Band-Stop Antenna with Enhanced Bandwidth by Using Several Pairs of Inverted L-Shaped Sleeves on the Ground for Wireless Applications

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Abstract **─** A very wideband rectangular monopole antenna with band notched performance for wireless applications is proposed. The very wideband performance is obtained by introducing a new technique on the ground plane including several pairs of inverted L-shaped sleeves which provide a very wide bandwidth. By utilizing two radiating stubs in which an inverted Ω-shaped strip is protruded, band-notched characteristics can be obtained. The measured results exhibit that the antenna is able to covers the bandwidth from 2.5 to 17.5 GHz, excluding the rejected bands from 3.1 to 4 GHz and from 5 to 6 GHz.

Index Terms **─** Antenna, stop band, UWB, very wide band.

I. INTRODUCTION

The impending and widespread requirements from commercial and military domains on wireless systems, in particular UWB systems, have sparked great interest in the field of UWB antenna design [1]. Different sorts of UWB antennas have been studied and proposed [2-4]. However, due to the allocation of the extended frequency range in UWB system (e.g., a portion of the spectrum between 3.1 and 10.6 GHz is dedicated for UWB system by Federal Communications Commission), a UWB antenna is quite susceptible to interference by receiving several narrow band signals of neighboring RF systems, such as 3.5 GHz Worldwide Interoperability for the Microwave Access (WiMAX) and 5.2/5.8 GHz Wireless Local Area Network (WLAN) communication systems. Therefore, it is desirable to design a UWB antenna with multiple band-notched characteristics to avoid the potential interference [1]. In the published literatures, there have been some reports on the UWB antennas with band-notched characteristics [5-7]. Although, the majority of these antennas are designed to generate only one notched frequency band, so that just one narrow band of disturbance can be eliminated. Consequently, these antennas are still open to other potential disturbance from neighboring RF systems. In this paper, a very wide band antenna with band-notched characteristics for Wireless and also UWB applications is proposed. By utilizing the set of new techniques on radiating patch and ground plane, very wide band and band-notched UWB characteristics can be obtained.

II. ANTENNA DESIGN

The configuration of the proposed antenna is demonstrated in Fig. 1. The antenna is designed and fabricated on a FR4 substrate with dielectric constant of 4.4, thickness of 1 mm, and overall dimension of 18mm×12mm. The structure of basic antenna consists of a square radiating patch, a

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ground plane, and a feed line which its width is fixed at 2 mm. Furthermore, the antenna is connected to a 50-Ω SMA connector for signal transmission. The size of the square patch is 10×10 mm^2 and the gap between the patch and ground plane is 4 mm. The dimensions of the ground plane is 12×3 mm^2. This is basic antenna; i.e., Printed Rectangular Monopole Antenna (PRMA) named as Antenna 1. To achieve optimum impedance matching at UWB frequency band, the ground plane with several pairs of inverted L-shaped sleeves play important roles in the broadband characteristics of this antenna, because they can adjust the electromagnetic coupling effects between the patch and the ground plane, and improves its impedance bandwidth without any cost of size or expense. Based on the design shown in Fig. 1, by using two radiating stubs in which an inverted Ω-shaped strip is protruded, band-notched characteristics at 3.5 GHz and 5.5 GHz can be obtained.

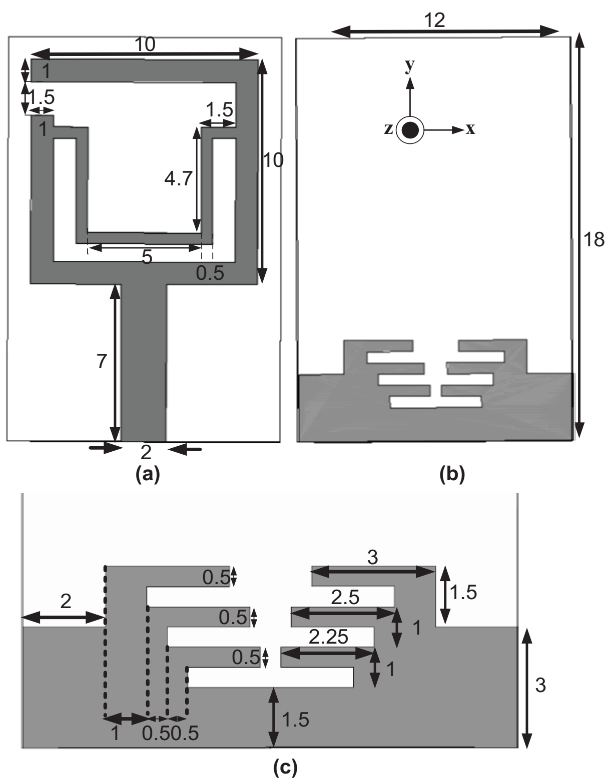

Fig. 1. Geometry of the proposed antenna: (a) top layer, (b) bottom layer, and (c) the ground plane with three pairs of inverted L-shaped sleeves.

III. ANTENNA PERFORMANCE AND DISCUSSION

A. Very wideband monopole antenna

In this section, the numerical and experimental results of the input impedance and radiation characteristics are discussed. The simulated results are obtained using the Ansoft simulation software High-Frequency Structure sSmulator (HFSS) [8]. The main idea of the antenna suggested has come from [9], which a pair of inverted L-shaped sleeves has been used. Figure 2 exhibits the simulated reflection coefficient characteristics for the various antenna structures with pairs of inverted L-shaped sleeves on the ground plane. As illustrated in Fig. 2 (a), PRMA without any sleeves has a resonant frequency at 3.5 GHz and its impedance bandwidth is limited from 3 to 5 GHz, while by using a pair of sleeves, Fig. 2 (b), another resonant frequency is obtained at 8.5 GHz causing the impedance bandwidth from 3.2 to 10 GHz. Ultimately, from Fig. 2 (d), can be found that by applying three pairs of sleeves three resonant frequency except the main resonant frequency of PRMA (at around 4 GHz) can be achieved, which it ends up extending impedance bandwidth (133%) from 3.4 to 17 GHz. Therefore, bandwidth is effectively improved at the upper frequency by utilizing several pairs of sleeves shown in Fig. 1 (c).

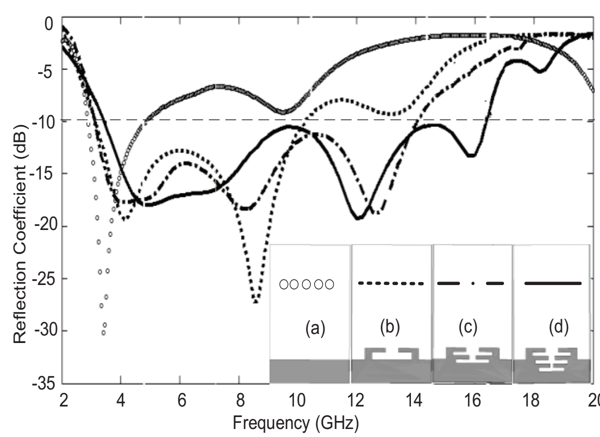

Fig. 2. Simulated reflection coefficient characteristics for the various antenna structures with pairs of inverted L-shaped sleeves on the ground plane: (a) PRMA without any sleeves, (b) with a pair of sleeves, (c) with two pairs of sleeves, and (d) with three pairs of sleeves

Simulated surface current distributions on the various ground structures at 16 GHz is shown in Fig. 3. It can be found that the current is more concentrated on edges of the interior and exterior of each three pairs of the sleeves at 16 GHz. Therefore, the antenna impedance changes at this frequency due to the resonant properties of its coupling. In addition, it is seen that by using this structure, an additional resonant mode occurs at about 16 GHz in the simulation.

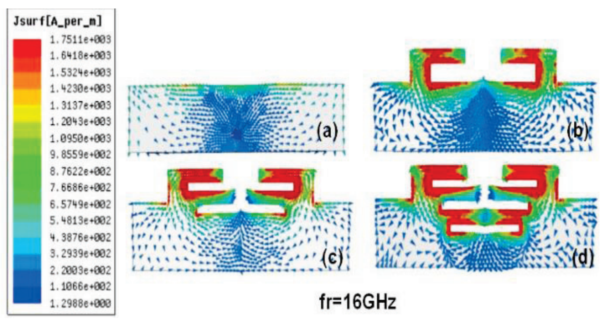

Fig. 3. Simulated surface current distributions on the various ground structures at 16 GHz: (a) PRMA without any sleeves, (b) with a pair of sleeves, (c) with two pairs of sleeves, and (d) with three pairs of sleeves.

B. Very wideband monopole antenna with frequency band-notch characteristics

In this letter, in order to generate the frequency band stop performances, two radiating stubs and an inverted Ω-shaped strip is used as displayed in Fig. 1. The simulated VSWR curves for the antenna structures are plotted in Fig. 4. As shown in Fig. 4, when radiating square patch (PRMA) is varied to radiating stub, impedance matching is nearly ruined. While by changing radiating stub in Fig. 4 (b) to two radiating strips in Fig. 4 (c), not only impedance bandwidth is improved but also a notched band is obtained at center frequency 3.5 GHz. On the other hand, by adding an inverted Ω-shaped strip between the both of radiating strip as shown in Fig. 4 (d), another notched band at center frequency 5.5 GHz is achieved. Therefore, it is found that by using two new techniques, a dual band–notch function can be earned that covers all the 5.2/5.8 GHz WLAN and 3.5/5.5 GHz WiMAX. The simulated peak gain and radiation efficiency are plotted in Fig. 5. The gains are started from -3.8 dBi at 2.5 GHz and ended up 2 dBi at 10 GHz. It is crystal clear that small size is the most important reason for being decrease gain. Besides, due to the rejected bands, -10 dBi and -8 dBi at frequencies 3.7 GHz and 5.5 GHz can be seen.

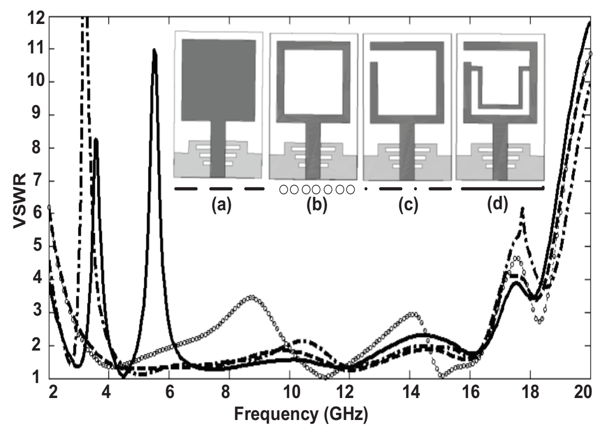

Fig. 4. Simulated VSWR characteristics for the various antenna structures with three pairs of inverted L-shaped sleeves on the ground plane: (a) PRMA, (b) with radiating stub, (c) with two radiating strips, and (d) the proposed antenna.

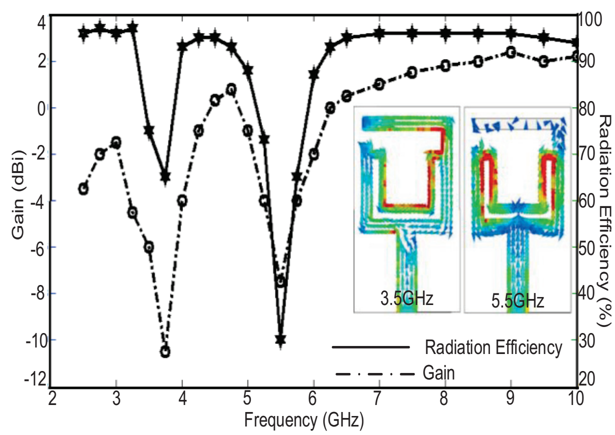

Fig. 5. Simulated gain and radiation efficiency of the proposed antenna and surface current distributions on two radiating strips with an inverted Ω-shaped strip at: (a) 3.5 GHz, and (b) 5.5 GHz.

As expected before, radiation efficiency on over frequency band except notched bands is more than 90%. The mechanism of the band-notched characteristics can be investigated from the currents on the antenna. Then, the simulated current distributions at 3.5 and 5.5 GHz for the proposed antenna are presented in Figs. 5 (a) and (b). It can be found that the currents at 3.5 and 5.5 GHz mainly distributed along two radiating strips at 3.5 GHz and an inverted Ω-shaped strip at 5.5 GHz, respectively. The prototype of the proposed antenna has been constructed and experimentally studied. With the help of the Ansoft HFSS software and an Agilent E8363B Network Analyzer, the simulated and measured VSWR curves are shown in Fig. 6. From the measured results we observed that the impedance band for VSWR≤2 is (150%) from 2.5 to 17.5 GHz, excluding the rejected bands from 3.1 to 4 GHz and from 5.0 to 6.0 GHz. The E-plane and H-plane radiation patterns for the proposed antenna at 4.5 and 7 GHz are shown in Fig. 7. It can be seen that the radiation patterns are bi-directional in the E-plane and almost omni-directional in the H-plane, which indicate good monopole-like radiation characteristics are achieved over the operating bands.

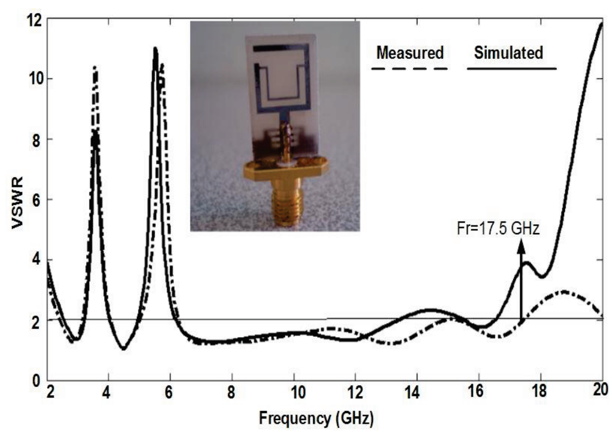

Fig. 6. Measured and simulated VSWR characteristics for the antenna and photo of the fabricated antenna.

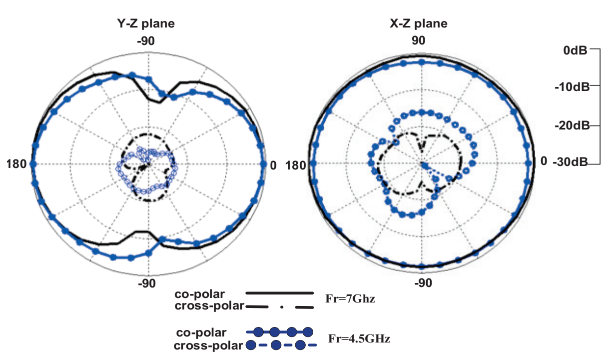

Fig. 7. Radiation patterns of the proposed antenna at 4.5 GHz and 7 GHz: (a) H-plane, and (b) E-plane.

IV. CONCLUSION

In this letter, a new antenna with band-stop characteristics has been proposed for wireless applications. The fabricated antenna is able to cover the frequency band of 2.5 to 17.5 GHz, except two rejection bands around 3.1-4.0 GHz and 5.0-6.0 GHz. The proposed antenna has a simple configuration and is easy to fabricate. Experimental results exhibit that the proposed antenna could be a good candidate for UWB application.

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