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Planar Miniature Dual-Band RFID / WlFi Antenna for Postal Application

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Abstract

In this paper, a novel dual-band RFID / WiFi antenna designed with a one-sided planar structure is presented. The proposed dual-band antenna is fabricated and experimentally measured. The measured results are in good agreement with simulated results. The corresponding two passbands are recorded at 933 MHz and 2.398 GHz, with impedance bandwidth of 12.0% and 4.67%, respectively. Compared with the conventional 920 MHz RFID antenna, a size reduction of about 50% is achieved. With proposed antenna, an audio RFID postal box is designed and it is expected to provide some self services for the tourists in Macao.

1. Introduction

The applications of radio frequency identification (RFID) technology has been widely existed in industry, it can be used for item tracking, inventory management and monitoring and so forth. Due to the long reading range and high speed data transmission [1], ultra high frequency (UHF) RFID systems are more attractive. Nowadays, to satisfy the development of internet of things (IOT) market, various applications in UHF RFID systems are required. One of these applications is to design RFID postal system to fulfil the postal automation, which is necessary and important for the tourist cities.

In order to install the proposed RFID postal system conveniently in the postal box, a compact dual-band reader antenna is designed. Several works about how to realize dual-band antenna performance have been carried out [2]-[4]. In [2], by introducing two slots to the folded shorted patch, wide impedance bandwidth of the dual-band antenna could be achieved. A high-gain antenna was proposed with using the U-shaped strip as the feeding probe to feed a printed rectangular ring [3]. Using the aluminium plate and 5-mm printed circuit broad (PCB) stands, a dual-band antenna with good directional radiation patterns was introduced [4]. However, these antennas designed with multilayer and large size are not so easy to be fabricated and suitable for the small device applications. Therefore, it is necessary to design a miniature antenna to satisfy the requirement of the proposed RFID system.

In this paper, a planar dual-band antenna without ground plane is proposed [5]. Besides this introduction, the proposed antenna will be studied in section 2, the simulated and measured results will be also provided. In section 3, The Macao's RFID postal box tourist network will be simply presented. Finally, a conclusion will be drawn in section 4.

2. Compact dual-band planar antenna

The proposed dual-band antenna is illustrated in Fig. 1. To achieve a compact antenna, there is no any reflector on the bottom layer of the substrate. By using this technique, the 50-Ω SMA connector is directly connected to the feeding line, and another feeding line is short to ground plane of the connector. In order to design proposed antenna, two slot lines are etched on the top layer of the substrate. By adjusting the length of these two slot lines, the current distribution against

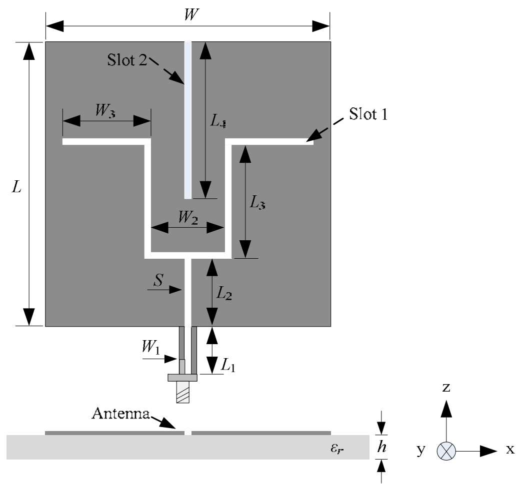


Figure 1: Layout of proposed antenna.

desired dual passbands on the planar antenna is optimized and a dual-band antenna operated at 920 MHz and 2.40 GHz can be realized. As described in Fig. 1, the proposed antenna is designed with dimensions (all in mm) of $L = W = 80$, $L_1 = 10$, $L_2 = 20$, $L_3 = 30$, $L_4 = 44$, $W_1 = 1$, $W_2 = 18$, $W_3 = 24$ and $S = 2$.

2.1 Parameter analysis of proposed antenna

To operate the antenna operated at 920 MHz and 2.4 GHz, the effects of varying the length of slot 2 (L_4) are analyzed. As demonstrated in Fig. 2, the centre frequency of first passband of proposed antenna is lower of a longer L_4. By increasing L_4 from 0 mm to 44 mm, the operating frequency of first passband lowers from 1.11 GHz to 912 MHz. It is found that the desired operating frequency with good matching can be achieved when L_4 =44 mm. However, the second passband is kept at about 2.4 GHz for the above L_4 change.

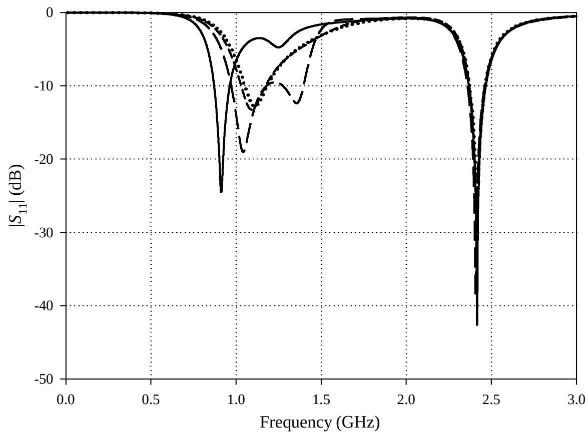


Figure 2: Simulated results of proposed antenna with variation of L_4 (····· L_4 = 0 mm, - - - L_4 = 15 mm, — — L_4 = 30 mm, —— L_4 = 44 mm).

2.2 Experimental results and discussion

The antenna is designed on RO4003 substrate with dielectric constant of $\varepsilon_r = 3.38$, thickness of h = 1.524 mm. With IE3D commercial simulator [6], the proposed antenna is simulated and experimentally characterized. The simulated and measured return losses are plotted in Fig. 3. For the simulated result, the proposed antenna is operated at 912 MHz and 2.42 GHz with return loss – 24.5 and – 42.5 dB, respectively. Compared with the simulation, there is some slight frequency shift for the measured two resonated frequencies. The measured antenna is excited at 933 MHz with – 10 dB impedance bandwidth of 12.0% and at 2.40 GHz with impedance bandwidth of 4.67%.

As shown in Fig .4, the radiation patterns of proposed antenna are simulated. Fig 4(a) shows the simulated radiation patterns at 912 MHz, with maximum gain of 2.12 dBi at Z-direction.

The simulated antenna pattern at 2.42 GHz is illustrated in Fig. 4(b). It can be found that the maximum gain is about 1.85 dBi at 145° in H-plane. The simulated antenna efficiencies of these two frequencies are 93.1% and 70.6%, respectively. A prototype proposed antenna is measured with total size of 92 × 96 mm^2, as shown in Fig. 5. Compared with the conventional 920 MHz RFID antenna, a size reduction of about 50% is achieved.

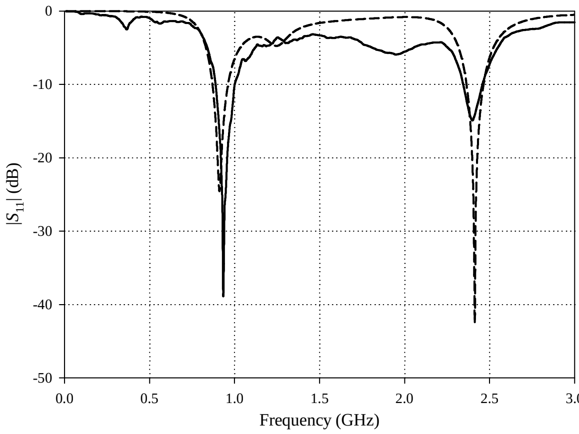
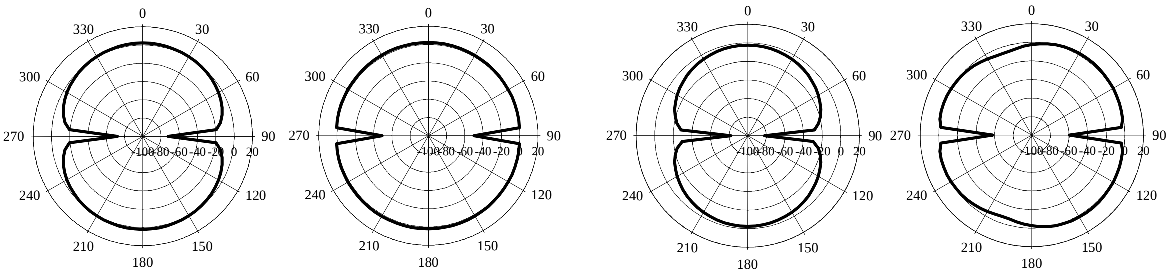


Figure 3: Simulated and measured results of proposed antenna, (- - - simulated, ——— measured).



E-plane H-plane E-plane H-plane

(a) 912 MHz (b) 2.42 GHz

Figure 4: Simulated radiation patterns of proposed antenna, (a) 912 MHz and (b) 2.42 GHz.

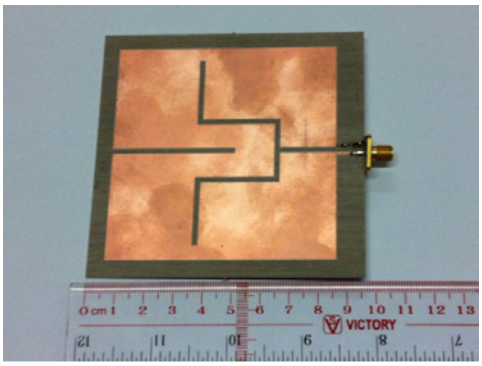


Figure 5: Photos of proposed dual-band antenna

3. Macao's RFID postal box touristic network

As a tourist city, every year there are a large number of tourists to Macao for world heritage usually Ruins of St. Paul's etc., and it is necessary to provide them some useful information when they travel to local world heritages. As described in Fig.6, it is a map of postal boxes' distribution and there are about 100 postal boxes in Macao. Most of them are around the above world heritages.

Since this postal service network has been built, it is interesting to double its function as an information platform to provide some self services for tourists. Therefore, a RFID postal box touristic network is presented. With theses postal boxes, a UHF RFID system can be built, not only improving the efficiency and fulfilling the postal automation for MacauPost, but also providing self services for tourists.

As an important component of this touristic network, an audio RFID postal box is developed. The tourists can take a postcard attached with UHF RFID tag to trigger the RFID postal box, and then some audio information will be provided, such as weather, temperature, hotels and restaurants around. This proposed RFID postal box contains an antenna, reader module, microprocessor control unit (MCU) and an audio module. A prototype RFID postal box is shown in Fig.7. With designed 920 MHz / 2.4GHz dual-band antenna, the postal box can work normally and it will be extended to integrate with WiFi or Bluetooth modules to realized versatile connectivity at 2.4GHz.

Figure 6: Postal boxes’ distribution.

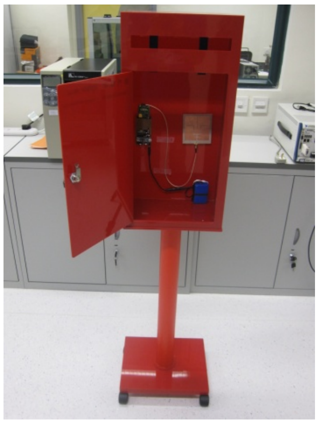


Figure 7: Proposed RFID postal box.

4. Conclusion

In this paper, a novel dual-band RFID / WiFi antenna designed with a one-sided planar structure is proposed and measured. Good agreement is achieved between simulation and experimental results. The measured dual-band antenna is operated at 933 MHz and 2.398 GHz, with impedance bandwidth of 12.0% and 4.67%, respectively. Using proposed dual-band antenna, good performance of this RFID postal box can be realized for particular touristic application.

Acknowledgments

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