Compact crossed dipole antenna for a broadband UHF-RFID tag

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Abstract— **A planar, inductively coupled, ring-fed, crossed dipole with broadband characteristics is proposed for an ultra-high frequency (UHF) radio frequency identification (RFID) tag. By using an inductively coupled feeding technique, the proposed tag antenna achieves a good conjugate impedance matching with the tag chip and yields a –10 dB impedance bandwidth of 92 MHz (from 870 MHz to 962 MHz). In addition, the antenna has an omnidirectional radiation pattern with the highest gain of 3.5 dBi.**

Keywords: UHF RFID; tag antenna; broadband; compact crossed-dipole; inductively coupled feed; omnidirectional radiation

I. INTRODUCTION

Radio frequency identification (RFID) in the ultra-high frequency (UHF) band is a widespread and rapidly developing technology in many fields of applications, such as object identification, livestock tracking, accessing control, and supply chain management. There are three essential parts in the RFID system: a reader, a tag, and data processing system. It is obvious that the tag plays a key role in the overall RFID system performance because it has substantial effects on the overall size, reading range, and compatibility with the tagged object. The tag antenna must be carefully designed to provide the best conjugate matching condition between the tag chip and the antenna. Recently, the RFID tag antenna design has been described [1–8] with broadband characteristics by using an alternative capacitive-coupled structure [1], double T-matching network for broadband matching [2], a pair of U slots to excite two adjacent resonant modes with similar radiation characteristics [3], dual-layer with four parasitic planar inverted-F antennas [4], and a T-matching network with double symmetrical radiating patches shorted to the ground plane [5]. However, these designs have some drawbacks, such as large size, high thickness due to fabricating on multilayers, and narrow bandwidth.

In this paper, we propose a single layer, compact, broadband, UHF-RFID tag antenna consisting of two dipoles that are orthogonally arranged to each other. The tag antenna is fed by an inductively coupled structure for the broad impedance matching bandwidth [6, 7]. In contrast to the large size of a conventional dipole, two dipoles with each arm containing a meander line and a triangular ending are used to significantly reduce the overall size of the antenna.

II. ANTENNA DESIGN

The geometry of the proposed RFID tag antenna is illustrated in Fig. 1. The antenna is designed on a 60 × 60 mm Rogers RO4003 substrate with a dielectric constant of 3.38, a loss tangent of 0.0027, and a thickness of 0.508 mm. Two dipoles with each arm composed of a meander line and a triangular ending are employed and arranged spatially orthogonal to each other to reduce the size of the antenna [9].

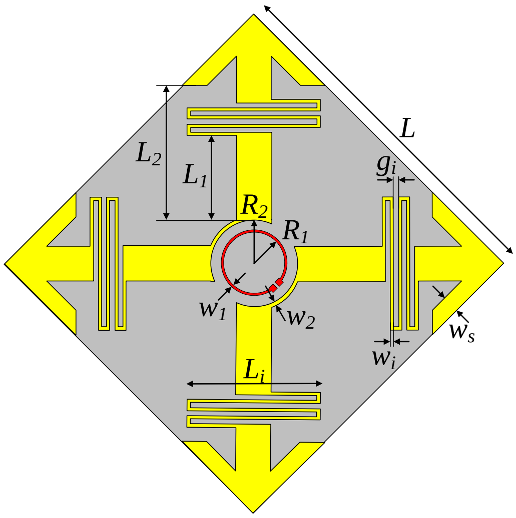


Figure 1. Antenna geometry.

An inductively coupled ring feeding structure for complex conjugate matching between the tag chip and the antenna is applied. The antenna is designed to incorporate a UCODE G2XM chip from NXP Semiconductors, which has an input impedance of 24–j195Ω at 910 MHz. The design of the proposed antenna was carried out by using an ANSYS high-frequency structure simulator (HFSS). The optimized antenna design parameters were chosen for wide impedance matching bandwidth, and its optimize parameters are as follows: L = 61.4 mm, L_1 = 14.9 mm, L_2 = 23.6 mm, L_i = 22.4 mm, w_i = 0.6 mm, g_i = 0.8 mm, w_s = 3 mm, R_1 = 6 mm, w_1 = 0.2 mm, R_2 = 7.6 mm, w_2 = 0.8 mm.

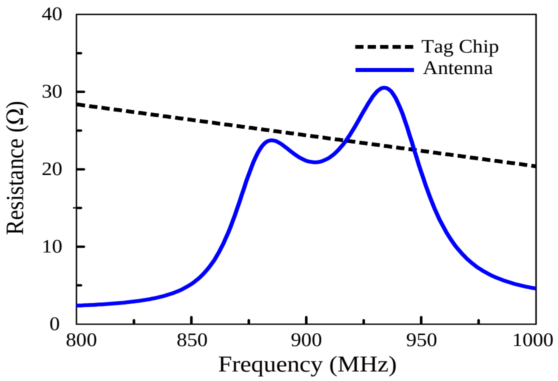
III. SIMULATION RESULTS

In this section, we discuss the performance of the proposed antenna based on the simulation results obtained by using the ANSYS HFSS. The input impedance of the tag antenna and chip with resistance and reactance values are shown in Fig. 2a and Fig. 2b, respectively. Based on the analytical model for the inductively coupled feed, which was investigated in [6], the appropriate size of the ring and the distance from the ring to the crossed dipoles was obtained for the broadband characteristic. Only a small different was observed between the impedance of the antenna and the tag chip, with fluctuations of the resistance and reactance values of 24 ± 5 Ω at 875–950 MHz and 195 ± 8 Ω at 840–980 MHz, respectively. Therefore, the proposed antenna performs fairly good impedance matching in the broadband frequency.

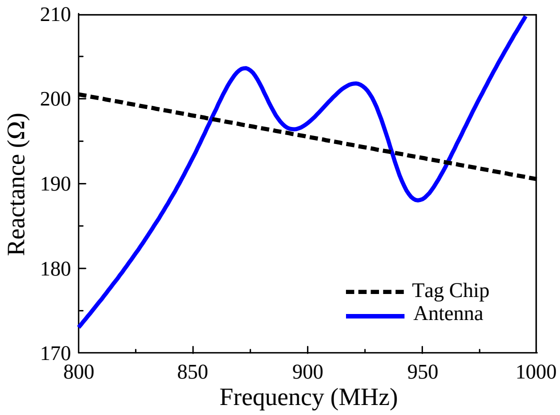
Fig. 3 denotes the simulated reflection coefficient of the optimized design, which was determined by using the following formula:

$$\left|S_{11}\right| = -20\log\left|\frac{Z_a - Z_c^*}{Z_a + Z_c}\right|$$

where Z_a is an input impedance of the antenna and Z_c is an impedance of the tag chip. The best conjugate match with the smallest difference between Z_a and Z_c occurred at 889 MHz where the values of Z_a and Z_c were 23.38 + j196.96 Ω and 24.48 – j196.05 Ω, respectively.



(a) Resistance



(b) Reactance

Figure 2. Simulated input impedances of the proposed tag antenna.

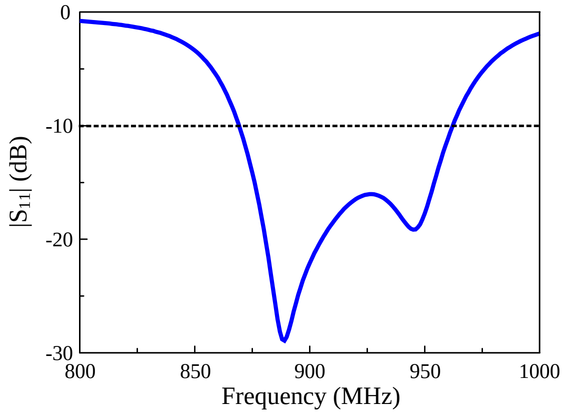


Figure 3. Reflection coefficient $|S_{11}|$ of the proposed tag antenna.

Fig. 4 shows the radiation pattern at the center frequency of 915 MHz in the ϕ = 45°, ϕ = 135°, and θ = 90° planes. The antenna radiated almost uniformly in all directions in the ϕ = 45° plane with the highest directivity of 3.5 dBi. Meanwhile, in the ϕ = 135° plane, the radiation pattern was directional, and the highest directivity was 1.71 dBi at θ = 0º, 180º and the lowest directivity was –12.25 dBi at θ = ±90º. The radiation pattern in the θ = 90º plane had the highest directivity of 3.5 dBi at ϕ = –45º and the lowest directivity of –33 dBi at ϕ = 45º, 225º. Therefore, the proposed antenna demonstrated a good omnidirectional radiation pattern with respect to the ϕ = 45° plane.

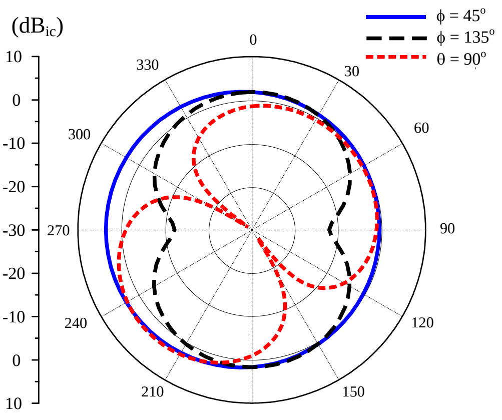


Figure 4. Simulated radiation pattern at 915 MHz.

IV. CONCLUSIONS

An RFID tag antenna with broadband characteristic is proposed for the UHF-RFID band. The antenna is composed of two orthogonal dipoles and an inductively coupled ring-fed matching network. The optimized structure was presented and simulated to have good conjugate matching to a UCODE G2XM commercially available tag chip. The broadband characteristic is illustrated through the –10 dB impedance bandwidth of 92 MHz, and the antenna has an omnidirectional radiation pattern with the highest directivity of 3.5 dBi. According to the simulated results, the proposed antenna conforms to the required conditions and is completely appropriate for RFID applications.

REFERENCES

[1] C. C. Chang and Y. C. Lo, "Broadband RFID tag antenna with capacitively coupled structure," *Electron. Lett.*, vol. 42, no. 23, pp. 1322–1323, Nov. 2006.

[2] C. Cho, H. Choo, and I. Park, "Broadband RFID tag antenna with quasi-isotropic radiation pattern," *Electron. Lett.*, vol. 41, no. 20, pp. 1091–1092, Sep. 2005.

[3] L. Mo, H. Zhang, and H. Zhou, "Broadband UHF RFID tag antenna with a pair of U slots mountable on metallic objects," *Electron. Lett.*, vol. 44, no. 20, pp. 1173–1174, Sep. 2008.

[4] J. Zhang and Y. Long, "A dual-layer broadband compact UHF RFID tag antenna for platform tolerant application," *IEEE Trans. Antennas Propag.*, vol. 61, no. 9, pp. 4447–4455, Sep. 2013.

[5] L. Xu, B. J. Hu, and J. Wang, "UHF RFID tag antenna with broadband characteristic," *Electron. Lett.*, vol. 44, no. 2, pp. 79–80, Jan. 2008.

[6] H. W. Son and C. S. Pyo, "Design of RFID tag antennas using an inductively coupled feed," *Electron. Lett.*, vol. 41, no. 18, pp. 994–996, Sep. 2005.

[7] J. Ahn, H. Jang, H. Moon, J. W. Lee, and B. Lee, "Inductively coupled compact RFID tag antenna at 910 MHz with near-isotropic radar cross-section (RCS) patterns," *IEEE Antennas Wireless Propag. Lett.*, vol. 6, pp. 518–520, 2007.

[8] C. Cho, H. Choo, and I. Park, "Printed symmetric inverted-F antenna with a quasi-isotropic radiation pattern," *Microwave Opt. Technol. Lett.*, vol. 50, no. 4, pp. 927–930, 2008.

[9] S. X. Ta, H. Choo, and I. Park, "Planar, lightweight, circularly polarized crossed dipole antenna for handheld UHF RFID reader," *Microwave Opt. Technol. Lett.*, vol. 55, no. 8, pp. 1874–1878, Aug. 2013.