A Compact Planar Inverted-F Antenna With a PBG-Type Ground Plane for Mobile Communications

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***Abstract*—The ground plane affects the characteristics of a planar inverted-F antenna (PIFA) significantly. Using the idea of the high-impedance surface to construct the ground plane, a new type of compact PIFA with a photonic bandgap type (PBG-type) ground plane is proposed. Both the traditional PIFA and the proposed antenna are analyzed using the finite-difference time-domain (FDTD) method in detail. It is found that the two antennas have similar directivity pattern characteristics, but the size of the latter can be reduced obviously. The results also show that the bandwidth of a traditional PIFA is not greatly affected by the thickness of the metallic ground plane and that the shapes of the directivity patterns are not greatly affected by the ground plane under the small size condition. The operating-frequency band of the proposed antenna can be adjusted by changing the dielectric substrate thickness of the ground plane. They are suitable for mobile communication applications.**

***Index Terms*—finite-difference time-domain (FDTD) method, high-impedance surface, mobile antennas, mobile communication, photonic bandgap, planar inverted-F antenna (PIFA).**

I. Introduction

N RECENT years, more and more attention is paid to develop small-size and low-profile antennas for mobile communications. For optimum system performance, the antennas must have high radiation efficiency, small volume, isotropic radiation characteristics, simple impedance matching, and simple mechanical construction [1]. How to reduce the volume and broaden the bandwidth are hot topics on mobile antennas. A traditional planar inverted-F antenna (PIFA) with a finite metallic ground plane [shown in Fig. 1(a)] has been widely used as a mobile-communication antenna [2] and [3]. This type of antenna allows a simple impedance match in a low-profile design and can produce both vertically and horizontally polarized electric fields [3]. To reduce the size of the antenna, many measures, such as capacitively loaded PIFA [4] and [5], have been taken. Although a capacitively loaded PIFA [4] can reduce the size of the antenna, its structure is too complex to produce. The size of the ground plane on which the antenna is mounted affects the characteristics of the antenna markedly. By reducing the ground-plane size, the bandwidth of a PIFA system can be broadened [3]. In fact, mobile-communication systems such as handsets cannot provide large ground plane. Therefore, the size of the ground plane is unsuitable to be too large.

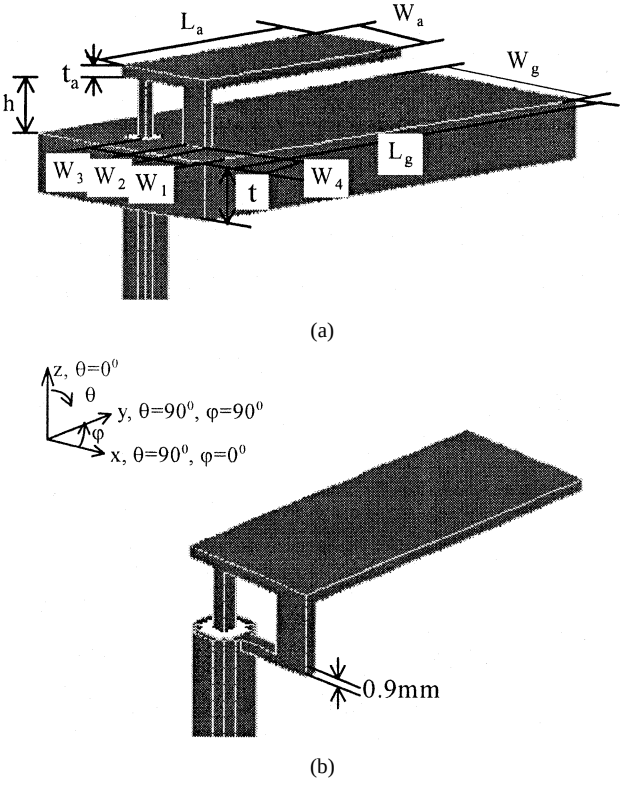

Fig. 1. Traditional PIFA.

Photonic bandgap (PBG) materials are periodic structures capable of prohibiting the propagation of electromagnetic waves within a certain frequency band [6]. With the development of the researches on PBG, high-impedance electromagnetic surfaces are proposed [7] and [8]. Wire antennas do not function effectively when positioned parallel and close to the traditional perfect electric-conductor (PEC) ground plane due to the reverse-image currents. However, they work efficiently above a high-impedance surface due to its in-phase reflection character and high surface impedance [8]. The high surface impedance helps to suppress the surface wave on the ground plane of the antennas, resulting in high radiation efficiency with a little backward radiation. Therefore, the high-impedance surface provides good potential for building a low-profile and high-efficiency antenna structure. However, analyzing the references about high-impedance surfaces, one can find that the size of the ground plane that is approximately $1\lambda \times 1\lambda \times 0.04\lambda$ is too large for

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