A SSR-Based Near Field RFID Reader Antenna

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Abstract - *In this paper , a compact near field reader - antenna is proposed for ultra-high frequency (UHF) radio frequency identification (RFID) applications. The antenna structure is composed of two split-ring resonators (SRRs) and miniaturized to a special small size of 21*21*1.6 mm³ for mobile RFID application . The measured bandwidth of antenna prototype is 20 MHz (912 - 932 MHz) with a reflection coefficient less than -10 dB , which covers the China RFID band II (920 -925 MHz) . Simulation shows that the proposed antenna achieves a strong and uniform magnetic field distribution in the near field region.*

1. INTRODUCTION

Radio-frequency-identification (RFID) has played a major role for automated identifying and tracking objects in various applications, such as warehouse, supply chain, industry , and commerce . Generally, there are two kinds of RFID systems: far-field and near-field system. The far - field RFID systems only operate at UHF (840 - 960 MHz) bands using with electromagnetic waves propagating between the readers and tags. Relatively, the near - field RFID systems based on inductive coupling to transfer power and transmit data between the readers and tags. In near-field systems, the inductive coupling stores most of the reactive energy in the magnetic field near to the reader antenna region. Compared to the far-field system, the advantage of near-field system is that the reader antenna will be only affected by high magnetic permeability objects and operates well in close proximity to metals and liquid. The near-field systems can operate at low frequency (LF, 125-134 kHz), high frequency (HF, 13.56 MHz) and UHF bands. The conventional LF/HF near-field RFID tag has complex multiturn loop structure, and the data transmission rate is lower compared to UHF near-field systems. In order to address the size constraint problem, we make a tentative suggestion of a novel type of RFID reader antenna for near- field application. In this paper, we present formally the compact SRR-based RFID antenna and give more details of the near-field characteristics by simulation and measurements. The compact antenna prototype is fabricated with a special small size of 21 * 21 * 1.6 mm^3, which is one of the smallest dimension of RFID reader antenna in the world. The measured result of prototype shows good impedance matching over 20MHz (912-932 MHz) with reflection coefficient less than -10 dB, which covers the China RFID band II (920-925 MHz). Simulation shows that the antenna features a strong and uniform magnetic field distribution.

2. THEORY OF SRR

Split Ring Resonator (SRR), as shown in Fig. 1, is formed by two different diameter size concentric metal rings with one gap on the opposite position of each one. As a resonator, the inductive effect of SRR is created by the rings while the capacitive effect is determined by the gap between split rings and the gaps at each ring.

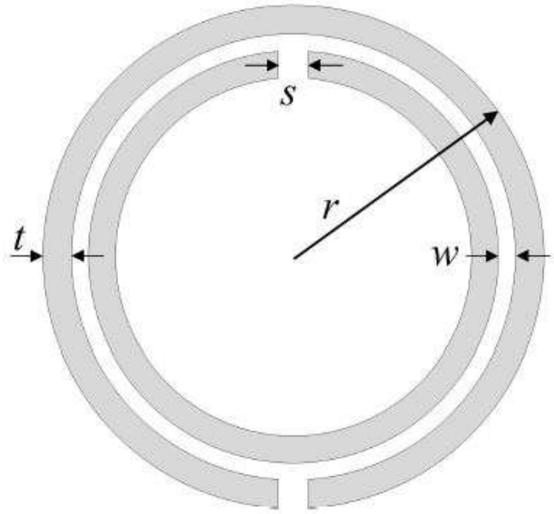


Figure 1 . SRR Structure

It is seen that there is a strong magnetic field near the central axis and close to the resonator, when current in-phase on SRR varies at the resonance frequency. We propose SRR structure in near-field antenna design and obtain significant effect on miniaturization of antenna and good bandwidth. Due to the high capacitance value the structure size reduction is possible.

3. ANTENNA DESIGN AND STRUCTURE

The configuration of proposed antenna is shown in Fig. 2. The SRR structure and ground are respectively fabricated on the opposite sides of the FR-4 substrate. The SRR structure is formed by two coupled square-rings separated by a gap, each with a split at opposite sides. On the top view of Fig. 2, $L1$ is the edge side of the fabrication, and $L2$ is the edge of the outer square. Then, g is the gap between the inner and outer, $s1$ is the split width of the inner square, and $s2$ is the outer square. Particularly, the inner square has the same line width$w1$, but the outer square has two different line widths of $w1$ and $w2$. This can broaden the bandwidth of the antenna. Finally, $L4$ is the distance between the feed point and a corner of the outer square. On the bottom view, $L3$ is the long edge of the rectangle ground, and W is the short edge.

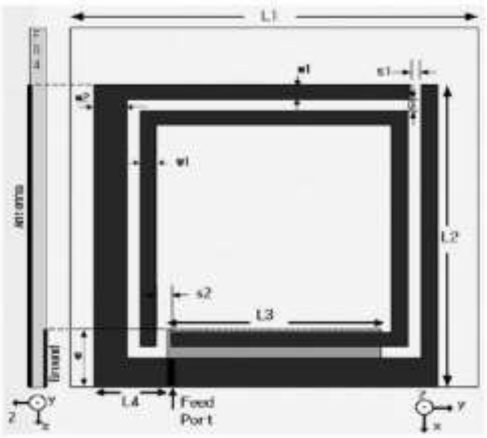


Figure 2 . Proposed antenna structure

Table 1 . Parameters of proposed antenna

Antenna Square Edge(mm)	L1	25
SRR Structure(mm)	L2	21
	L4	4.5
	S1	1
	S2	1
	W1	1
	W2	2
	g	0.8
Metal Ground(mm)	L3	13
	W	4

4 SIMULATION AND MEASUREMENT RESULTS

The simulated frequency distribution is shown in Fig. 4. Simulations of the proposed antenna were performed using Ansoft High Frequency Structure Simulator (HFSS) software, which uses the finite element method (FEM). The measured impedance bandwidth of the antenna prototype is 20MHz (912-932 MHz) under the condition of reflection coefficient less than ¡10 dB, which agrees well with the simulated results and covers the China RFID Band II standard (920{925 MHz) completely.

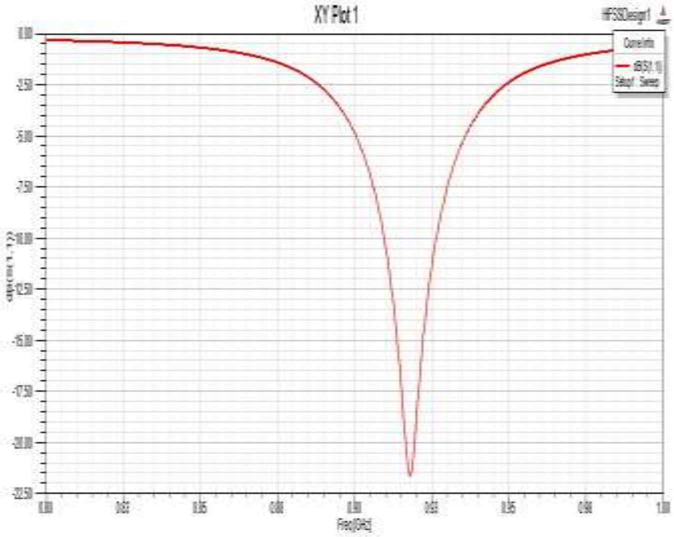


Figure 4 . Frequency distribution of proposed antenna

Since the size of SMA connector is comparable to the proposed antenna in Fig. 3 and extends the ground in measurement, the measured result of $S11$ is better than the simulated result in Fig. 4. The antenna ground is often connected to the PCB in application, so we consider the effect of SMA connector equivalent to the effect of PCB ground. The measurement is more close to practical use rather than simulation.

The simulation result of current distribution is shown in Fig. 5. We can see the current remains constant along the outer square, which can provide a uniform magnetic field distribution and be suitable for near-field antenna.

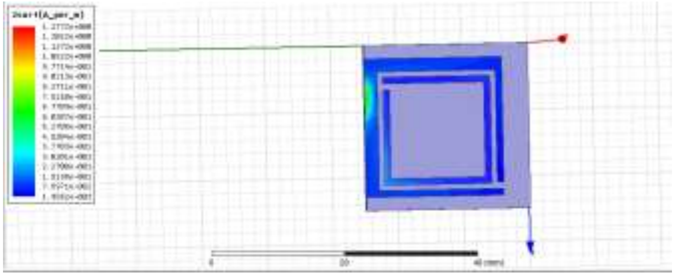


Figure 5. Current Distribution Plot

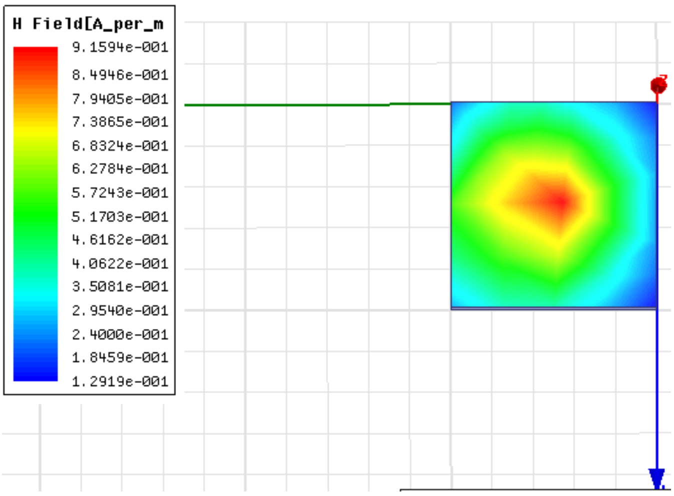


Figure 6 a) Magnetic distribution at z=10mm

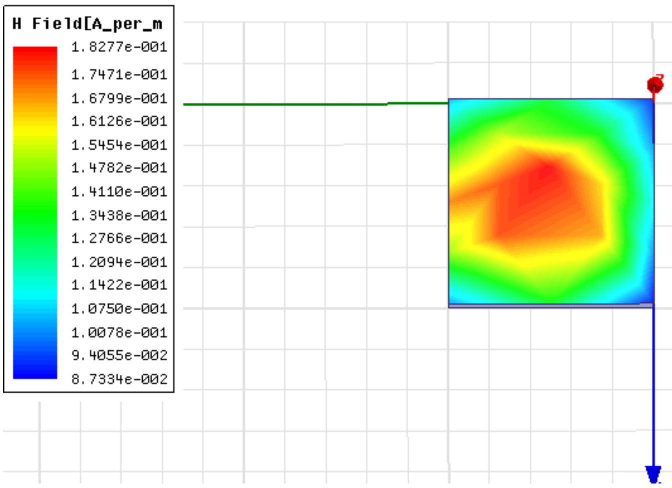
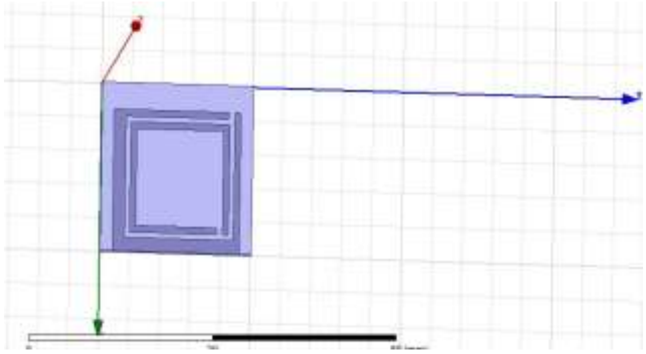


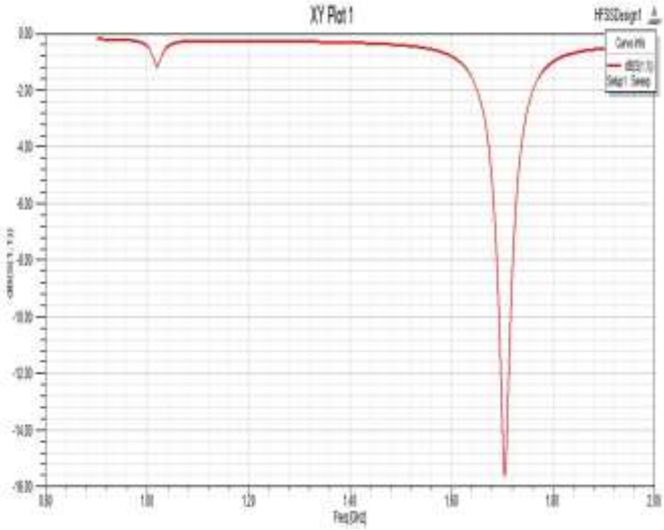
Figure 6 b) Magnetic distribution at z=20mm

Figs.6(a)&(b) show the magnetic field above the antenna at different *xoy* planes. The interrogation zone in Figs. 6(a) & (b) is uniform on the most region of antenna, and agrees well with the simulation of current in phase along the antenna in Fig. 5.

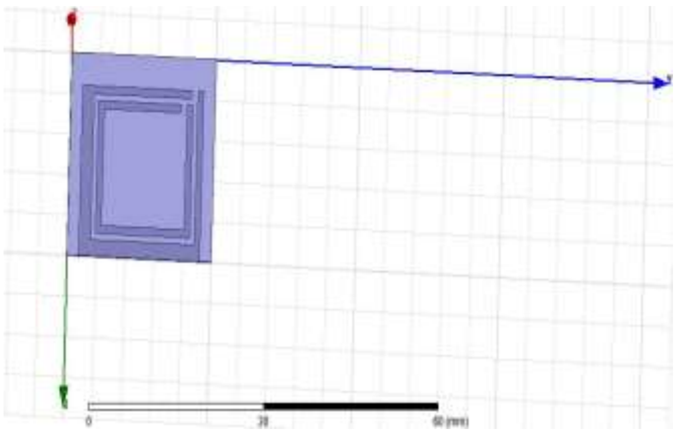
5. VARIATION STUDY



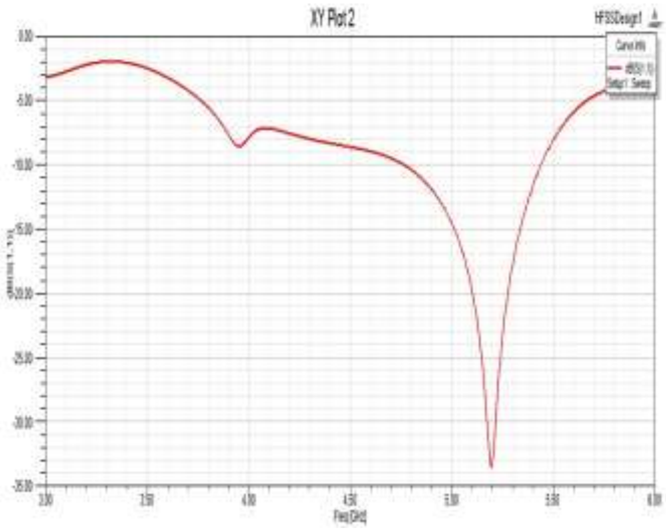
Structure 1



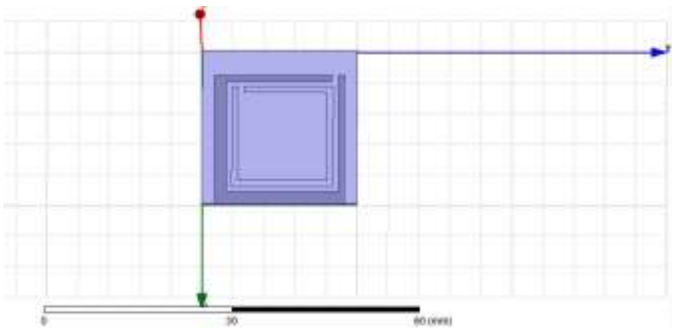
Frequency Distribution Plot of Structure 1



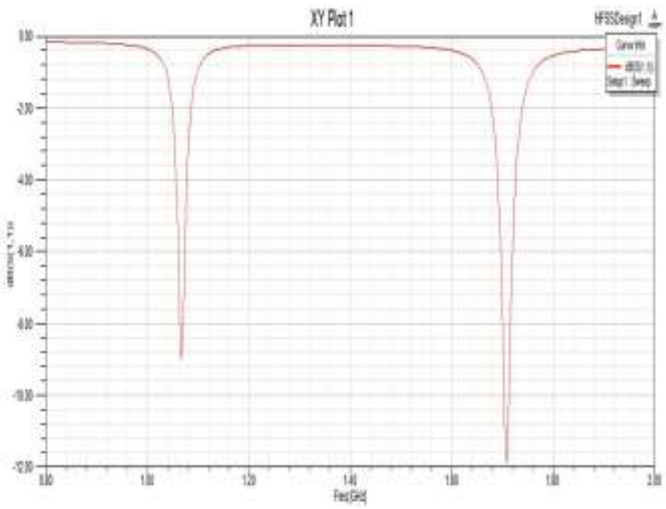
Structure 2



Frequency Distribution Plot Of Structure 2



Structure 3



Frequency Distribution Plot Of Structure 3

In this modification we are changing the split position of the inner square. An increase in resonant frequency and change of single band to multiband are observations of above modifications. As a result there is a decrease in bandwidth. So the quality factor and selectivity of the antenna increases.

6. CONCLUSIONS

In this paper, the proposed antenna uses two SRRs to obtain a small dimension of 21 * 21 * 1:6mm3. From Table 1 and Fig. 4, the edge of the antenna outer ring is 21 mm, which is approximately equal to 1/16 wavelength at 920 MHz, and the edge of the classical patch antenna must be 163 mm, which is about ½ wavelength at 920 MHz. Thus, the proposed antenna is one of the smallest RFID reader antennas all over the world, which is suitable for mobile application.

Finally, a proposed antenna prototype is fabricated and detects passive UHF RFID tag in near region successfully. It provides the bandwidth of 13MHz (912-932 MHz) with reflection coefficient less than ¡10 dB, which can cover the China RFID band II (920-925 MHz) completely.

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BIOGRAPHIES

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