ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

A Novel Ultra High Frequency Flexible Anti-Metal Tag Antenna Design

Wenpeng Zhao[1, a]

[1]School of Arts and Science, Shanghai Maritime Univeristy, Shanghai, China

[a]wpzhao_5921@163.com

Abstract

In order to solve the interference of metallic environments on tag antennas and the problem that common tag antennas can not bend and deform on the uneven surfaces of packaging boxes, a flexible ultra-high frequency (UHF) anti-metal tag antenna has been designed by employing a microstrip patch. Slots on the radiation patch can reduce the antenna size, and its dielectric substrate is foamed cotton with 2.6mm in thickness which can bend and deform at a large angle. By using HFSS software, simulation results show that the antenna has an operating frequency bandwidth of up to 45 MHz, which completely covers the ultra-high frequency band of China (920 MHz-925 MHz). It is shown that the UHF flexible anti-metal tag antenna can solve the problems of metallic environment interference and surface irregularity of goods, and suitable for use in various items with uneven outer packaging.

Keywords

Anti-metal tag antenna; flexibility; ultra-high frequency; microstrip patch; RFID.

1. INTRODUCTION

With the gradual rise of express delivery industry, express delivery enterprises pay more and more attention to warehouse logistics cargo management. In order to facilitate the management and statistics of the goods, the goods are often labeled and marked. Although the traditional two-dimensional code and bar code are relatively simple to use, there are problems such as short reading distance, slow identification speed, and low sensitivity. Compared with them, UHF RFID tags not only solve these problems well, but also have several advantages: they can penetrate obstacles such as snow, fog, paint, and dust to read targets, and are less affected by the harsh environment; The speed of reading is fast, multiple targets can be recognized at the same time, and there is no need for directional close identification; High repeat usage rate and high data memory capacity; The security level is high, its content can be protected by passwords, and the content is difficult to be forged and changed; It has a variety of forms and is less restricted by the shape and size of the object when reading. In recent years, with the continuous advancement of processing technology, the advantages of UHF RF identification tags are becoming more and more obvious. Research institutes and companies at home and abroad have invested more and more funds in UHF RF identification tags. The research on UHF tags includes three aspects: the chip circuit design of tags[1-2],research on Impedance Matching Theory of RF Identification Labels[3-4]and the antenna structure design of the label[5-6].

In many cases, UHF tags are pasted on metal packaging boxes, and labels that work in metal environments must have anti-metal properties that are not disturbed by the metal environment. The results show that the effects of glass, wood board, plastic and water on the performance of labels are small, while that of metals are relatively large. Ordinary labels are placed in metal

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

environments. Due to poor anti-metal properties, the identification distance is greatly reduced and even unable to work properly. In order to improve the identification distance of the label in metal environment, the anti-metal problem of UHF label must be solved. Many domestic and foreign research institutions have done many design schemes and practical tests. At present, it is a common concern to consider the miniaturization and low cost flexible anti-metal label.

In addition, it is often necessary to bend the label to adapt to uneven surfaces, which requires that the label be designed with good flexibility. At present, there is still little research on flexible label in label manufacturers and research institutes, and there is still a lot of room for research on flexible anti-metal label. In the development of the label antenna, it is necessary to take fully into account various factors that may affect the performance of the label, such as the parameters of the radiation metal plate, various parameters of the dielectric substrate, and the thickness of the adhesive. After bending the label and pasting it to the identified item, the structure of the label will undergo minor deformation. Therefore, the design of a high-performance flexible label must have strict requirements for the material and thickness of the dielectric substrate, in which bending conformal is essential.

2. RESEARCH BACKGROUND

At present, there are two main ways to solve the anti-metal of ordinary labels: one is to load additional materials or structures on ordinary labels. There are three main methods: adding a bracket to increase the distance between the label and the metal environment; The use of ferrite, carbon fiber and other absorbing materials; High impedance substrates such as EBG substrates and AMC substrates are introduced. All three methods are based on the external environment disturbance factors to overcome the metal disturbance by changing the label use environment. The use of these structures or materials can achieve the anti-metal properties of ordinary labels, but there are also many other problems, such as increased costs, larger sizes, complex structures, and it is difficult to achieve large-scale production and application. The other is a microstrip patch, plane inverted F and other structures. Labels such as microstrip patches and surface inverted F solve the problem of anti-metal, and can be matched with different types of chips by changing the shape of the tag antenna. The microstrip patch antenna and the inverted F antenna have the characteristics of small size, strong directionality, light weight, low profile, simple processing technology and low cost, and are widely used in the design of anti-metal label antennas.

The external metal environment has a significant impact on the use of UHF RFID tags. It is mainly because metal materials reflect electromagnetic wave signals. The reflected signals and incident signals superimpose each other to form standing waves, causing energy to be unable to transmit outward and the identification distance to be reduced. Foster's study found that the metal environment has a significant effect on the impedance value and radiation power of RFID flexible label antennas operating in the ultra-high frequency segment[7]. The paper published by Mo L confirmed that the metal plane has a greater impact on the electromagnetic wave signal emitted by the reader, resulting in the loss of electromagnetic energy[8]. The label chip does not obtain enough energy to activate normally, thus affecting the normal use of the label. Dobkin analyzed the trend of the impedance value of the tag antenna when the conventional label is used in a metal environment, and concluded that the main factor affecting the reduction of antenna recognition distance is the difference in impedance compatibility between the antenna and the chip[9].Raumonen studied the performance of dipole type tag antennas sticking to different metal planes[10]. The larger the metal plane size, the narrower the width of the main flap of the tag antenna; The closer the label is to the metal, the more the number of side valves. Griffin used simulation software to calculate the attenuation characteristics of dipole type

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

antennas attached to different types of material planes, and concluded that the attenuation on the plane of metal products was the largest[11].

When the surface of the identified item is uneven, appropriate deformation of the label is required to achieve close integration with the item. The first step is to choose flexible medium material as substrate, which is the premise of designing flexible anti-metal label antenna. The flexible materials selected for the label antenna media substrate include PE, Teflon, PVC and other polymer materials, EVA, PE foam and composite paper materials. When the thickness of the polymer material is less than 0.5mm,it can be bent at a larger angle;The foam material is generally relatively flexible, and the thickness below 5mm can be bent at a larger angle, and the price is relatively low;Composite paper materials have good flexibility, but the production process is complex and requires high machining accuracy, and the price is relatively high, which is not conducive to mass production.

UHF RFID tag antennas are widely used in Warehouse management, logistics and transportation due to their long reading distance, large information storage, sensitive response, and good confidentiality. Based on the previous research, this paper analyzes the combination of anti-metal properties and flexibility of the tag antenna, and designs a flexible UHF tag antenna with small size, low profile and easy bending.

3. STRUCTURE DESIGN OF LABEL ANTENNA

The structure and size of the antenna are shown in Fig. 1 The medium substrate adopts a flexible foam with a thickness of 2.6 mm, its relative dielectric constant is 1.2, and the loss tangent angle is 0.02; The size of the radiation patch is L0*W0(57.5 mm*26.2mm). Short circuit board connection between the radiation patch and the metal floor;The label chip uses Alien H3 with a sensitivity of -18 dBm and an impedance value of 27-j200Ω at the resonance frequency 920 MHz. In order for the chip to be conjugated to the antenna, the impedance value of the antenna at the resonance frequency 920 MHz should be 27+j200 Ω.

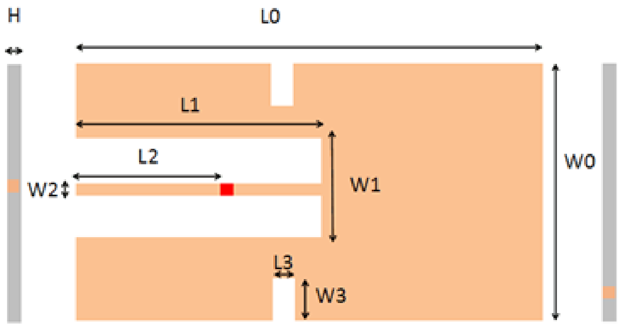

Fig 1. Structure and size of label antenna

The miniaturized anti-metal label antenna uses a short-cut feed form that connects the pins at both ends of the label chip directly to the metal radiation patch of the antenna. The advantage is that the impedance value of the antenna can be adjusted by using the slot width W1, the chip embedding depth L2, and the short cut line length L1.The opening of two slots of the same size L3*W3(2mm*4.2 mm) on the long edge of the radiation patch L0 is conducive to adjusting the antenna resonance frequency and improving the compatibility of the antenna and the chip.

4. SIMULATION RESULTS

In Fig. 2(a), the length of the short cut line L1 and the embedded depth of the chip are unchanged, and the slot width W1 is changed. As the slot width increases, the impedance value

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

of the antenna decreases slowly first, and then rapidly decreases and remains stable value; In(b), maintain the chip embedding depth L2, slot width W1, change the short cut line length L1, as the short cut line length increases, the antenna impedance value slowly decreases; In(c), maintain a short cut line length of L1 and a slot width of W1, change the chip embedding depth L2, and as the embedding depth increases, the antenna impedance value decreases at a uniform speed. After optimization, it was determined that W1 = 9.8 mm, L1 = 26.7 mm, and L2 = 15.6 mm. In (d), at the resonance frequency 920MHz, the antenna impedance value was 27 + j201.5 Ω.

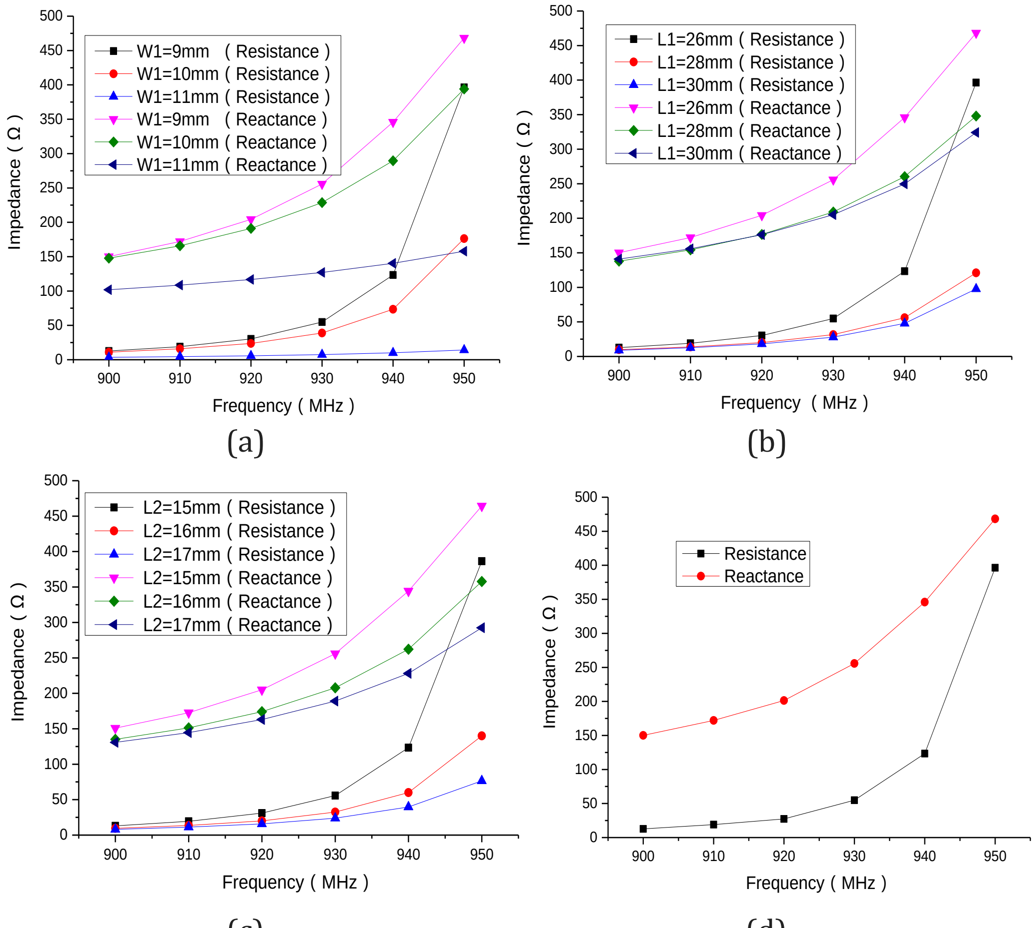

Fig 2. Impedance characteristic simulation:(a),(b),(c) antenna impedance with slot width W1, short cut line length L1, chip embedding depth L2,(d) optimized antenna impedance change curve graph

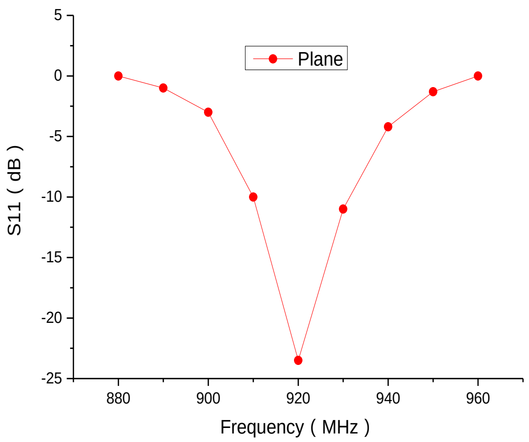

Fig 3. Reflection coefficient

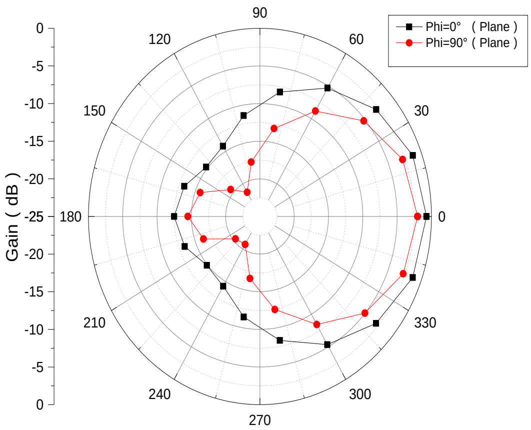

Fig 4. Gain

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

Fig. 3 shows the antenna reflection coefficient S11 graph after the HFSS simulation. From the figure, at the resonance frequency center f=920 MHz, the reflection coefficient after the label antenna is placed on the plane is -23.5 dB. The -3dB frequency ranges are 900MHz-945MHz (45MHz) and 902MHz-938MHz (36MHz), respectively, completely covering China's stipulated ultra-high frequency band range (920MHz-925MHz). Fig.4 shows the gain of the antenna at different angles of the plane and arc, with maximum gain of -1.2 dB.

Formula for calculating the transmission distance by Frith:

$$R = \frac{\lambda}{4\pi}\sqrt{\frac{EIRP \bullet G_r \bullet \tau}{P_{th}}} \tag{1}$$

Among them, EIRP represents the equivalent omnidirectional radiation power, the Chinese standard is set at 33dBm, Gr is the gain of the receiving antenna, τ is the transmission efficiency, and Pth is the read sensitivity of the chip. The calculation of the measurement data into the formula results in a maximum recognition distance of 2.95 m in the plane.

5. CONCLUSION

Ordinary labels are difficult to cope with problems such as uneven surface and metal environment. In order to solve these problems, an ultra-thin flexible anti-metal label antenna is designed in this paper, and structural drawings and simulation operations are drawn through HFSS software to obtain reflection coefficients and gain. Calculate the identification distance. By changing the width of the short cut line, the size of the slot, and the position of the short-circuit patch, the label compatibility is continuously improved and the antenna that meets the requirements is designed. Finally, the antenna parameters have good performance and can be used for the management of uneven metal items in express freight.

REFERENCES

[1] Karthaus U, Fischer M. Fully integrated passive UHF RFID transponder IC with 16.7-/spl mu/W minimum RF input power[J]. IEEE Journal of Solid-State Circuits, 2003, 38(10):1602-1608.

[2] Lee J H, Kim J H, Lim G H, et al. Low-Power 512-Bit EEPROM Designed for UHF RFID Tag Chip[J]. Etri Journal, 2008, 30(3):721-724.

[3] Prothro J T, Durgin G D, Griffin J D. The Effects of a Metal Ground Plane on RFID Tag Antennas[C]// Antennas and Propagation Society International Symposium. IEEE, 2006:3241-3244.

[4] Nikitin P V, Rao K V S. Theory and measurement of backscattering from RFID tags[J]. IEEE Trans.antennas Propag.mag, 2007, 48(6):212-218.

[5] Marrocco G. The art of UHF RFID antenna design: impedance-matching and size-reduction techniques[J]. Antennas & Propagation Magazine IEEE, 2008, 50(1):66-79.

[6] Jaakkola K. Small On-Metal UHF RFID Transponder With Long Read Range[J]. IEEE Transactions on Antennas & Propagation, 2016, PP(99):1-1.

[7] Foster P R, Burberry R A. Antenna problems in RFID systems[C]// Rfid Technology. IET, 1999:3/1-3/5.

[8] Mo L, Zhang H. RFID Antenna Near the Surface of Metal[C]// International Symposium on Microwave, Antenna, Propagation and Emc Technologies for Wireless Communications. IEEE, 2007:803-806.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201912_5(12).0009

[9] Dobkin D M, Weigand S M. Environmental effects on RFID tag antennas[C]// Microwave Symposium Digest, 2005 IEEE MTT-S International. IEEE Xplore, 2005:4 pp.

[10] Raumonen P, Sydanheimo L, Ukkonen L, et al. Folded dipole antenna near metal plate[C]// Antennas and Propagation Society International Symposium. IEEE, 2003:848-851 vol.1.

[11] Griffin J D, Durgin G D, Haldi A, et al. RF Tag Antenna Performance on Various Materials Using Radio Link Budgets[J]. IEEE Antennas & Wireless Propagation Letters, 2006, 5(1):247-250.