

SMALL TAPERED SLOT ANTENNA WITH A BAND-NOTCHED FUNCTION FOR WIRELESS APPLICATIONS

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Abstract—A small tapered slot antenna with a notched band for wireless applications is proposed in this paper. A modified transition from microstrip to slotline is used to introduce a notched band from 4.90 to 6.34 GHz. Corrugated edges on the ground is also used to improve the radiation patterns at the lower frequency band. Relatively stable radiation patterns and consistent group delay except the notched band have been obtained as proved experimentally.

1. INTRODUCTION

Modern communication systems have drawn more and more attention such as Universal Mobile Telecommunications System (UMTS), the 2.4- and 5-GHz wireless local-area network (WLAN), Worldwide Interoperability for Microwave Access (WiMAX) and Ultra-wideband (UWB). In these systems, antennas of dual-, multi- or wide impedance bandwidths with a low-profile structure and stable radiation patterns are required. Many antennas as popular candidates are proposed and analyzed such as folded structure [1], elliptical monopole antennas [2], slot antenna [3, 4] and tapered slot antenna [5, 6]. In addition, many efforts have been made to introduce band-notched functions for UWB applications, in order to reduce the influence caused by the crossover of operation band between UWB and other wireless bands [7–11]. However, few tapered slot antennas with a notched band have been proposed [12].

In this paper, a small tapered slot antenna with a notched band is proposed for the wireless communications. A modified microstrip-to-slotline transition is introduced for band-notched function. Corrugated

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edges are also used to improve the radiation characteristics of the proposed antenna at the lower frequency band. The prototype with an overall size of $6\text{ cm} \times 7\text{ cm} \times 0.6\text{ cm}$ achieves good impedance matching, stable radiation patterns, constant gain, and consistent group delay covering the UWB bandwidth of 3.1–10.6 GHz.

2. ANTENNA DESIGN

According to the constraint $0.005\lambda_o < t_o\sqrt{(\varepsilon_r - 1)} < 0.03\lambda_o$ on the substrate, where t_o is the thickness of the substrate of dielectric constant ε_r and λ_o is the free space wavelength at the operation frequency [13], the proposed antenna is fabricated on a 0.6 mm substrate with dielectric constant $\varepsilon_r = 2.65$. The small tapered slot antenna schematic is presented in Figure 1. The width W of the proposed antenna controls the lowest operation frequency, which is set at $0.47\lambda_L$, where λ_L is the free space wavelength at 2 GHz. The length L can affect the front-to-back ratio of the radiation patterns at the lower frequency band, which is set at about $0.4\lambda_L$. The optimal antenna geometric parameters are summarized in Table 1. A modified microstrip-to-slotline transition is introduced which consists of a modified microstrip radial stub, a circle slot, and a multisection matching transition. A 0.02 cm wide slotline with the length of L_3 is connected between the circle slot and tapered slot flare. The exponent slot flare is determined by the follow equation:

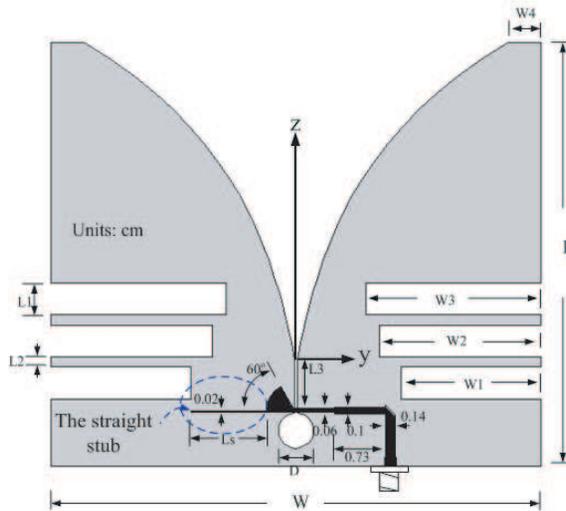


Figure 1. Geometry of the proposed antenna.

Table 1. The optimal parameter of the proposed antenna.

DIMENSIONS OF THE PROPOSED ANTENNAS	
R_1	1.5
L_1	0.45 cm
L_2	0.15 cm
L_3	0.75 cm
D	0.5 cm
W_1	2 cm
W_2	2.3 cm
W_3	2.5 cm
W_4	0.5 cm

$$y = c_1 \cdot e^{R_1 \cdot z} + c_2$$

where

$$c_1 = \frac{y_2 - y_1}{e^{R_1 \cdot z_1} - e^{R_1 \cdot z_2}} \quad c_2 = y_2 - c_1 \cdot e^{R_1 \cdot z_2}$$

$$y \in [0.0225 \text{ cm}, 3.0225 \text{ cm}]$$

Note that (y_1, z_1) and (y_2, z_2) are the coordinate of the origin and end of flare curve, respectively.

The corrugated edges are introduced to improve the directive radiation characteristics [14, 15]. Because of the finite dimension, only three slots are used, whose lengths are chosen about a sixth of the 2 GHz wavelength in the free space. Further more, these slots are designed with different length in order to decrease the influence on the flare slot.

The straight stub with length L_s connected with the microstrip radial short stub, where L_s is set at about 1/5 of the free-space wavelength at 5.8 GHz, is equivalent to a series branch of the radial stub which can be syntonc at 5.8 GHz. Therefor, when the proposed antenna is operated at 5.8 GHz, a notched band between 4.90 and 6.34 GHz is achieved [11].

3. RESULTS AND DISCUSSION

The simulated and measured VSWRs obtained with the aid of HFSS and WILTRON37269A vector network analyzer are presented in Figure 2. Both of the results are basically similar. The small differences may be caused by the use of SMA connector and fabrication error. It

can be observed that the impedance bandwidth of $VSWR \leq 2$ of the prototype antenna is from 2.0 to above 11.9 GHz.

The influence of the corrugated edges on the radiation pattern at 2 GHz is simulated and given in Figure 3. It can be seen that the directivity of E -plane radiation pattern at 2 GHz is improved by the use of these corrugated edges.

The radiation patterns of the proposed antenna in x - z and y - z planes at 2.0, 7.0 and 10.9 GHz are measured in a chamber and shown in Figure 4, respectively. It can be observed that the front-to-back ratio of the radiation patterns at 2.0 GHz is about 8 dB because of the decreasing electric length of the flare slot, although the corrugated edges on the ground are used. The cross polarization level is less than -15.2 dB in both x - z and y - z planes at the sample frequencies.

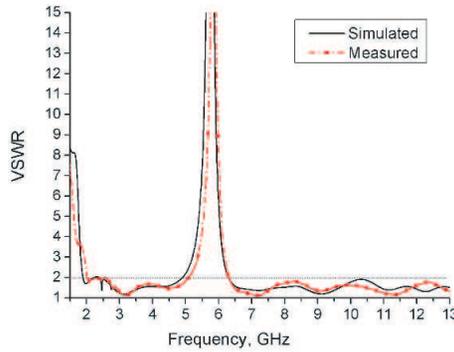


Figure 2. Simulated and measured VSWR of the proposed antenna.

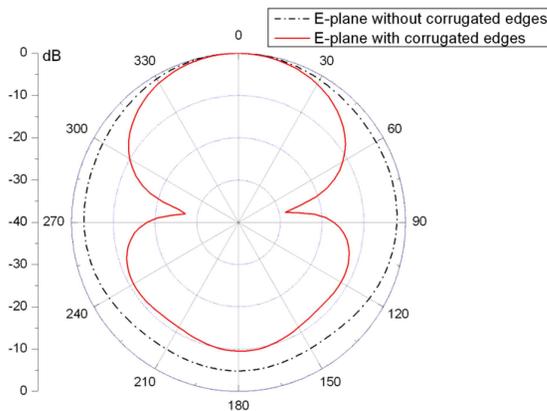


Figure 3. Simulated radiation pattern at 2 GHz with and without the corrugated edges.

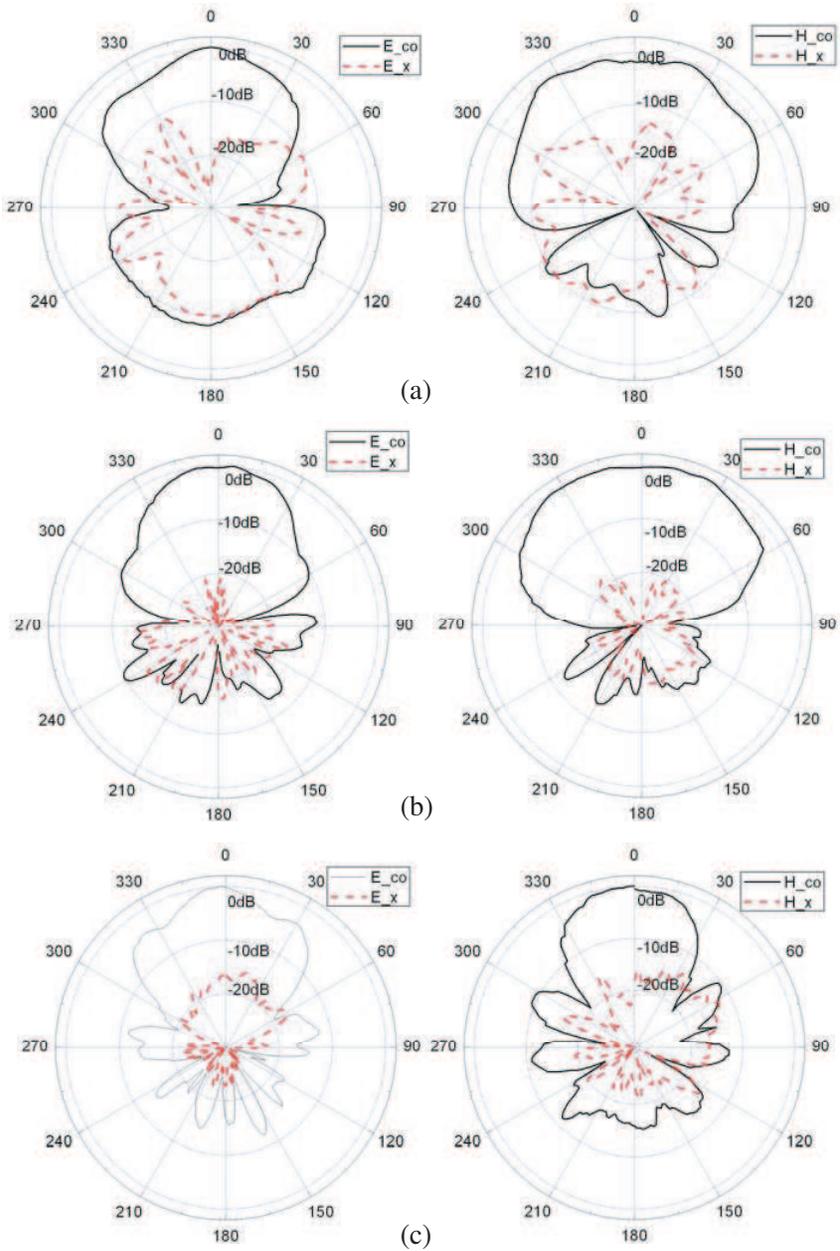


Figure 4. Measured radiation patterns of the proposed antenna at (a) 2.0 GHz, (b) 7.0 GHz, and (c) 10.9 GHz.

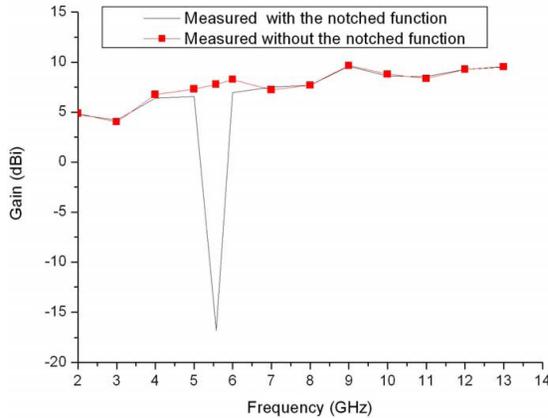


Figure 5. Measured gains of the proposed antenna with and without the notched function.

The measured gain values of the proposed antenna with and without a band-notched function, which has the same size and ground with corrugated edges, have been obtained between 2.0 and 10.9 GHz as shown in Figure 5, respectively. It can be seen that, except the notched band, the measured gains of the proposed small tapered slot antenna increase from 4.0 to 9.5 dBi between 2.0 and 13 GHz. The proposed antenna's gains are decreased in the 5.8-GHz band sharply, where the biggest variation is about 25 dB.

In UWB communications applications, the system transfer function of a transmitting-receiving UWB antenna link is desired. The system transfer function of the proposed antenna pair is exhibited in Figure 6, which is composed of two identical compact tapered slot antenna prototypes and positioned side to side with a separation of 1 meter. It can be seen that the proposed antenna pair features magnitude of from -35.6 to -25.8 dB over the UWB band of 3.1–10.6 GHz except the notched band, where a sharp drop about 39 dB is obtained. The measured group delay is also shown in Figure 6. Except a 11.3-ns variation in the notched band, it is stable in the UWB band with the value of 3.4 ns.

Figure 7 shows the effect of the stub with length L_s on the band-notched characteristics. It is obvious that the center frequency of the notched band can be controlled by changing the length of L_s .

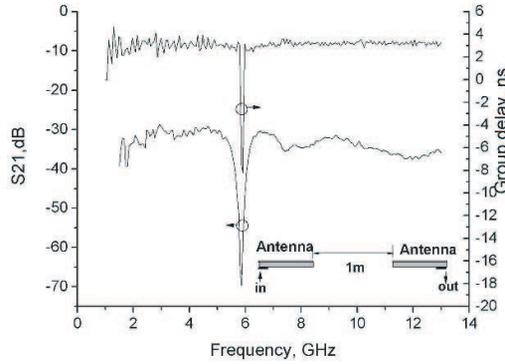


Figure 6. Measured antenna system transfer function of the proposed antenna pair.

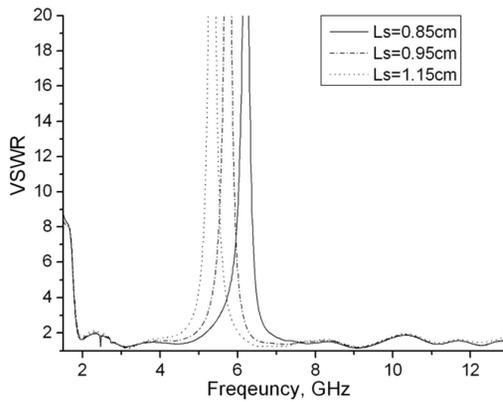


Figure 7. Simulated VSWR of the proposed antenna by changing of L_s .

4. CONCLUSION

A small tapered slot antenna with a notched band has been proposed for wireless applications, such as UMTS, 2.4/5-GHz WLAN, and UWB systems. By use of a modified microstrip-to-slotline transition, a notched band centered at 5.8 GHz is achieved. The small size, flat measured gain and group delay with a sharp drop demonstrate that the proposed small tapered slot antenna is a good candidate for UWB applications.

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