A Small Wideband Microstrip-fed Monopole Antenna

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1. Introduction

Nowdays, 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 higher 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. Modern and future wireless communication systems are placing greater demands on antenna design. For many years, various antennas for wideband operation have been studied for communications and radar systems [2]. The wideband antenna design 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, omni-directional pattern and ease of construction, several wideband monopole configurations, such as circular, square, elliptical, pentagonal and hexagonal, have been proposed for UWB applications [3-4]. 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 for integration with hand-held terminal owing to its attractive features such as low profile, low cost, and light weight.

In this paper, we present a novel compact ultra wideband microstip-fed printed monopole antenna. To achieve the maximum impedance bandwidth using a conventional simple square monopole, 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. Both simulated and experimental results are presented to demonstrate the performance of a suggested antenna.

2. 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 dimensions of 16×18 mm^2 ($W_{sub} \times L_{sub}$), is constructed on FR4 substrate with thickness of 1.6 mm and relative dielectric constant of 4.4. The width of the microstrip feedline is fixed at $W_f = 2$ mm to achieve 50 Ω impedance. On the front surface of the substrate, a rectangular patch of size 7×11 mm^2 ($W \times L$) is printed. The rectangular patch has a distance of L_3 to the ground plane printed on the back surface of the substrate. This distance is required for achieving good wideband matching of the proposed antenna [5]. The rectangular patch can control the occurrence of the lower or fundamental resonant mode for operating in the frequency band of interest [5]. 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. In addition, the modified truncated ground plane acts as an impedance matching element to control the impedance bandwidth of a square monopole. The dimension of the notch ($W_2 \times L_2$) embedded in the truncated ground plane and feed gap distance L_3 are important parameters in determining the sensitivity of

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impedance matching.

The dimensions of the designed antenna are as follows: W_{sub} = 16 mm, L_{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_{grd} = 4 mm. It is found that this antenna satisfies all the requirements in UWB frequency band ranging 3.1 GHz to 12 GHz. The size of the designed antenna is much smaller than the UWB antennas reported recently.

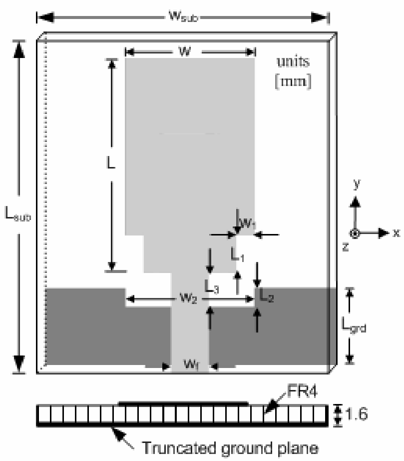


Fig. 1 Configuration of the proposed microstrip-fed monopole antenna

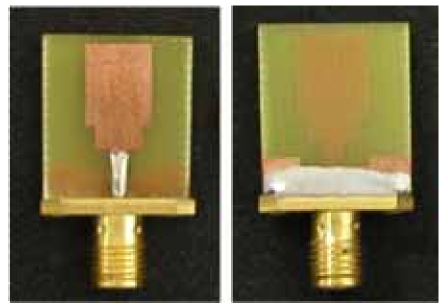


Fig. 2 Photograph of the fabricated antenna

3. Results and discussions

Fig. 2 shows the phothgraph of the fabricated antenna. The microstip-fed monopole antenna with various parameters to demonstrate the proposed bandwidth-enhancement technique was constructed and studied. The simulated results obtained using the Ansoft simulation software High-Frequency Structure Simulator (HFSS) are also shown for comparison. Fig. 3 shows the simulated return loss for various notch sizes at the two lower corners of the proposed monopole antenna. As the notch sizes ($W_1 \times L_1$) are varied from 1×1 to 1×7 mm^2, the impedance bandwidths become greater than 5 GHz, with a frequency ratio bandwidth (f_U / f_L) of about 2.5. It is also interesting to see that the variation in notch length L_1 causes significant effects on the upper frequency f_U. 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 when W_2 is fixed at 6 mm are plotted in Fig. 4. The -10 dB bandwidth changes very significantly as the values of L_2 vary. It is observed that the operating bandwidth of the proposed monopole antenna is critically dependent on the notch length L_2 of the truncated ground plane, and this parameter should be optimized for maximum bandwidth. The optimized notch length on the truncated ground plane is found to be at L_2 = 1 mm. The simulated return loss curves with the optimal notch length L_2 of 1 mm for various notch widths W_2 on the truncated ground plane are plotted in Fig. 5. By increasing the notch width W_2, the lower frequency f_L is slightly changed and the upper frequency f_U is markedly changed. The notch width W_2 is chosen as 7 mm to yield near optimal bandwidth. It is found that the operational bandwidth is very sensitive to the values of all these parameters (L_1, L_2 and W_2).

The return loss characteristics of proposed antenna were measured using an Agilent's Vector Network Analyzer (8719ES). Fig. 6 shows that the fabricated antenna satisfies the -10 dB return loss bandwidth from 3.1 GHz to 12 GHz. Simulated radiation patterns at four different frequencies are shown in Fig. 7. Over the entire operating frequency band, monopole-like omni-directional patterns in both x-z and y-z planes are observed.

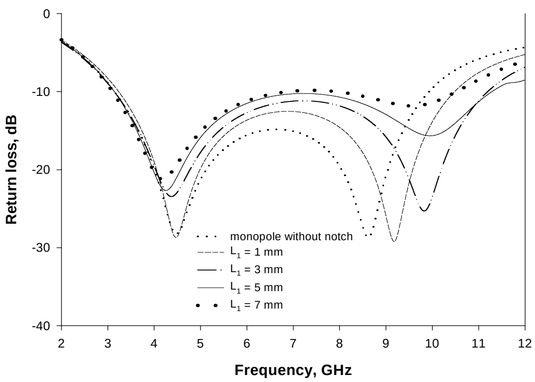


Fig. 3 Simulated return loss for different values of L_1 at the two lower corners of the proposed monopole antenna

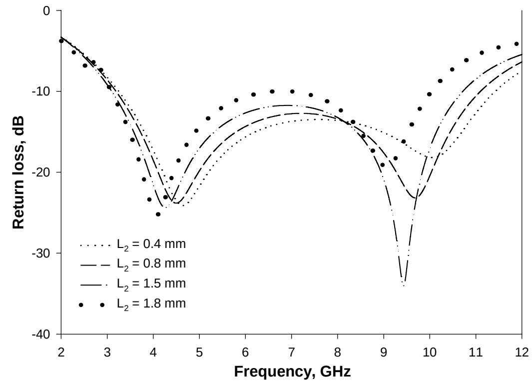


Fig. 4 Simulated return loss for different values of L_2 on the truncated ground plane

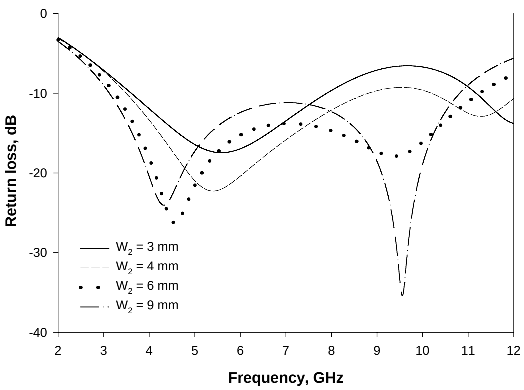


Fig. 5 Simulated return loss for different values of W_2 on the truncated ground plane

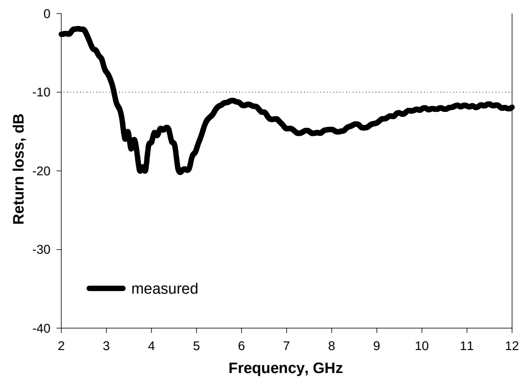
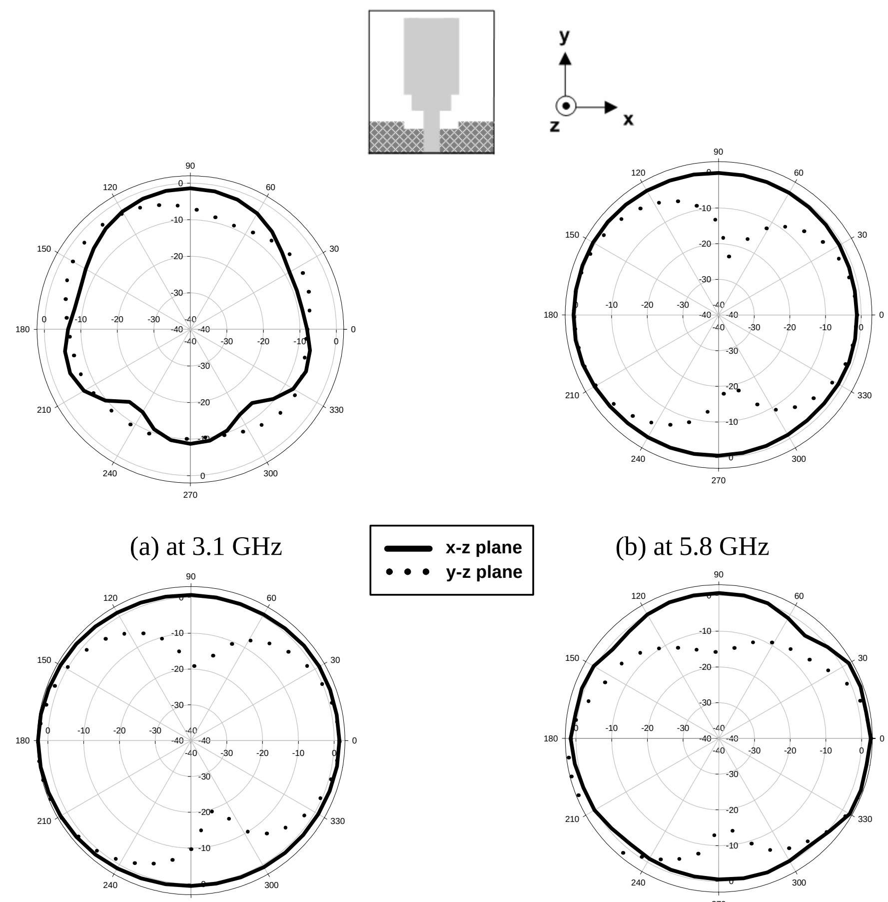


Fig. 6 measured results for the return loss of the optimized microstrip-fed monopole antenna

4. Conclusion

A novel compact microstrip-fed monopole antenna has been proposed and implemented for ultra wideband applications. 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 bandwidth from 3.1 GHz to 12 GHz and provides good monopole-like radiation patterns. Numerical and experimental results show that the proposed antenna could be a good candidate for hand-held UWB applications.



(a) at 3.1 GHz (b) at 5.8 GHz

(c) at 8.1 GHz (d) at 10.2 GHz

Fig. 7 Simulated radiation patterns of the proposed antenna

Acknowledgements

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