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| Author(s) | MA, Z; Jiang, L; Xi, JT; Ye, TT |
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A Compact HF/UHF Dual Band RFID Tag Antenna

Zi Long Ma
 Department of Electrical and
 Electronic Engineering
 The University of Hong Kong
 Hong Kong
 Email: zlma@eee.hku.hk

Li Jun Jiang
 Department of Electrical and
 Electronic Engineering
 The University of Hong Kong
 Hong Kong
 Email: jianglj@hku.hk

Jingtian Xi
 and Terry Tao Ye
 The Hong Kong R&D Centre for Logistics
 and Supply Chain Management Enabling Technologies
 Hong Kong

Abstract—This paper presents a novel dual band RFID (radio frequency identification) tag antenna. Two challenges are faced: the compact dimension and the impaired bandwidth due to the couplings between two band structures. A spiral coil is designed to handle the HF (13.56MHz) near field coupling, and a diagonal symmetric design consisting of two meander lines are placed inside the coil for UHF band (915MHz). This structure supports multiple resonance modes around 915MHz to broaden the working bandwidth under the large inductive circumstance from the HF coil. The proposed antenna is easy to adjust by both coarse tuning and fine tuning. Its overall dimension is of a credit card size on a single layer thin substrate.

I. INTRODUCTION

Frequency identification (RFID), as a fast growing technology in recent years, has been applied in many areas. In terms of operating frequency bands, HF and UHF are widely applied in short and long distance reading applications, respectively. For special cases, such as highway tracking and tolls, both short and long distance are needed. Hence, a single RFID card with dual standards is demanded. From academic point of view, the design of a dual band antenna with nearly 70 times frequency difference is also an interesting challenge. Some researches have been conducted in the past few years[1]-[2]. Mono feeding port type and dual feeding port type were discussed. For the dual feeding port type, the spiral coil and meander line dipole are used as the HF antenna and the UHF antenna, respectively. Due to the existence of large inductive coil, the quality factor Q is very high. For serial circuits, $Q = \omega_0 L/R$, and the bandwidth is proportional to $1/Q$. The larger the L , the narrower the bandwidth. Placing UHF antenna inside the coil can reduce the whole antenna dimension. But its narrow bandwidth becomes an issue to be solved. Some broadband dipole structures were also discussed before. In [3], a broadband structure consisting of two meander line dipoles is showed.

II. ANTENNA STRUCTURE

The proposed antenna structure is showed in Fig. 1. HF antenna is a spiral coil with $W_c = 51.4$, $L_c = 83.6$, $D = 0.4$, and $t_1 = 0.6$. The UHF antenna structure parameters are $W_d = 36$, $L_d = 68$, $D_x = 2.2$, $D_y = 2.2$, $D_1 = 2.3$, $D_2 = 3.8$, $D_3 = 2.5$, $D_4 = 4$, $D_c = 2$, $M_1 = 14$, $M_2 = 26$, $M_3 = 4$, $M_4 = 4$, $M_5 = 6$, $W = 9$, $A = 6$, $B = 6$, $S = 4$, $t_2 = 1$, $W_p = 2$ and $L_p = 2$. All dimensions are in mm. It should be noted that

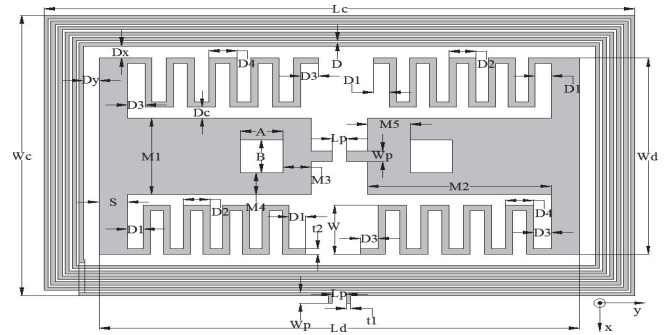


Fig. 1. The proposed antenna structure.

the UHF antenna is a diagonal symmetric structure. D_1 and D_2 are different from their counterparts D_3 and D_4 . We use FR4 ($\epsilon = 4.2$, $\tan \delta = 0.02$) as substrate with the dimension of $85 \times 54 \times 0.8$ mm³.

III. ANTENNA DESIGN AND ANALYSIS

A. HF and UHF Band Antenna Design

In the HF frequency band, 13.56MHz antenna operates as the near field coupling antenna. The LC resonance relationship can be obtained by microchip's impedance and external spiral coil. The microchip's impedance is equivalent to a 17pF capacitor. Hence, the external coil provides needed inductance. The suitable equivalent inductor of resonance can be achieved by adjusting dimensions of the coil. Due to existence of extra coupling capacitances in reading process, we set the resonance frequency without contact a little higher than 13.56MHz. At 13.56MHz, the simulated and measured input impedances are $2.4 + j544\Omega$ and $5.4 + j519.8\Omega$, respectively.

The UHF antenna design is mainly focused on solving the narrow band issue under large inductance and high quality factor circumstances. Fig. 2 shows the input impedance comparison with and without external coil. It's obvious that the external coil increases the inductor of the UHF antenna.

For UHF design, our motivation is to build up a structure that has multiple mode. Then two of them are excited through adjustments. To add more adjustment capability and ensure multi modes, this structure in Fig. 1 is proposed. The meander lines' dimensions are diagonally identical. Each two opposite

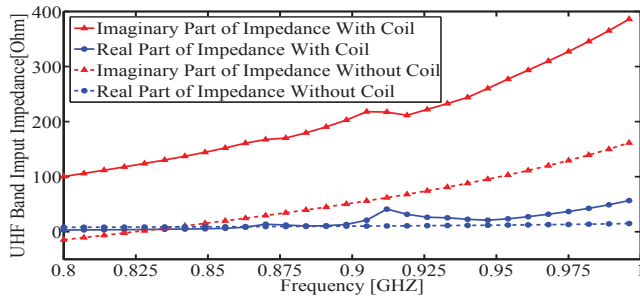


Fig. 2. The input impedance comparison with and without external coil.

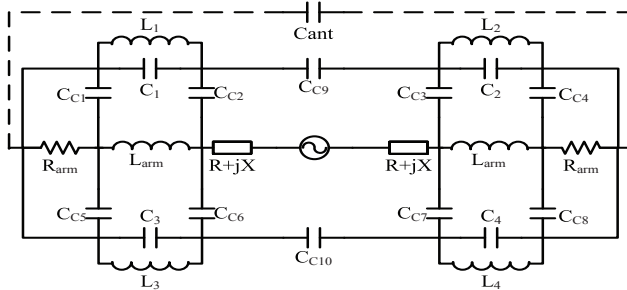


Fig. 3. The equivalent circuit of the design at the UHF band.

meander lines parallel along y axis are different in dimensions. This ensures multiple resonance modes. According to the antenna design, the equivalent circuit model is given in Fig. 3. From the structure and its equivalent circuit model, it is easy to excite multiple resonance modes in this antenna. By adjusting four meander lines' dimensions, two adjacent resonance modes around 915MHz can be easily obtained. Fig. 4 shows the simulated and measured reflection coefficients. From the comparison, the simulated and measured data appear to be in a good agreement. Two obvious resonance peaks can be observed. The bandwidth is thereby broadened. The measured bandwidth is around 40MHz. The measured reading range is showed in Fig. 5.

B. Impedance Matching

In this design, we expand the width of main arm patches to conduct the coarse tuning and use rectangle slots to conduct the fine tuning. Fig. 6 shows impacts of the arm width and two slots' dimensions. From this figure, when $M_1 = 7$ mm, $A = B = 6$ mm, the reflection coefficient curve is relatively smoothen and the difference between two peaks is minimum.

IV. CONCLUSION

This paper presents a novel single layer compact RFID tag antenna, which operates in both HF (13.56MHz) and UHF (915MHz) bands. It features the credit card compact size, low cost and easy fabrication. Both operation principles in the HF and UHF band are analyzed and discussed. It solves the narrow band issue under the large inductive circumstance by using two adjacent UHF resonance modes. For the impedance

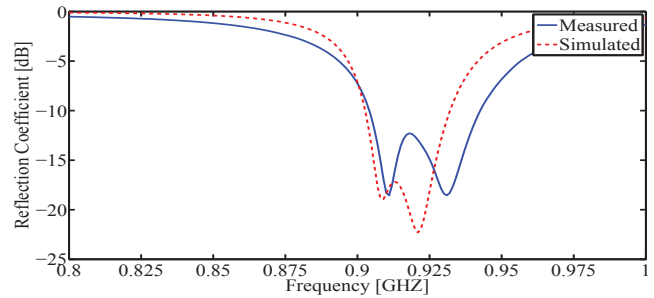


Fig. 4. Simulated and measured reflection coefficient of the antenna at the UHF band.

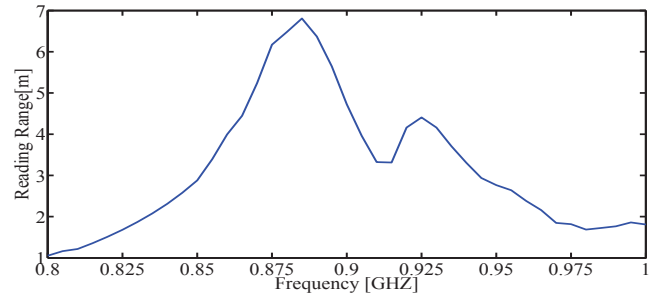


Fig. 5. Measured reading range.

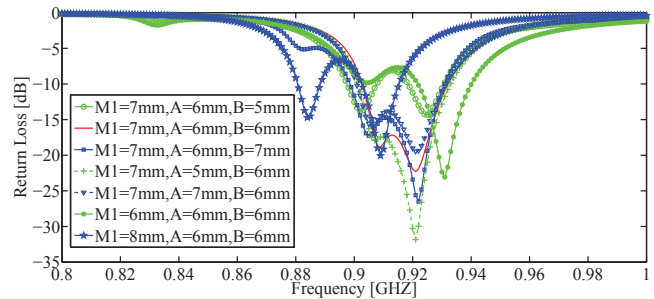


Fig. 6. Reflection coefficient for various main arm pathes width M_1 , slot length A and slot width B .

matching, the methods of coarse tuning and fine tuning are also presented. Through practical manufacture and measurement, this antenna shows very good performance.

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