A Dual Band (WLAN/WIMAX) Rejection UWB Antenna Using CSRRS

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ABSTRACT

A compact microstrip-fed ultra-wideband (UWB) planar monopole antenna with dual band rejected characteristic is presented in this paper. By etching two identical complementary square split ring resonators (CSRRs) in the radiation patch, dual band rejections in the WiMAX and WLAN bands are achieved. The proposed antenna, with the size of 30×34mm2, has been design. And the simulated results show that the antenna can operate over the frequency band between 3 and 11 GHz for VSWR < 2 with dual band notches of 3.4-3.6 GHz and 5.1-5.9 GHz. Besides, in the working bands, the antenna shows good omnidirectional radiation patterns in the H-plane and monopole-like radiation patterns in the E-plane and has good time-domain characteristic as well.

Index Terms—Coplanar waveguide, dual-band antennas, printed antennas, wireless local area networks (WLANs).

I. INTRODUCTION

Since the Federal Communications Commission (FCC) authorized the unlicensed use of ultra-wideband (UWB), range of 3.1-10.6 GHz) for commercial purposes [1], UWB technology has attracted much more attention for communication applications [2-5]. However, the frequency range for UWB systems will cause interference to the existing communication systems such as the worldwide interoperability for microwave access (WiMAX 3.5 GHz) and the wireless local area network (WLAN 5.2/5.8 GHz) bands.

Therefore, the UWB antenna with rejected characteristic is required. In the present literatures, the most popular methods to generate the frequency band-notch function are embedding slots [6-8], using defected ground structure (DGS) [9-11], or employing the above two methods simultaneously [12-14].

Unfortunately, these designs can only obtain one rejected band with the complicated structures. Recently, researches in split ring resonator (SRR) and its complementary structure (CSRR) have risen drastically because of their novel properties, both of which have been increasingly used in the designs of antennas and filters [15-18].

In this paper, a simple and compact planar monopole antenna with dual band notches for WiMAX 3.5 GHz and WLAN 5.2/5.8 GHz is proposed. The antenna consists of a microstrip feed line, a ground plane and a mushroom-shaped radiation patch with two identical square complementary split ring resonators (CSRRs) which realize the dual band stop-band function etched in it. Since both the lower and higher resonant modes of the CSRRs has been fully used to generate the notched bands, the designed antenna can realize the dual band rejection conveniently by etching the CSRRs in the radiation patch only, while most of the antennas reported in the references had to employ the DGS structure as well to realize the same function. Details of the proposed antenna are described and studied.

II. ANTENNA DESIGN

The geometry of the designed antenna is shown in Fig. 1(a). The antenna is printed on a substrate with size of 30 ×34mm2, thickness of 1 mm, and relative permittivity of 2.65. It has a semicircular patch with two steps on the front side and a ground plane of 30×12mm2 on the back side. A 50Ω microstrip feed line is designed with a width of 2.84 mm. To realize the filtering property, two identical square complementary split ring resonators (CSRRs) are etched in the radiation patch. A CSRR is constructed by etching two concentric square split rings with small cuts which are placed on opposite sides of each ring in the metal plate. The geometry of the UWB antenna without rejection is depicted in Fig. 1(b) for comparison. The reference antenna has the same dimensions as the proposed antenna, except that it doesn't have the structure of CSRRs. The detailed dimensions of the radiation patch can be found in Fig. 1 and the analyses of the CSRRs are given below.

CSRR is inspired on Babinet principle [19], and as occurs with the SRR, it also exhibits a quasi-static resonance. Usually, the total dimension of the CSRR is approximately equal to half of the guided wavelength at the notched frequency, which is.

\[ L_{total} \approx \frac{\lambda}{2} = \frac{c}{2 \cdot f_{notch} \cdot \sqrt{\varepsilon_{eff}}} \] (1)

Where c is the velocity of the light; \( L_{total} \) is the total length of the CSRR; \( \varepsilon_{eff} \) is the effective dielectric constant. In our study, for \( f_{notch} = 3.5 \text{ GHz} \), the total length of the CSRR can be calculated to be \( L \approx 31.75 \text{ mm} \), so that the initial length of the outer ring of the square CSRR is \( L = L_{total}/4 \approx 7.9 \text{ mm} \). The final dimensions and the distances between two CSRRs can be optimized through full- wave EM simulation. The optimal results are given as: \( L = 7.5 \text{ mm}, R = G = 0.4 \text{ mm}, W = 0.3 \text{ mm} \). Fig. 2 depicts the model and the characteristics of a CSRR entity embedded in the substrate's ground plane with the dimensions above. It can be observed that two resonant frequencies were generated at 3.4 GHz and 5.5 GHz by a single CSRR. When the single CSRR was etched in the radiation patch of the reference antenna, two narrow stop bands at 3.4 GHz and 5.5 GHz can be realized, which can be
observed in Fig. 3. However, the stop bands are too narrow to cover the WiMAX/WLAN bands, so that two CSRRs have to be embedded in the radiation patch to widen the bandwidth of the notched bands.

The equivalent circuit model of the proposed antenna is shown in Fig. 4. Approximately, the radiating element of UWB antenna can be seen as several parallel RLC cells in series [20]. The CSRRs behave as a parallel and a series LC resonator, respectively, and the resonant frequency is given by 

\[ f = \frac{1}{2\pi\sqrt{LC}} \] 

[21], which is related to the dimensions of the CSRRs.

III. RESULTS AND DISCUSSIONS

The proposed antenna and the reference antenna are simulated by Ansoft HFSS v12, the prototype of the antennas are shown in Fig. 1. It is clear that the results show a good agreement, Fig. 2(a) depicts that the designed antenna operates over the frequency band between 3-11 GHz, which covers the UWB frequency range, with two steep stop bands of 3.4-3.6 GHz and 5.1-5.9 GHz.

Figure 5 illustrates the current distribution of the proposed antenna at 3.5 GHz, 5.5 GHz and 6.5 GHz, respectively. It can be found that the current flows mainly along the edge between the inner and outer ring of the CSRRs at 3.5 GHz and 5.5 GHz where the CSRRs resonate. While at 6.5 GHz, the current mainly distributes in the radiation patch. It justifies that the CSRRs operate as a resonator and disturb the current distribution on the patch at 3.5 and 5.5 GHz destructively, which make the input impedance singular and prevent the antenna from radiating normally.

Figure 6 shows the simulated far-field radiation patterns of $E$-plane and $H$-plane at 4.2, 6.5 and 9.8 GHz, respectively. It can be seen that a monopole-like radiation pattern in the $E$-plane ($y$-$z$-plane) and a nearly omnidirectional radiation plane ($x$-$z$-plane) are realized by the proposed antenna. Fig. 7 shows the simulated peak gain of the antenna with and without the rejected band. Two sharp decreases of the realized gain at 3.5 GHz and 5.5 GHz can be observed, which shows the rejected characteristic clearly.
In this article, a novel UWB planar monopole antenna with dual band rejected characteristic is proposed. The two stop bands are generated by etching two identical square CSRRs in the radiation patch. The proposed antenna covers the entire UWB frequency band and has good radiation performance and time-domain characteristic in the working bands. It achieves dual band rejection for WiMAX 3.5 GHz and WLAN 5.2/5.8 GHz, which can eliminate the interference among UWB systems and WiMAX/WLAN systems. In addition, the designed antenna has simple structure, which makes it a good candidate for UWB systems.

IV. CONCLUSION

In this article, a novel UWB planar monopole antenna with dual band rejected characteristic is proposed. The two stop bands are generated by etching two identical square CSRRs in the radiation patch. The proposed antenna covers the entire UWB frequency band and has good radiation performance and time-domain characteristic in the working bands. It achieves dual band rejection for WiMAX 3.5 GHz and WLAN 5.2/5.8 GHz, which can eliminate the interference among UWB systems and WiMAX/WLAN systems. In addition, the designed antenna has simple structure, which makes it a good candidate for UWB systems.

REFERENCES

[16] Deng, J. Y., Y. Z. Yin, X. S. Ren, and Q. Z. Liu, ‘Study on a dual-band notched aperture UWB antenna using resonant Strip and