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Micro RFID Tag Applied to Logistics Equipment Components

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Abstract. It involves a micro RFID tag antenna which can be mounted in multi-scenario. By designing antenna line type, it enlarges the antenna's bandwidth and helps resist environmental impacts. When the tag is directly pasted on metal, plastic, wooden, or paper surfaces, the tag can exhibit robust properties and still work normally. The design has a micro shape with a diameter of nearly 8mm, and an area of under 200mm2. It is especially suitable for the identification of screws, equipment parts in logistics warehouse. The structure with one-sided design results in low manufacture cost and further mass promotion. By means of the electronic identification of small-sized grip components, it contributes to achieve goods' anti-counterfeiting and refined management purposes.

Keywords: RFID; Micro Tag; component; logistics; Anti-counterfeiting

1. Introduction

To meet the requirements of refined management and anti-counterfeiting in logistics enterprises, equipment components with high cost, such as some isolating switches, operation tools, need to be individual identified. By common optical methods such as barcodes/QR codes, the identification of tag needs assistances from a Personal Digital Assistant (PDA) [1]. Regardless of PDA configured with the latest barcode reading module, the current one-by-one scanning state restricts the response rate of the barcode, leading to low efficiency, large workload, and easy copying of labels [2]. Furthermore, in case of small label size, such as 2~4mm2, the recognition sensitivity of barcodes/QR codes drops a lot, and it often takes more time to acquire the label information. Therefore, optical method is basically excluded to identify too small labels in practical applications. Nowadays, commercial HF RFID tags are also used to identify expensive tools and some warehouse components [3]. Oriented some metal goods, for tags with abilities of metal resistance, the way of loading absorbing materials such as ferrite on back side of the tag is usually adapted, what followed is complex overall structure and relatively large size [4]. In addition, the cost of the HF tag is higher than UHF tag in processing procedure. Complementary, the introduction of ferrite increases the cost substantially. Due to the large cost of HF RFID tag and limit of overall volume, it generally appears in identifying few substances with high value and large size. Gradually, UHF band is explored to identify and consider anti-counterfeiting of ordinary small-sized parts, metal or non-metal stuffs [5].

2. Structure of the Tag Antenna

This paper introduces a micro RFID tag antenna, orienting to multi-scenes, multi-type items, general-purpose, and low-cost RFID tags.

2.1 Structure of the Overall Tag

Considering of the usual application, a common tag can be implemented as shown in Fig.1. From top to bottom, it respectively includes 5 layers: Protective layer, antenna, substrate, adhesive and release paper. In Fig.1, the numerical value behind stands for the recommended thickness for each layer. Here, polyethylene terephthalate (PET, εr:3.2, tanδ: 0.02, thickness:0.1mm) is utilized to sustain the provided aluminum etched antenna and the chipset. The tag can be stripped off the release paper and be pasted onto the stuff surface.

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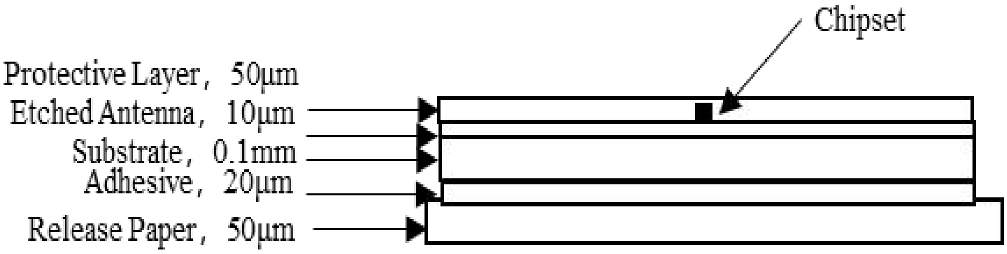

Fig. 1 Example of a tag structure.

2.2 Structure of the Antenna

The contour of provided tag antenna plane is shown as in Fig.2. It embodies four main parts: chipset, Outer Loop, Middle Loop and Inner Loop. Qstar 7U from Quanray Electronics [6]is bound between the opposite ports of Outer Loop.

The functions of each part is list as below:

- Outer Loop: to adjust the impedance of the port, further to adapt the conjugate impedance of the chip (the chip port impedance for the design is 6-j137@920MHz).
- Middle Loop: the two narrow arms in the middle are designed for coupling among the outer loop and the two arms mutually, so that the antenna can work within RFID UHF frequency band, specifically, 840-960 MHz.
- Inner Patch: to combine the two narrow arms in Middle Loop to extend the current path of the antenna arm and reduce the resonant frequency band of the antenna to the UHF frequency band; simultaneously, since the current flows through the center of the label, the electromagnetic field distribution is strengthened and homogenized, resulting in no obvious dead zone for tag recognition.

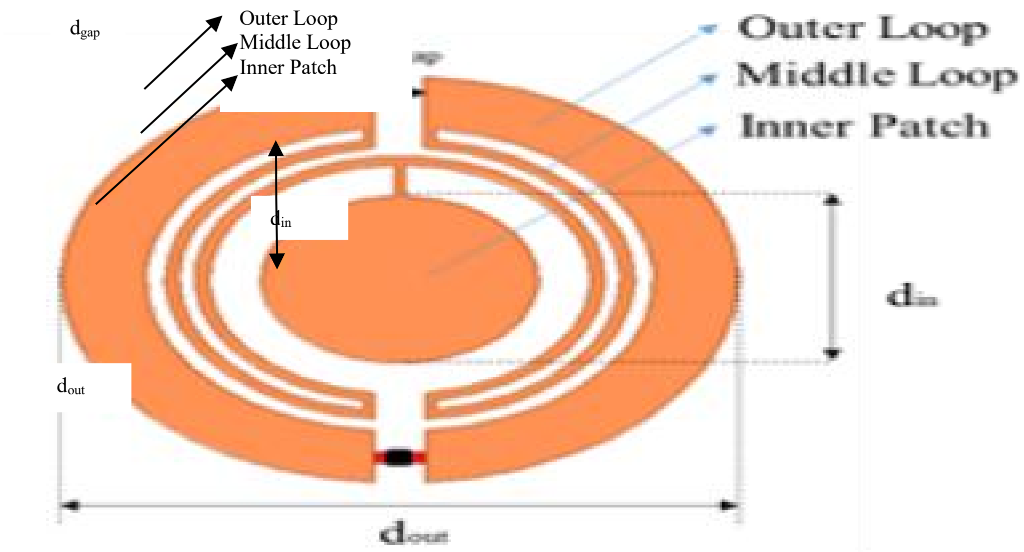

Fig. 2 Example of provided antenna structure.

For warehouse components management, the recommended data for core dimension is enumerated in Table.1.

Table 1. Recommended Dimensions for the Antenna

Items	din	dout	dgap
Recommended dimensions (mm)	3.3	8.0	0.6

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3. Characteristics of the Tag Antenna

3.1 Antenna Characteristics on None Metal Surfaces

In this part, antenna in air is considered.

When the tag is in the situation of no load or in air, the simulated return loss (S11) along the band of interest, i.e. [840,960] MHz [7], is displayed in Fig.3.

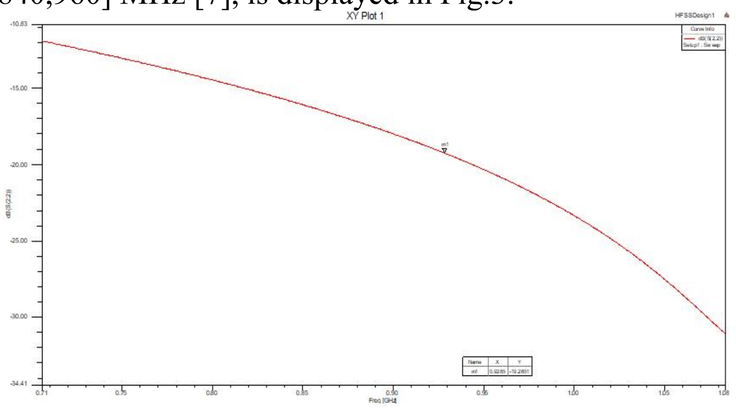

Fig. 2 The return loss curve of the designed tag with no load.

When the tag described in this case is placed in the air, the return loss value (S11) in the [710MHz, 1050MHz] frequency band (the upper limit should exceed 1050MHz) is <-10dB. According to existing criterion [8], the working bandwidth of the tag described in this case covers the entire UHF RFID application frequency band of [840,960] MHz when it is vacant.

Fig.4 shows the radiation pattern for the designed tag under no road conditions. Under the same state, the electromagnetic distribution for near-field may refer to Fig. 5.

In Fig.4, the gain of the tag antenna is about -4dB, and the theoretical recognition distance [9] is more than 100cm along XOY Plane.

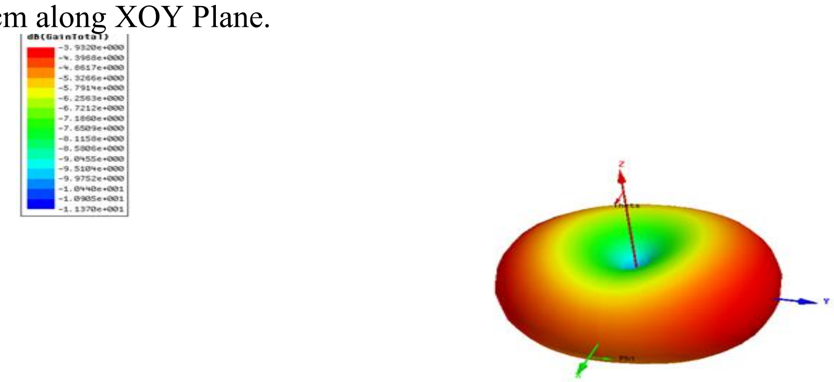

Fig. 3 3D orientation diagram of the designed tag with no load.

As shown in Figure 5, within the near-field region, the electromagnetic distribution is relatively uniform. There is no obvious weak area for electric field distribution, which symbolizes legibility of information stored in the chip.

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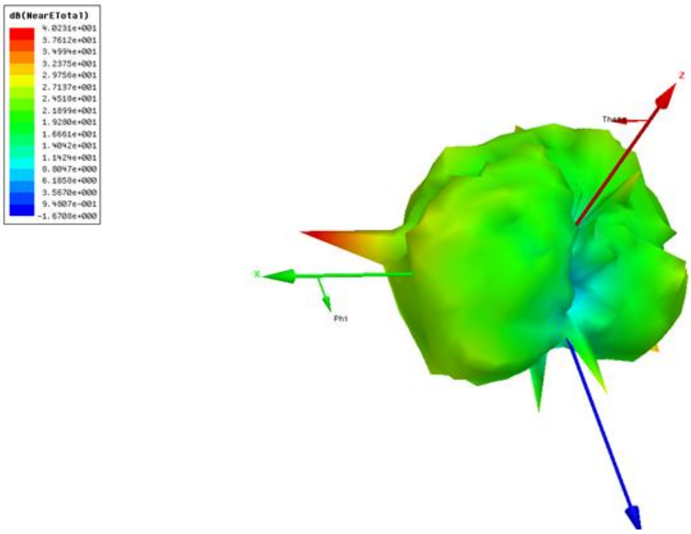

Fig. 4 3D pattern of near-field electromagnetic distribution for tag with no load.

3.2 Antenna Characteristics on Metal Surfaces

In this part, performances of tag pasted on metal model is studied. Similar to the case of A., three characteristics are discussed, S11, Radiation Pattern in far field, and Electromagnetic Distribution in near field.

When the tag is placed on the metal surface, S11 within the frequency band [720MHz, 1040MHz] is <-10dB, which covers the American standard [902,928] MHz and the national standard [920,925] MHz frequency band. The simulated curve as shown in Fig. 6. It indicates the antenna will work efficiently in the metal case.

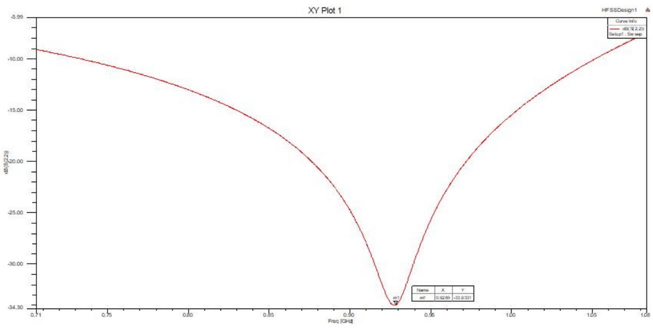

Fig. 5 The return loss curve of the designed tag on metal surface.

Fig.7 shows its gain reaches -40dB, when the tag directly affixed to metal surfaces in the direction of 45。plane of YOZ.

According to Friis formula [10], the tag still can be implemented at a close range of 6cm. In case of anti-counterfeiting and traceability, the range is enough for identification of warehouse components with small size [11].

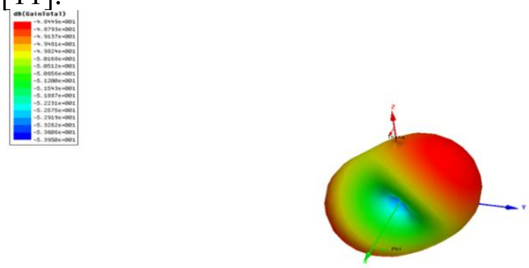

Fig. 6 3D orientation diagram of the designed tag on metal surface.

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One step closer, RFID reader moves into near field of the tag antenna. As a result of the concentrated electromagnetic distribution above the tag shown in Fig. 8, little chance exists for the tag not being activated.

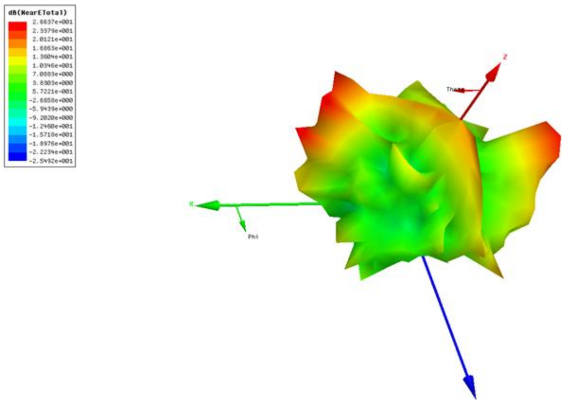

Fig. 7 3D pattern of near-field electromagnetic distribution for tag on metal surface.

4. Analysis

As stated in former chapters, the paper indicates the designed tag antenna under two extreme cases, one is in air, and the other is in metal environment. As for other material stuffs, it's convincing to speculate that the tag's performances will locate between those of the two extreme cases. When it is mounted on the surface of metal goods, the entire tag works as a patch antenna structure. The antenna plane and the attachment surface build a resonant cavity [12] to radiate RF signals. However, when the tag is attached to non-metallic surface, the main antenna body acts as a dipole structure [13]. Non-metallic surface exists as an environmental substrate. Since the current is mainly distributed within the antenna plane, the back surroundings has a limited influence on the antenna radiation.

5. Conclusion

A novel UHF RFID tag antenna is proposed. It has a low profile design, resulting in easy integration with existing products. Compared with the traditional design, the novel structure is sing-sided design and does not require additional metal ground. It's anti-metal properties come from full use of metal surface of the attached object and gain similar effect of traditional tags with double-sided patch structure. For non-metallic attachment, contrast to existing tags with similar volume, the provided tag can achieve even better effects, such as long-distance, batch identification, etc. Its overall ring structure helps widen the impedance bandwidth and strengthen its compatibility. The inner loop structure brings benefit to even distribution of electromagnetic field and srinks the coverage area of dead zone in near field. Especially, it has a micro volume and low cost. Both are beneficial for large-scaled promotion and application in asset management and anti-counterfeiting traceability for some valuable equipment components in logistic warehouse.

Acknowledgment

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