Compact Size Dual-band Antenna Printed on Flexible Substrate for WLAN Operation

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1. Introduction

Antenna designs fabricated on thin flexible substrate material with thickness as thin as 45 μm [1] are presently receiving a lot of attention in the antenna industry. This is because such antenna with very thin substrate can be more sophisticated (bend and fold) and un-obstructive when integrated with the RF circuit. Furthermore, to accommodate the emerging trend for mobile devices such as ultra-thin notebook or mobile phone, lesser spaces are now given to the antenna engineer to insert the antennas, especially for WLAN applications. Therefore, rigid substrate material (such as FR4, Taconic, and Roger) for the fabrication of antennas will eventually be replaced by thin flexible substrate with a low-cost of approximately US $5 / per sheet (dimension 250 × 230 mm^2). Various dual-band WLAN antenna designs that fabricated on flexible substrate have been reported [1-3]. However, these antennas have demonstrated either a complicated fabricating process [2] or a large antenna size of up to 33 × 28 mm^2 [3]. In this paper, a compact size (11 × 7 mm^2) planar antenna printed on a thin flexible substrate for dual-band operation in the 2.4/5.2 GHz WLAN application is proposed. Details of the flexible substrate are presented, and typical antenna performances such as return loss, radiation patterns, and gain variation are also discussed.

2. Antenna Design and Flexible Substrate

The proposed dual-band antenna is fabricated on a halogen-free single side adhesive flexible copper clad laminate (FCCL). This single side FCCL is a composite material comprised of an upper layer copper and a bottom layer of polyimide film with thickness 18 μm and 25 μm, respectively, in which the upper and lower layers are bonded together by an adhesive layer of 20 μm thick. Therefore, the total thickness of the antenna is approximately 63 μm. In this case, the dielectric constant of this polyimide film is approximately 3.5 with loss tangent 0.003. The geometry and dimensions of the proposed antenna fed by a 50-Ω mini-coaxial line is depicted in Figure 1. It is loaded 2 mm above a copper plate with dimension 150 × 200 mm^2 that act as the ground plane. To achieve satisfactory bandwidths to cover the 2.4/5.2 WLAN operating bands, the structure of the proposed antenna is devised as a meandered monopole type top loaded by a narrow inverted L-shaped strip.

3. Experimental Results and Discussion

The simulated and measured return losses of the proposed dual-band antenna are presented in Figure 2, and good validation is demonstrated between the two results. From the measured results, two resonant modes; f_L and f_H are exactly excited at 2.4 and 5.2 GHz, respectively. The measured 10-dB impedance bandwidth of f_L and f_H are 10.64 % (290 MHz) and 5.83 % (305 MHz), respectively, which allow the operation of 2.4/5.2 GHz WLAN band. The measured far-field radiation patterns of the proposed antenna in three principal planes (*xz*-, *yz*-, and *xy*-planes) are plotted with respect to the two resonant modes; f_L and f_H as shown in Figures 3 and 4, respectively. Here, near omni-directional patterns are observed in the *xy* planes of both resonant modes. The measured peak gain level and efficiency variation diagrams of the proposed antenna are depicted in Figure 5. In this figure, a gain variation of approximately 1 ~ 1.6 dBi and 2 ~ 2.8 dBi are observed within the 2.4 and 5.2 GHz WLAN operating bands, respectively. Furthermore, their corresponding efficiencies are approximately 52 ~ 56 % and 57 ~ 60 % throughout the bands of interest. To indentify the tolerance of the proposed flexible antenna, three bending positions (1 to 3) of the antenna are conducted and their respective return losses are measured and depicted in Figure 6. In this figure, it is obvious that the impedance matching of f_L will be deteriorated when bending is performed on the proposed antenna, while f_H remains unaffected. Nevertheless, at bending position 2, in which the top edge of the proposed antenna is bent forward at approximately 45 degrees, the 10-dB bandwidth of f_L is measured between 2.31 and 2.52 GHz, which can also cover the 2.4 GHz WLAN operating band.

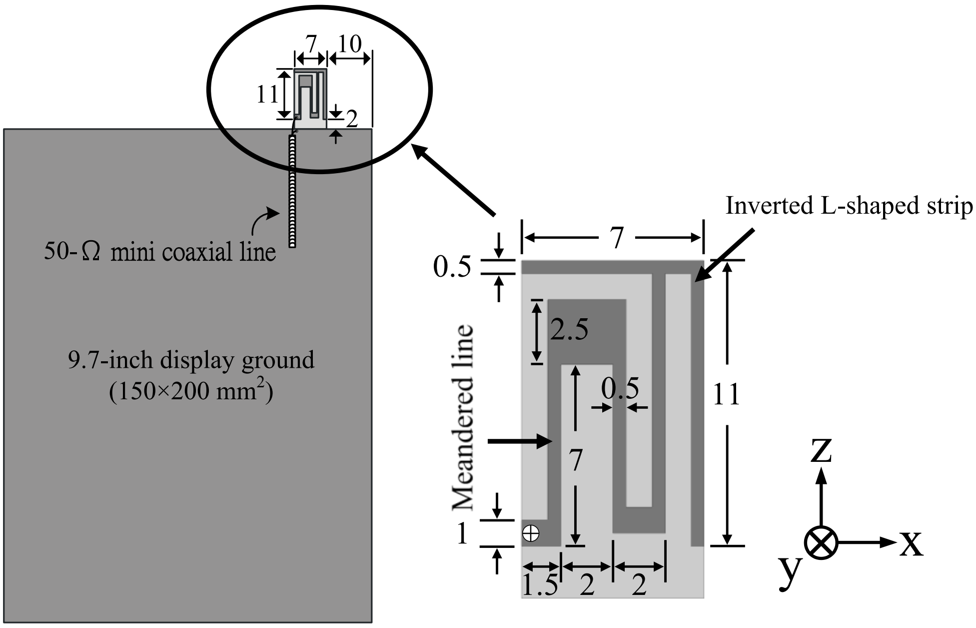


Figure 1: Geometry of proposed dual-band antenna printed on flexible substrate.

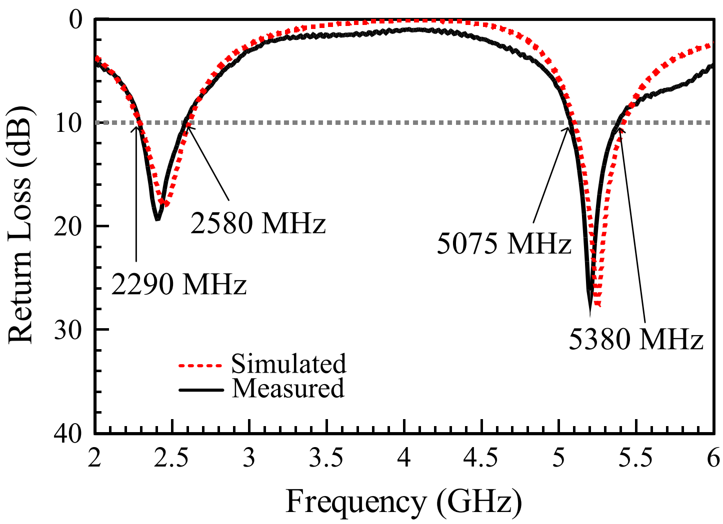


Figure 2: Measured and simulated return losses of proposed antenna.

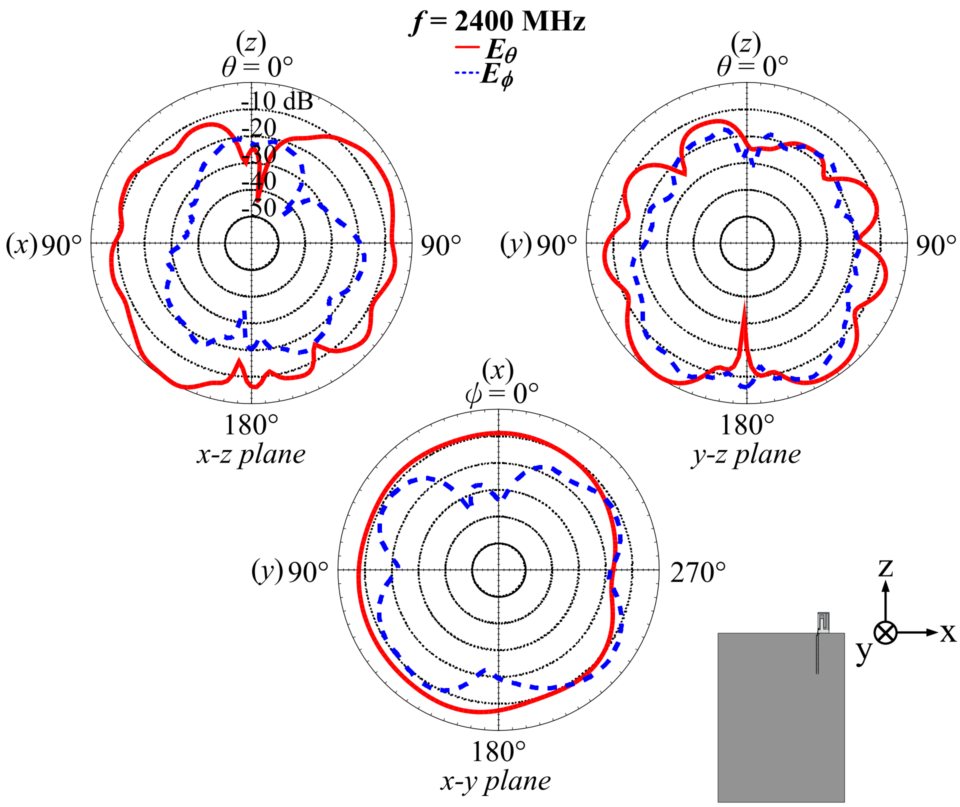


Figure 3: Measured radiation patterns for 2.4 GHz WLAN band

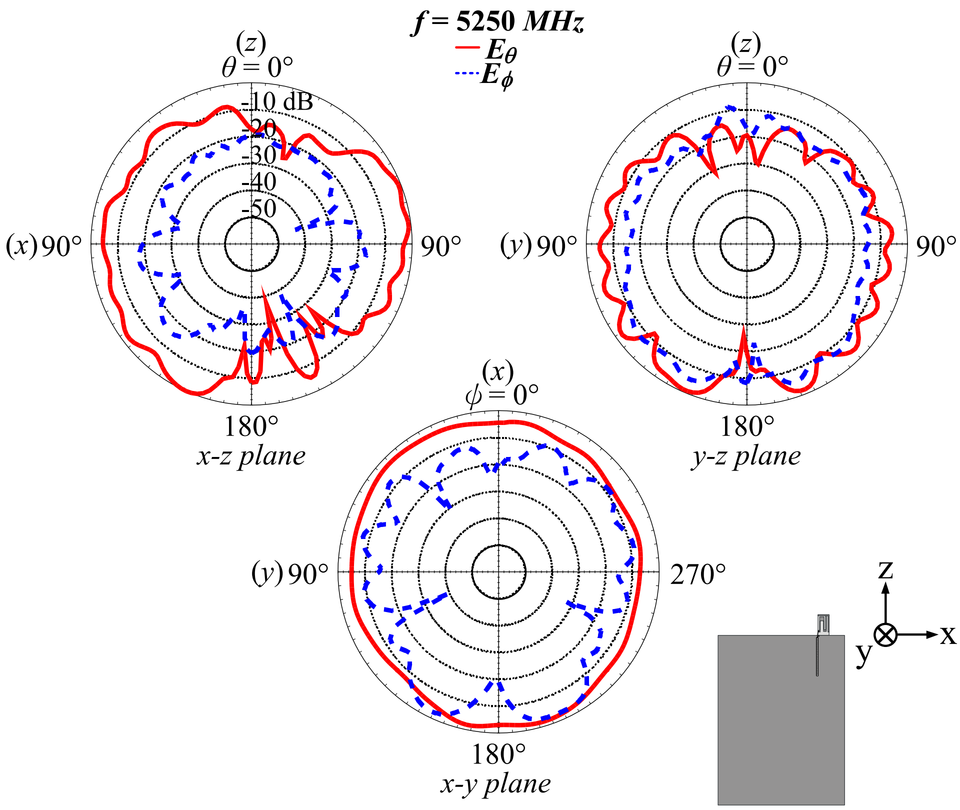
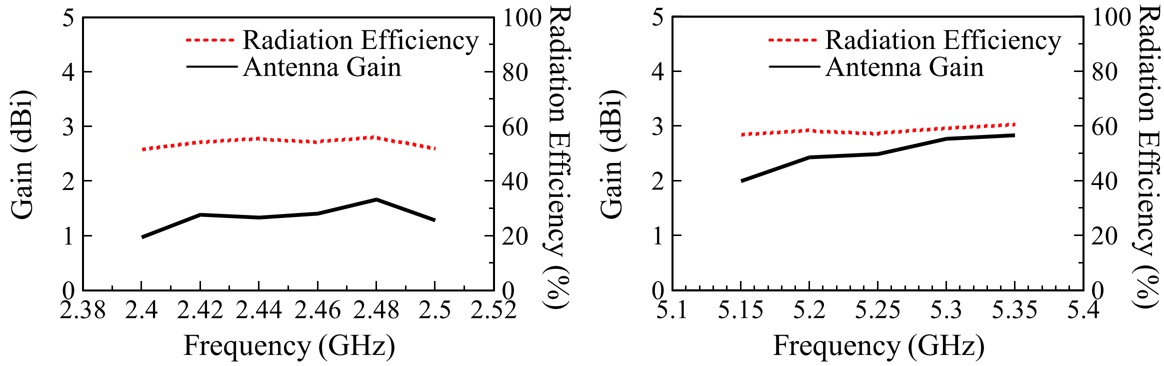


Figure 4: Measured radiation patterns for 5.2 GHz WLAN band



(a) (b)

Figure 5: Measured peak gain and efficiency variations of proposed antenna (a) 2.4 GHz WLAN band, and (b) 5.2 GHz WLAN band

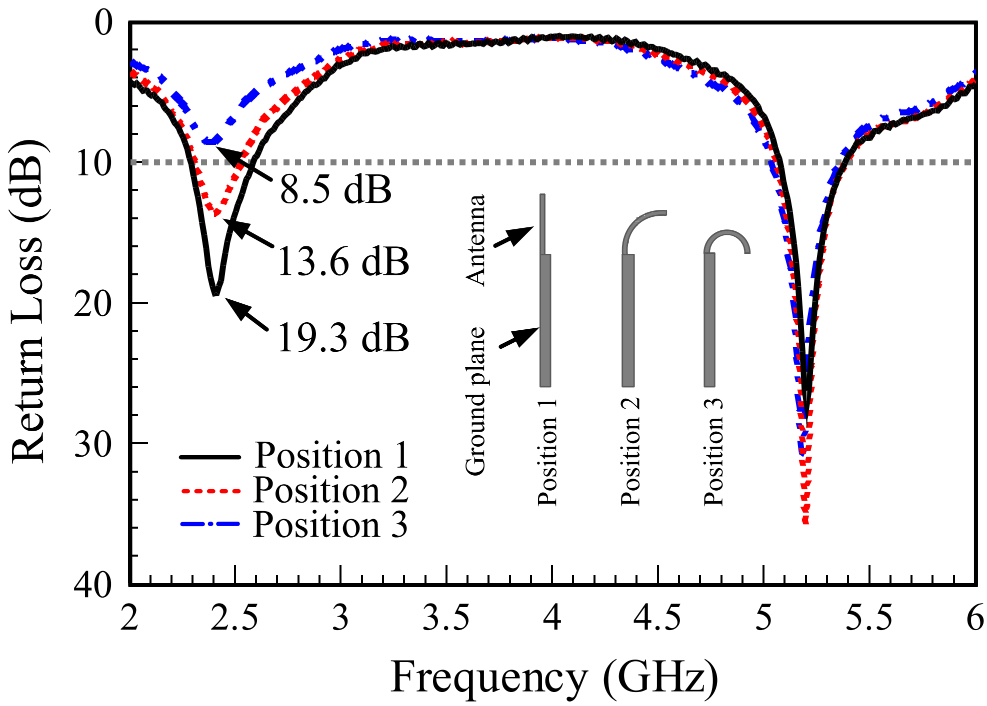


Figure 6: Measured return losses of proposed antenna at various bending positions

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