RFID Tag Antenna for Metallic Objects

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Abstract – An RFID patch antenna for metallic object has been designed. The effects of variation of distance between the tag antenna and ground of the antenna have been studied. Various dielectric constants, thickness, permittivity, width of transmission line and length of transmission line have been used to design the better tag antenna for metallic object.

Keywords: RFID tag antenna

1 Introduction

RFID (Radio frequency identification) system is getting popular and also helpful for recognizing information of a product with an RFID. The RFID tag can give detailed information of the products: name of manufacture, delivered location, expiration date, storage temperature and etc. An RFID is also applied to the applications dealing with metallic objects; military armor logistics, metallic products manufacturing process, automobile manufacturing process and any metallic machinery parts logistics. Since a passive tag does not have its own power source, the passive tag receives all the required energy from the RF energy of the carrier signal of the reader. It requires strong RF field strength to power up the tag chip and to answer to the signal from a reader.

The performance of tag antenna can be changed based on the environment of the tag. When a tag is attached to a nonmetallic object, the performance of the tag antenna does not change. Attached to a metallic objects, it requires a different tag antenna structure [1-4] since the performance of tag antenna is degraded.

Generally, a dipole type tag antenna has been popular for a RFID tag antenna structure. When this dipole antenna attached to a metallic object, the dipole tag antenna cannot be powered up by the field strength emitted by the reader since the metallic object reflects RF wave. 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. [2, 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 addition, the dipole tag antenna has a finite ground plane itself at the other side of the tag antenna. Therefore, when the tag is attached to a metallic object, the characteristics of the tag antenna will not change much since there is a ground at the bottom of the dielectric constant.

An RFID system consists of a reader, a transponder (tag) and a computer connected to the reader. Among the RFID frequency categories: LF (125kHz, 135kHz), HF(13.56MHz), UHF(433.92MHz, 860~960MHz), Microwave(2.45GHz) [1], this paper only considers UHF band (860~960MHz) RFID tag for a metallic object. Input impedance of a RFID Tag antenna has real and imaginary impedance due to the parasitic capacitor existing in an RFID IC chip [1].

References [4~7] introduce some of RFID tag antennas for metallic objects. Electromagnetic band gap (EBG) structures have been discussed in [8-11]. These EBG structures of antennas will help to design an RFID tag for a metallic object. This paper shows a design and parametric research of an UHF band (860-960MHz) RFID tag antenna for metallic objects.

2. Tag Antenna Design

When a tag antenna is attached to a metallic object, resonant frequency, efficiency and performance of the dipole RFID tag antenna will be changed due to the parasitic capacitance between the antenna and the metallic object, and the reflection of the RF wave by the metal object. A UHF band (860~960MHz) RFID tag antenna for a metallic object has been designed and parametric researches also have been done with the center frequency of the UHF band, fc=910MHz. One of the questions is how much performance and resonant frequency of a normal RFID dipole antenna will be changed after the tag antenna is attached to a metallic object. An RFID antenna is simulated with a finite and infinite ground plane sizes to compare the performance of the antenna with and without the metallic object. The sizes of all parameters of a patch

RFID antenna vary, and a suitable parameter is found for a best matching antenna to a given RFID chip.

Figure 1 shows a patch antenna driven by a transmission line. The transmission line connected from antenna to the RFID chip. The ground plane of the antenna is also connected to the ground pin of the RFID chip with the transmission line as shown in Figure 1. The RFID chip impedance of EM4223 (EM Microelectonic inc.) is about 19-282j at 910MHz.

The range of parameters of the RFID antenna are following:

- width (w=0.5cm~1.2cm),
- height (h=1cm~3cm),
- distance between antenna and chip su_h(1cm~3cm),
- distance between GND to chip sb_h(0.2cm~1cm),
- width of the transmission line b_w(0.2~1cm)
- substrate width g_w(12cm~20cm)
- substrate hight g_h(9cm~20cm)
- substrate thickness g_t(0.3cm~1cm).

A suitable design parameters are: g_w=12cm, g_h=9cm, g_t=0.3cm (permittivity εr=6.5), w=8cm, h=1.1cm, su_h=2cm, sb_h=2.8cm, b_w=0.2cm, chip_h=0.2cm chip_w=0.2cm g_fe=0.1cm. S11 of this design is shown in Figure 2. Bandwidth is about 320MHz which covers all UHF RFID band (860~960MHz).

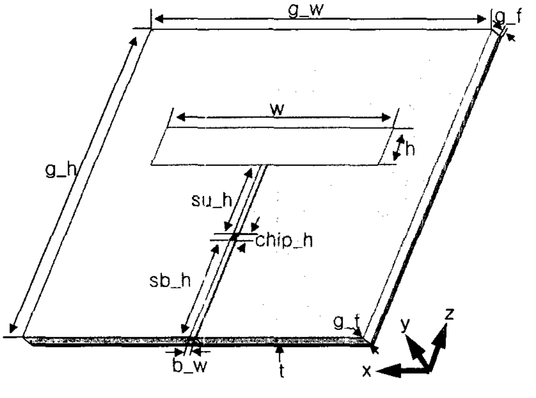

Figure 1. Tag antenna

When the permittivity is changed from εr =6.5 to 2.1 with g_t=1cm and h=1.5cm. This result gives bandwidth of 450MHz. Lower permittivity produces wider bandwidth while the resonant frequency increases. In other words, the electrical size of the antenna is smaller. The parametric research of the permittivity is shown in Figure 3. The low frequency and high frequency are the frequency of -10dB points. The bandwidth is frequency range between low frequency (lowfreq) and high frequency (highfreq). When permittivity increases from 2.2 to 6.5, the resonant frequency decreases from 1.24GHz to 0.71GHz and the bandwidth decreases to 0.32GHz. That means the electrical length of the antenna becomes larger.

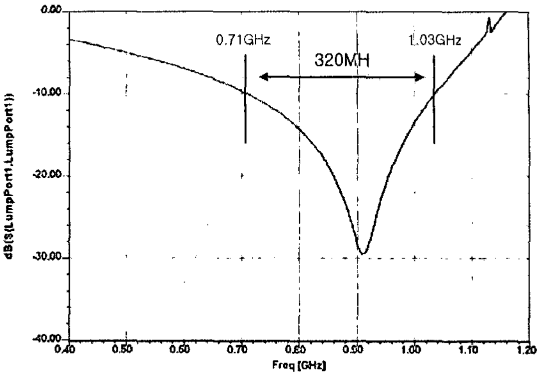

Figure 2. Tag antenna s11

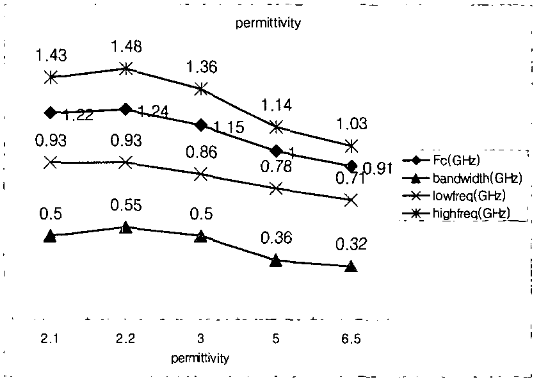

Figure 3. Resonant frequency and bandwidth of antenna permittivity.

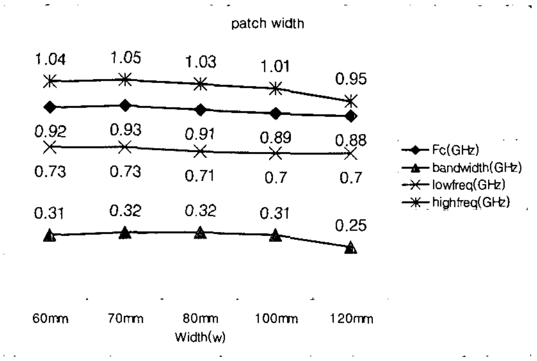

Figure 4. Resonant frequency and bandwidth of antenna vs. patch width.

Figure 4 shows the parch width increases, the resonant frequency decreases. This means the electrical length of the antenna becomes larger. In Figure 4, the variation of the resonant frequency is not much while the patch width changed from 6 cm to 12cm as 100% changes.

Figure 5 shows variation of height of the patch antenna does not change the resonant frequency and bandwidth much. When height of patch changes from 5mm to 31mm, the resonant frequency of antenna decreases from 0.92GHz to 0.91GHz. There is only 10MHz difference when height of patch becomes 31mm.

Figure 6 shows the results of the different thickness of substrate. When the thickness changes from 3mm to 10mm, the resonant frequency changes from 0.91GHz to 0.7GHz while the bandwidth of the antenna is maintained around 310MHz.

Figure 7 shows variation of bandwidth and resonant frequency while the width of the transmission line varies from 2mm to 10mm. The bandwidth decreases to 130MHz when width of the transmission line increases to 10mm while resonant frequency increases only about 30MHz.

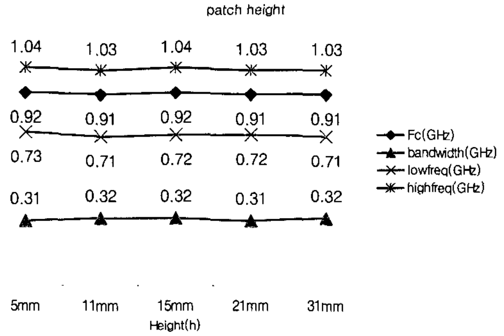

Figure 5. Resonant frequency and bandwidth of antenna vs. patch height

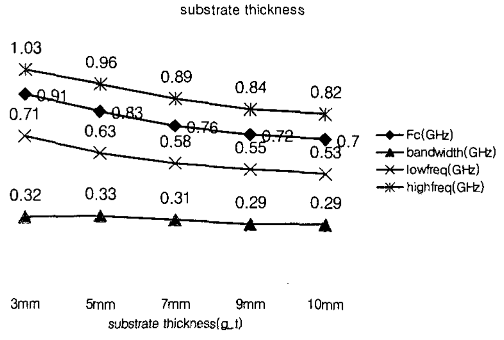

Figure 6. Resonant frequency and bandwidth of antenna vs. substrate thickness

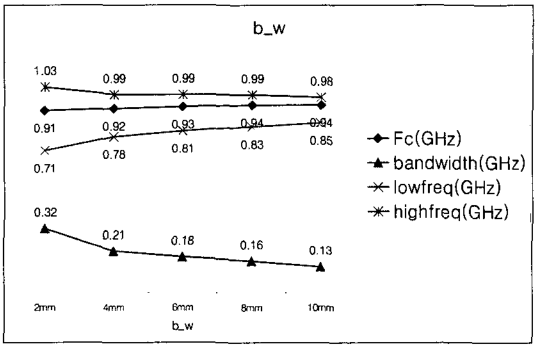

Figure 7. Resonant frequency and bandwidth of antenna vs. transmission line width

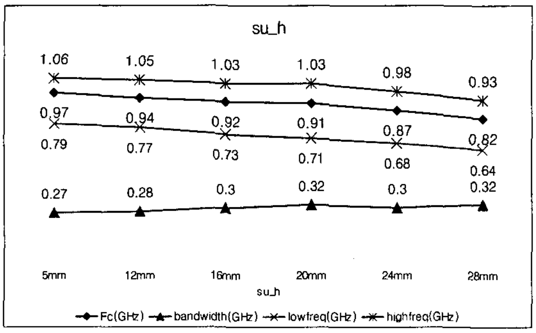

Figure 8. Resonant frequency and bandwidth of antenna vs. su_h length of transmission line between RFID chip and patch antenna

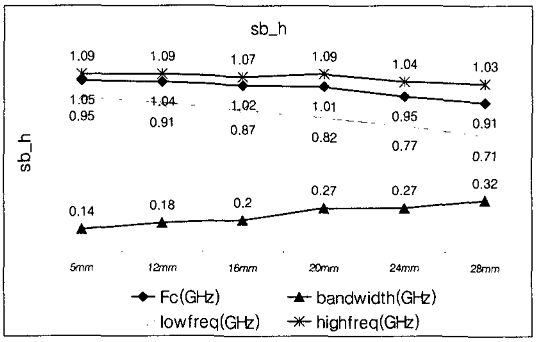

Figure 9. Resonant frequency and bandwidth of antenna vs. sb_h length of transmission line between RFID chip and ground.

Figures 8 and 9 shows variation of resonant frequency and bandwidth of antenna when length of transmission line between RFID chip and patch antenna, and between RFID chip and ground plain, respectively. Both Figures 8 and 9 show when length of transmission line increases the bandwidth increase and resonant frequency decreases.

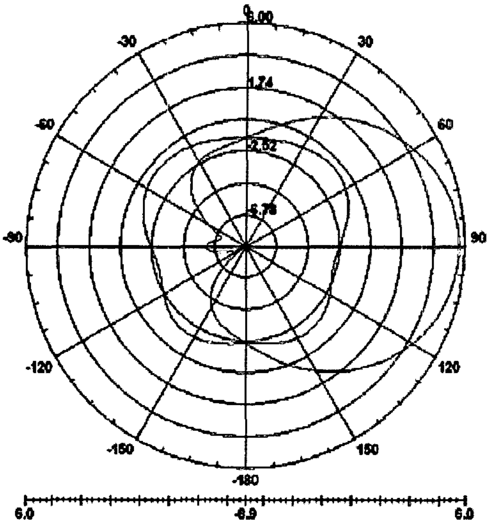

Figure 10. E and H pkane of RFID antenna pattern

Figure 10 shows radiation pattern of the RFID antenna. Gain is about 6dB. Based on the parametric researches, the dominant parameters are permittivity, substrate thickness, and length of transmission line. The patch width and height change little bit of the bandwidth and resonant frequency compared to other parameters.

3. Conclusions

This paper proposed a microstrip patch RFID tag antenna for metallic object as shown in Figure 1. The ground plane of antenna is larger than the patch antenna. The effects of dominant parameters, permittivity, substrate thickness, and length of transmission line are considered. Figures from 3 to 9 show all the effects of dielectric constants, size of antenna, thickness, permittivity, width of transmission line and length of transmission line have been used to design the better tag antenna for metallic object.

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