Multiband Flat-Plate Inverted-F Antenna for Wi-Fi/WiMAX Operation
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Abstract—A printed multiband flat-plate inverted-F antenna (IFA) is presented. The antenna is complexly structured and can operate as an internal laptop antenna over multiple Wi-Fi and WiMAX frequency bands. The antenna was studied by means of numerical simulations. The predicted achievable $-10$ dB return loss criterion, which is $10$ dB level. Moreover, experimental measurements. The predicted achievable $-10$ dB return loss of the antenna is confirmed and demonstrated by experimental measurements.

Index Terms—Flat-plate antenna, inverted-F antenna (IFA), multiband antenna.

I. INTRODUCTION

Compact laptop internal antennas for wireless local area network (WLAN) systems, capable of operating in as many as possible frequency bands of the Wi-Fi (IEEE 802.11 standard) and mobile WiMAX (IEEE 802.16e-2005 standard), are highly desirable. The Wi-Fi operates in the 2.4 GHz band (frequency range 2.4–2.5 GHz) and 5 GHz band (frequency ranges 5.15–5.35 GHz, 5.47–5.725 GHz, and 5.725–5.875 GHz). The mobile WiMAX operating bands are 2.3 GHz (frequency range 2.3–2.4 GHz), 2.5 GHz (frequency range 2.5–2.7 GHz), and 3.5 GHz (frequency range 3.4–3.6 GHz). Clearly, for mass production, flat antennas fabricated on thin flexible substrate using printing technology are desirable.

To realize multiband Wi-Fi operation, several schemes of complexly structured inverted-F antennas (IFAs) were suggested [1], [2]. These multiband IFAs are combinations of conventional IFAs with coupled and branching printed strip elements. The feasibility of covering the WiMAX bands was not considered in [1], [2]. With a view towards achieving combined Wi-Fi/WiMAX operation, two versions of a complexly structured IFA were later proposed [3], [4]. Each of the complexly structured IFAs in [3], [4] is actually a conventional IFA with an added backward branch. The IFA in [3] has a simple strip backward branch and it is designed to operate at frequencies from 2.3 up to 6 GHz. However, to define this frequency range, the authors used a $-7.36$ dB return loss criterion, which is higher than the commonly required $-10$ dB level. Moreover, their measurement of the input return loss of the IFA in [3] was taken not at the antenna terminals but at the input of a 500-mm long miniature coaxial cable (1.1 mm in outer diameter), which introduces additional decrease in the measured return loss. The IFA suggested in [4] has a more complicated backward branch, formed by a soldered ceramic chip with embedded helical metal pattern. Indeed, it showed an improved performance. It demonstrated three bands of operation, namely, 2.37–2.72 GHz, 3.19–3.79 GHz, and 5.05–5.89 GHz, where the input return loss at the antenna terminals is less than $-10$ dB, making it a possible antenna candidate for Wi-Fi and mobile WiMAX applications. However, its complicated backward branch makes it less suitable for mass production. In this letter, we propose a new complexly structured printed flat-plate IFA with simple strip backward branch. The proposed antenna operates in all the Wi-Fi bands, namely, 2.4 and 5 GHz, as well as in the mobile WiMAX 3.5 GHz band. These desired frequency characteristics of the antenna are achieved simply by a proper choice of the dimensions of the printed antenna elements. Thus, the need for additional soldered element such as that used in [4] is obviated. The proposed antenna design was simulated using the commercial CST Microwave Studio software. The antenna model has been fabricated and its return loss was measured using an Agilent N5230A network analyzer. The results of the simulations and measurements were found to be in a good agreement.

II. ANTENNA DESIGN

Starting from the complexly structured dual-band IFA for the 2.4/5 GHz bands proposed in [2] and assuming that the antenna would be fabricated using printing technology, we examined the possibility of increasing the number of the antenna operating bands to include the 3.5 GHz mobile WiMAX operating band. The geometry of the resultant multiband IFA is shown in Fig. 1. It consists of a multi-arm monopole and a finite-size ground plane, both printed on one side of a flexible Rogers RT5800 no-ground dielectric substrate with relative permittivity $\varepsilon_r = 2.2$ and thickness of 0.127 mm. An antenna of this type actually includes two resonant radiating structures. One radiating structure is the T-shaped monopole that operates, as explained in [2], in two frequency bands. The other radiating structure is the elongated slot that is formed by the following three metal parts: the inverted-L shorting strip that constitutes the middle part of the monopole, the right arm of the monopole T-shaped part, and the ground plane. In the IFA shown in Fig. 1, the longer part of the inverted-L shorting strip is 2.5 mm wide. Its short end, which is connected to the ground plane, is 2 mm wide. The two arms of the T-shaped monopole, the longer one branching out from the middle part of the monopole in the backward direction and the shorter open end one, are 1 mm wide. The backwardly directed arm and the middle part of the monopole are separated by a