Various UHF RFID Tag Antennas for Metallic Object

Sang-Gon Lee, You Chung Chung
Information and Communication Engineering Dept, Daegu University
Kyungsan, Kyungbuk 712-714 Korea,
cyberlsg@nate.com, youchung@daegu.ac.kr

Abstract

Three different types of UHF RFID tag antennas for metallic object have been designed. A meander line type of transmission line and a shorted patch type of RFID tag antennas for metallic object are introduced. The reading ranges and patterns of the tag antennas have been tested and compared.

1. INTRODUCTION

A passive tag consists of an antenna and an RFID IC chip connected at the feeding point of the tag antenna. A passive tag receives the required power from the carrier signal from the reader by backscattering method, and communicates with the reader [1-2].

References [5-17] introduced various RFID tag antennas. A meander line tag antenna [3], a folded dipole tag [4] and inverted F topology tag antennas [5, 9] were introduced. References [6-9] introduced the RFID Microstrip and Patch antennas. The RFID tag antenna designs for a metallic object were introduced in references [5, 7, 9]. A tag for tangling metallic object was introduced in [8]. The two layers of substrate were used in the antenna design to improve the performance of the antenna by insulating tag antenna from metallic surface, and the EBG (Electromagnetic Band Gap) ground plane improved the impedance matching of the antenna [7]. Reference [10] showed the performance a tag antenna can be changed based on the environment of the tag, attached to a metallic object.

A normal RFID tag antenna does not operate properly when it is attached to a metallic object since there is parasitic capacitance between the antenna and the metallic object. When a normal passive tag is attached to a non-metallic object, the performance of the tag antenna can be changed slightly. A normal tag attached to a metallic objects, requires a different tag antenna structure [1-4] since the performance of a normal passive tag antenna is degraded by metallic object.

Generally, a dipole type tag antenna has been popular for a RFID tag antenna structure for non-metallic object. When the dipole antenna attached to a metallic object, the dipole tag antenna cannot be powered up by the RF field strength emitted by the reader antenna since the metallic object reflects RF field energy. When a normal passive tag antenna is attached to a metallic object, the impedance of the tag antenna, resonant frequency of the antenna and radiation efficiency will be changed due to the parasitic capacitance between the tag antenna and the metallic object [1-3]. To minimize effects of the parasitic capacitor between the dipole antenna and metallic object and the effect of the reflection of the RF wave by metallic object, it is better to put a gap between tag antenna and the metallic object, and to add dielectric material between them.

In this paper, 3 different types of UHF RFID tag antennas are introduced. The first type used a meander line type of transmission line, connected between the ground of RFID Chip and the ground of the antenna. The second design used the shorted patch antenna to the ground and, the third antenna used the meander line transmission line and L shape of patch structure antenna. Because all three tag antennas have the ground plane of the antenna, the performance of the tag antennas has not been changed much when the tags are attached to the large metallic plate.

2. TAG ANTENNA DESIGN

According to ISO-18000, the frequency band of the UHF RFID is 860~960MHz, and the frequency bands of different countries are following: Europe 865~868 MHz, America and Canada 902~928 MHz, Korea 908.5~914 MHz and Japan 950~956 MHz.

Alien RFID chip has been used to design the UHF RFID antennas. HFSS was used for simulation, and the lamination board for fabrication is RT Duroid 5880 (ε=2.2, thickness=125mil), manufactured by Rogers. The metallic object under the tag antenna has been taken into account. The three tag antennas have been designed.

The tag antenna 1 is shown as Figure 1. The impedance of the antenna is matched to the conjugate of the RFID chip impedance. The structure of the antenna has a transmission line connected between ground plane and the ground of the RFID chip. The parameters of antenna, shown in Figure 1, have been optimized to match the impedance of the chip. The parameters, Sub_x and Sub_z are the sizes of the x and z axes. P1_x and P1_Z are the patch sizes of the antenna in x and z directions. P2_X and P2_z are the dimensions of the short length transmission line as shown in Figure 1. P4_X and P6_X are the horizontal length of the long length transmission lines. P5 and P7 are the vertical short length transmission line dimensions. At the end of P7 is shorted to the ground of antenna. Sub_Y is fixed as thickness 125mil (3.175mm). The parameters are shown in Table 1.

The S11 value is -29.48 dB at the resonant frequency 910MHz, and the band width is about 340MHz based on the simulated results as shown in Figure 2. The radiation pattern of the tag antenna 1 is shown in Figure 3.

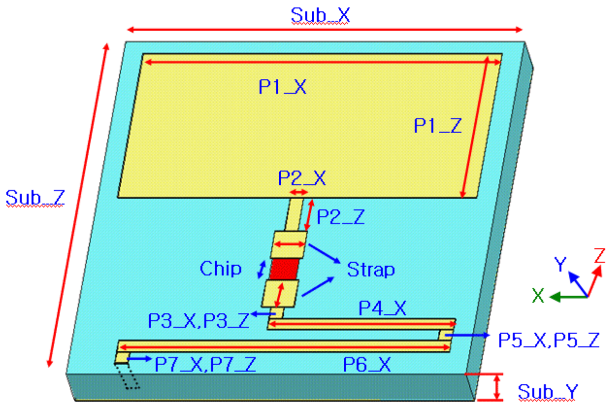

Figure 1. Structure of tag antenna 1

Table 1. Optimized parameters of tag antenna 1 (Unit: mm)

Sub_X	Sub_Z	Sub_Y	P1_X	P1_Z	P2_X	P2_Z
30	30	3.175	27	13	1	3
Strap	Chip	P4_X	P4_Z	P6_X	P6_Z	
2.45	2	14	1	25	1	
P3_X	P3_Z	P5_X	P5_Z	P7_X	P7_Z	
1	1	1	1	1	1	

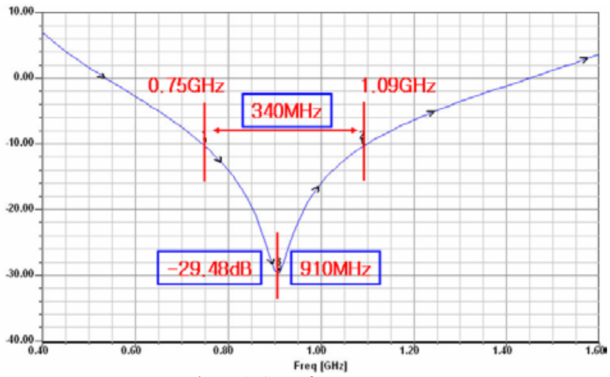

Figure 2. S11 of tag antenna 1

The second antenna has a shorted patch as shown in Figure 4. The parameters are similar manner as tag antenna 1 as shown in Figure 1. P2, P3 and P4 are the length of the transmission lines. The location of short at P4 is carefully selected. The end of transmission lines at P3 and P4 are shorted to the ground plane of the antenna. The optimized results of al parameters are shown in Table 2. The S11 value is -29.61 dB at resonant frequency 910MHz, and the bandwidth is about 320MHz based on the simulated results. The radiation pattern of the tag antenna 2 is shown as Figure 6.

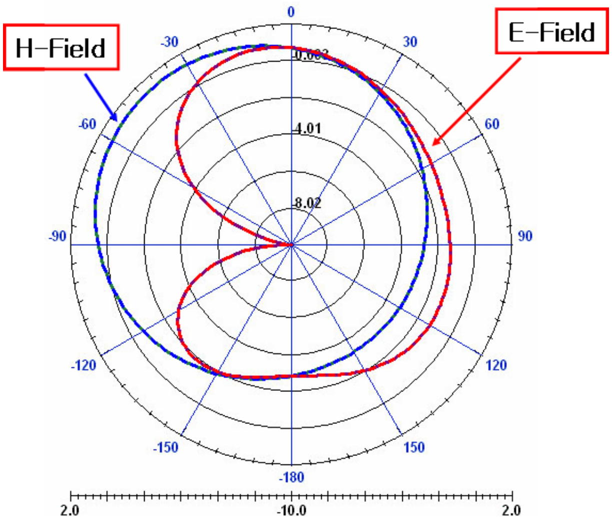

Figure 3. Simulated Radiation Pattern of tag antenna 1

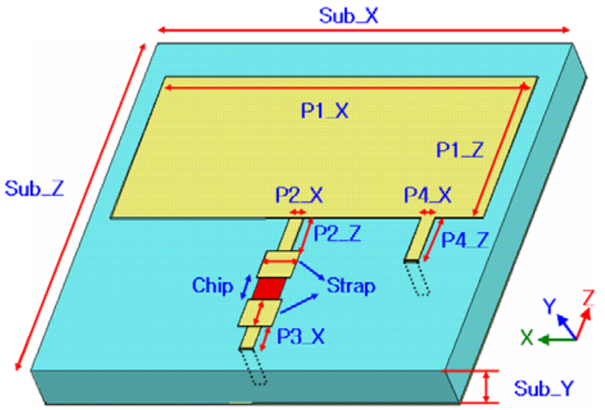

Figure 4. Structure of tag antenna 2

Table 2. Optimized parameters of tag antenna 2 (Unit: mm)

Sub_X	Sub_Z	Sub_Y	P1_X	P1_Z	P2_X	P2_Z
30	30	3.175	27	13	3	1
Strap	Chip	P3_X	P3_Z	P4_X	P4_Z	
2.45	2	2	1	1	4	

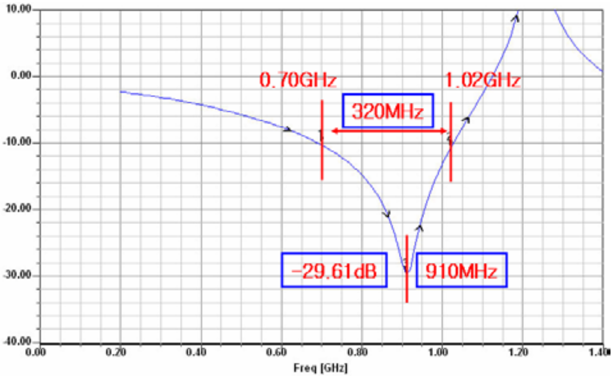

Figure 5. S11 of tag antenna 2

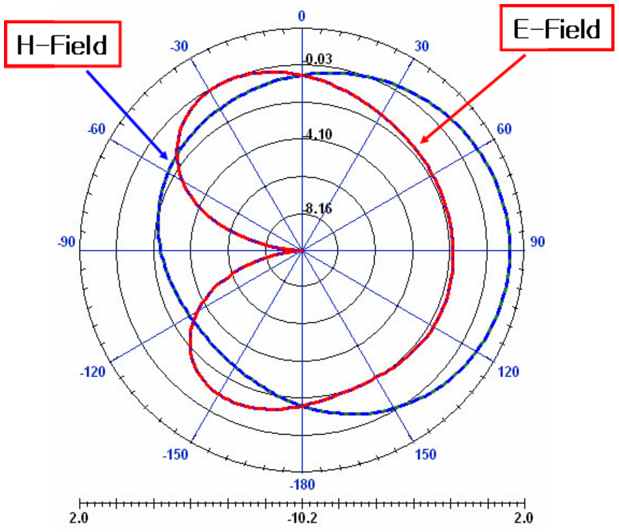

Figure 6. Simulated Radiation pattern of tag antenna 2

The third antenna is shown in Figure 7. This design has a transmission line as the first design, and L shape of the patch antenna.

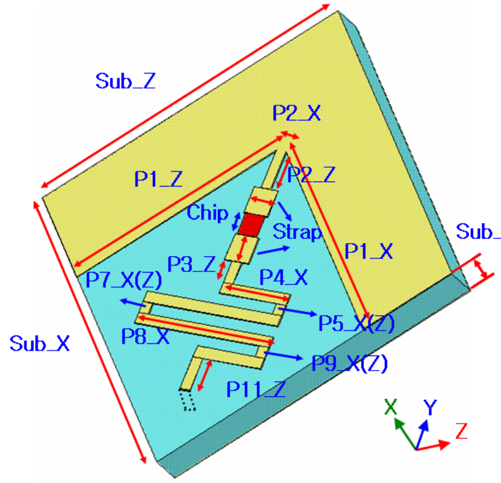

Figure 7. Structure of tag antenna 3

The optimized parameters are shown in Table 3. The S11 value is -29.48 dB at the resonant frequency at 910MHz, and the bandwidth is about 340MHz based on the simulation results. The radiation pattern of the tag antenna 3 is shown in Figure 9.

Table 3. Optimized parameters of tag antenna 3 (Unit: mm)

Sub_X	Sub_Z	Sub_Y	P1_X	P1_Z	P2_X	P2_Z
30	30	3.175	21	21	1	3.5
Strap	Chip	P3_X	P3_Z	P4_X	P4_Z	P5_X
2.45	2	1	2	7	1	1
P5_Z	P6_X	P6_Z	P7_X	P7_Z	P8_X	P8_Z
1	14	1	1	1	14	1
P9_X	P9_Z	P10_X	P10_Z	P11_X	P11_Z	
1	1	7	1	1	3	

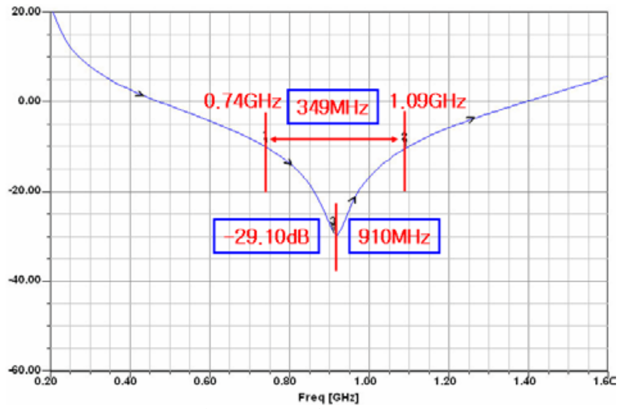

Figure 8. S11 of tag antenna 3

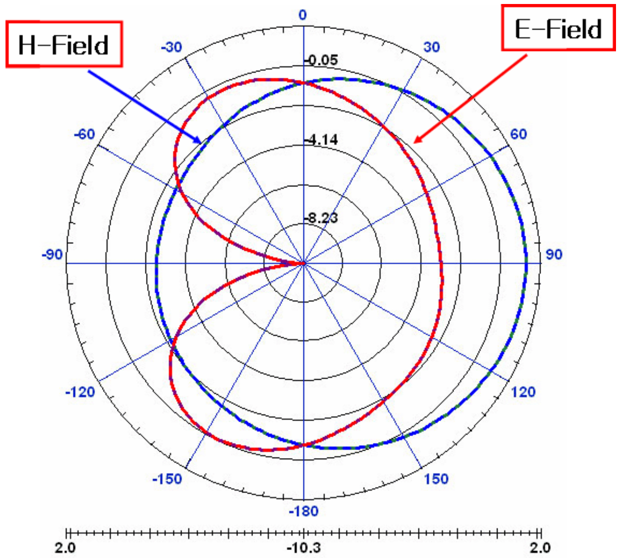

Figure 9. Simulated Radiation pattern of tag antenna 3

3. Fabrication and Measurements

Figures 10, 11 and 12 show the fabricated tag antennas. The lamination board for fabrication is RT Duroid 5880 (ε=2.2, thickness=125mil), manufactured by Rogers. The sizes of the antennas are about 30mm by 30mm. The RFID Chip is the one manufactured by Alien inc.

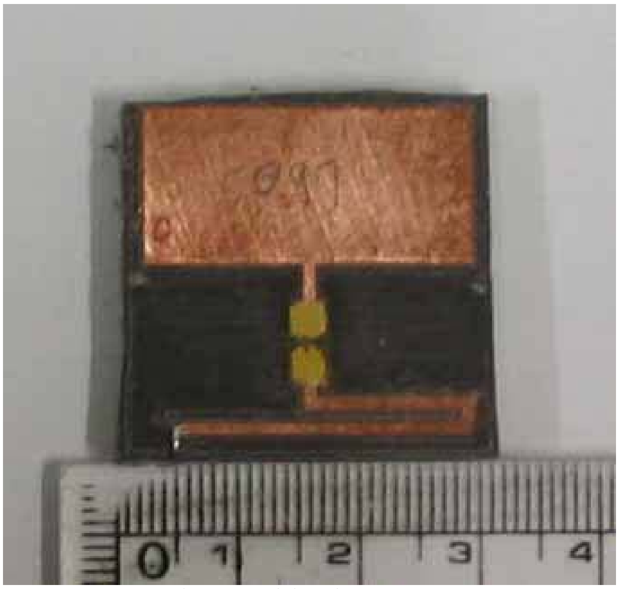

Figure 10. Fabricated tag antenna 1

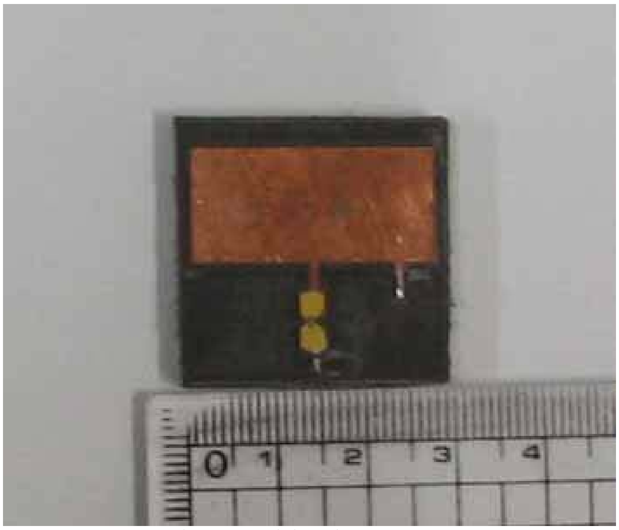

Figure 11. Fabricated tag antenna 2

The reading range of the tag antenna 1 is 1.7m. The reading range of tag 2 antenna is 1.9m. The reading range of tag antenna 3 is 0.85m. The reading range pattern of three antennas for all different directions will be presented at the conference meeting.

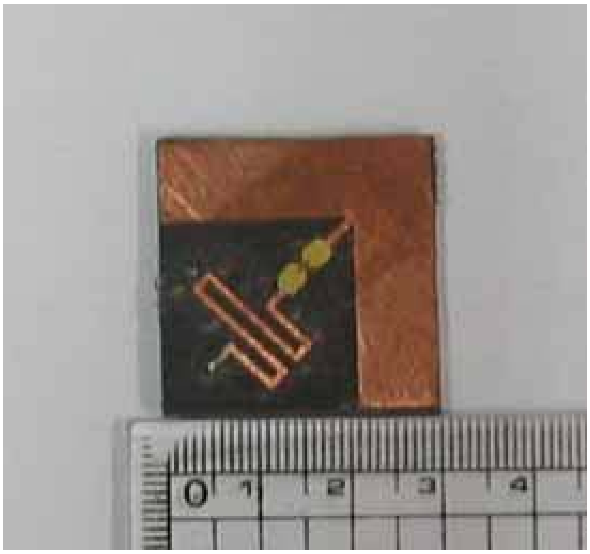

Figure 12. Fabricated tag antenna 3

4. Conclusions

Three different UHF RFID tag antennas are designed and fabricated. The reading ranges of tags are 1.7m, 1.9m and 0.85m. The first tag antenna used the transmission line, and the second tag antenna used a shorted patch antenna. The third antenna used the transmission line and L shape patch antenna to match the impedance of the tag antenna to the conjugate of chip impedance.

For the future work, the reading distance for all directions should be measured, and a new design without a null should be designed.

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