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A COMPACT C-SHAPED PRINTED UWB ANTENNA WITH BAND-NOTCHED CHARACTERISTIC

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Abstract—A compact printed ultra-wideband (UWB) antenna with band-notched characteristic is proposed. The presented antenna consists of a modified ground plane structure and a novel C-shaped radiation patch fed by a microstrip line. By etching a C-shaped slot in the radiating patch, the notched band of 3.3–3.8 GHz for WiMAX is generated. The notched band can be easily tuned by controlling the size of the slot. The measured results show that the proposed antenna operates over a wide bandwidth from 3 GHz to 16 GHz with return loss less than −10, except a stop-band of 3.3–3.8 GHz. Some key parameters of the antenna are discussed in details. The time-domain characteristics are given.

1. INTRODUCTION

Ultra-wideband (UWB) communication systems have attracted great attention in the radio world since the Federal Communications Commission (FCC) released the 3.1 to 10.6 GHz. The UWB communication systems possess the characteristics of high speed data rate, small power consumption, and resistant to severe multipath and jamming. However, over 3.1 to 10.6 GHz, there exist some narrowband wireless signals such as WiMAX (3.3–3.8 GHz), which might cause interference to the UWB communication systems. Thus, as a key component of UWB communication systems, UWB antennas with band-notched function are required. Recently, several UWB antennas have been reported [1–9]. The typical shapes of these configurations are circle [1–4], rectangle [5–7], and folded shape [8, 9]. Using coupled parasitic elements and etching different kinds of slots

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on the patch or ground are the common methods to realize band-notched performance. However, these designs usually have large size, complicated structures, and lots of parameters leading to a hard work in integration and applications. Therefore, it is desirable to design band-notched low cost UWB antenna with simple structure, small size, and good characteristics.

We have designed and discussed a band-notched UWB antenna in [4]. In this paper, a C-shaped UWB antenna with band-notch function is proposed. The geometry of the proposed UWB antenna is simple with fewer parameters. This new structure has a much more compact size than those radiation patches mentioned above. A modified ground plane with two beveled edges and a rectangular slot is introduced to achieve a wide impedance bandwidth. With the use of a C-shaped slot in the radiation patch, a notched band in 3.3–3.8 GHz is obtained. By adjusting the dimension of the C-shaped slot, the notched band can be controlled independently while the characteristics of the proposed antenna almost keep unchanged in the frequencies outside the notched band. In order to understand the operation of the proposed UWB antenna, some key parameters and current distributions are studied. Furthermore, time-domain characteristics are investigated as flat group delay and small signal distortion is a primary requisite for UWB communication systems.

2. ANTENNA DESIGN AND ANALYSIS

The proposed antenna is simulated and optimized by the High-Frequency Structure Simulator (HFSS). The proposed UWB antenna is illustrated in Figure 1(a). The C-shaped radiation patch connected with a microstrip feed line is printed on the top side of the low cost FR4 substrate of thickness 1 mm, relative permittivity of 4.4, and loss tangent of 0.02. A modified ground plane is printed on the other side of the substrate. By properly adjusting the size of the slots in the ground plane, the impedance matching can be improved as this structure changes the inductance and capacitance of the input impedance.

By embedding a C-shaped slot in the C-shaped radiation patch, a stop band of 3.3–3.8 GHz is obtained. The key parameters of the C-shaped slot are θ_s and R_s. The notched-band is obtained by adjusting the C-shaped slot to be about a half-wavelength at the notched frequency. The final dimensions are optimized to be $\theta_s = 88^\circ$ and $R_s = 5.2\,\text{mm}$. A photo of the fabricated antenna is shown in Figure 1(b). For measurements, a $50\,\Omega$ SMA is connected to the end of the feed line.

The measured return loss curves of the proposed UWB antenna

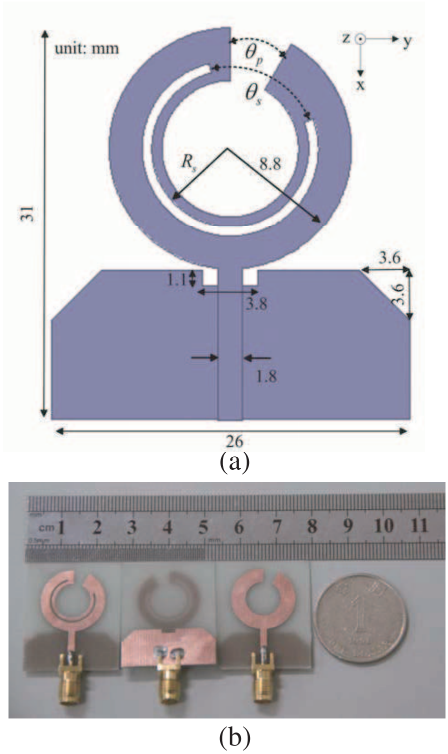

Figure 1. (a) Geometry and configuration of the proposed antenna, (b) photograph of the fabricated antenna.

and the original UWB antenna without notched band are shown in Figure 2. We can find that the proposed antenna operates from 3 to 16 GHz covering the entire UWB band with a sharp rejection band around 3.3–3.8 GHz. The proposed antenna is measured with a network analyzer Agilent E8363B (10 MHz–40 GHz).

3. RESULTS AND DISCUSSION

Figures 3(a)–(c) illustrate the simulated current distributions of the proposed antenna at 3.5, 7.5, and 9.5 GHz. For comparison, Figure 3(d) shows the current distributions of the original UWB antenna without notched band at 7.5 GHz. As shown in Figures 3(b) and (c), at the operating frequencies, the current is mainly distributed along the feed line, the edge of the C-shaped radiating patch, and the upper edge of the ground plane. That means the upper portion

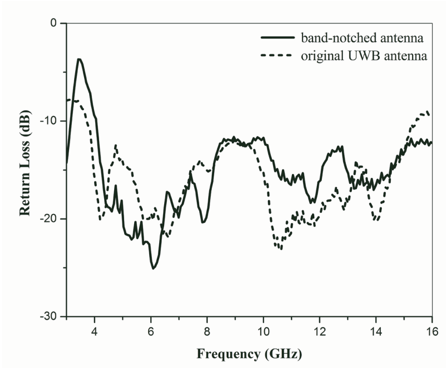

Figure 2. The measured return loss of the original antenna and band-notched antenna.

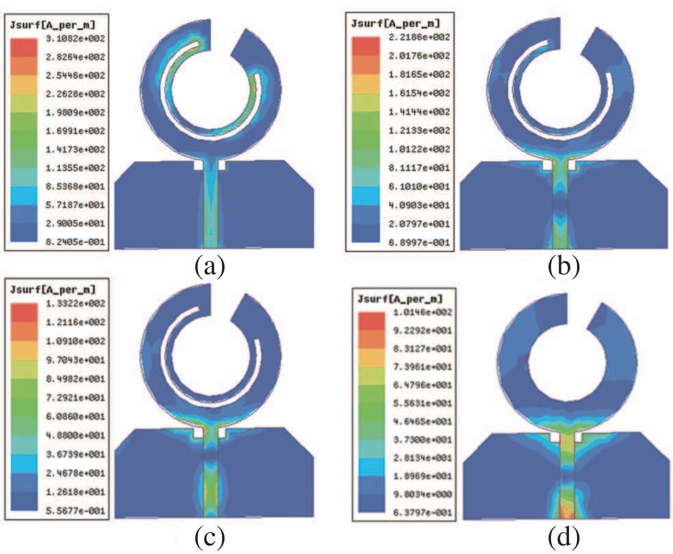

Figure 3. Distribution of currents on antenna. (a) 3.5 GHz, (b) 7.5 GHz, (c) 9.5 GHz, (d) original antenna at 7.5 GHz.

of the ground plane has a great effect on the performance of the proposed antenna. This is the reason why the modified ground plane can achieve a wide impedance bandwidth. From Figure 3(a), we can find that the majority of the currents distribute around the C-shaped

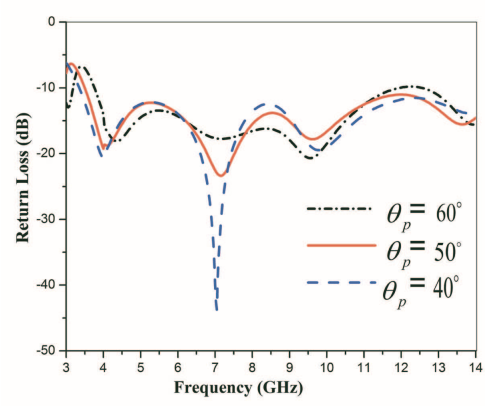

Figure 4. Return loss characteristic with different values of C-shaped radiation patch dimension.

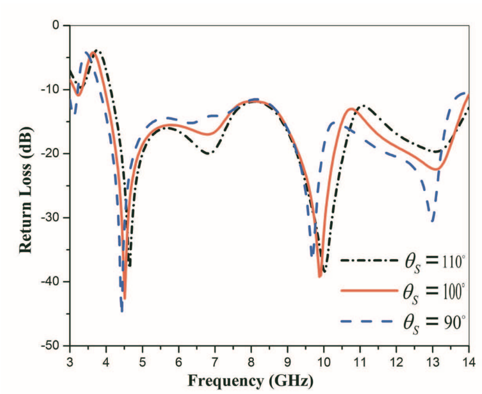

Figure 5. Return loss characteristic with different values of C-shaped slot dimension.

slot, just like about shorted, which causes impedance mismatching. As a result, strong reflection occurs, and the currents cannot be radiated efficiently. As shown in Figures 3(b) and (d), we can find that the band-notched structure do not perturb the current distribution at the operating frequencies.

Figure 4 shows the effect of the length of the C-shaped radiation patch on return loss of the original antenna. It can be seen that the edge of low frequency (3.1 GHz), a starting frequency of UWB antenna, increases as θ_p increases. This is equal to decreasing the current path. The length of the C-shaped radiation patch is optimized to cover the

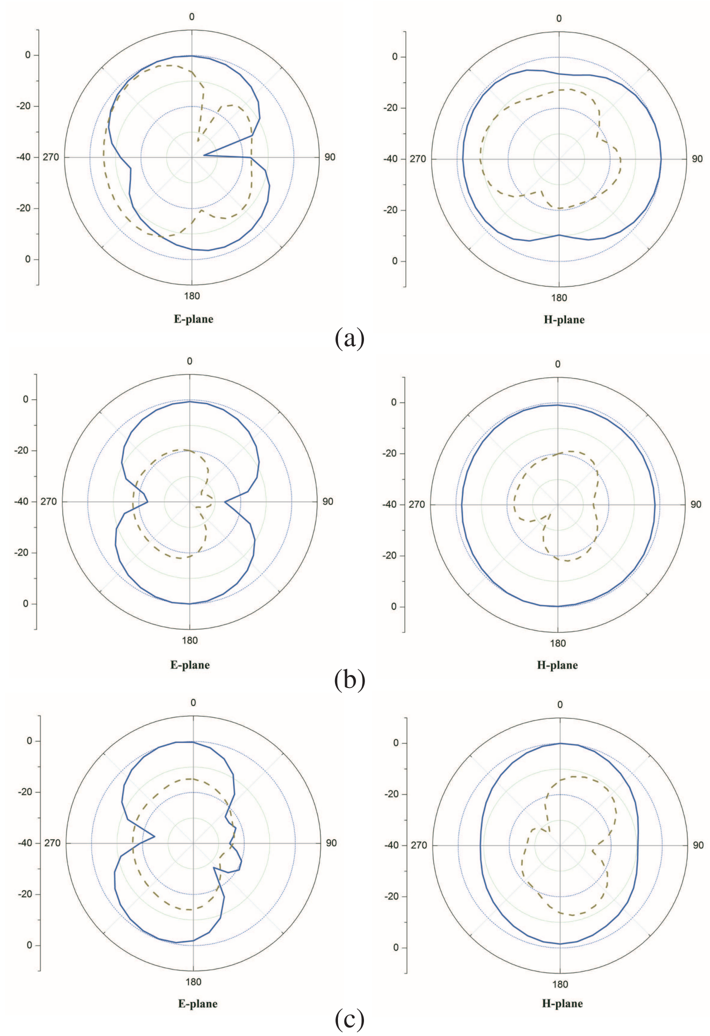

Figure 6. Radiation patterns of the proposed antenna. (a) 4.6 GHz, (b) 5.6 GHz, (c) 7.6 GHz. (— Co-polarization, - - - cross-polarization).

low frequency band. The final optimized value of θ_p is 31°.

The simulated return loss curves with different values of θ_s are shown in Figure 5. Note that the longer the total length of the C-shaped slot, the lower the first resonant frequency. It is seen that the notched band can be easily controlled by varying the dimension of the C-shaped slot.

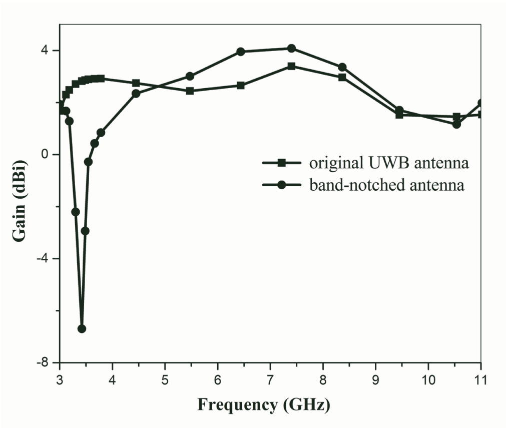

Figure 7. Antenna gain against frequency for the proposed antenna.

The far-filed radiation patterns including the co-polarization and cross-polarization of the proposed antenna at 4.6, 5.6, and 7.6 GHz in E-plane (xz-plane) and H-plane (yz-plane) are displayed in Figure 6. We can see that the radiation patterns are omnidirectional in the H-plane.

Figure 7 presents the antenna gain of the proposed antenna. The gain of the original UWB antenna without notched band is also given. It is observed that antenna gain decreases sharply in the notched band. However, for the operating frequencies, the proposed antenna exhibits flat gain performance.

The measured results of group delay and phase in time domain are shown in Figures 8(a) and (b). For measurement, two identical band-notched antennas are separated at a distance of 30 cm. As shown in Figure 8(a), the group delay variation is less than 1 ns in the operating UWB band. The maximum value of group delay is about 7 ns at center frequency of the notched band. A larger nonlinear phase occurs at the rejection band. A good agreement is achieved between group delay and measured phase. The measured magnitude of transfer function (S_{21}) is shown in Figure 9. We can find the magnitude of S_{21} is relatively flat in the entire band except in the notched band. It can also be observed in Figures 8 and 9 that they exhibit more ripples at low frequencies. The small ripple is due to many reflections, which may result from SMA connector, cable, and chamber scattering. The proposed antenna shows good phase linearity and low dispersion in the desired UWB band, which make it possible to communicate without signal distortion.

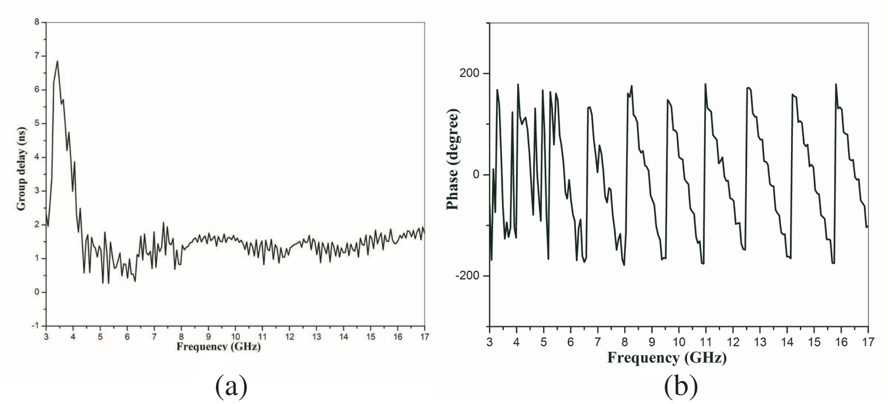

Figure 8. Measured result in time domain. (a) Group delay, (b) phase.

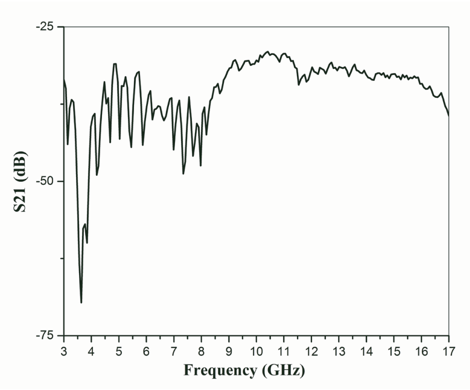

Figure 9. Measured magnitude of the transfer function of the proposed antenna.

4. CONCLUSION

A novel C-shaped UWB antenna with band-notched function is presented. To create a notched band, a C-shaped slot is introduced. The notched band can be easily controlled by changing the dimension of the slot. The properties of small profile, low cost, wide impedance matching, good omnidirectional radiation pattern, stable gain, and low distortion indicate that the proposed antenna is a good candidate for UWB communication systems.

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