Small-size Tag Antenna for UHF Active RFID System

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***Abstract* - This work describes a novel compact design of planar ultra-high-frequency (UHF) tag antenna for radio-frequency identification (RFID) system by introducing an L-shaped metal plate connecting with the spiral monopole antenna. The obtained impedance bandwidth of 12 MHz can meet with Taiwan UHF operating band (922 ~ 928 MHz). The overall antenna size is only 13 × 9 × 1.6 mm^3. The measured peak gain and antenna efficiency are approximately -1.1 dBi and 27 % for Taiwan UHF band, respectively. Meanwhile, the measured reading distance can approach 250 m. Good tag sensitivity is obtained across the desired frequency band.**

***Index Terms* — Tag, UHF, Active RFID system.**

I. Introduction

Radio frequency identification (RFID) systems have recently received considerable attention and have been used in a wide range of applications, such as object identification, livestock tracking, access control, point of sale and supply chain management. UHF-band RFID systems particularly provide long-range, faster reading and larger information storage capability performance than those operated in the low- and high- frequency (LF or HF) bands. Additionally, in the case of passive systems, in which there is no battery involved in the tag, this tag is fed by the incoming electromagnetic wave from the reader. This makes the tag antenna a key component of the power collection system. Consequently, an increased interest for UHF RFID tag antenna technology has arisen recently to assure good communication qualities such as the longer detection range and high accuracy. Numerous tag antennas for UHF RFID systems have been developed and include the symmetrical dipole antenna to increase the operating bandwidth [1-3]; meander antennas to reduce the antenna's dimensions [4-6], a planar compact inverted-E tag antenna with dual resonant modes [7], the F-shaped dipole antenna [8], the loop antenna with a pair of rectangular parasitic patches [9], the dual-branch dipole antenna with a shorting pin [10] and the dual meander-dipole antenna with a square loop [11]. However, the demand for a compact tag antenna for RFID systems is also growing. In this article, we present a novel compact tag antenna for UHF active RFID system. By introducing an L-shaped plate connecting with the spiral monopole antenna, a novel compact tag antenna is proposed with the obtained impedance bandwidth of 12 MHz to cover Taiwan UHF operating band (922 ~ 928 MHz). The overall antenna size is only 13 × 9 × 1.6 mm^3. The measured peak gain and antenna efficiency are approximately -1.1 dBi and 27 % for Taiwan UHF band, respectively. Moreover, the maximum reading distance is about 250 m.

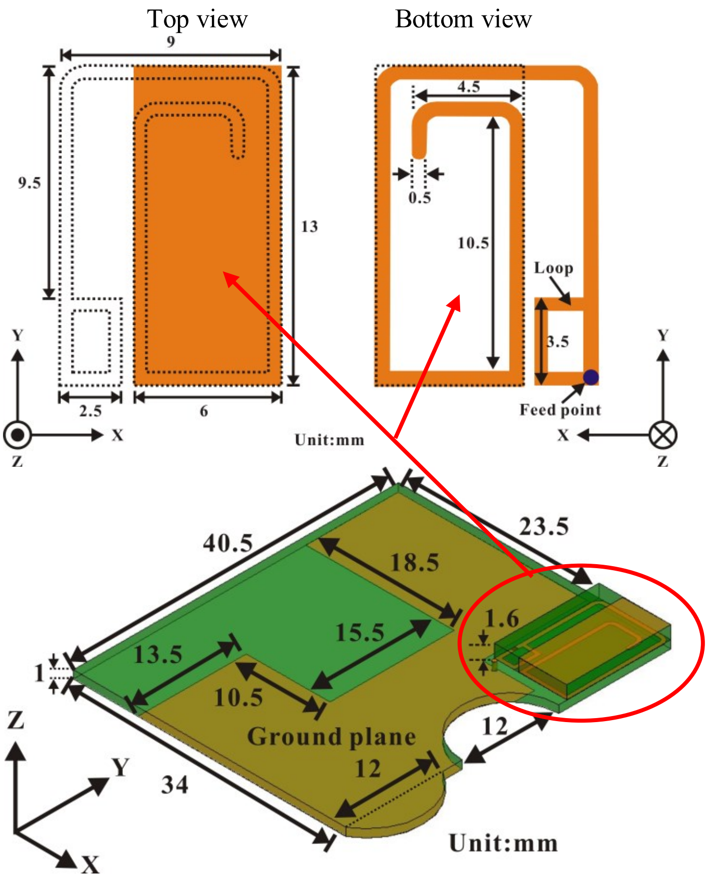


Fig. 1. Geometry of the proposed compact tag antenna for UHF active RFID system.

II. ANTENNA DESIGN AND EXPERIMENTAL RESULTS

Figure 1 shows the geometry of the proposed compact tag antenna for UHF active RFID system. This tag antenna with the size of 13 × 9 × 1.6 mm^3 is printed on an FR4 substrate (ε_r = 4.4, loss tangent = 0.0245) and attached on the top-right main board with the other circuit for active RFID system. The proposed spiral monopole is arranged at the bottom of the tag antenna and connected with an L-shaped plate along the section DF. A 50-Ω mini coaxial line is utilized to connect at the feeding point of the spiral driven monopole and the system grounding point (point G). The driven spiral strip is first arranged as a quarter-wavelength monopole to generate the fundamental resonant mode at approximately 925 MHz. Then, to enhance the impedance bandwidth of the operating band, a closed loop strip is utilized to reduce the input impedance of the antenna similar to the feeding designs in [10-11]. Moreover, an L-shaped metal plate is introduced to enhance the antenna efficiency of this proposed compact tag antenna. The electromagnetic simulator HFSS based on the finite element method [12] has been applied for the proposed tag antenna design. Fig. 1 displays the design parameter values obtained by the above strategy.

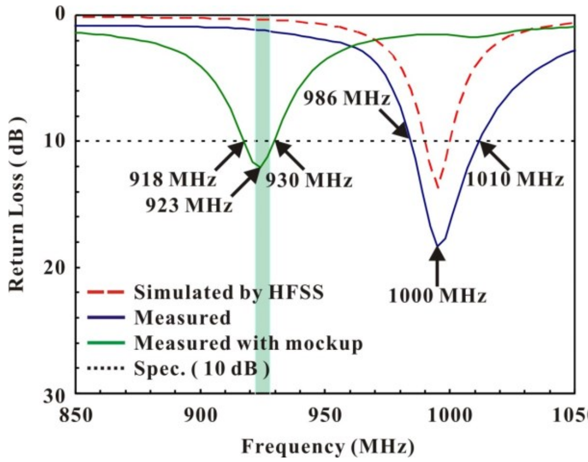
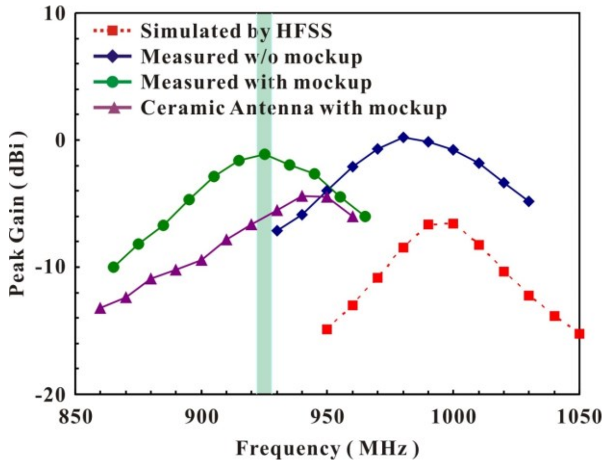
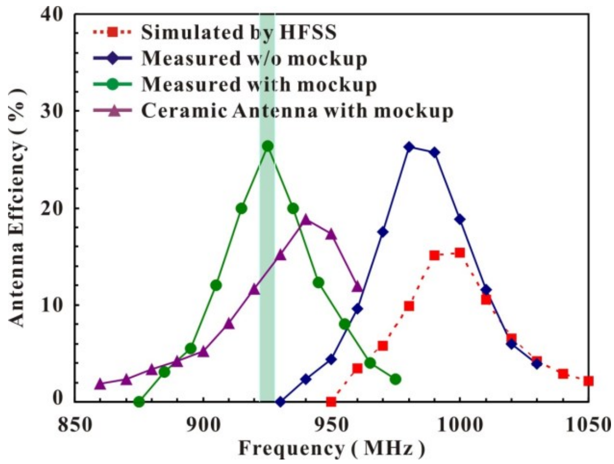


Fig. 2. Simulated and measured return loss against frequency for the proposed tag antenna.

Fig. 2 illustrates the related simulated and experimental results of the return loss for the proposed tag antenna with or without the mockup. From the experimental results for the tag antenna embedded into the mockup, the measured bandwidth (RL ≧ 10 dB) can be more than 12 MHz (918 ~ 930 MHz) to cover Taiwan UHF band (922 ~ 928 MHz). Since the dielectric constant and loss tangent of FR4 substrate fluctuate with operating frequency [13-14], the measured resonant frequencies and input impedance for the proposed antenna slightly differ from the simulated results obtained at some substrate parameter settings such as a relative permittivity of 4.3 and a loss tangent of 0.02 across the operating bands. Additionally, the proposed tag antenna is embedded into the plastic mockup with the relative permittivity of 3.0 and loss tangent of 0.02 [15] to explain why the measured result for the operating band is decreased and less than that of the proposed antenna without the mockup. Fig. 3 presents the simulated and measured antenna gain and efficiency (mismatching loss included, [16]) for the proposed compact tag antenna. The simulation results are summarized in this figure for comparison with the measured ones. For frequencies over the lower band, the measured peak gain and antenna efficiency are approximately -1.1 dBi and 27 % for Taiwan UHF band, respectively.



(a) Peak gain



(b) Antenna efficiency

Fig. 3. Measured and simulated peak gain and antenna efficiency for the antenna studied in Fig. 2.

To determine the angular sensitivity towards the radiating wave from the reader antenna, the tag was rotated in intervals of 15 degrees from 0^o to 360^o in the X-Z, X-Y and Y-Z planes, as displayed in Fig. 4. The radiation patterns in all planes are observed with the maximum reading distance of 250 m.

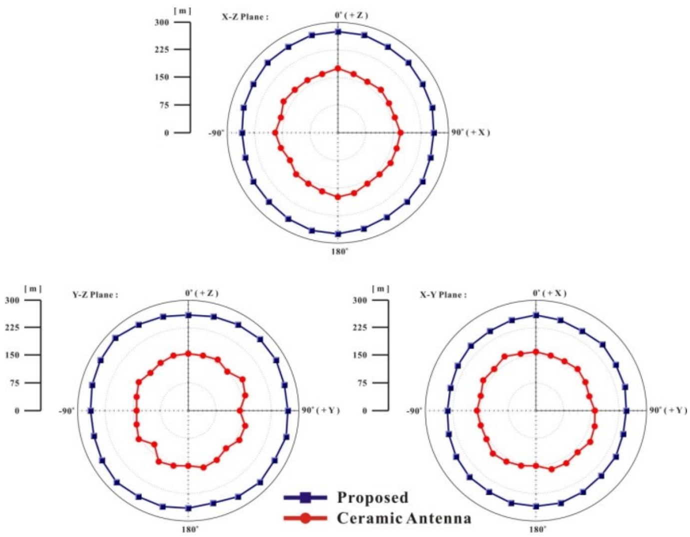


Fig. 4. Measured reading range pattern for the proposed tag at 925 MHz band.

III. Conclusions

A novel compact design of planar tag antenna for UHF RFID system has been proposed. By introducing an L-shaped plate connecting with the spiral monopole antenna, the measured impedance bandwidth of 12 MHz can be more than the required bandwidth of 6 MHz for Taiwan UHF (922 ~ 928 MHz) RFID system. The overall antenna size is only 13 × 9 × 1.6 mm^3. The measured peak gain and antenna efficiency are approximately -1.1 dBi and 27 % for Taiwan UHF band. Meanwhile, the measured reading distance can approach 250 m. Good tag sensitivity is obtained across the desired frequency band.

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