Meandering Cross Dipole Antenna for RFID Applications

Wei He [1, 2], #Yejun He [1] and Hang Wong[2]

[1]Shenzhen Key Lab of Advanced Communications and Information Processing, College of Information Engineering, Shenzhen University, 518060, P. R. China

[2]Shenzhen Key Lab of Millimeterwave and Wideband Wireless Communications, Information and Communication Technology Center, Shenzhen Research Institute, City University of Hong Kong, 518057, P.R. China

#Corresponding author: heyejun@126.com

Abstract

A circularly polarized (*CP*) *UHF RFID tag antenna is proposed in this paper. This antenna is realized by a meandering cross dipole. The meandering structure of the dipole could adjust amplitudes and phases from the two orthogonal arms of the cross dipole such that a CP frequency would be generated by the mutually-orthogonal mode. Therefore, we can achieve CP operation from the tag. The maximum transmitted power can be obtained when the input impedance of the tag is conjugate-match with the impedance of the RFID chip. A special matching structure is employed in this design to control the input impedance of the tag. This tag antenna is designed to cover whole UHF band* (840-960 MHz), *and its* 3-dB *axial-ratio* (*AR*) *bandwidth is* 43 MHz (905-948 MHz).

***Index Terms*—circularly polarized, tag antenna, dipole antenna, radio frequency identification (RFID).**

1. INTRODUCTION

Radio Frequency Identification (RFID) is a kind of contactless automatic identification technology based on radio frequency principle. Utilizing radio frequency (RF) signals and their spatial coupling and transmission characteristics, RFID technology drives RFID tag circuit to launch its storage displacement encoder, automatically identify stationary or moving targets, and efficiently get targeting information and data. The combination of RFID technology with the Internet and wireless communications network can achieve the tracking of goods and sharing of information worldwide. Therefore, it has broad applications in many areas such as the logistics supply chain, production automation, public information services, traffic management and tracking applications.

In recent years, radio frequency identification (RFID) in the ultra-high-frequency (UHF) band has become popular in many applications [1]. With the extensive use of radio frequency identification (RFID) technology in the ultra-high frequency (UHF) band (840-960 MHz), various RFID tag antenna has been studied such as broadband tag antennas, anti-metal tag antennas, dual-band tag antennas and so on. The tag antenna is one of the key components in the RFID system, and it is commonly designed in the commercial domain as a dipole type or microstrip type [2]–[4] with linear polarization (LP) in the UHF-band. Currently, the reader antenna with circular polarization (CP) is employed in most of commercial UHF band RFID applications to increase orientation diversity. Recently, some RFID tags exhibited CP radiations are proposed [5] – [6]; however, their impedance bandwidth and axial ratio bandwidth are very narrow. The 3-dB axial-ratio (AR) bandwidth of these CP tags was less than 20 MHz and the impedance bandwidth (for S11 ≤ –10 dB) was less than 50 MHz.

In this paper, we propose a new passive circularly-polarized RFID tag antenna in UHF band. The antenna consists of radiating part and match structure. we can make the input impedance of the tag antenna conjugate match with the impedance of the tag chip by adjust the matching structure [7], so as to achieve maximum transmitted power. The impedence bandwidth of the proposed antenna covers the whole UHF band (840 MHz-960 MHz), and its 3-dB axial ratio bandwidth is around 43MHz (905 MHz-948 MHz).

2. ANTENNA DESIGN

The geometry of the proposed passive circularly-polarized RFID tag is shown in Fig. 1. The tag is designed for operating from 840 to 960 MHz, and fabricated on a FR4 substrate with a thickness of 2 mm, a relative permittivity of 4.4, and a loss tangent of 0.02. The size of the whole tag is 96×96 mm^2. A cross dipole has a pair of unbalanced arms. One arm is formed in a meandering structure, and other is straight with a cap loaded. In this manner, the tag can excited two orthogonal mode from the dipole and results in having a CP operation. A RFID chip from Impinj's Monza-4 is chosen. Its input impedance is $Z=4.9–j69.8$ (Ω) at 915 MHz. In order to make the impedance of the antenna is matched with the chip , a match structure have been added to the proposed tag. The match structure is shown in Fig. 2. Details of the design parameters are listed in Table I.

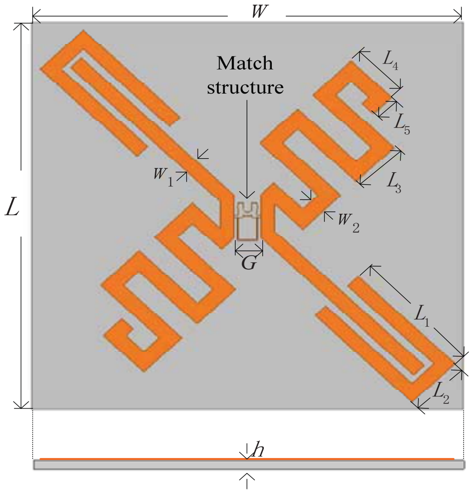


Fig. 1: Antenna structure.

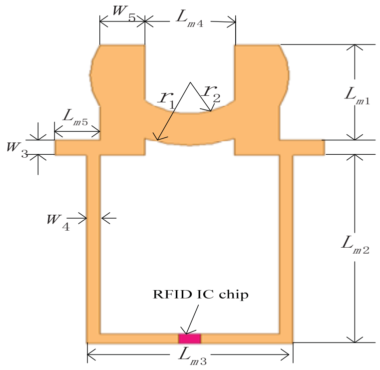


Fig. 2: Match structure.

Table I: The design parameters (unit:mm)

L	L_1	L_2	L_3	L_4	L_5	L_{m1}	L_{m2}	L_{m3}	L_{m4}
96	30.5	13.5	12	12.8	5.8	3.5	6	4.6	2
L_{m5}	w	w_1	w_2	w_3	w_4	w_5	r_1	r_2	G
1	96	3.3	3.6	0.5	0.3	1	3.2	2.2	6

3. Simulation Result and Discussions

The design and development of the proposed tag antenna was achieved by using the commercial EM software HFSS. In addition, we used the ADS software to draw the equivalent circuit for the RFID chip, Monza-4, and tested it. From the simulation, the impedance of the chip is $Z = 4.9 - j69.8$ (Ω) at 915 MHz as shown in Fig. 4 (a) and Fig. 4 (b). Therefore, the design goal of the UHF passive tag should be $Z = 4.9+j69.8$(Ω) at 915MHz.

In the following simulation, two parameters W_4 and L_{m2} were varied to obtain the best matching for the chip impedance. In Fig. 5 and Fig. 6, the optimal values for W_4 and L_{m2} should be around 0.3mm and 6mm, respectively. And thefinal input impedance of the tag is $Z = 4.8 + j70$ (Ω).

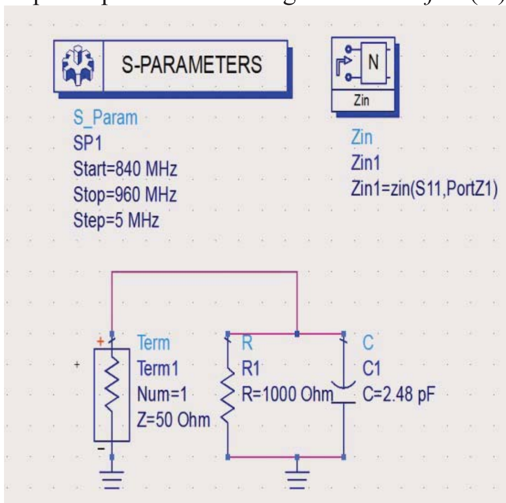


Fig. 3: The equivalent circuit diagram of RFID IC chip.

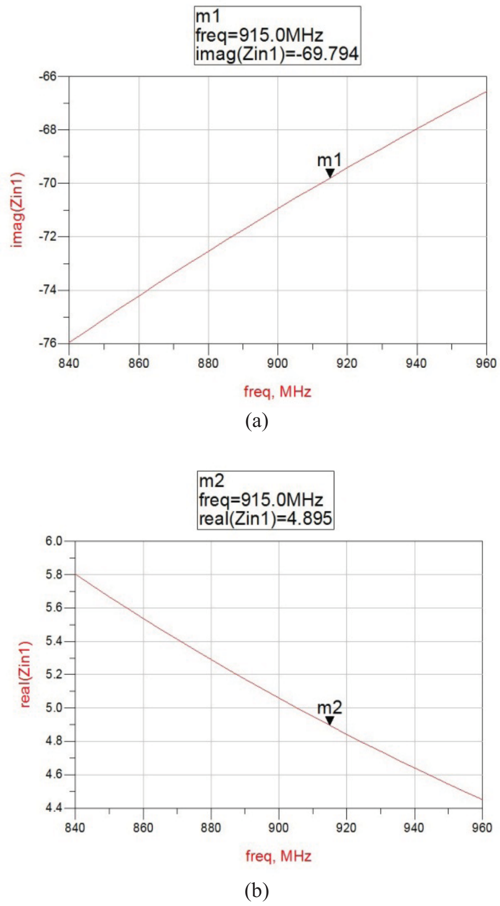
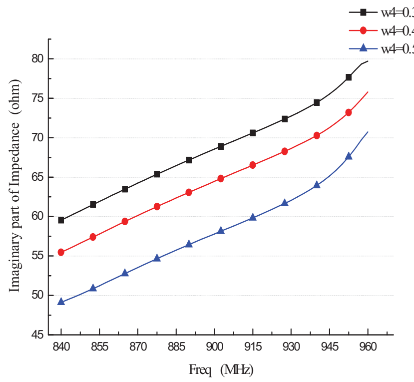
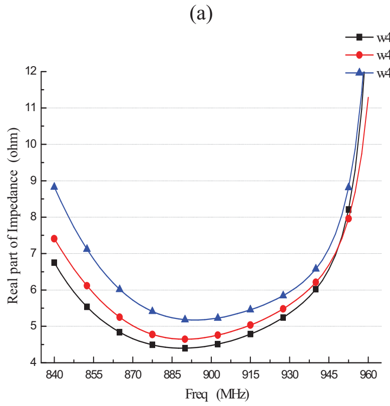


Fig. 4: The impedance of Monza-4 at different frequency. (a) Imaginary part (reactance). (b) Real part (resistance).

Figure 7 shows the input impedances of the tag and the chip. The curve of reflection coefficient (dB) of the proposed tag is shown in Fig. 8. The axial ratio and radiation pattern of the right-hand circularly polarization are shown in Fig. 9 and Fig. 10, respectively.

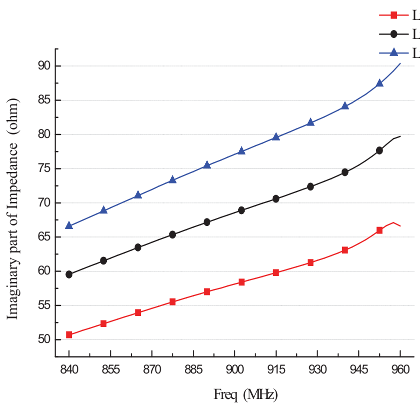


(a)



(b)

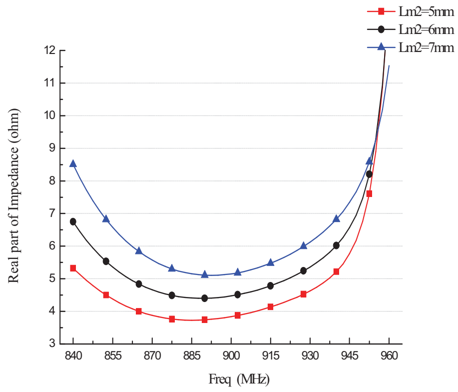
Fig. 5: The variation of antenna impedance with different W_4 at L_{m2}= 6 mm. (a) Imaginary part (reactance). (b) Real part (resistance).



(a)

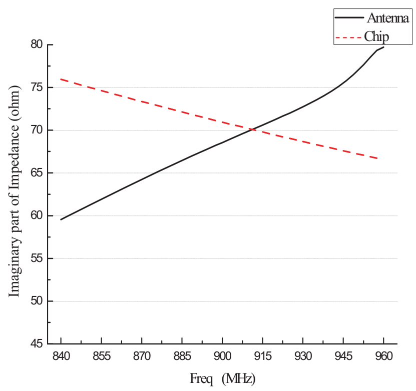
4. CONCLUSION

A circularly polarized RFID tag antenna in UHF band was proposed. Good radiation performance is obtained from simulations. This proposed tag has very broad impedance bandwidth, which covers the required RFID UHF band. Moreover, it has good CP characteristics. The proposed tag antenna can be applied in wireless communication systems.

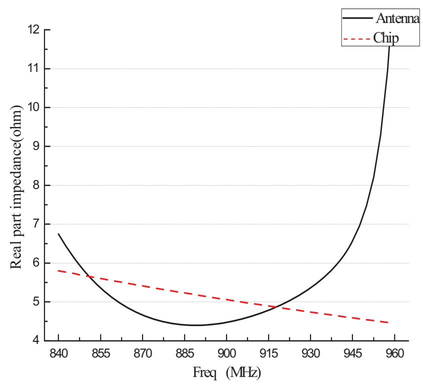


(b)

Fig. 6: The variation of antenna impedance with different L_{m2} at W_4 = 0.3 mm.(a) Imaginary part (reactance). (b) Real part (resistance).



(a)



(b)

Fig. 7: Impedance of tag antenna and chip. (a) imaginary part (reactance) . (b) Real part (resistance).

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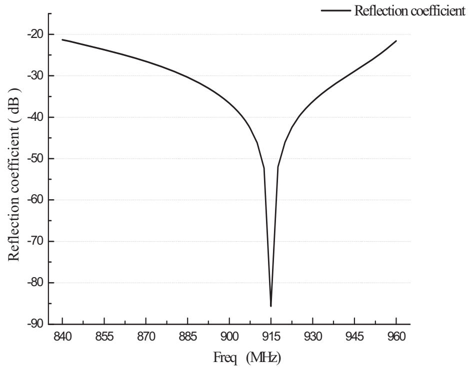

Fig. 8: Reflection coefficient of the tag antenna.

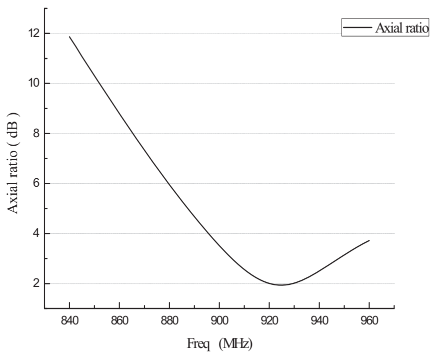

Fig. 9: Aixal ratio of the antenna.

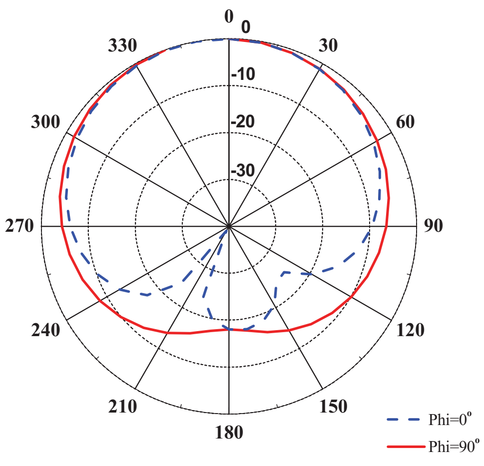

Fig. 10: Radiation pattern of the antenna.

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