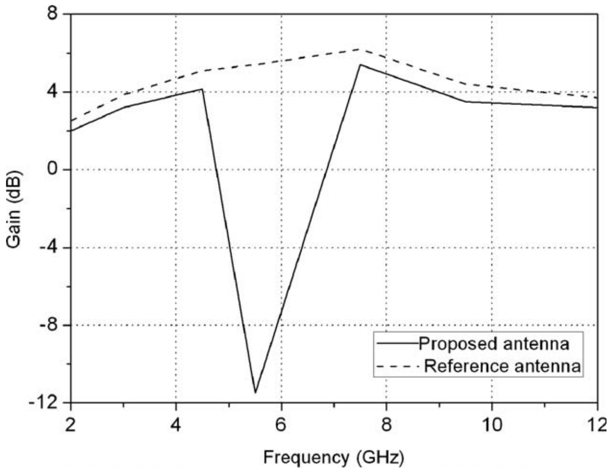

Figure 5 Measured gain of the proposed antenna and the referenced antenna

3. RESULTS AND DISCUSSION

The parameters (S_1, S_2, G, D, and L_s), based on parametric analysis of the proposed antenna, are optimized to achieve excellent band-notch characteristics. The band-notch characteristics with different parameter values are shown in Table 1. It is observed in Table 1 that the band-notch bandwidth is mainly decided by D and S_2, and the band-notch center frequency is primarily determined by S_1 and L_s. The band-notch width increases as the width of D and S_2 increase, while the center frequency of notched band lowers as the width of S_1 and the length of L_s increases. However, the value of G has no effective influence on band-notch characteristics. Therefore, the optimized values of the parameters are shown as follows: $D = 0.9$ mm, $G = 0.6$ mm, $S_1 = 0.15$ mm, $S_2 = 0.1$ mm, and $L_s = 8.6$ mm. Compared to band-notch UWB printed antennas in other literatures, the advantage of the proposed antenna is that it exhibits more design freedom.

The proposed band-notch UWB printed antenna with CSRR is fabricated, and the photograph is shown in Figure 2. Figure 3 depicts the simulated and measured VSWR curves. As is shown in Figure 3, the proposed antenna has good impedance characteristics and shows a sharp rejection between 4.89 GHz and 6.12 GHz. There are a little discrepancy between simulation and measurement because the simulation environment is different from the measured at a tolerant range. The radiation patterns have been measured at three sampling frequencies of 4.5 GHz, 6.5 GHz, and 8.5 GHz, respectively.

As can be seen in Figure 4, the presented antenna has excellent omnidirectional patterns in the *y–z* plane and dipole-like patterns in the *x–z* plane. Figure 5 shows the measured peak gains of the proposed antenna and the reference antenna without CSRR in feed line. The results clearly indicate a sharp antenna gain decreases in the band-notch band.

4. CONCLUSIONS

In this article, a novel band-notch UWB printed antenna is proposed, and the band-notch characteristic at 4.89–6.12 GHz can be achieved by embedding one CSRR circuit. Meanwhile, one method of designing the band-notch UWB printed antenna is presented, which can simplify the design procedure. The ultra-wideband band-notch printed antenna considered here exhibits excellent impedance matching and radiation characteristics. Therefore, it should have promising future in short-range wireless communication systems.

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A COMPACT PENTAGONAL MONOPOLE ANTENNA FOR PORTABLE UWB SYSTEMS

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ABSTRACT: *Design of a compact microstrip-fed ultra-wideband antenna suitable for USB dongle and other such space constraint applications is presented. The structure consists of a pentagonal monopole element and a modified ground plane that gives an impedance bandwidth from 2.8 to 12 GHz. Radiation patterns are stable and omni-directional throughout the band with an average gain of 2.84 dBi. The antenna occupies only 11 × 30 mm^2 on FR4 substrate with permittivity 4.4*. © 2010 Wiley Periodicals, Inc. Microwave Opt Technol Lett 52:2390–2393, 2010; Published online in Wiley InterScience (www.interscience.wiley.com). DOI 10.1002/mop.25449

Key words: *UWB; microstrip; monopole*

1. INTRODUCTION

A major challenge in the transmission of narrow pulses is in the design of the antenna, since a comparable propagation delay and retardation time of the pulse in the antenna with its rise time or duration can result in significant undulations. The antenna should be Ultra-Wideband which is usually realized by perturbing multiple resonances in the radiating structure. Multiple resonances can be detrimental to baseband pulses, but the effects are minimized in small element antennas, where surface currents are always in phase unison [1]. Pattern degradation at higher frequencies is minimized in these antennas enabling superior pulse handling capabilities. However, as the size of the antenna shrinks, creating multiple resonances to match and achieve UWB becomes difficult. A few significant research works in this direction can be found in Refs. 2–4.

In this letter, we propose the design of a compact pentagonal monopole antenna for use in space constrained applications such as a wireless dongle [5]. UWB antennas designed by employing pentagonal monopoles have been reported in Refs. 6 and 7. In the present work, multiple matching techniques are incorporated in a pentagonal monopole to realize an ultra compact UWB antenna.

2. ANTENNA GEOMETRY

Figure 1 depicts the configuration of the proposed antenna fabricated on FR4 substrate ($\varepsilon_r = 4.4$, $h = 1.6$ mm). A 50 Ω microstrip line excites the pentagon shaped monopole element as shown. The ground plane of the antenna has a rectangular cut beneath the feed and has flared sides. These along with the pentagonal monopole element perturb multiple resonances in the antenna. Compactness while ultra wide impedance bandwidth is ensured when the cut parameters l_s and w_s, flare parameters θ_m and θ_g, and the microstrip width w_2 are properly optimized. On FR4, with optimal geometric parameters, size of the antenna is restricted to 11 × 30 mm^2. These are as follows. Parameters for the monopole are: $L = 30$ mm, $l_m = 9$ mm, $l = 2.9$ mm, $\theta_m = 106°$. Parameters for the ground are: $W = 11$ mm, $\theta_g = 130°$, $l_s = 4$ mm, $w_s = 7$ mm. Parameters for the microstrip line are: $w_1 = 3$ mm, $w_2 = 1.2$ mm, $g = 3.8$ mm.

3. RESULTS AND DISCUSSION

A prototype of the proposed antenna with optimal geometric parameters was fabricated and tested using R&S ZVB20 VNA. Measured and simulated return losses of the antenna are in good agreement as shown in Figure 2. The measured −10 dB impedance bandwidth is from 2.8 to 12.0 GHz. The effect of the cut

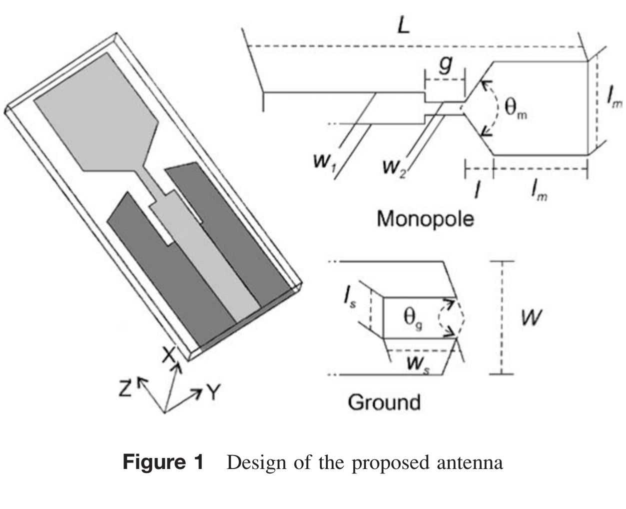

Figure 1 Design of the proposed antenna

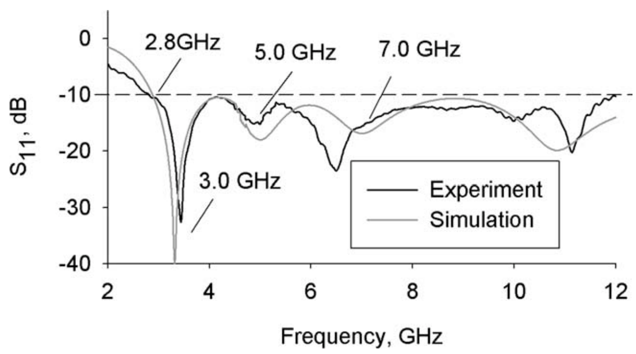

Figure 2 Measured and simulated S_{11}

in the ground plane is on the lower band edge and on the overall impedance bandwidth. The first resonance of the antenna can be approximately quantified to a quarter wave variation OA as shown in Figure 3, which shows the vector distribution of currents in the antenna, i.e.,

$$f_1 = \frac{75}{\sqrt{(\in_{\text{eff}} \times OA)}}.$$

Occurrence of the higher resonances can be attributed to the lower edges of the monopole element and the modified ground plane as seen in Figure 3.

Radiation patterns of the antenna at the three resonances in all the three planes are shown in Figure 4. The patterns remain omni-directional in the H-plane (*x–z* plane) and bi-directional in the other two planes (*x–y*, *y–z*). Antenna polarization is in the *y*-direction throughout the band as is evident from the current distribution in Figure 3. Measured gain of the antenna is shown in Figure 5, and the average gain is found to be 2.84 dBi. The antenna transfer function computed as in Ref. 8 remains flat with variation within 10 dB in the entire operational band as shown in Figure 5, which is highly desirable for deployment in discrete spread UWB systems. Fidelity of a transmitted fourth order Gaussian pulse in the broad side direction is found to be

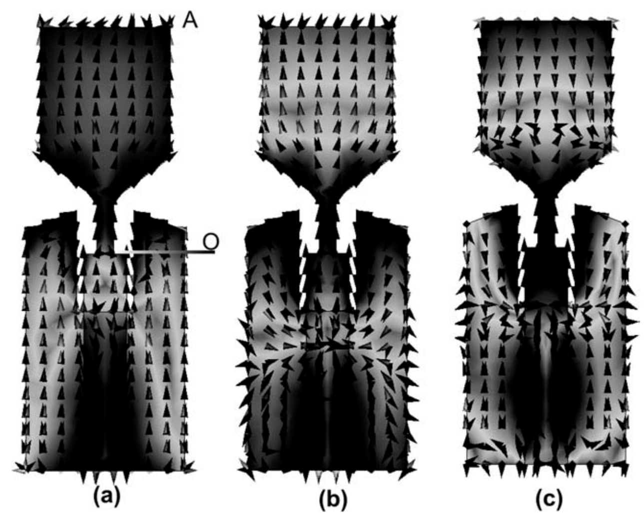

Figure 3 Electric field (intensity) and surface current (vector) distributions (dark shade indicates high field intensity) at the three resonances: (a) 3.0 GHz, (b) 5.0 GHz, and (c) 7.0 GHz

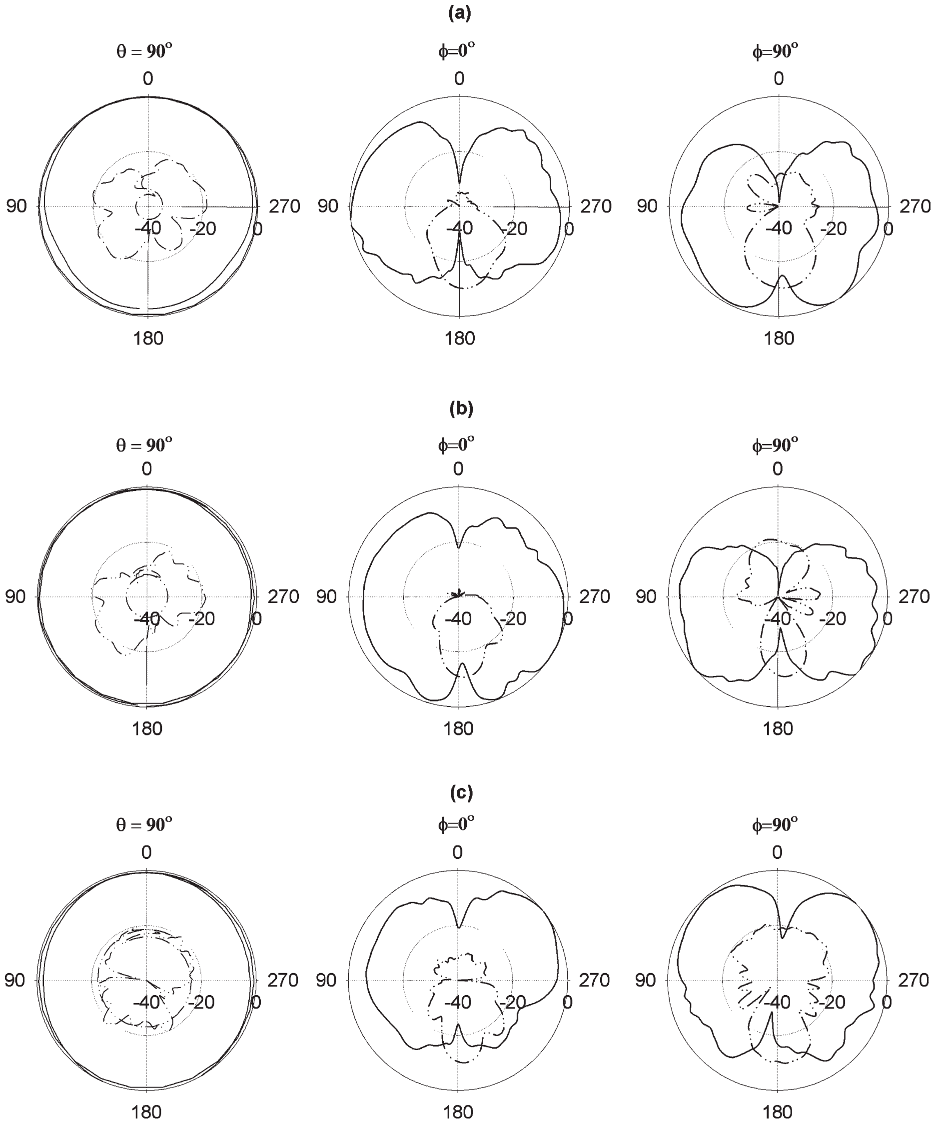

Figure 4 Radiation patterns at three resonances

89% when $\theta = 0^\circ$, $\varphi = 0^\circ$ and 88% when $\theta = 90^\circ$ /2700, $\varphi = 0^\circ$. Unlike in many antennas, fidelity is almost a constant indicating towards superior pulse handling capabilities of this antenna.

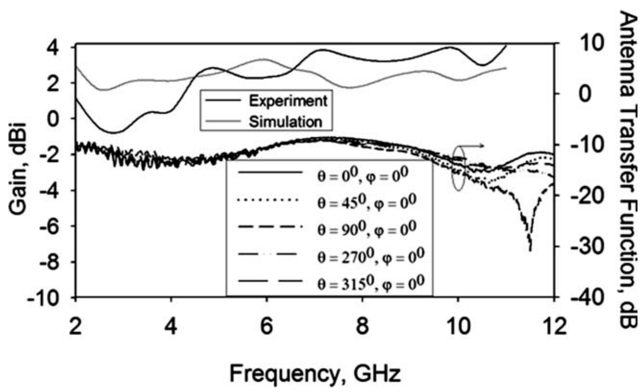

Figure 5 Measured gain of the antenna

4. CONCLUSIONS

A planar ultra compact antenna occupying an area of 11 × 30 mm^2 is proposed for UWB systems. The impedance bandwidth encompasses the FCC specification for UWB applications and more from 2.8 to 12.0 GHz. Small element size of the antenna results in stable radiation patterns at all frequencies with reasonable gain and excellent pulse handling capabilities. These achievements make the proposed design a good candidate for space constraint UWB applications such as USB dongle and PDA systems.

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