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Coding of Chipless RFID Tag using Multiresonator

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Abstract

This research presents the design and simulation of chipless RFID tag based on retransmission. Chipless RFID tag design using inverted L-shaped multi-resonator is proposed in this research. The coding capacity of the tag is 10 bits and the design is simulated using FR4 substrate. Total of 2^(10) individual data can be encoded through the proposed design. Occupied frequency range of the design is from 2 GHz to 4 GHz. Chipless RFID tags have its wide applications due to its low cost and compact structure. The printed versions of this tags can be effectively employed in supply chain management for industries.

Keywords: RFID, Chipless RFID Tag, Multiresonators, Retransmission

1. Introduction

RFID (Radio Frequency Identification) technology was one of the modes of wireless communication emerged in early 1970's to identify and track objects. An RFID system comprises of an RFID reader and an RFID tag. RFID system works on the principle of retransmission. The Reader (also called as interrogator) will transmit the radio waves and is made incident on the RFID tag [11]. Each tag will generate a unique code indicating its identity. The incident radio waves will be modified based on the design in the tag and retransmitted to the reader. Thus, the reader identifies the objects based on the information received. Similarly, RFID tags were effectively used in several commercial and industrial applications to identify and track objects attached to it. Majorly, RFID tags were used as a successful alternative to

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barcodes as RFID's does not require line of sight communication. RFID tags are classified into active, semi passive and passive tags based on power requirement.

Chipless RFID tags are the passive tags that neither have power source nor IC's for memory storage. Basically, a chipless tag consists of a data transmission unit and the coding unit. Data transmission unit consist of antennas to receive and transmit the tag information. Whereas the coding unit is used to modify the received input signal uniquely through its geometric shape and structure Sohrab Majidifar et.al [1]. Coding in chipless RFID tags can be implemented in three domains (time, frequency, phase) Yun Jing Zhang et.al [2]. Tags coded in time domain works based on the principle of Surface Acoustic Waves (SAW). Time coded tags can be printed only on piezoelectric substrates. Because SAW can be generated only through them. Piezo electric substrates are costly and so time coded tags can't be used for low cost applications Maximilian Pöpperl et.al [3]. In frequency domain, spectral signatures are generated based on two methods such as backscattering and retransmission. In backscattering, the coding information from the tag is determined by the resonating elements present and the backscattering signals represent the pattern of unique information Fangming Denga et.al [4]. The geometric pattern of the resonating elements ensures a frequency selective reflection spectrum when the tag is exposed to the incident electromagnetic wave Hui-fen Huang et.al [5]. Another concept is generating spectral signature using multiresonator. The multiresonator is a set of cascaded resonators on the transmission line which is designed to resonate at various resonant frequencies and create respective stop bands Nijas R et.al [6]. According to the design theory, placing several microstrip resonators over the 50 Ω microstrip transmission line would either represent the functionality of bandstop filter or bandpass filter Zhonghua Ma et.al [7]. By altering the features of the tag's shape, size, and composition, chipless RFID sensing tags can be made to resonate in a certain frequency band. Thauda, Tharindu A., et al. [8]. The fundamental component of a chipless RFID tag is the resonance frequency response because changes in the input signal result in a coded pattern. Rashmi A et.al [9]. Tags designed based on multiresonators requires antennas for transmitting the input signal to the tag and to retransmit the signal to the reader. Ultrawide band antennas such as monopole antennas are widely used as transceiving antennas as the RFID tags have to transmit wide spectrum of data Salemi Het.al [10].

The research is organized in such ways that in section 1, the basic working principle of chipless RFID tags are discussed. Section 2 proposes the novel coding of chipless RFID tag using inverted L-shaped multiresonator. Section 3 discusses on the results obtained, followed by conclusion and future work in section 4.

2. Working Principle of Chipless RFID Tag based on Multiresonator

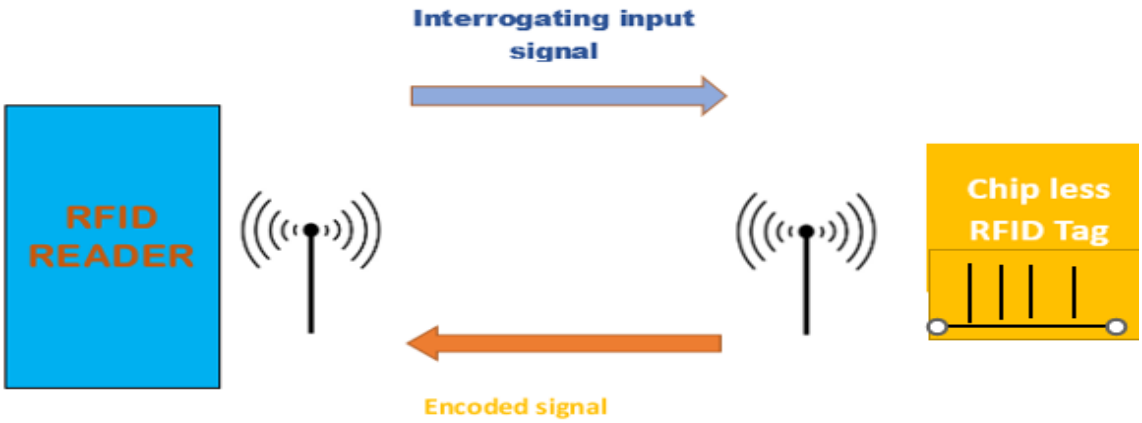

Figure 1. Principle of Retransmission based RFID Tag without Microchips

Frequency coding of chip less RFID tags can be done in two ways:

(i) Backscattering

(ii) Retransmission using Multiresonator.

This section discusses on the second method of coding. The above figure.1 represents the method of designing chipless RFID tags using multiresonator. In this method, chip less tag is coded based on the placement of resonators on the transmission line. Spectral signature will be generated based on the existence or absence of resonators on transmission line. It also depends on other parameters including geometric structures (size and shape) of the resonators. The incident radio waves from the RFID reader will be modified based on the resonator's presence or absence on the Tx line and retransmitted to the reader. Each chip attached to the objects will have unique resonator patterns. Thus, the RFID reader will detect the objects based on the uniquely encoded signal received from the tag.

3. Coding of Chipless RFID Tag using Multiresonator

Coding of chipless RFID tag using inverted L-shaped multi-resonator is proposed in this research. “coding capacity” is 10 bits. Tags are coded based on the presence or absence of resonators. Designing of resonators is implemented based on microstrip line theory.

Eqn (1) and eqn (2) gives the lengths of resonators at phase of 90 and 180 degrees respectively.

$$L = \lambda g/4(90^{o}\text{Txline}) \quad (1)$$

$$L = \lambda g/2(180^{o}\text{Txline}) \quad (2)$$

$$\lambda g = \lambda/\sqrt{\varepsilon}\, eff \quad (3)$$

$$\lambda = C/f \quad (4)$$

f = resonant frequency of the resonators. With these equations, the length of the resonators can be calculated at desired frequencies. The resonators designed with eqn (1) will have lower lengths than the resonators designed with eqn (2). It is because the length of resonators designed through half wave line ($\lambda_g/2$) will be double that of the length of resonators designed through quarter wave line ($\lambda_g/4$). Hence in order to reduce the size of the tag, $\lambda g/4$ transmission line and multiresonator using $\lambda_g/4$ are chosed. The substrate chosen for simulation is FR4. The substrate parameters are as follows in table I. The $\lambda_g/4$ transmission line is designed at 2.4 GHz and the length (L) and width (W) of the transmission line is 17mm and 3mm respectively (fig 2).

Table 1. Substrate Parameters

Parameters	Values(mm)
“Dielectric constant”(εr)	4.4
“Tangent loss”(tanδ)	0.01
Substrate Thickness(H)	1.6 mm
Conductor Thickness (T)	0.035 mm

Inverted L-Shaped resonator structure will doublely decrease the tag size. It is because designing the inverted L – shape by bending the resonators will reduce the length by half. Figure 2 gives the layout design of chipless RFID tag using inverted L-shaped multiresonator. The widths of the resonators are chosen to be 0.5mm.

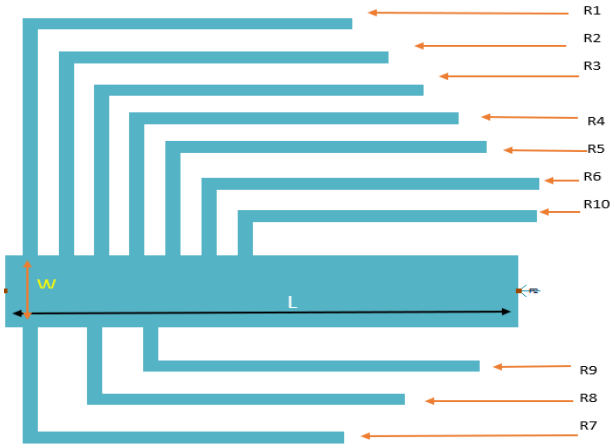

Figure 2. Block Diagram of Inverted L-shaped Multiresonator

Table 2 gives the inverted L shaped resonators length. Resonators are designed in the frequency range from 2 to 4 GHz. The bandwidth occupied by the Multi-resonator design is 2 GHz.

Table 2. Length of Resonators

Resonators	Length(mm)
R1	20.4
R2	19
R3	17.75
R4	16.47
R5	15
R6	14.6
R7	14.04
R8	13.4

R9	12.6
R10	11.28

4. Results and Discussion

The software used for designing the tag is ADS version 20. Layout design of the inverted L-shaped Multiresonator is given in figure 3.

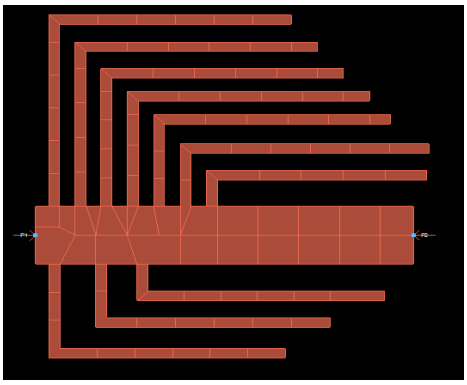

Figure 3. Layout Design of Inverted L-Shaped Multi-Resonator in ADS Software.

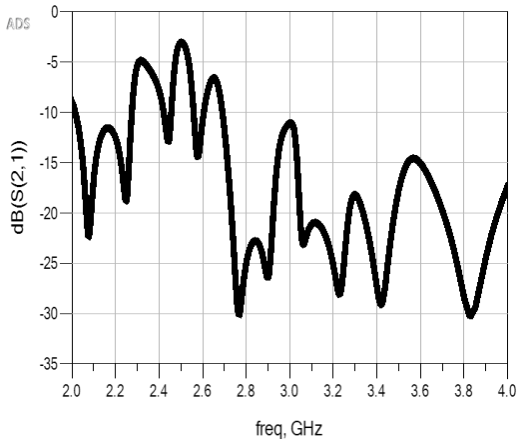

Figure 4. Simulation Result of Design Encoded as “1111111111”.

According to the placement of resonators, if the resonator is placed, encoded data is one. The resonator placed on the transmission line will retransmit the given input signal. If resonator is removed, encoded data is zero.

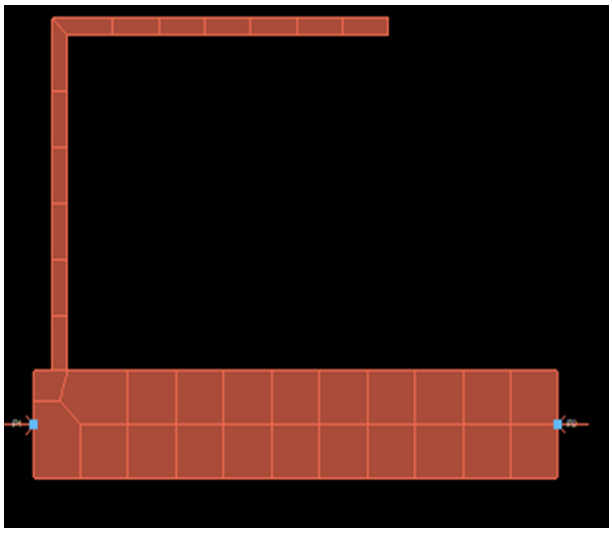

Figure 5. First Resonator

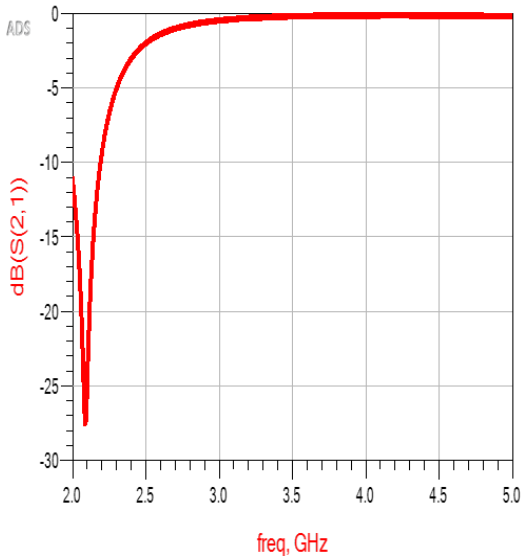

Figure 6. Encoded data ‘1000000000’.

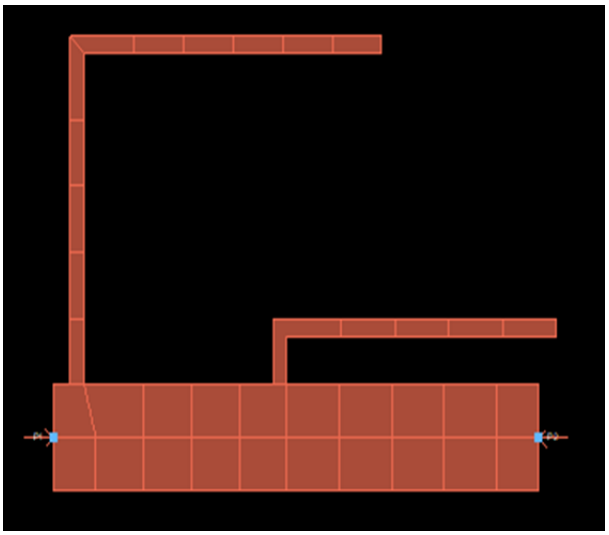

Figure 7. First and Tenth Resonator

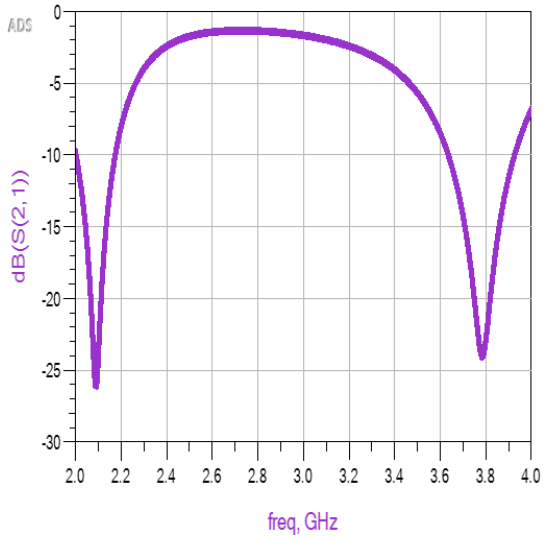

Figure 8. According to Placement of Resonators, Data is encoded as '1000000001'.

Fig.3 to fig 8 represents the varied placement of resonators along the transmission line. In figure.3, all resonators are placed and as a result of that, encoded data is '1111111111', given in figure 4. In figure 5, first resonator is alone placed, remaining all are removed. Hence, encoded data is '1000000000'in figure 6. Figure 7 represents 1st and 10th resonators alone placed.1st and 10th bit alone encoded to be one and remaining all are encoded as 0. Hence encoded data is '1000000001' in figure 8.

5. Conclusion and Future Work

The chipless RFID tag using multiresonator of 10 bit coding capacity has been presented. The coding technique was used for encoding. Since the coding capacity is 10, total of 2^10 individual data can be coded through the proposed design. Hence maximum of 1024 individual objects can be identified or tracked through the proposed design. In future, the coding capacity of the tag can be increased by employing other coding techniques such as amplitude coding, phase coding and hybrid coding etc.,

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Author's biography

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