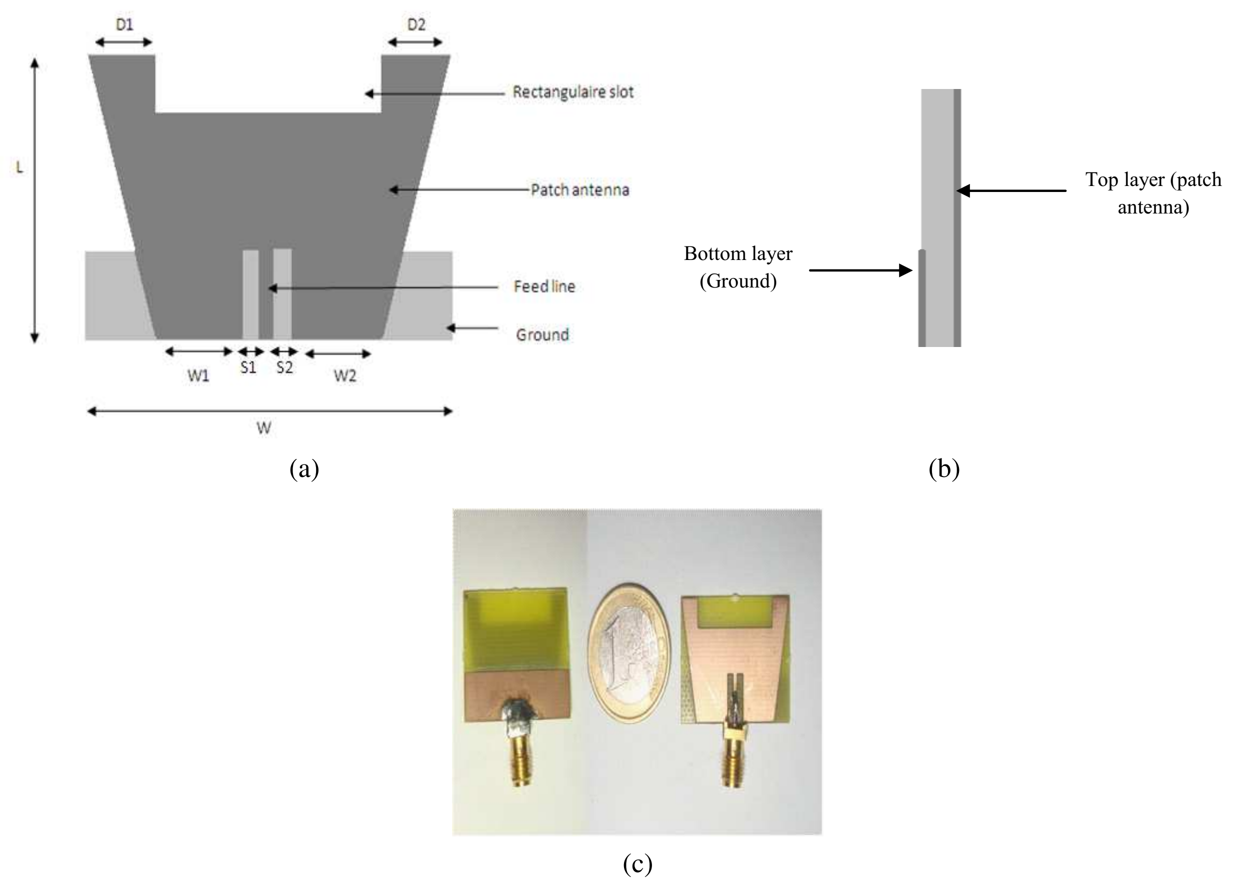
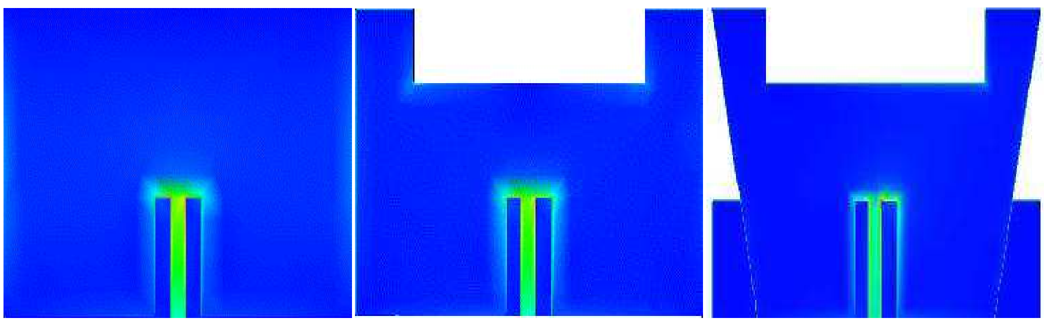


Figure 1. Geometry of the proposed antenna: (a) Top view; (b) side view; and (c) photograph of a manufactured prototype of this antenna.

Table 1. Dimensions of all part of the proposed antenna.

W_1; W_2 (X, X)	8.8 mm
Slot rectangular (X, Y)	20 mm × 5 mm
Feed Line (X, Y)	1.3 mm × 8 mm
S_1; S_2 (X, X)	1.3 mm × 1.3 mm
D_1; D_2 $(X.X)$	5 mm
Ground (X, Y)	30 mm × 8 mm
FR4 Substrate (X, Y, Z) $\varepsilon_r = 4.4$	30 mm × 21 mm × 1.5 mm
Copper thickness	35 µm



(a) (b) (c)

Figure 2. Design evolution of proposed antenna: (a) Antenna without slots; (b) Antenna with a rectangular slot; (c) Antenna with rectangular slot and symmetric triangular slot.

Figures 2(a)–(b) and (c) show the design evolution of the proposed dual UWB antenna. Figure 2(a) shows the conventional rectangular patch antenna which is used as the base of the design for antenna. Figures 2(b)–(c) show the use of slot technique to improve the bandwidth.

3. RESULTS AND DISCUSSION

The antenna is well matched to 50 Ω impedance and provides a return-loss of −15 dB over a wide frequency band ranging from 6.8 to 7.3 GHz, which exceeds the requirement for C-band operation. The second frequency resonance of this antenna can be tuned to X-band in the 9.7–11.7 GHz frequency

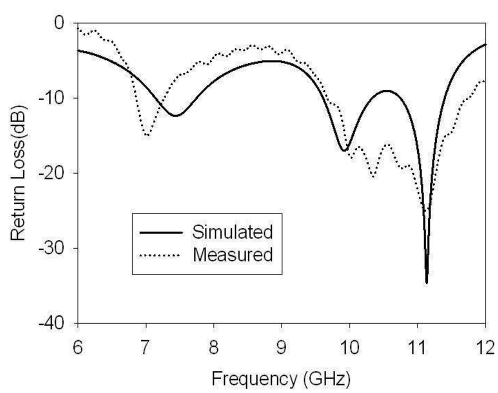


Figure 3. Measured and simulated return loss for the proposed antenna.

band providing a return-loss of −20 dB. Figure 3 shows the simulated and measured return loss for the proposed optimized antenna.

The measured results agree with the simulated ones which help to verify the accuracy of the simulation. The small discrepancy between the simulated and measured results may be due to the errors of the manufactured antenna and the SMA connector, which is included in the measurements but not taken into account in the calculated results.

Figures 4, 5 give the measured and simulated radiation patterns and the measured and simulated cross polars of the proposed antenna at 7 and 11 GHz. It is observed that the radiation patterns of the proposed antenna are similar to monopole antenna at 7 GHz and similar to dipole antenna at 11 GHz. The maximum gain of the dual band-notched antenna is measured and exhibited in Figure 7. The 3-dimensional view of this radiation pattern is given in Figures 6, 7. The maximum gain of the dual band-notched antenna is measured and exhibited in Figure 8.

The measured gain over both operating frequency bands is around 5 dB as shown in Table 2.

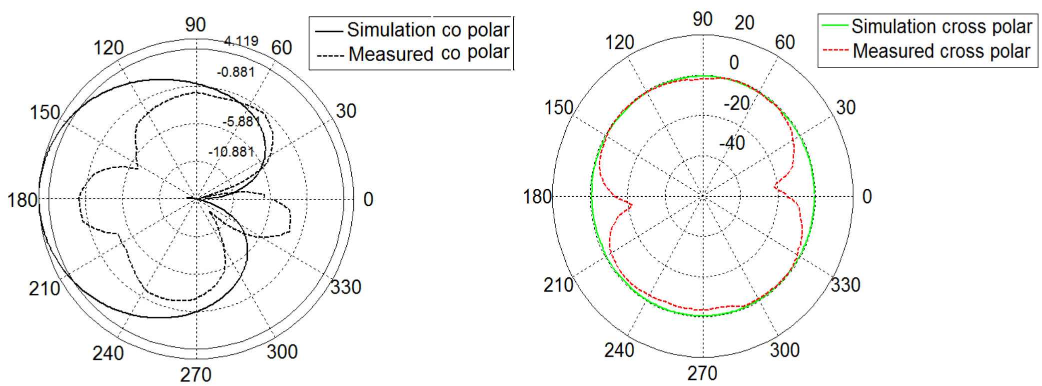


Figure 4. Radiation pattern at 7 GHz.

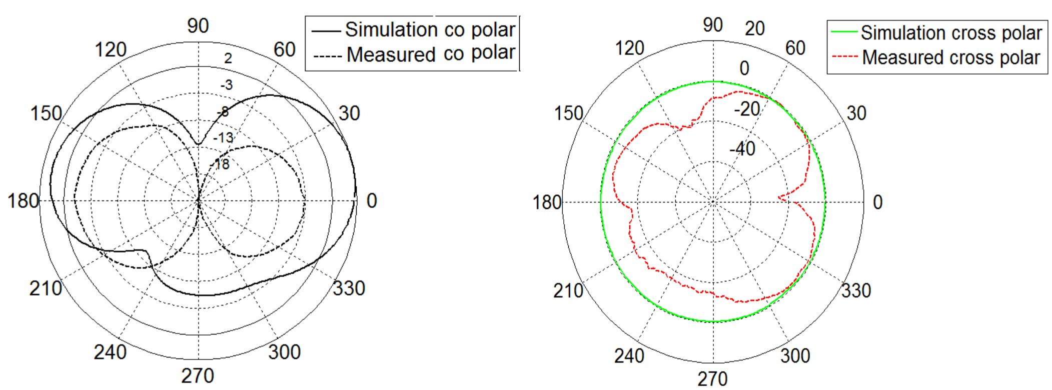


Figure 5. Radiation pattern at 11 GHz.

Table 2. Measured gain 7 and 11 GHz frequency bands.

Frequency (GHz)	Maximum Gain value (dB)
7	5.54
11	5.35

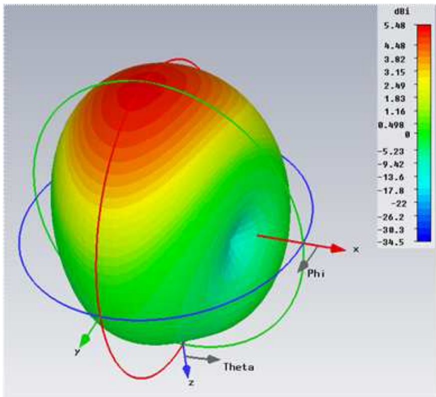


Figure 6. Computed 3D radiation pattern at 7 GHz.

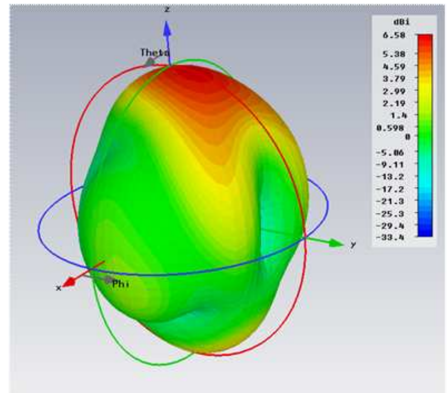


Figure 7. Computed 3D radiation pattern at 11 GHz.

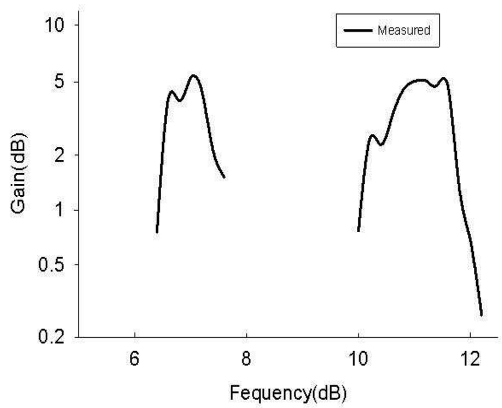


Figure 8. Measured gains dual-bands range frequency.

4. CONCLUSION

In this paper, we propose a novel compact ($30 \times 21 \times 1.5\,\text{mm}^3$) dual-band antenna that operates at two wide frequency bands which make it suitable for C and X-bands applications. The radiation pattern of this antenna for both frequency bands provides almost dipole-like behavior. By properly choosing the location of the slots, two bands can be achieved. Furthermore, the proposed antenna can be scaled to meet other wireless communication systems just by changing the dimension of the main antenna.

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