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WIDEBAND OMNIDIRECTIONAL OPERATION MONOPOLE ANTENNA

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Abstract—This paper presents a square cylindrical monopole antenna easily fabricated using a cross-shaped metal plate for wideband omnidirectional operation. A prototype of the proposed antenna with a cross-sectional area of $8 \times 8\,\mathrm{mm}^2$ is implemented, and the antenna provides a wide operating bandwidth of about 7.5 GHz (1.8–9.4 GHz here), making it very promising for WMAN operation with the 802.16e standard in the 2 to 6 GHz. In addition, over the operating bandwidth, the antenna shows very good omnidirectional radiation patterns.

1. INTRODUCTION

Wire monopole antennas have the attractive feature of generating a very good omnidirectional radiation. However, the simple wire-monopole antenna usually suffers a drawback of narrow bandwidth, which limits its practical applications [1, 2]. To overcome this problem, the hollow cylindrical monopole antenna with an input conical section has been reported [3], and making a wider bandwidth for omnidirectional radiation operation. However, the cylindrical monopole and the input conical section need to be fabricated separately and then connected together (usually by welding), which complicates the fabrication process. In addition, for a wide impedance bandwidth, the planar metal-plate monopole antennas have been shown to be promising designs [1, 2]. However, for higher operating frequencies, the planar monopole antenna usually suffers the drawback of showing poor omnidirectional radiation characteristics. This is largely owing to the path-length difference caused by large monopole width, and the antenna's radiated fields contributed from the excited surface currents near the two side edges of the planar monopole will be destructive in the direction parallel to the planar monopole [4]. To overcome this problem, the use of a tri-plate monopole [5] and a cross-plate monopole [6] have been recently reported, and improved omnidirectional radiation patterns have been obtained. However, due to the use of two or three metal-plate elements, this kind of crossed planar-monopole antenna needs to be welded together.

In this paper we demonstrate that, by bending a cross-shaped metal plate into a square cylindrical shape (see Fig. 1), with no additional welding process required, a wideband monopole antenna with a good omnidirectional radiation patterns can be obtained. Furthermore, the antenna shows a compact structure with a small cross-sectional area occupied (about $8 \times 8\,\text{mm}^2$ in this study). A design example of the proposed antenna suitable for application in the wireless metropolitan area network (WMAN) system with the IEEE 802.16e standard for mobile broadband wireless access in the 2–6 GHz band [7, 8] is demonstrated. Details of the antenna design are described, and experimental results of the constructed prototype are presented.

2. ANTENNA DESIGN

Figure 1(a) shows the geometry of the proposed wideband monopole antenna for omnidirectional operation. The antenna is mounted at the center of a square ground plane (size $120 \times 120\,\text{mm}^2$) with a feed gap of 2 mm, and is easily obtained from bending a cross-shaped metal plate (a 0.2-mm-thick copper plate in this study), shown in Fig. 1(b). The antenna is connected to the probe pin or central conductor (diameter 1.2 mm) of a $50\,\Omega$ SMA connector located below a via-hole in the center of the ground plane. It is noted that, the antenna shows a small cross-sectional area of $8 \times 8\,\text{mm}^2$ and a length of 28 mm in this study. The antenna occupies a small cross-sectional area and yet provides a large bandwidth of about 7.5 GHz (about 1855–9415 MHz). In addition, a feed gap of 2 mm between the antenna and the ground plane is required for achieving optimal impedance matching over a wide bandwidth.

The proposed antenna has a symmetric configuration, which is expected to provide good omnidirectional radiation. In addition, similar to the reported [3], the square cylindrical monopole proposed here is also capable of providing a wide bandwidth. For the input-

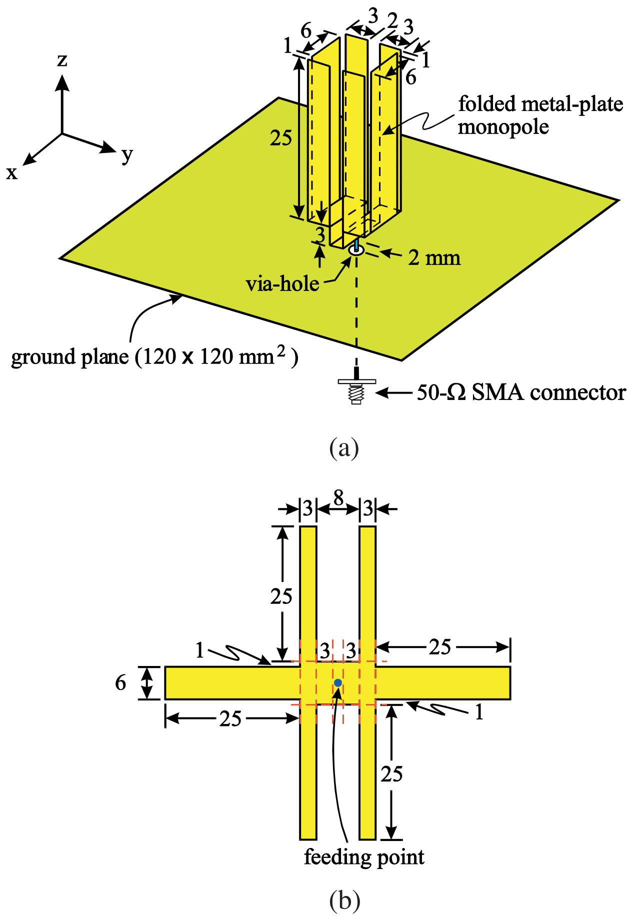

Figure 1. (a) Geometry of proposed wideband monopole antenna, (b) the antenna unbent into a planar cross-plate structure.

matching section, as seen in Fig. 1(b), it is formed from bending the central portion of the metal plate. The input-matching section has a function similar to that of the input conical section discussed in [3]. That is, with proper dimensions as given in Fig. 1, the input-matching section can lead to good impedance matching for the proposed antenna over a wide bandwidth. Also note that, by viewing the y-z plane in Fig. 1(a), the proposed antenna has a configuration similar to that of a planar square-monopole antenna with two notches cut in the antenna's two lower corners [9], in which the two cut notches lead to improved impedance matching. For this reason, the proposed antenna can be considered to have two three-dimensional notches formed in the antenna's input-matching section, which makes possible a wide bandwidth for the antenna.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed antenna with an 8-mm square-cylindrical diameter was constructed and studied. Fig. 2 shows the measured and simulated return loss for the constructed prototype. The simulation results are obtained using the Ansoft simulation software high-frequency structure simulator (HFSS) [10], and good agreement between the experiment data and simulation result is seen. A wide impedance bandwidth (10 dB return loss) is obtained. The impedance bandwidth is about 7.5 GHz (about 1855–9415 MHz), which makes the antenna easily cover the 2–6 GHz band for IEEE 802.16e operation. The radiation characteristics were also studied. Figs. 3, 4 and 5 plots the measured radiation patterns at 3, 6 and 9 GHz, respectively. Note that, in each figure, the radiation patterns in three principal planes are normalized with respect to the measured peak gain of the antenna. The obtained radiation patterns are all similar to that of a wire monopole antenna, and good omnidirectional radiation patterns in the azimuthal plane (x-y plane) are also observed, especially for the patterns at lower frequencies. Fig. 6 shows the measured antenna gain against frequency. The antenna gain in general increases with frequency and varies in a range of about 3–7 dBi across the bandwidth.

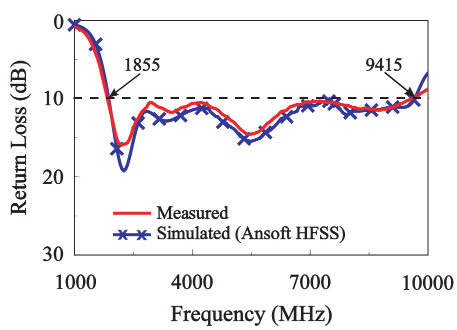

Figure 2. Measured and simulated return loss for proposed antenna.

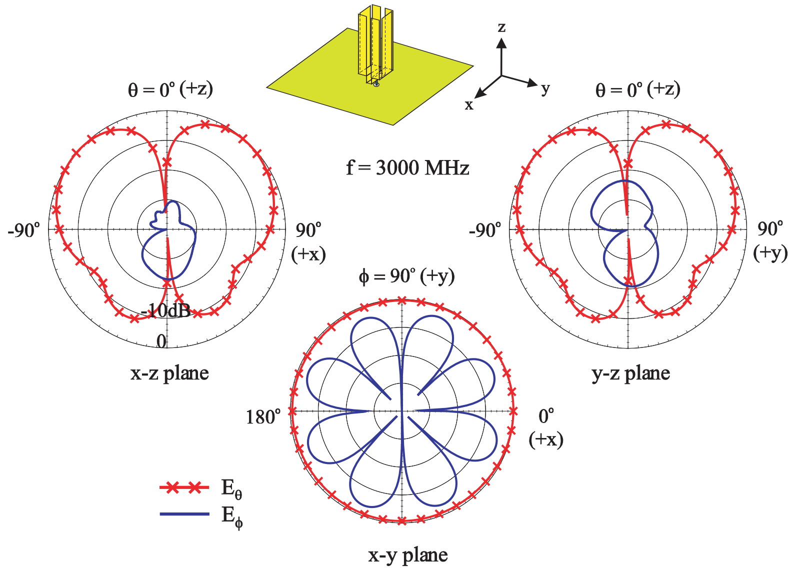

Figure 3. Measured radiation patterns at 3000 MHz.

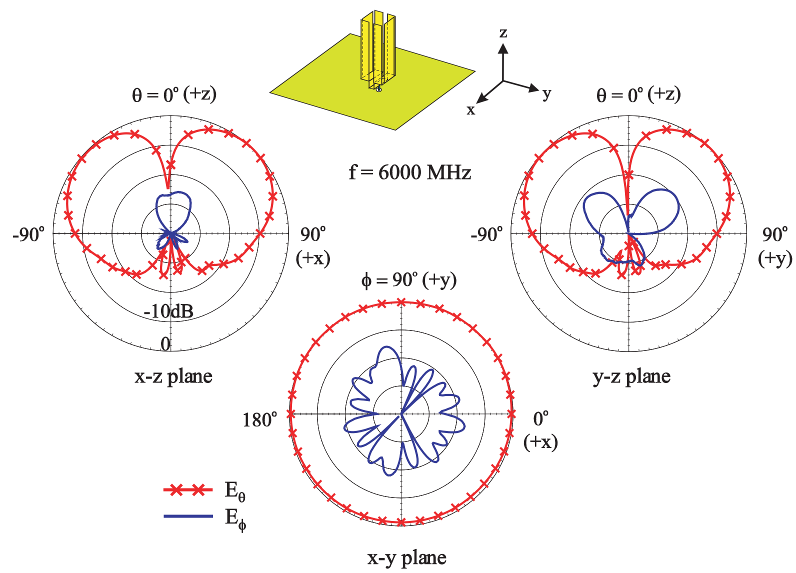

Figure 4. Measured radiation patterns at 6000 MHz.

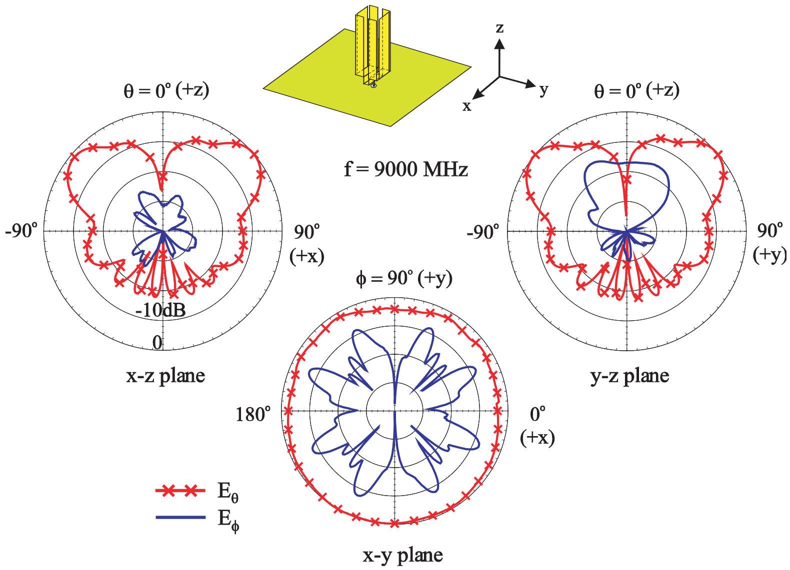

Figure 5. Measured radiation patterns at 9000 MHz.

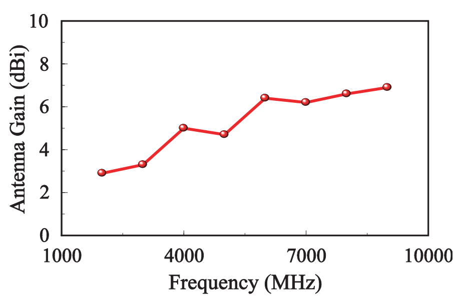

Figure 6. Measured antenna gain against frequency.

4. CONCLUSION

A wideband monopole antenna fabricated using a cross-shaped metal plate for achieving omnidirectional operation has been proposed. The proposed antenna has a simple configuration and is easy to implement with a low cost, and yet provides a large bandwidth. A design example of the proposed antenna suitable for IEEE 802.16e operation in the 2–6 GHz band has been successfully implemented. Very good omnidirectional radiation over the operating bandwidth has been obtained. The experimental results indicate that good radiation characteristics over a wide frequency band have been also observed.

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