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COMPACT RING MONOPOLE ANTENNA WITH DOUBLE MEANDER LINES FOR 2.4/5 GHZ DUAL-BAND OPERATION

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Abstract—A novel compact ring monopole antenna with double meander lines is proposed for wireless local area networks (WLAN) applications in IEEE 802.11b/g/a systems. The designed antenna, fed by a $50\,\Omega$ microstrip transmission line, is only 32 mm in height and 16 mm in width. By introducing a horizontal and a vertical branched strips to a closed rectangular strip ring, the proposed antenna can generate two separate impedance bandwidths. Prototypes of the proposed antenna have been constructed and tested. The obtained impedance bandwidths reach about 12% for the 2.4 GHz band and 45.3% for the 5 GHz band, which meet the required bandwidth specification of 2.4/5 GHz WLAN standard. Also, good radiation performance and antenna gain over the two frequency ranges have been obtained.

1. INTRODUCTION

Recently, there are rapid developments in wireless local area networks (WLAN). To adapt to various WLAN environments, a WLAN antenna should be capable of operating at multiple frequency bands [1–6]. For instance, these frequency bands may cover 2.400–2.484 GHz (specified by IEEE 802.11b/g) and 5.150–5.350/5.725–5.825 GHz (specified by IEEE 802.11a). Some monopole antennas for single-band is not suitable for this application [7]. Most of the monopole antennas reported in the literature, such as the various lengths of two monopoles antenna [8], rectangular microstrip patch antenna with a rectangular notch [9], and CPW-fed circular slot antenna with a slit back-patch [10] etc., are either large in antenna size or narrow in bandwidth.

In this letter, a novel design of a dual-band planar monopole antenna, consisting of a rectangular strip ring with double meander lines and a top loaded vertical strip, is presented. By introducing a horizontally and a vertically branched strips to the antenna, compact antenna size, dual-band operation and good radiation performance suitable for the WLAN systems could be achieved. Details of the antenna design are described, and both simulated and measured results such as input return loss, impedance bandwidths, radiation patterns, and antenna gains are presented and discussed.

2. ANTENNA CONFIGURATION

Figure 1 shows the structure and dimensions of the proposed antenna, whose conductor is fabricated on an inexpensive FR4 substrate with the dielectric constant of 4.4 and the substrate thickness of 1.6 mm. The antenna shape and its dimensions were first searched by using the Ansoft's High Frequency Structure Simulator (HFSS) and then the optimal dimensions were determined from experimental adjustment. The dimensions of the designed antenna, including the substrate, is $32\,\text{mm}\times 16\,\text{mm}$, or about $0.25\lambda \times 0.12\lambda$ with respect to 2.4 GHz. A $50\,\Omega$ microstrip feed line with width of 3.1 mm and length of 4.2 mm, is used for centrally feeding the antenna from the bottom edge of the rectangular strip ring. The antenna is symmetrical with respect to the longitudinal direction and its basis is a closed rectangular strip ring with double rectangular meander lines. A vertical strip with length of $L5 = 9.9$ mm centrally positioned at the top edge of the ring. Thus, this antenna provides a resonant path having a length of about 32 mm $(= L1 + L2 + L3 \times 2 + L4 + L5)$ or about 0.31 wavelength relative to the frequency of 2.4 GHz. In this design, the meander lines increase the current path of the antenna's resonant mode, which reduces the required size of the proposed antenna for a fixed operating frequency. Two branched strips — a horizontally branched strip and a vertically branched strip — are selected to be added to the antenna for providing different current paths so as to obtain broadband and dual-frequency operations. It should be noted that the lengths of the branched strips, denoted as $L6$ and $L7$, both will significantly affect on the impedance matching of the proposed antenna, the influence will also be discussed in the following section. These geometry parameters were all carefully adjusted and then obtained for achieving good impedance matching over two wide bandwidths suitable for 2.4/5 GHz WLAN operation.

3. EXPERIMENTAL RESULTS AND DISCUSSION

The prototype of the proposed antenna with optimal geometrical parameters as shown in Fig. 1 was constructed and tested. The measurement was made with a Wiltron 37269A network analyser. Fig. 2 shows the measured and simulated return losses for the proposed antenna in case of $L6 = 13.2\,\text{mm}$ and $L7 = 10\,\text{mm}$. As can be seen from the measured results, three resonant modes are excited at 2.4, 5.1, and 6.7 GHz. In the 2.4 GHz band, the 10 dB bandwidth is about 288 MHz (2252–2540 MHz) or about 12% for the frequency of 2.4 GHz, which meets the bandwidth requirement for IEEE 802.11b/g. In the 5 GHz band, the 10 dB bandwidth is about 2357 MHz (4855–7212 MHz) or about 45.3% for the frequency of 5.2 GHz, which also meets the bandwidth requirement for IEEE 802.11a. Agreement between the experiment and simulation is not very good, mainly because of the

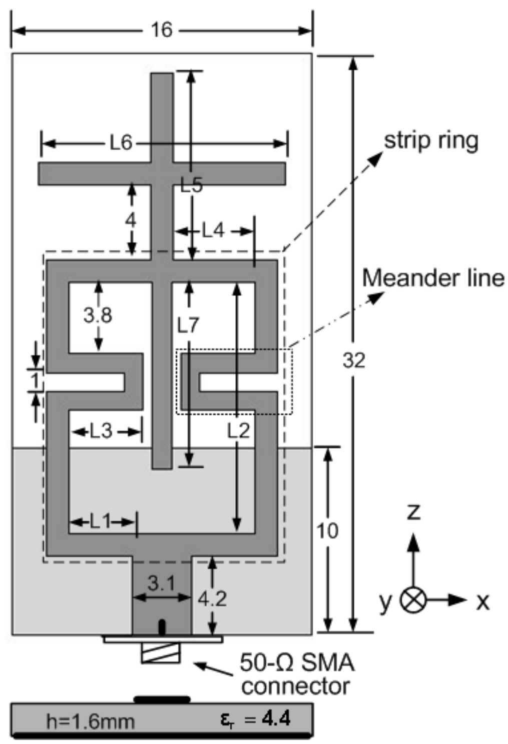

Figure 1. Geometry and dimensions of proposed antenna (in mm) $L1 = 3.35\,\text{mm}$, $L2 = 13.8\,\text{mm}$, $L3 = 3.9\,\text{mm}$, $L4 = 4.3\,\text{mm}$, $L5 = 9.9\,\text{mm}$.

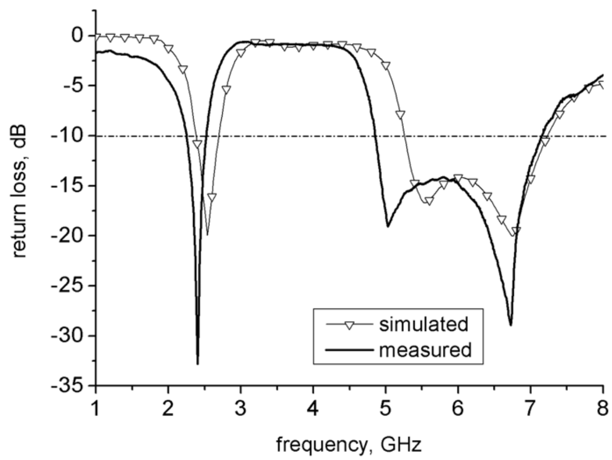

Figure 2. Measured and simulated return loss against frequency for proposed antenna.

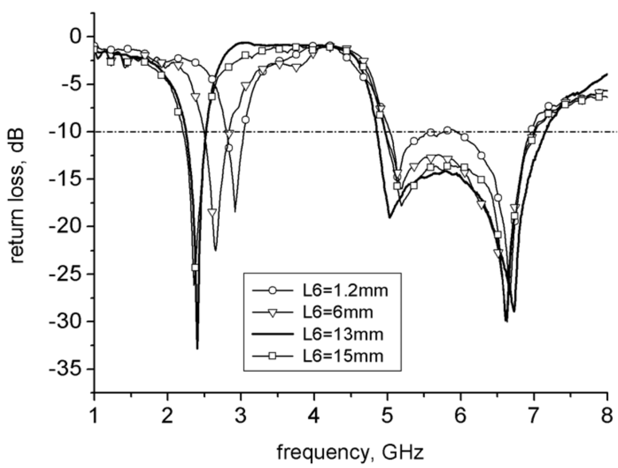

Figure 3. Measured return loss against frequency for the proposed antenna with various length $L6$ (other parameters are the same as in Fig. 2).

effect of the cable connector in addition to errors in processing. That connector is not accounted for in the simulation but was used in the experiment loading a vary reactance. The cases for the two branched strips with various lengths of $L6$ and $L7$ were also constructed and examined. Fig. 3 shows the tuning effect of varying the horizontally branched strip length as $L6 = 1.2, 6, 13$, and 15 mm with a fixed $L7$

of 10 mm on the proposed antenna's impedance matching. It can be seen from Fig. 3 that with increasing length of $L6$, the lower resonant frequency shift down, while the bandwidths of the upper band change slightly. For the lower band, to increase the length of $L6$ will lengthen effective current path, which turns the resonant frequency at 2.4 GHz. The measured return loss curves with length $L6$ of 13.2 mm and different length $L7$ of the vertically branched strip are plotted in Fig. 4. It can be observed that the impedance matching of the upper band is improved with increasing $L7$. This can be explained in that the electromagnetic coupling between the meander lines and the vertically branched strip is enhanced as $L7$ increases.

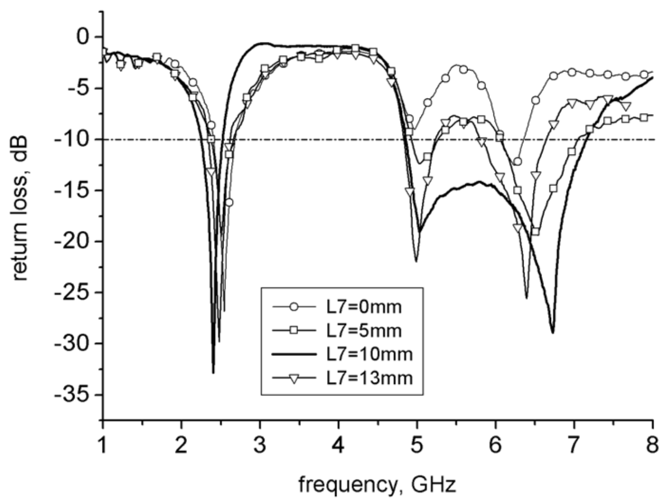

Figure 4. Measured return loss against frequency for the proposed antenna with various length $L7$ (other parameters are the same as in Fig. 2).

The radiation characteristics are also investigated. Fig. 5 presents the measured far-field radiation patterns of both co-polarization and cross-polarization for the designed antenna at resonant frequencies of 2.45.2 and 5.8 GHz. The measured results show that the radiation patterns of the antenna are broadside and bidirectional in the E-plane and nearly omnidirectional in the H-plane. The peak antenna gain for frequencies throughout the matching bands for the proposed antenna are measured and shown in Fig. 6. The obtained average gains are 2.8 dBi (2.5–3.0 dBi) and 4.29 dBi (3.2–5.2 dBi), respectively, within the bandwidths of 2.4 and 5 GHz operating bands.

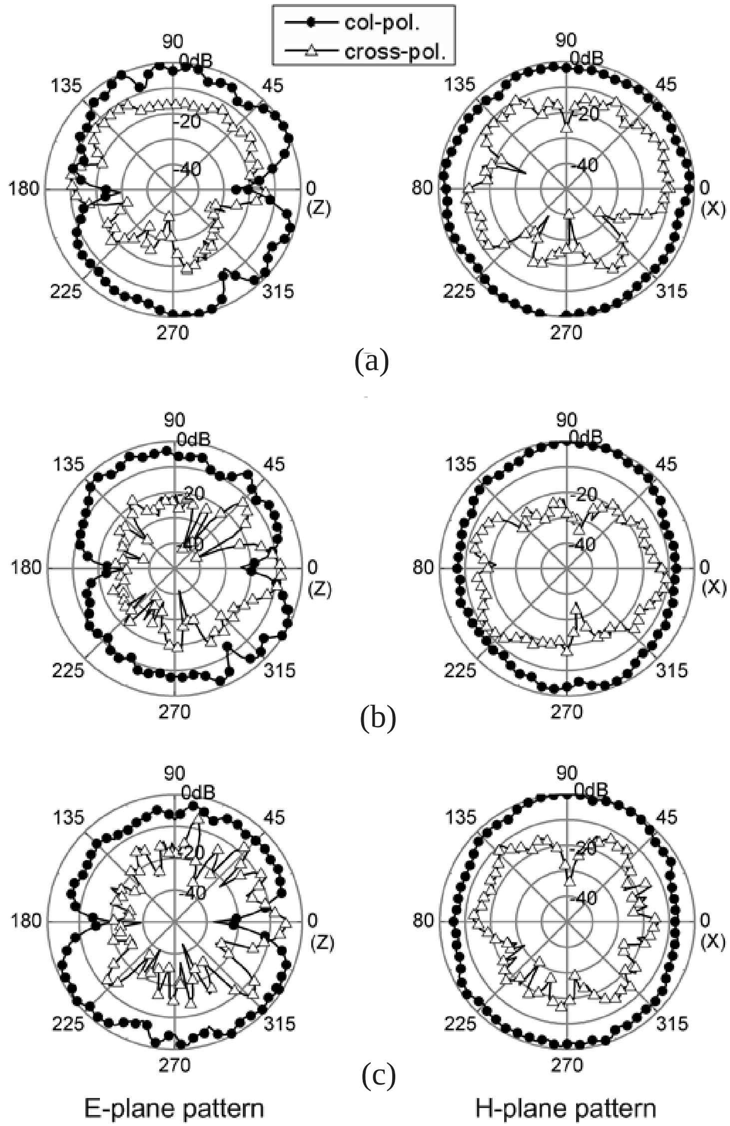

Figure 5. Measured radiation patterns for the proposed antenna studied in Fig. 2: (a) $f = 2.4\,\mathrm{GHz}$, (b) $f = 5.2\,\mathrm{GHz}$, (c) $f = 5.8\,\mathrm{GHz}$.

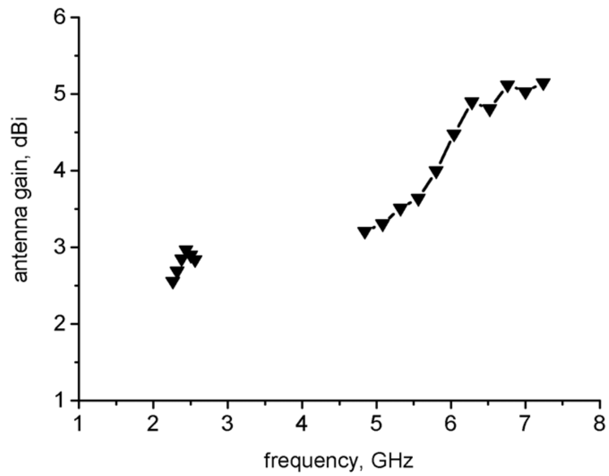

Figure 6. Measured antenna gains for the proposed antenna studied in Fig. 2.

4. CONCLUSION

A compact microstrip-line-fed monopole antenna for 2.4/5 GHz dual-band operation has been proposed and implemented. The overall size of the obtained antenna is only 16 mm×22 mm. By adding a horizontally and a vertically branched strips to the closed rectangular strip ring with double rectangular meander lines, the proposed antenna can provide 12% and 39.3% impedance bandwidths for the 2.4 and 5 GHz bands, respectively. Omni-directional radiation performance and sufficient antenna gain of operating frequencies across the two bands can also be obtained. This design is not only suitable for use in dual-band WLAN systems but also applicable to dual-band systems for RFID applications.

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