A Small Wideband Microstrip-fed Monopole Antenna

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***Abstract*—A small microstip-fed monopole antenna, which consists of a rectangular patch and a truncated ground plane, is presented for ultra wideband application. The proposed antenna is designed to operate over 3.1 to 11 GHz for $S_{11} < -10$ dB. Good return loss and radiation pattern characteristics are obtained in the frequency band of interest.**

***Index Terms*—Monopole antennas, truncated ground plane, ultra wideband (UWB).**

I. INTRODUCTION

NOWADAYS, wireless communication systems are becoming increasingly popular. However, the technologies for wireless communication still need to be improved further to satisfy the higher resolution and data rate requirements. That is why ultra wideband (UWB) communication systems covering from 3.1 GHz to 10.6 GHz released by the FCC in 2002 [1] are currently under development. For many years, various antennas for wideband operation have been studied for communications and radar systems [2], [3]. The design of wideband antenna is very difficult task especially for hand-held terminal since the compromise between size, cost, and simplicity has to be achieved. In UWB communication systems, one of key issues is the design of a compact antenna while providing wideband characteristic over the whole operating band. Due to their appealing features of wide bandwidth, simple structure, omnidirectional radiation pattern, and ease of construction several wideband monopole configurations, such as circular, square, elliptical, pentagonal, and hexagonal have been proposed for UWB applications [4]–[6]. However, they are not suitable for integration with printed circuit boards since they do not have planar structures. Thus, a microstrip-fed monopole antenna is suitable candidate for integration with hand-held terminal owing to its attractive features such as low profile, low cost, and light weight.

In this letter, we present a novel compact ultra wideband microstip-fed printed monopole antenna. To achieve the maximum impedance bandwidth, a pair of notches is placed at the two lower corners of the patch and the notch structure is embedded in the truncated ground plane. Simulated and experimental results are presented to demonstrate the performance of a suggested antenna.

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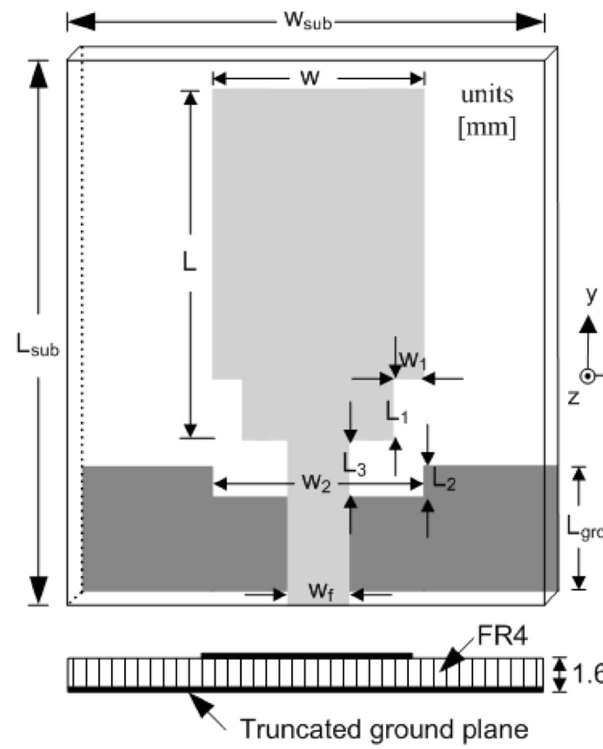

Fig. 1. Configuration of the proposed microstrip-fed monopole antenna.

II. ANTENNA DESIGN

Fig. 1 shows the configuration of the proposed wideband antenna which consists of a rectangular patch with two notches at the two lower corners of the rectangular patch and a truncated ground plane with the notch structure.

The proposed antenna, which has compact dimension of 16 mm × 18 mm $(W_{\rm sub} \times L_{\rm sub})$, is constructed on FR4 substrate with thickness of 1.6 mm and relative dielectric constant of 4.4. The width W_f of the microstrip feedline is fixed at 2 mm. On the front surface of the substrate, a rectangular patch with size of $W \times L$ is printed. The rectangular patch has a distance of L_3 to the ground plane printed on the back surface of the substrate. By cutting the two notches of suitable dimensions $(W_1 \times L_1)$ at the monopole's two lower corners, it is found that much enhanced impedance bandwidth can be achieved for the proposed antenna. This phenomenon occurs because the two notches affect the electromagnetic coupling between the rectangular patch and the ground plane [7]. In addition, to achieve good wideband matching of the proposed antenna, the separation L_3 between the rectangular patch and the notch in the ground plane is used. The modified truncated ground plane acts as an impedance matching element to control the impedance bandwidth of a square monopole [8]. The dimension of the notch $(W_2 \times L_2)$ embedded in the truncated ground

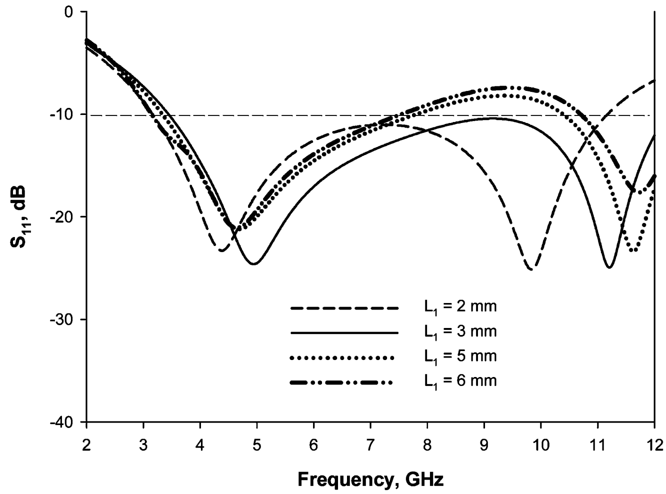

Fig. 2. Simulated return loss for various L_1 at the two lower corners of the proposed monopole antenna. (W_1 is fixed at 1 mm).

plane and feed gap distance L_3 are important parameters in determining the sensitivity of impedance matching.

The optimal dimensions of the designed antenna are as follows: $W_{\text{sub}} = 16$ mm, $L_{\text{sub}} = 18$ mm, $W = 7$ mm, $L = 11$ mm, $W_1 = 1$ mm, $L_1 = 2$ mm, $W_2 = 7$ mm, $L_2 = 1$ mm, $L_3 = 3$ mm, $W_f = 2$ mm, and $L_{\text{grd}} = 4$ mm. It is found that the designed antenna satisfies all the requirements in UWB frequency band ranging 3.1 GHz to 11 GHz. The size of the designed antenna is much smaller than the UWB antennas reported recently.

III. Results and Discussions

The microstip-fed monopole antennas with various parameters (L_1, L_2, and W_2) were constructed and studied to demonstrate the proposed bandwidth-enhancement technique. The simulated results are obtained using the Ansoft simulation software high-frequency structure simulator (HFSS) [9]. Fig. 2 shows the simulated return loss curves for various notch sizes ($W_1 \times L_1$). As the notch sizes ($W_1 \times L_1$) are changed from 1×6 to 1 mm $\times 2$ mm, the impedance bandwidth becomes greater than 4 GHz, with decrease of the upper frequency f_U. It is also observed that the upper frequency f_U is significantly affected by the variation in notch length L_1. On the other hand, the lower frequency f_L is insensitive to the change of L_1.

The simulated return loss curves with different values of L_2 are plotted in Fig. 3 when W_2 is fixed at 6 mm. From the simulation results in Fig. 3, it is found that the 10 dB impedance bandwidth decreases as the notch length L_2 increases. The optimized notch length L_2 on the truncated ground plane is 1 mm. The simulated return loss curves with the optimal notch length L_2 for various notch widths W_2 on the truncated ground plane are plotted in Fig. 4. As the notch width W_2 increases, the lower frequency f_L is slightly lowered and the upper frequency f_U is markedly increased. It is observed that the notch width W_2 is the most critical parameter to determine the upper frequency f_U. The notch width W_2 is chosen as 7 mm to yield near optimal bandwidth.

Fig. 5 shows measured and simulated return loss characteristics of the proposed antenna. Measured impedance bandwidth is wider than simulated one in Fig. 5. The fabricated antenna

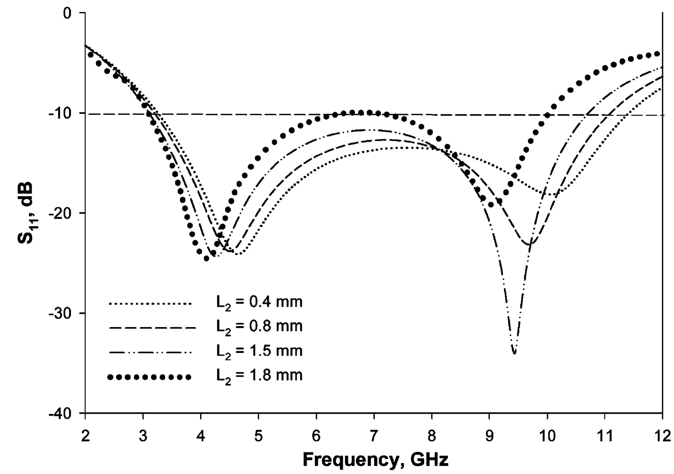

Fig. 3. Simulated return loss for various L_2 on the truncated ground plane.

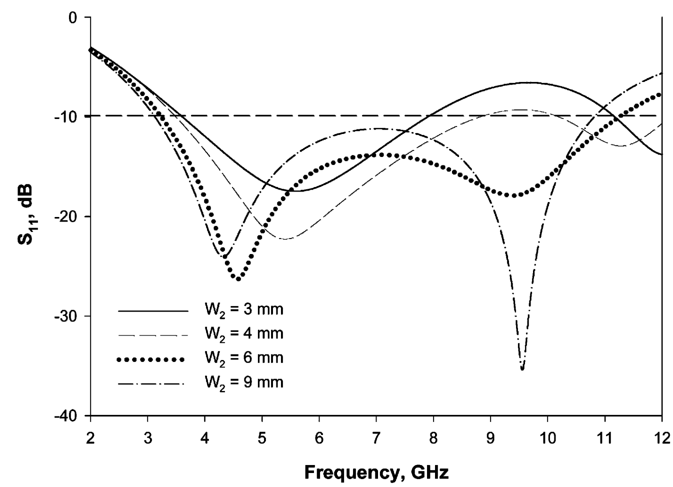

Fig. 4. Simulated return loss for various W_2 on the truncated ground plane.

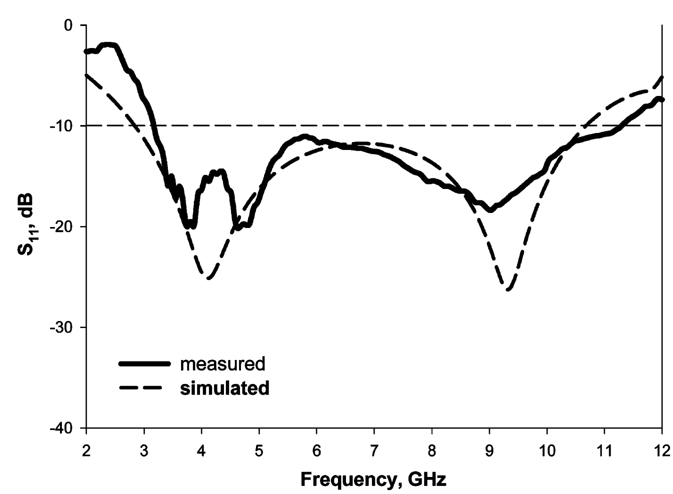

Fig. 5. Measured and simulated return loss characteristics for an optimized microstrip-fed monopole antenna.($W_{\text{sub}} = 16$ mm, $L_{\text{sub}} = 18$ mm, $W = 7$ mm, $L = 11$ mm, $W_1 = 1$ mm, $L_1 = 2$ mm, $W_2 = 7$ mm, $L_2 = 1$ mm, $L_3 = 3$ mm, $W_f = 2$ mm, and $L_{\text{grd}} = 4$ mm).

satisfies the 10-dB return loss requirement from 3.1 to 11 GHz. Measured radiation patterns at 3, 6, and 9 GHz are shown in Fig. 6. Monopole-like radiation patterns in y–z planes

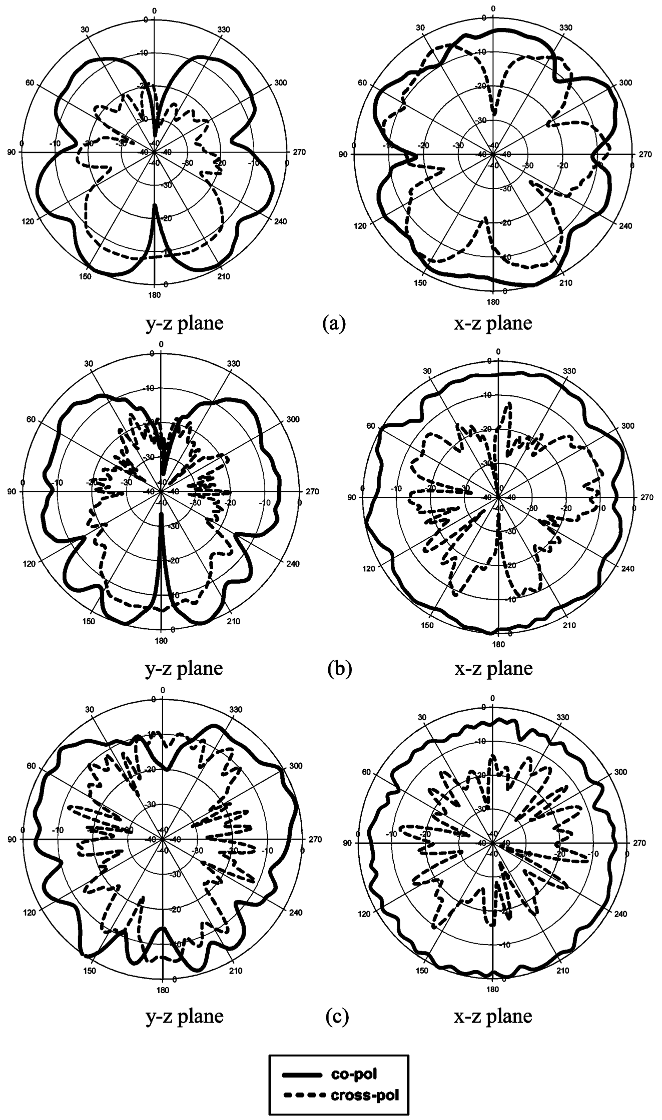

Fig. 6. Measured radiation patterns of the proposed antenna. (a) 3 GHz. (b) 6 GHz. (c) 9 GHz.

are observed. The radiation patterns in x–z planes are approximately omnidirectional, especially for the upper operating frequencies. Fig. 7 shows measured antenna gain from 3 to 10 GHz for the proposed antenna. The maximum gain variation is less than 2.8 dB with the peak antenna gain at about 5.26 dBi.

IV. Conclusion

A novel compact microstrip-fed monopole antenna has been proposed and implemented for ultra wideband application. The proposed antenna has a simple configuration and is easy to fabricate. To obtain the wide bandwidth, the sizes of notches at the two lower corners of the patch and notch on the truncated ground plane have been optimized by parametric analysis. The designed antenna satisfies the 10 dB return loss requirement from 3.1 to 11 GHz and provides good monopole-like radiation patterns. Experimental results show that the proposed antenna could be a good candidate for hand-held UWB application.

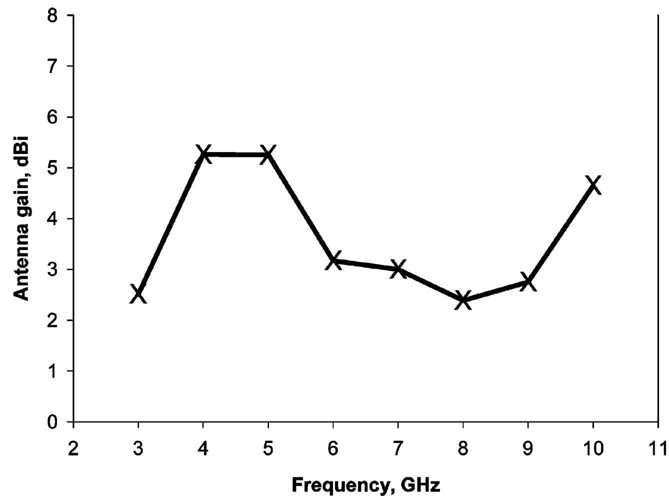

Fig. 7. Measured antenna gain of the proposed antenna.

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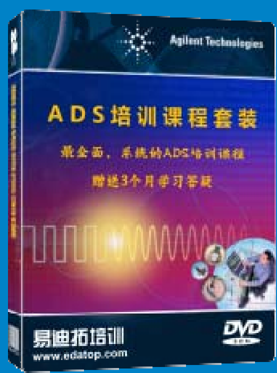

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