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Design of Flexible RFID Tag Antenna Suitable for Aviation Material Management

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Abstract: In order to reduce the operating costs of airlines, eliminate outdated labor-intensive maintenance, assist in the management of civil aircraft onboard equipment, track and manage aircraft components. Especially for the maintenance and management of bending components on airplanes, this paper designs and studies a flexible RFID tag in the UHF frequency band based on its usage characteristics. The tag antenna adopts a T-shaped matching network structure and bending antenna method, with a size of 64mm*12mm*1mm; The working frequency of the antenna does not change significantly after bending, meeting the reading and writing distance requirements of the entire system. The simulation results show that the working frequency of the RFID antenna is still within the range when bent, and the maximum reading distance is 6.5 meters, which meets the actual working requirements.

Keywords: UHF RFID; Flexible Labels; Curved Antenna.

1. Introduction

The commonly used tag antennas are mainly divided into two types, namely: hard tags and flexible tags [1]. For hard labels, they are mainly produced using traditional PCB technology, which has high reliability, high density, high processing accuracy, and good mechanical and electrical properties [2]. In the management of aviation materials, there will be components with diverse shapes, so labels need to work not only on flat surfaces, but also on curved surfaces with a certain degree of curvature, such as the surface of radar covers, the outer packaging surface of life jackets, etc. [3]. In order to avoid the problems of easy folding, damage, and weak adhesion, using flexible RFID tags is easier to achieve common type with devices. As the main substrate materials used are polyvinyl alcohol (PVA), polyester (PET), paper, textile materials, etc., it has the characteristics of being bendable, low in price, and light in weight [4].

2. Antenna Design

Radio frequency identification (RFID) systems have many applications in the ultra-high frequency (UHF) band because they provide a longer reading range and fast reading speed [5]. RFID technology involves short-range wireless communication and the use of radio frequency to read certain information from devices (tags). When the tag antenna is in an ideal working state, the power density at the position where the tag is located is:

$$S = \frac{P_t G_t}{4\pi R^2} \tag{1}$$

In the design process of tag antennas, the recognition distance of the tag antenna is one of the important performance parameters. The Friis Transmission Fonnula [6] provides the relationship between the maximum reading distance of the tag antenna and its threshold energy:

$$\frac{P_{tag}}{P_t} = G_t G_r \left(\frac{\lambda}{4\pi R}\right)^2 \tag{2}$$

Among them, P_{tag} represents the received power of the tag antenna; Is the output power of the reader; G_r is the gain of the reader's transmitting antenna; G_t is the gain of the tag antenna; R represents the distance from the reader antenna to the label [7]. When the power obtained by the chip is greater than the threshold power of the chip, the chip is activated: $P_c > P_{th}$; P_{th} represents the reading sensitivity of the tag chip, and it can be concluded that the maximum reading distance of the tag is [8]:

$$R_{max} = \frac{\lambda}{4\pi}\sqrt{\frac{P_t G_t G_r \tau}{P_{th}}} \tag{3}$$

3. Simulation Parameter Optimization

To verify the feasibility of this design and obtain better results, the HFSS simulation platform was used to model, simulate, and optimize the tag antenna designed in this paper. The tag antenna designed in this article uses Impinj MR6, and the impedance of the antenna is (12-j119.6) Ω at 915MHz. The dielectric substrate of the antenna is made of PET ($\varepsilon_\gamma = 3.9$, $\tan\delta = 0.003$). Its thickness is h=1mm.

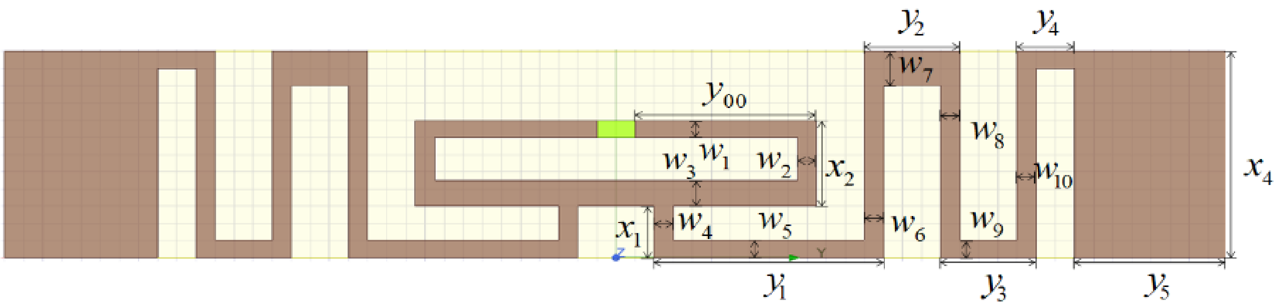

Figure 1. Antenna Model Diagram

Table 1. Antenna Structural Parameter Values (mm)

Parameter	y_{00}	w_1	w_2	w_3	y_1	y_2	y_3	y_4	y_5
Value	9.5	1	1	1.5	12	5	5	3	8

The numerical value shown in Figure 1 is the RFID tag antenna model designed in this article. The tag antenna uses a typical T-shaped branch matched coplanar dipole antenna, which can adjust the impedance of the tag antenna by changing the width and height of the T-shaped branch and increasing the width of the outermost antenna.

4. Analysis of Simulation Results

As shown in Figures 2, 3, and 4, the simulation results show that the tag antenna is in a flat state. From Figure 2, it can be concluded that at 915MHz, the antenna impedance of the tag antenna is approximately 119.7 Ω, and the matching effect between the antenna and the chip is good.

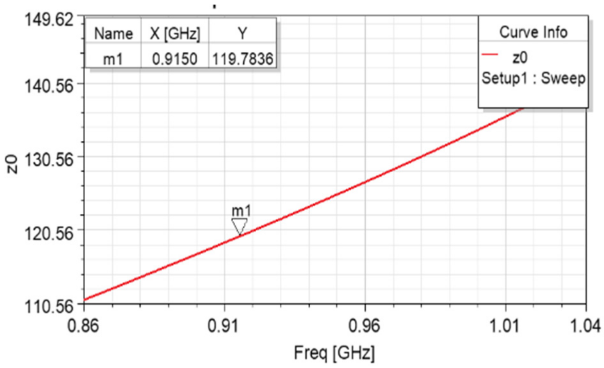

Figure 2. Impedance of planar structure antenna

Figure 3 shows the antenna return loss. When the antenna operates at 915MHz, the corresponding return loss of the tag antenna is -26.2dB; Figure 4 shows the antenna gain, with omnidirectivity on the E-plane and a maximum antenna gain of 1.96 dB.

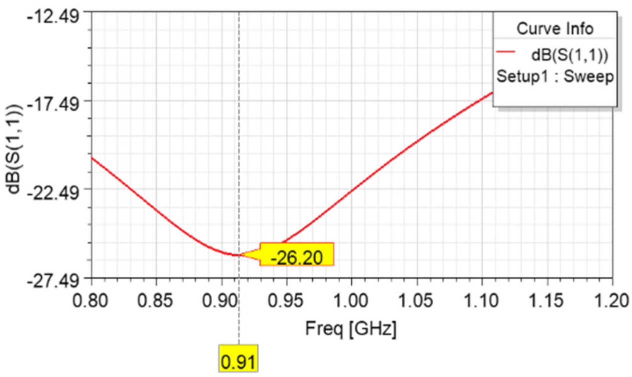

Figure 3. Echo loss diagram of planar structure antenna

In order to simulate the working environment of a flexible RFID tag antenna on a curved surface, a cylindrical component with a radius of 30mm was constructed. At this point, the directional pattern of the antenna at the center frequency point of 915MHz is shown in Figure 5, and the maximum gain of the antenna is 1.56 dB. Through the above experiments, it was found that the tag antenna designed in this article has a relatively small impact on the gain at the central frequency point when working on a curved object surface, and the reading distance of the tag antenna is about 6m.

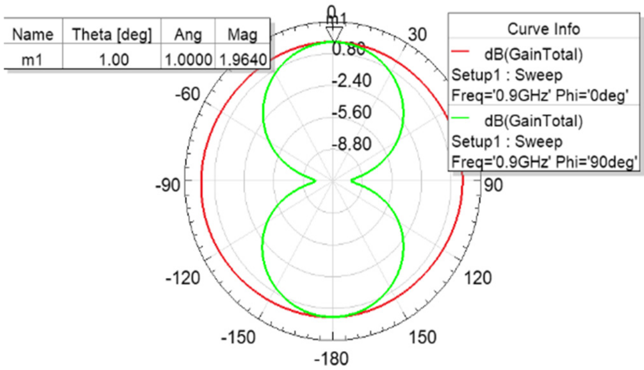

Figure 4. Directional diagram of a planar antenna at the central frequency point

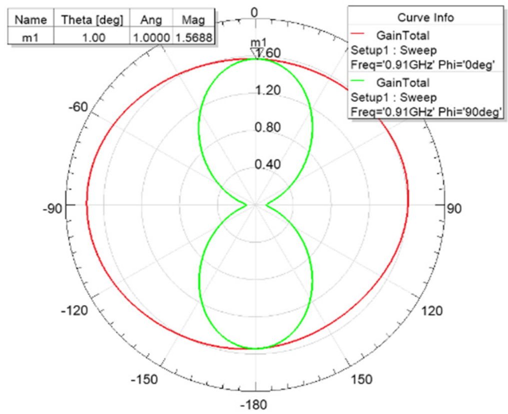

Figure 5. Direction diagram of the curved structure antenna at the central frequency point

5. Conclusion

This article designs a flexible RFID tag antenna with a center frequency of 915 MHz. The overall size of the antenna is: $64mm * 12mm * 1mm$. Through simulation verification, when the tag is in a planar structure, the tag bandwidth can be covered; The maximum reading distance is 6.5 meters; And the label was attached to the surface of a curved object for experimentation, and the results showed that the reading distance under a cylindrical component with a radius of 30 mm was about 6 meters, which meets the design requirements.

Acknowledgments

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