Research on Printable Chipless Slot-Loaded RFID Tags

Xiao Xiao Liu and Xian Qi Lin

Abstract—**In this project, novel and practical chipless RFID tags have been proposed and then fabricated. The structures of chipless tags originate from the following two schemes. One is to design chipless RFID tags made of metal patches loaded with slots. The other is to design chipless RFID tags consisting of a receiving antenna and a transmitting antenna, both of which are loaded with slots. Specifically, in terms of chipless RFID tags made of metal patches loaded with slots, several types of slot structure are proposed and analyzed. As a result, a chipless tag with semicircle slots is chosen for its good performance and practical applicability. Moreover, the testing procedure and results are discussed in detail, as well as the market prospect of the proposed chipless tags. Since our proposed chipless RFID tags have many advantages over the present widely-used barcode, while at the same time keep a low cost, thus it is possible to occupy the prevailing market. There exists not only novelty but also practical engineering value in this project.**

***Keywords*—RFID, chipless tags, slot-loaded, tags, barcode**

I. Introduction

Radio-frequency identification (RFID) is a wireless data capturing technique that utilizes radio frequency (RF) waves for automatic identification of objects. An RFID tag or transponder, which contains the identification code, serves as one of the major components in a typical RFID system. However, the large cost of the silicon chip in conventional RFID tags has restricted the wide-spread use of RFID technology in market, and little progress will be made unless chipless RFID technology based on simple production facilities are introduced[1].

The project focuses on the design and fabrication of a new type of chipless RFID tag with high practical value, and explores how to achieve small size, more than 8-bit coding, printable benefits, non-directional characteristics while at the same time meeting the requirements of low cost. Therefore, this study has both theoretical and quite innovative engineering value.

The study consists of three parts. The first part is to design chipless RFID tags consisting of metal patches with several different types of slots. The second part is to design a chipless RFID tag consisting of slot-loaded transmitting and receiving antennas. The third part is to investigate the practicability of the designed and fabricated tags by measuring their performance in some simulated circumstances.

A. Slot-loaded chipless RFID tags with metal patches

Three types of loading slots have been investigated in this part, which are line slots, U slots[2] and semicircle slots respectively. Among these three semicircle slot-loaded chipless tags shows the most remarkable performance in data capacity, coding accuracy and small dimensions. By combining two schemes, complementary length of slots and dual polarization of slots, we managed to design a semicircle slot-loaded tag with excellent performance such as easy fabrication, as large as 16-bit data capacity, low cost, small size, and convenient coding mechanisms.

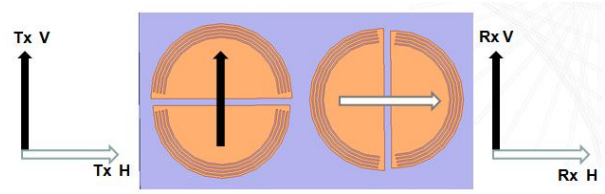


Fig. 1 A 16-bit dual-polarization chipless RFID tag.

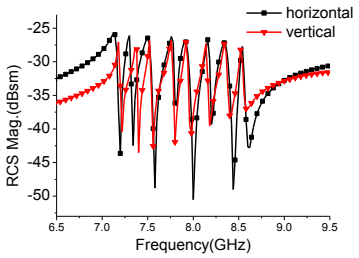


Fig. 2 Comparison of the frequency response of horizontal slots and vertical slots when encoded as “11111111”.

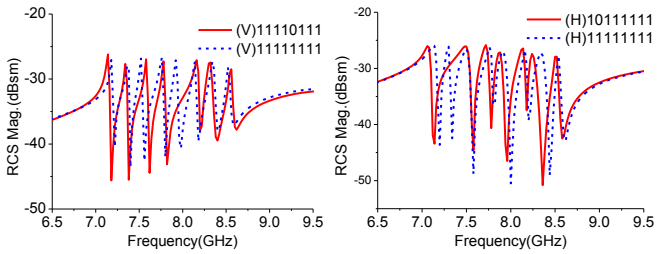


Fig. 3 Simulation results of (V) 111101111 (H) 10111111.

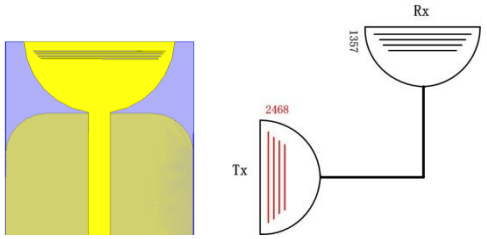
The structure of the 16-bit semicircle slot-loaded chipless RFID tag is shown in Fig. 1. By shorting some of the resonant slots, we are able to conveniently change the corresponding coding from "1" to "0", which will not affect the frequency response of other tag with perpendicular polarization direction. Fig. 2 shows the total 8 peak in the frequency domain of horizontal slots-loaded and vertical slots-loaded tags that are encoded as “11111111”. It can be seen that the frequency

The authors are with the EHF Key Laboratory of Fundamental Science, School of Electronic Engineering, University of Electronic Science and Technology of China (UESTC), Chengdu, 611731, China.

response of these two polarization slots have high similarity as expected. Fig. 3 is the simulation results under the coding of (V)111101111(H)10111111 as a demonstration of the coding ability of this tag. Apparently this tag has reliable and stable coding performance.

B. Chipless RFID tags consisting of slot-loaded transmitting and receiving antennas.

First we design a half disc-loaded ultra-wideband monopole antenna to serve as our transmitting and receiving antenna. The configuration of the antenna is shown in Fig. 4(a). The tag consists of two antennas acting as transmitter and receiver respectively. Each of these two antennas is line slots-loaded[3]. Besides, the length of these slots is complementary so that the frequency density is doubled. The schematic diagram of the tag is shown in Fig. 4(b). It is an 8-bit chipless tag with dual polarization.



(a) (b)

Fig. 4 (a) Configuration of the designed half disc-loaded ultra-wideband monopole antenna. (b) Schematic diagram of the slot-loaded chipless tag.

The simulation results are achieved by simulating the system shown in Fig. 5. The S_{21} curve of reader Tx and Rx is used to reflect the coding information.

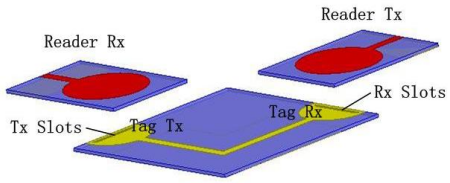


Fig. 5 Chipless RFID system general view.

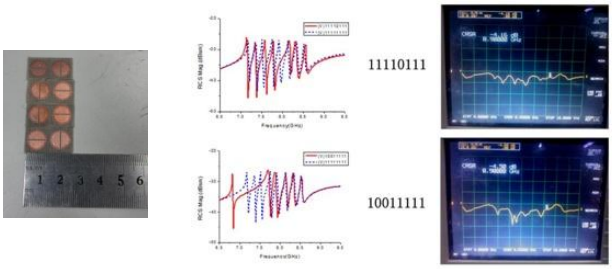
C. Testing and application analysis.

Fig. 6(a) is the picture of the real products of the chipless RFID tags designed in part 1. A near-field waveguide testing platform is designed to measure their coding performance. The measuring results of two codes are shown in Fig. 6(b).

The chipless tag designed in the second part is measured by virtue of a system shown in Fig. 7 and the comparison of simulation results and measuring results is shown in Fig. 8.

II. CONCLUSIONS

The advantages of our designed semicircle slot-loaded chipless RFID tags are as follows. 1) The cost is below \$0.01. 2) The dimension is as small as 2.45cm×1.3cm, while the data capacity is as large as 2^{16}. Thus the coding density is extremely high. 3) The tag is completely printable, which significantly simplify the fabrication process. 4) The working frequency band is 7.5-9.5GHz, with a high spectral density.



(a) (b)

Fig. 6 (a) Picture of four semicircle slot-loaded chipless RFID tags. (b) Measuring results of “11110111” and “10011111”.

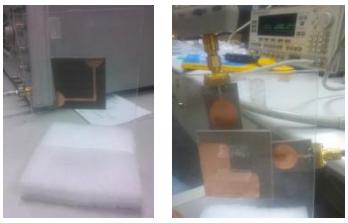


Fig. 7 Testing platform consisting of reader Tx and Rx.

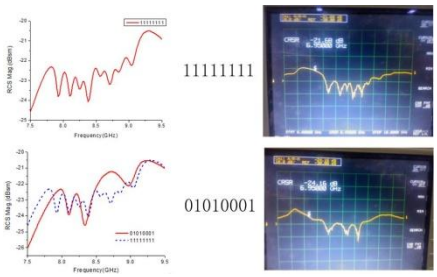


Fig. 8 Comparison of simulation results and measuring results of the chipless RFID tag consisting of slot-loaded transmitting and receiving antennas.

III. MY CAREER PLANS

Now I am studying in University of California, San Diego as a graduate student majoring in Electrical Circuits and System. I am now taking courses on Microwave Electronic Circuits and also Antenna Design. I really appreciate the help and encouragement provided by MTT-S Scholarship program, making me keep discovering the beauty of Microwave Engineering.

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