

## **ULTRA-WIDEBAND MONOPOLE ANTENNA WITH FOUR-BAND-NOTCHED CHARACTERISTICS**

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**Abstract**—A compact ultra-wideband (UWB) monopole antenna with four-band-notched characteristics is introduced in this paper. The proposed antenna can achieve four-band rejection at 3.4, 5.7, 8 and 11 GHz with desired bandwidths only using one novel structure called nested complementary split-ring resonator (CSRR) which is etched inside the ground plane. This method used to obtain four-band-notched characteristics is firstly proposed in this paper. The antenna has a small dimension of  $35 \times 27 \text{ mm}^2$ . The VSWR and radiation patterns of the fabricated antenna are presented, which prove that the designed antenna is a good candidate for various UWB applications.

### **1. INTRODUCTION**

In recent years, a lot of researches have been absorbed in the development of the ultra-wideband (UWB) antennas [1–12] due to its simple structures, low cost, convenient feeding structure and wide bandwidth. The Federal Communication Commission (FCC) has prescribed 3.1 to 10.6 GHz for commercial ultra-wideband (UWB) communication systems [13]. However, there are existing wireless local area network (WLAN) bands [14] and some satellite services at 8 GHz and 11 GHz, and these may generate interference with a wideband communication system operating from 2.9 to 12 GHz for the proposed antenna. Recent trend in UWB antenna design is to possess band-notched characteristics, a considerable amount of published literatures have reported that one band-notched characteristics can be realized by etching a U-shaped slot [15] or an arc-slot [16]. Some dual band-notched UWB antennas have been designed by embedding SRR [17] in

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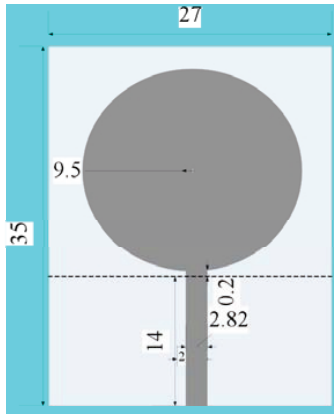
the radiate patch, and few literatures [18] have reported how to obtain tri-band-notched characteristics. To the authors' knowledge, this paper first introduces an ultra-wideband monopole antenna with four-band-notched characteristics, which is obtained only using a nested CSRR etched inside the ground plane for the first time.

Printed circular monopole antenna (PCMA) is used in this paper. This type of antenna can reject unwanted frequency bands by adjusting dimensions of nested CSRR.

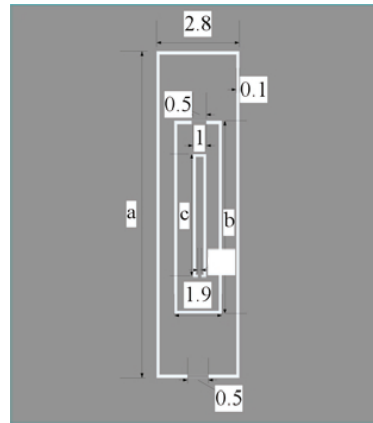
Details of antenna device are depicted, and experimental results are also presented and discussed.

## 2. ANTENNA DESIGN

The geometry of the designed antenna without nested CSRR is shown in Fig. 1. The proposed antenna is constructed on a substrate with thickness of 1 mm and relative dielectric constant of 2.65. The antenna occupies a small area with dimensions of  $35 \times 27 \text{ mm}^2$  and has a ground plane of  $27 \times 14 \text{ mm}^2$  on the back of it. A  $50\text{-}\Omega$  microstrip feed line is designed with a width of 2.82 mm. The radius of circular radiate patch is 9.5 mm. Fig. 2 shows configuration of nested CSRR. It is rectangle and has three split-rings compared with traditional CSRR [8].

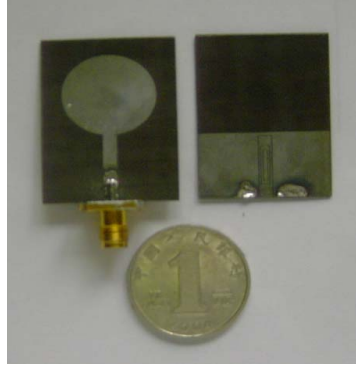


**Figure 1.** Geometry of the proposed antenna without nested CSRR.

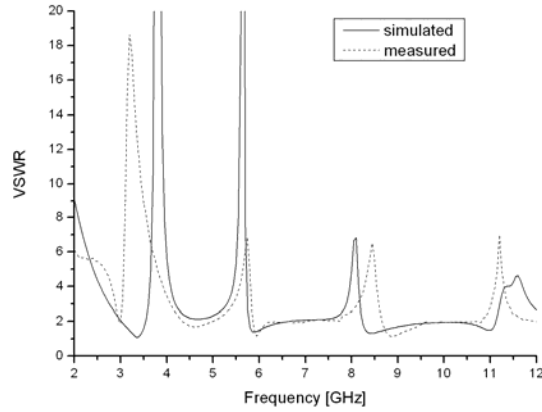


**Figure 2.** Geometry of nested CSRR.

Generally speaking, the design concept of the notch function is to adjust the length of nested CSRR to be about half-wavelength at the desired notched frequency making the input impedance singular. The



**Figure 3.** Photograph of the proposed antenna.

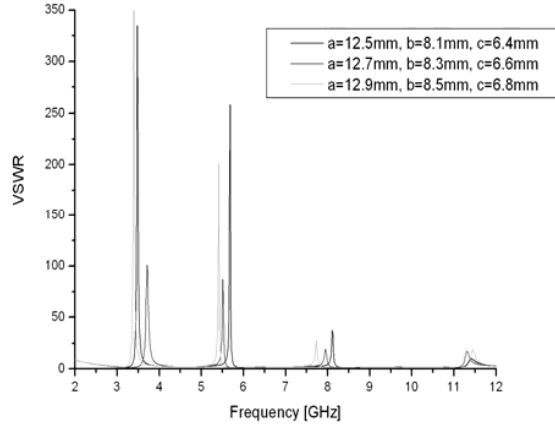


**Figure 4.** Simulated and measured VSWR for the proposed antenna.

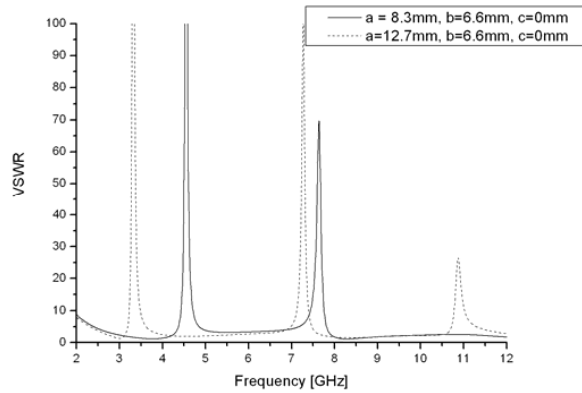
resonant frequency can be postulated as

$$f_{notch} = \frac{c}{2L\sqrt{J_{re}}} \quad (1)$$

where  $L$  is the total length of nested CSRR,  $\epsilon_{re}$  is the effective dielectric constant, and  $c$  is the speed of the light. We take (1) into account in obtaining the dimensions of nested CSRR at the very beginning of the design and then adjust the geometry for the final design. The detail dimensions (mm) of the designed antenna can be obtained from Fig. 2 ( $a = 12.7$  mm,  $b = 8.3$  mm,  $c = 6.6$  mm for the designed antenna).



**Figure 5.** Simulated VSWR of the proposed antenna with nested CSRR for various  $a/b/c$ .

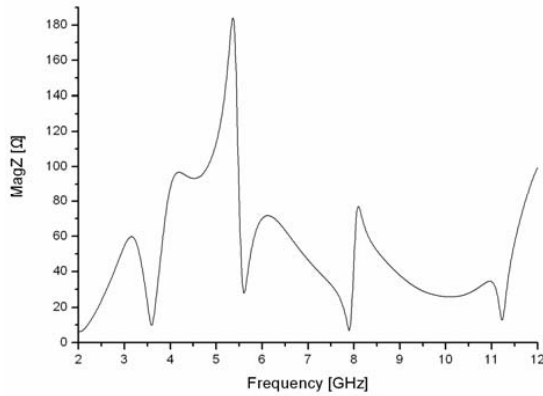


**Figure 6.** Simulated VSWR of the proposed antenna with nested CSRR for various  $a$ .

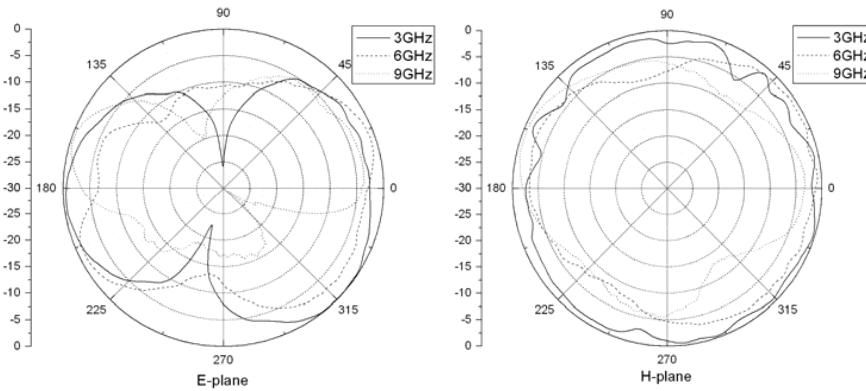
### 3. RESULT AND DESIGN

The prototype of the antenna is shown in Fig. 3. The simulated results are obtained using the software high-frequency structure simulator HFSS which is based on finite element method. VSWR of the fabricated antenna is measured by WILTRON37269A network analyzer.

As shown in Fig. 4, the designed antenna has an impedance bandwidth ( $VSWR \leq 2$ ) from 2.9 to 12 GHz, achieving four-notched frequency bands which we want to reject. The variety of notched



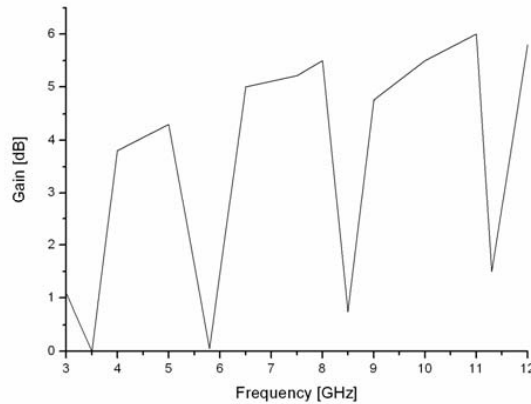
**Figure 7.** Magnitude of impedance for the designed antenna.



**Figure 8.** Measured radiation patterns of the proposed antenna at 3, 6 and 9 GHz.

frequency bands affected by the dimension of nested CSRR also has been presented as Fig. 5. It is noted that the notched frequency band at 11 GHz results from the coupling effect between the edge of the ground and the outer split-ring, which can be seen from Fig. 6. When the length of the outer split-ring ( $a$ ) increases to 12.7 mm, another notched frequency band appears at 11 GHz.

Figure 7 explains the reason for the forming of the four-notched frequency bands characteristics. The magnitude of the input impedance at 3.4, 8 and 11.2 GHz is closed to zero. On the other hand, the input impedance is very high at 5.4 GHz. Therefore, the



**Figure 9.** Measured gain of the proposed antenna.

four-band-notched characteristics can be obtained.

Figure 8 illustrates the measured radiation patterns in the  $E$ -plane and  $H$ -plane at 3, 6, 9 GHz. From an overall view of these radiation patterns, the patterns are almost omni-directional in the  $H$ -plane and monopole-like pattern in the  $E$ -plane. However, owing to the effect of higher modes, the radiation patterns are distorted at high frequencies.

Figure 9 shows the measured gain and the result presents a sharp gain decline in the notched frequencies.

#### 4. CONCLUSION

In this article, a compact, simple monopole antenna with four-band-notched characteristics has been first presented, which can reject unwanted frequency bands only using a nested CSRR which is firstly etched inside the ground plane. Therefore, the proposed antenna is a good candidate for UWB system.

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