Ultra Thin and Bendable RFID Tag for Wide Applications Using Metamaterials

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Abstract

Novel RFID tag design which can be available for almost objects has been developed. We demonstrate very thin and bendable RFID tag for wide applications using radiative metamaterial sheet (RMS). Combining RMS and loop shaped feeder (LSF), the thickness is shorten to 0.35 mm, 3 m reading range is achieved.

Keywords : RFID Metamaterial Tag antenna

1. Introduction

It is a great challenge for RFID tag antenna design to overcome a limitation from the objects. For example, a material of objects (especially, metallic surface) affects significantly to antenna impedance matching, as a results, reading range is extremely degraded. Also, because of the thickness, shape of object might be restricted to install to the object which has a curved surface or a cylindrical shape.

Various UHF RFID tags for metal mount have been proposed, e.g., microstrip patch antenna [1]-[3] PIFA antenna [4][5], dipole antenna with AMC (artificial magnetic conductor) structure [6][7] etc. However, since these all tags are very thick and rigid, in the case of IT asset management, it is not suitable for some application such as notebook computers. Thus, low profile tags are desirable and have been proposed [2][4][5], but considering usable with barcode label printer, they are not sufficient thinness yet.

In this paper, we demonstrate very thin and bendable RFID tag design for wide applications using RMS (Radiative Metamaterial Sheet). Combining RMS and loop shaped feeder (LSF), the thickness is shorten to 0.35 mm, 30mm bending radius is achieved. RFID tag configuration can be fabricated with cost effective process such as a role to role. The sample was measured by reader writer antenna in 952-954 MHz (Japan band) and reading range was about 3 m. And installing to the various objects (metal, plastic bottle filled water, and polystyrene), reading range was not changed.

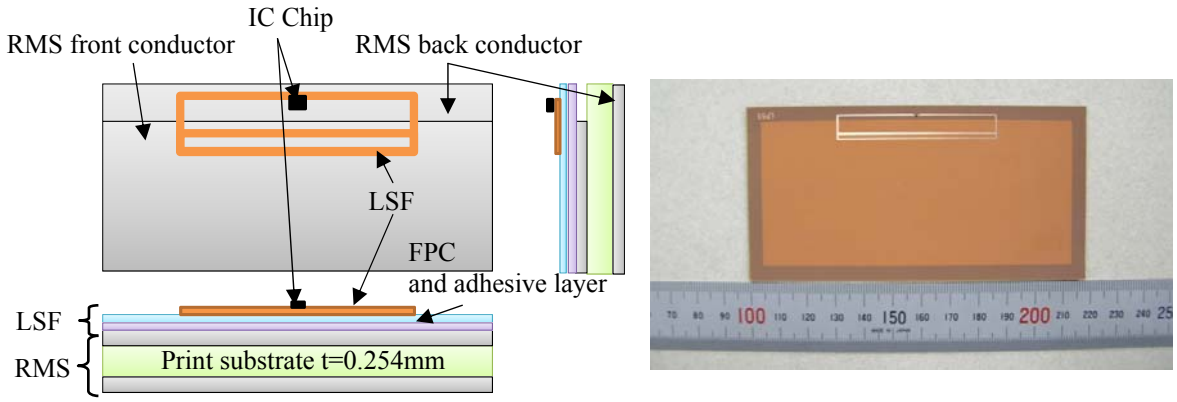

Figure 1: Configuration of the ultra thin metal-mountable tag antenna.

2. Antenna configuration

Proposed tag system is depicted on Fig. 1. The system consists of two parts; one is RMS, the other is LSF. RMS plays a key role in this system, it is a meta-atom of artificial magnetic media for decoupling system from the object surface. Furthermore, RMS has a function of radiator. The structure of RMS is two paralleled patch conductor on both side of dielectric substrate Arlon Diclad 880 (εr=2.17 tanδ=0.00085) with thickness of 0.254mm.

LSF is for matching IC chip to the system, is formed by the flexible printed circuits Nikkan Industries F30VC1 with thickness of 0.045mm. RMS and LSF are laminated by adhesive sheet Sony Chemical Corpolation T4100 with thickness of 0.050mm, and two parts are connected each other by an electromagnetic coupling manner. Impinj Monza 3 packaged type IC chip was used and the chip impedance is 17.8+j154[Ω].

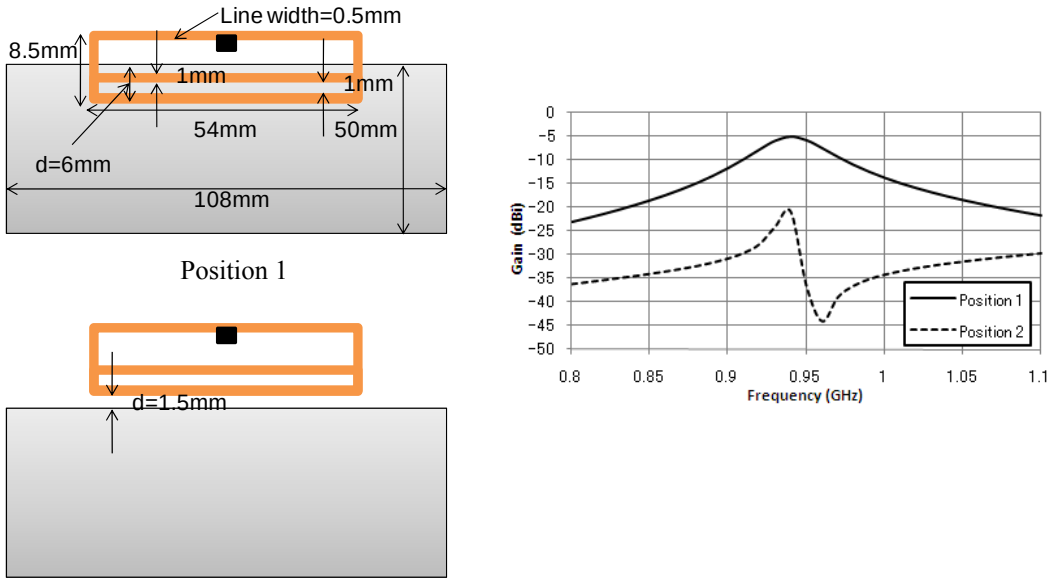

Figure 2: Radiation efficiency with two different of loop positions.

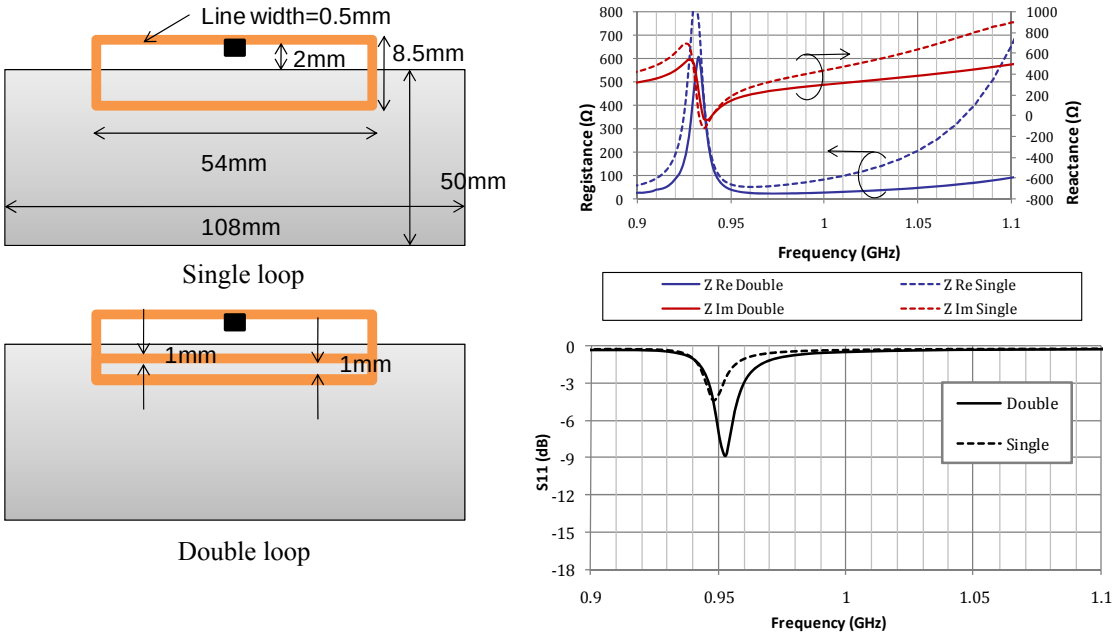

Figure 3: Antenna impedance characteristics with two different of loop shapes.

For achieving ultra thin tag design, it is quite important to maintain radiation efficiency high as much as possible. The simulated results the position of LSF parametric is depicted on Fig. 2. The simulation is done by commercial software SONNET. It is seen that the radiation efficiency is drastically improved in the case of overlapping a part of LSF and RMS. Also, impedance matching and bandwidth are essential for tag design. The antenna input impedance is controlled by the length and shape of LSF. Fig.3 shows simulated results of input impedance of two types of LSF, one is single loop, the other is double loop. The loop structure of LSF is extremely effective to control the impedance, the gradient of impedance of double loop becomes more moderate than that of single loop around 950MHz.

3. Results

In Fig.4, the measured and simulated results impedance and S11 of the fabricated tag is shown. The input impedance measurement was carried out on the metal stage with an Agilent E5071A network analyzer, and a Suss Microtec Z Probe 500μm pitch. A Differential mode is measured by using mix mode S parameter measurement function of network analyzer. There is a part more than 0dB in S11 result, this error occurs due to fail the calibration. The fabricated antenna is achieved a good impedance matching around 950MHz. In addition, the result of measurement was in good agreement with calculation..

Table.1 is the reading range results when the fabricated tag is mounted on various objects. The reading range measurement was performed in an anechoic chamber by using a commercial RFID reader (Omron V750) and a circular polarized antenna. The criterion of the reading range is the distance that is able to recognize tags ten times consecutively. As a result of experiment, it was demonstrated that the proposed tag antenna is not affected by any objects including metal or water.

The proposed tag is bendable because of thickness and flexibility of it, it can be mountable to curved surface of the bottle (Fig. 5). Due to an appropriate choice of resin, the flexibility (i.e. bending radius) can be improved, then the proposed tag is able to be printed code (name, ID, lot. number etc.) using a barcode label printer.

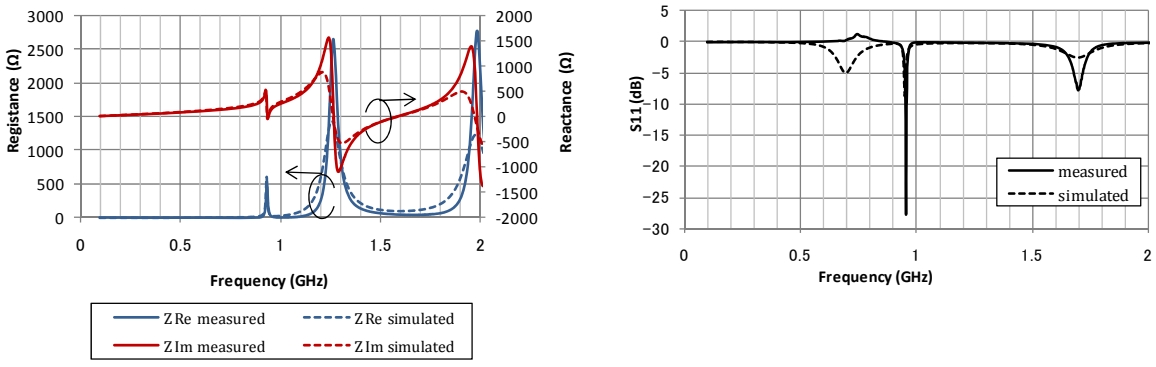

Figure 4: Measured and simulated antenna input impedance. (a) Input impedance. (b) S11.

4. Conclusions

Ultra thin and bendable RFID tag antenna which is not affected by any objects including metal or water is proposed. The tag achieved that the reading range is over 3 m at UHF band (952-954MHz), and its dimension is 108 × 55 × 0.35mm. Since the proposed tag is very simple structure without via holes and applicable to role to role fabrication process, the proposed tag is good candidate for cost effective solution for a versatile UHF tag.

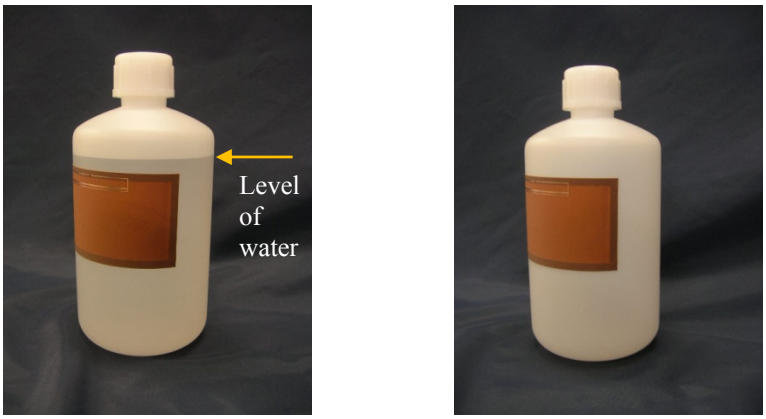

Figure 5: A Bendable tag placed on the bottle filled water (left) or emptied (right).

Table 1: Measured read range of prototype

Objects	Reading range
On polystyrene support	3.0m
On aluminium plate (300mm×300mm)	3.1m
On bottle filled water or emptied (Fig.5)	2.7m

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