Compact Surface-mount UWB Monopole Antenna for Mobile Applications

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Abstract—In this paper, a novel surface-mount ultra-wideband (UWB) monopole antenna with a compact size of only $12.5 \times 9 \times 1.5\,\mathrm{mm}^3$ is obtained by folding a metal-plate onto a low-profile rectangular-box foam base. By carefully adding a matching slit on the upper side of metal-plate, the antenna can achieve good impedance matching over a very wide bandwidth of about 7.97 GHz (3.03–11.0 GHz, defined by 2:1 VSWR). Experimental results of a constructed prototype of the proposed antenna are presented.

1. Introduction

In the recent years, short range and high data rate wireless communication is applied in multimedia device. UWB radio technology can meet these requests. Planar antennas have many advantages, such as low profile, small size and easy to fabricate, which are suitable for portable devices. There are several UWB planar antenna designs, including planar metal-plate antenna [1], half-disk antenna [2], and planar horn antenna [3], which have been reported.

In this paper, a novel surface-mount UWB monopole antenna, which is suitable for metal stamping processing and low fabricating cost, is presented. The proposed antenna has a compact structure, which makes it easy to fit in any possible margin within the housing of a mobile/hand-held wireless device, thus leading to an internal UWB antenna.

2. Antenna Design

Figure 1 shows the proposed UWB monopole antenna mounted at the front surface of a 0.8 mm thick FR4 substrate ($\varepsilon_r = 4.4$). The ground plane (length 40 mm and width 60 mm) printed on the back surface of the FR4 substrate can be considered as the system circuit board of a wireless access point. The proposed UWB antenna is easily constructed by folding a metal plate onto a rectangular form base of compact size $12.5 \times 9 \times 1.5\,\mathrm{mm}^3$.

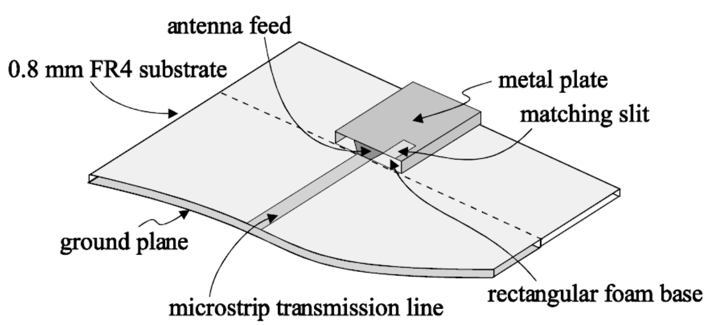

Figure 1: Proposed surface-mounted monopole antenna mounted on the PCB board of a wireless access point.

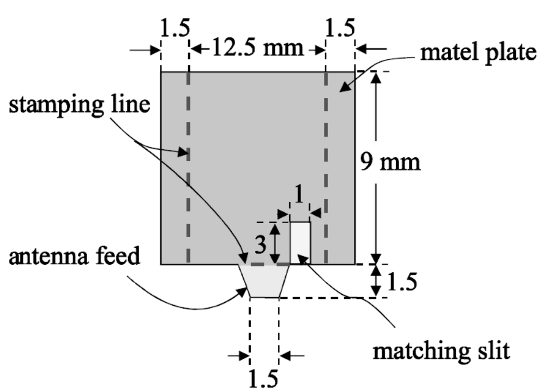

Figure 2: Planar structure of the unfolded metal plate (dashed lines on the metal plate are the stamping line).

Figure 2 shows the detailed dimension of the metal plate. The size of the metal plate is $15.5 \times 9\,\mathrm{mm}^2$ with a matching slit of $1 \times 3\,\mathrm{mm}$ near the antenna feed. The lowest resonant frequency and the highest resonant frequency of proposed antenna were mainly controlled by length and width of the metal-plate. Broadband matching technique is the key point in UWB antenna design, by carefully adding a matching slit on the upper side of metal-plate, the antenna can achieve a good impedance matching over a very wide bandwidth. With the matching slit, the current distribution on the surface of the radiation conductor can be altered. By carefully tuning the width and length of the matching slit, a very wide band impedance matching (defined by 2:1 VSWR) from 3.03 GHz to 11.0 GHz is obtained. This result is mainly due to the asymmetrically antenna structure which will lead to asymmetrically current path and it is helpful to achieve broadband impedance matching. Thus, the mechainism of the matching slit is similar to asymmetrically feed mentioned in [4].

The radiation energy of the proposed antenna is activated by the antenna feed via the microstrip transmission line. To accomplish the impedance matching between the metal plate and the microstrip transmission line, there are trapezoid-shaped metallic strip formed between the metal plate and the microstrip transmission line.

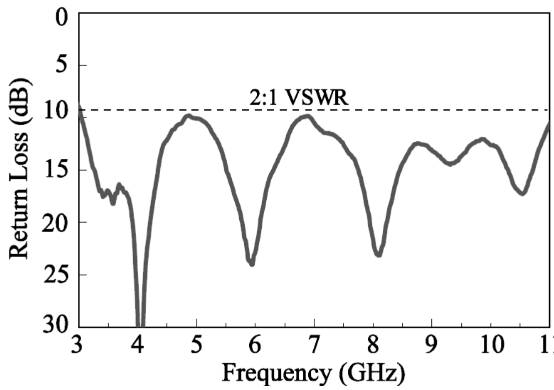

Figure 3: Measured return loss of the proposed antenna.

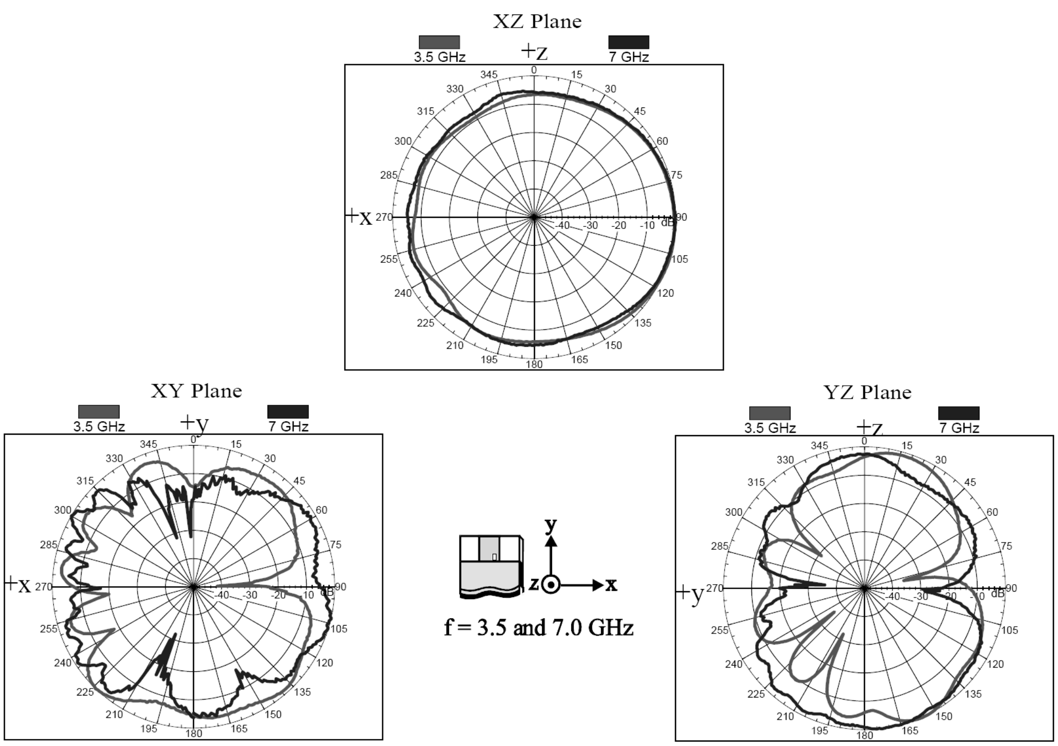

Figure 4: Measured radiation patterns at 3.5 and 7.0 GHz.

3. Experimental Results

Figure 2 shows the measured return loss for the proposed antenna. From the results, it clearly indicates that the impedance bandwidth, defined by 2:1 VSWR, is as large as 7.97 GHz. Thus, the proposed antenna can cover the full band of DS-UWB [5].

The far-field radiation characteristic across UWB bandwidth of the proposed antenna is also studied. The far-field radiation pattern (only co-polarization is showed) of the proposed antenna at 3.5 GHz (light color line) and 7.0 GHz (deep color line) are shown as Figure 4. It is first observed that, in vertical cut of azimuthal plane (or x–z plane), the radiation pattern of antenna shows an omni-directional radiation characteristic, but apparently shift to the $-x$ direction. It is mainly due to the ground plane effect. In the radiation pattern of horizontal cut of y–z plane, especially at 7.0 GHz, it is also seen that there are two null in $\pm y$ direction. According to what has been mentioned above, in brief, it is a monopole-like radiation pattern. The measured antenna gain against frequency is presented in Figure 5. Across the impedance bandwidth in 3.0 to 10.0 GHz, the measured antenna gain increases from about 1.7 to 3.3 dBi with increasing frequencies. Measured peak antenna in the lower band and the higher band of DS-UWB is about 2.4 dBi and 3.2 dBi, respectively.

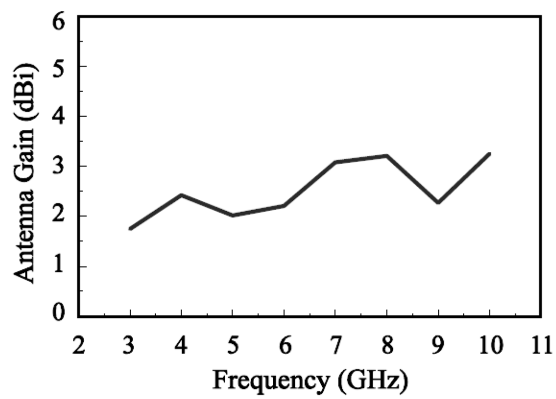

Figure 5: Measure peak antenna gain against frequency of the proposed antenna.

4. Conclusions

A compact surface-mount UWB chip antenna, which mainly constructed by stamping the metal plate has been fabricated and studied. Results indicate that the constructed prototype showed a very wide-impedance bandwidths covering the lower and higher bands of DS-UWB. Good antenna gain in the operation bands is also obtained. In addition, the antenna has a compact structure, which makes it easy to fit in any possible margin within the housing of a mobile/hand-held wireless device, thus leading to an internal UWB antenna. The small size UWB antenna is also suitable for surface-mountable fabrication process. Thus it can effectively reduce the overall manufacturing cost.

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