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DESIGN AND OPTIMIZATION OF A NOVEL RFID TAG ANTENNA

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Abstract. This article presents a new antenna structure design for the actual demands of an RFID tag antenna to meet the need of broadband and miniaturization. The influence of the parameters of center frequency, return loss and bandwidth is analyzed in detail because of the sensitive-side parameter changing. The bandwidth characteristics of the antenna are improved by multilayer medium. Based on this, a miniature antenna is introduced which can work at 923 MHz with a good return loss. The designed antenna has a size of 34×33 mm, which is the smallest in the class of tag antennas.

Keywords: RFID; tag antenna; return loss; multilayer substrate.

References

[1] Janeczek K., Serzysko T. Mechanical durability of RFID chip joints assembled on flexible substrates [J]. Soldering & Surface Mount Technology, 2012, 24(3).

[2] Amendola S., Manzari S., Marrocco G. A Passive RFID System for Remote Monitoring and Control of Overnight Living Environment [J]. Procedia Computer Science, 2014, 32.

[3] Zu J., Chen Z. H., Zhong S. Y. Research and Design of Novel Fractal Reader Antenna [J]. Applied Mechanics and Materials, 2011.

[4] RFID antenna has immunity for industrial systems [J]. Electronics Weekly, 2013.

[5] Zhao Z. M., Zhen L. RFID Tag as a Sensor – A Review on the Innovative Designs and Applications [J]. Measurement Science Review, 2016, 16(6).

[6] Suk Kyoung Kim, Min Jae Park, Eun Ji Ahn. Investigating the role of task-technology fit along with attractiveness of alternative technology to utilize RFID system in the organization [J]. Information Development, 2015, 31(5).

[7] RFID Multi-hop Relay Algorithms with Active Relay Tags in Tag-Talks-First Mode [J]. International Journal of Networking and Computing, 2014, 4(2).

[8] Hozak K., Collier D. RFID as an Enabler of Improved Manufacturing Performance [J]. Decision Sciences, 2008, 39(4).

[9] Cousin X., Leguay D. Early individual electronic identification of sea bass using RFID microtags: A first example of early phenotype of sex-related growth [J]. Aquaculture, 2014:426-427.

[10] Eun Jun Yoon. Improvement of the securing RFID systems conforming to EPC Class 1 Generation 2 standard [J]. Expert Systems With Applications, 2011, 39(1).

Problem statement. The technology of RFID (Radio-Frequency Identification) has drawn a swirl of attention in the past few years as it helps identify objects and people in a fast, accurate and inexpensive way. It has been applied to many areas, including passports, transportation payment, product tracing, automotive and animal identification, etc.

RFID consists of two main parts: an electronic label (tag) and a read/write device (reader). Accompanied by tag and reader coding, the process of automatic identification at a distance is accomplished via antenna non-contact data transmission. At present, the research and application of RFID antenna in the ultra-high frequency band are becoming more and more widespread. The potential use of UHF Tag would be tremendous.

In view of the existing problems in the antenna, this paper introduces a design of a small RFID transfiguration microstrip label antenna with a working frequency of 923 MHz. Besides, the main antenna parameters (structure, size, etc.) are simulated and analyzed. This antenna structure not only applies to the 923 MHz band, but also can be employed at the 2.45 GHZ microwave band.

Basic material.

1. Antenna structural design

The RFID antenna can have three basic forms: a coil, a microstrip patch, and a dipole. The RFID antennas of the close-range systems (operating on less than 1 m) are mainly low-cost coil antennas, which work in low-frequency bands. To cover more than 1 m, the system requires a microstrip patch or dipole RFID antenna, as they work in high and microwave frequencies.

The normal microstrip size is obviously too large, and even with the insertion of a short-circuit needle and other miniaturization techniques, the effect is not quite satisfactory. Therefore, we will adopt a smaller, deformed microstrip antenna, which is expected to optimize the antenna.

First, let us consider the antenna structure. The dielectric plate is made of teflon, its thickness is set to 3 mm, length — 34 mm, and width — 33 mm. The microstrip patch and microstrip line are made of electrically conductive materials. The size of the patch is 11×24 mm, while the size of the line can be changed to obtain the expected result. In this study, it is set to 75 mm. The details of geometry of the antenna are shown in Fig. 1.

2. Antenna performance analysis

Simulation and calculation of the characteristic parameters of the antenna. The HFSS software of MATLAB and ANSOFT have been used to simulate the antenna structure. The results are shown in Fig 2. As indicated in the graph, the resonant center frequency of the antenna is 923.2 mhz, the return loss is -23.88 dB, and the bandwidth is 22.2 MHz, which basically meets the requirements.

The key length of the antenna affects the antenna performance. In the antenna structure, every change of the length affects the radiation characteristics of the antenna. During the simulation, we have found that some of the edges have less influence on the antenna performance, while some of them have a greater influence. Having compared the simulation results, we choose the size structure that is relatively optimized for natural performance. The two relatively sensitive edges of the antennas are *W1* and *W2*. Let us change the length of the antenna S11 and discuss the effect that such a change has on its characteristics.

The plane diagram of the antenna is as demonstrated in Fig. 3.

Tables 1, 2, 3 show the main characteristic parameters of the deformed microstrip antenna with the changes of *W1, W2* and *L*. Fig. 4, 5, and 6 are the corresponding simulation diagrams.

Through the research on the key edges, we can get the following conclusions.

1). When the antenna microstrip line length is longer, the resonance frequency of the antenna is reduced. This is especially evidenced by Fig. 5; the formula is as follows:

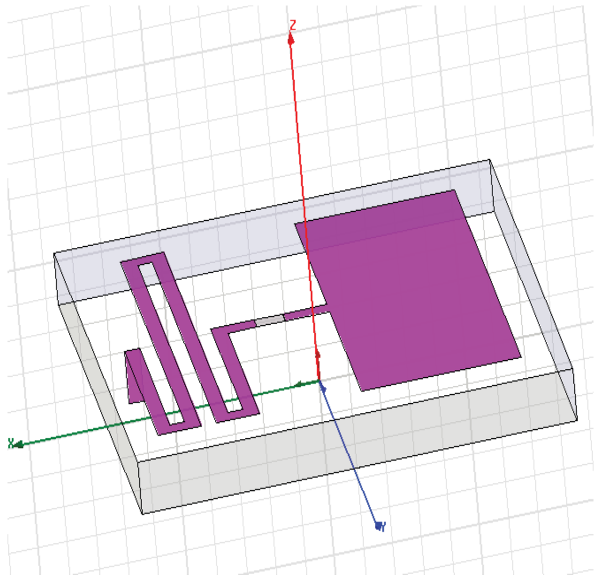

Fig. 1. Geometry of the antenna

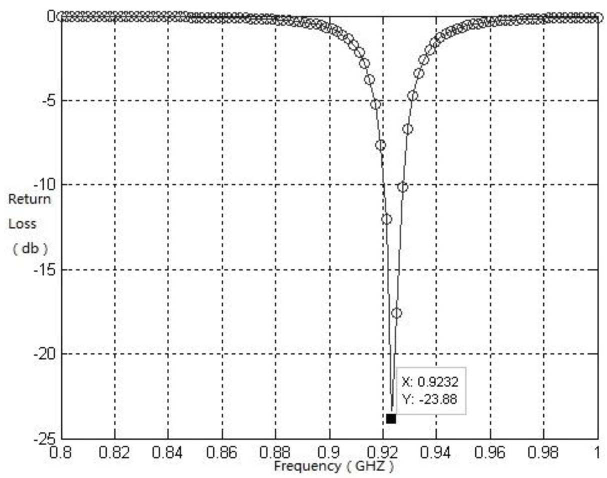

Fig. 2. Return loss of the antenna

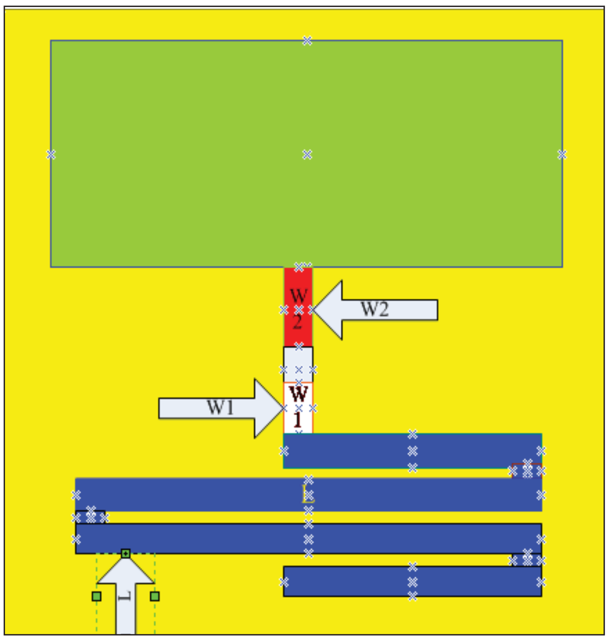

Fig. 3. Plane diagram of the antenna

Table 1. The effect of *W1* change on antenna performance

W1	Return Loss (dB)	3 dB Bandwidth (MHz)	Resonant Frequency (MHz)
1 mm	–34.13	20.2	965.7
2 mm	–28.37	22.2	943.4
3 mm	–23.88	20.2	923.2

Table 2. The effect of *W2* change on antenna performance

W2	Return Loss (dB)	3 dB Bandwidth (MHz)	Resonant Frequency (MHz)
1 mm	–27.52	20.2	937.4
2 mm	–25.55	19.8	931.3
3 mm	–26.45	20.2	927.2
4 mm	–23.88	20.1	923.2

Table 3. The effect of *L* change on antenna performance

L	Return Loss (dB)	3 dB Bandwidth (MHz)	Resonant Frequency (MHz)
73 mm	–26.83	18.2	973.7
74 mm	–25.12	21.3	951.2
75 mm	–23.88	20.2	923.2

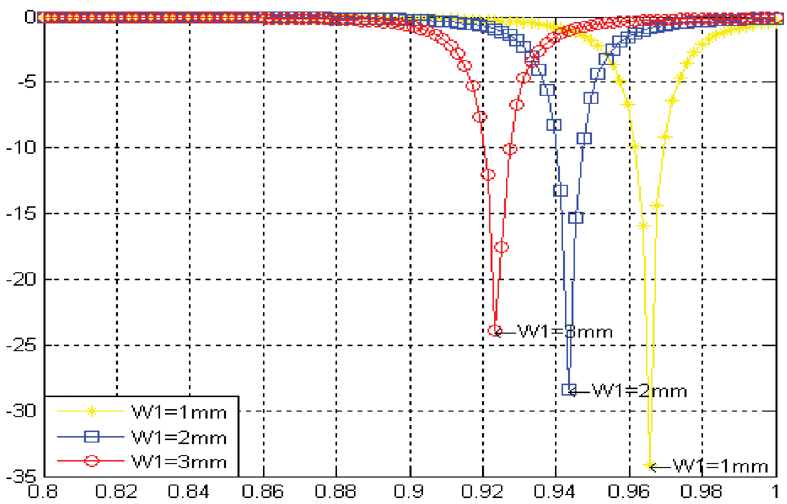

Fig. 4. The effect of *W1* on antenna performance

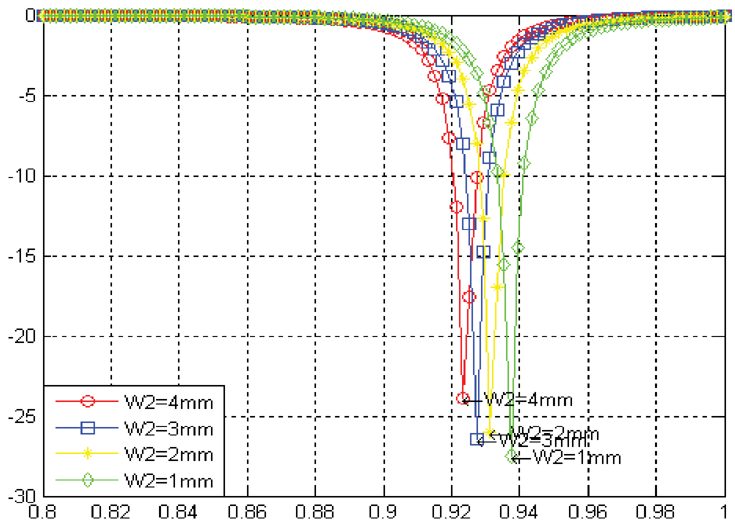

Fig. 5. The effect of *W2* change on antenna performance

$$L = \frac{c}{2 f_r \sqrt{\varepsilon_e \mu_e}},$$

where L is the length of the microstrip line, f_r is the resonant frequency, is the effective dielectric constant, ε_e is the magnetic conductivity, and c is the light velocity.

2). Looking at the differences between Fig. 4, Fig. 5, and Fig. 6, when the speed of *W2* is changed to 1 mm uniformly, the resonance point is obviously not changing as rapidly as the parameters of *W1* and *L*, which should be considered in the following two aspects.

First, we can combine the two methods above in relation to the adjustable antenna, that is, you need to change *W1* and *L* to adjust the antenna performance, or change *W2* to fine-tune the antenna performance.

Second, if the *W2* is not accurate due to technical or other reasons, the antenna performance will have a side effect.

3. Improved antenna bandwidth

There are many ways to entend the band of microstrip antennas, for example, using a thick base plate, using a smaller base plate, implementing additional impedance-matching network, or using a multilayer medium. However, due to the antenna structure and actual application, we can only improve the performance of the antenna by changing the base material and adopting the composite medium. Here are some studies on this issue.

Using a smaller ε_e base plate. When ε_e is reduced, the "bondage" from the medium to the field decreases, which is easy for radiation. At the same time, the antenna decreases as energy storage decreases, which results in a wider frequency band for the manufacturer. On the other hand, the reduced ε_e results not only in a wider band, but also in a lower efficiency, and the rise of return loss. The simulation results are shown in Fig. 7.

Using composite medium to extend the bandwidth. The choice of the base medium is determined by many factors influencing each other. In addition to the base thickness, the structural arrangement is also important. The base thickness in this paper is divided into three layers (3.0 mm in total): polytetrafluoroethylene, which

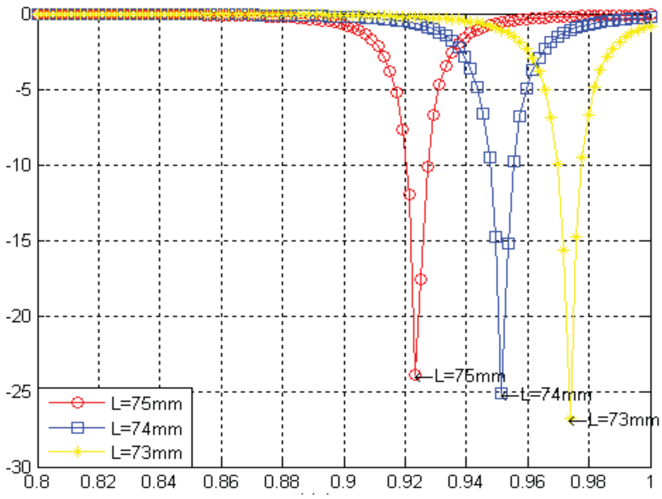

Fig. 6. The effect of *L* change on antenna performance

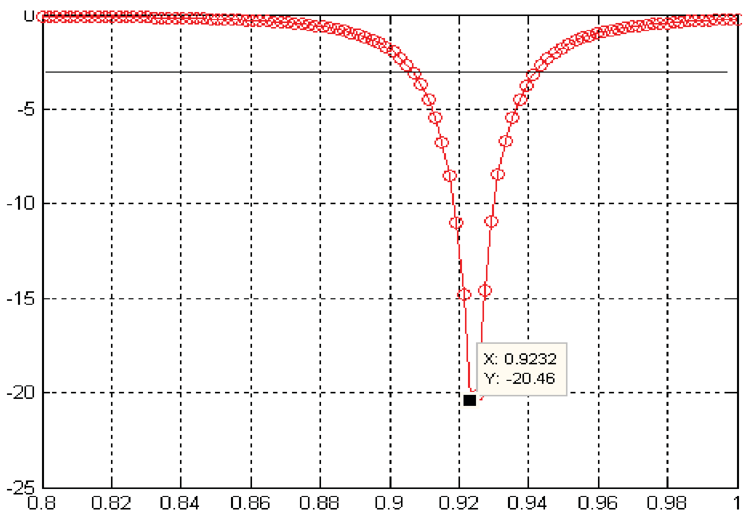

Fig. 7. Relationship between the dielectric constant and the bandwidth

is adjacent to the substrate (0.4 mm), ROGERS 4232 (2.1 mm), and ROGERS 5880 (0.5 mm). The three layers are equal in size and arranged vertically. The simulation results are shown in Fig. 8.

The antenna bandwidth obtained by using the three-layer medium is 42.3 MHz, and we can compare it with Fig. 2, Fig. 7 and Fig. 8. The specific parameter values are shown in Table 4.

The following conclusions can be drawn from analyzing three different antenna structures.

Implementation of the materials with a smaller dielectric constant is relatively traditional and simple. Yet, this method is not universally applicable to various microbelts, since the ε_r reduction will affect the key parameters of the antenna, such as echo loss, directivity, etc. This can be seen from Table 4, which implies that if we are to achieve the broadband goal, we have to sacrifice the return loss.

On the contrary, the multilayer dielectric plate technology not only can provide the bandwidth, but also has little impact on other key parameters. The optimized bandwidth is 42.3 MHz, and return loss reached 24.47 dB. Therefore, this method is recommended for use under allowable circumstances.

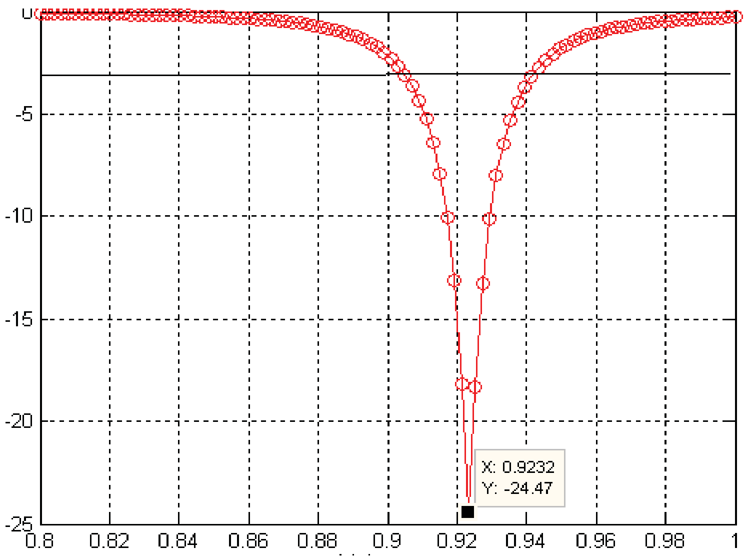

Fig. 8. The relationship between multilayer dielectric board and bandwidth

Table 4. Comparison of the bandwidth of the three antennas

	Non-optimized antenna	Smaller ε_r antenna	Three-layer medium antenna
Band Width (MHz)	20.2	38.2	42.3
Return Loss (dB)	–23.88	–20.46	–24.47

CONCLUSIONS. Based on a new model of the microstrip antenna, this paper proposes an improvement scheme, namely, the deformed microstrip antenna working at 923 MHz. A series of simulation is carried out on the scheme.

The simulation shows that the antenna's sensitive edge plays an important role in the overall performance. In the second part of this paper, the optimization scheme is presented, which is aimed at improving the antenna's structure by using a multilayer medium, and the simulation results are given. Some improvements can be made on this basis, such as extension of the range of practical applications by means of a patch or "open window".

A patch antenna with a small volume, simple manufacturing process and large gain is designed. The surface of the antenna is made of copper; it has a size of 30×40 mm. Two isosceles triangles (3 mm at the waist) are removed on the diagonal and a small square core is dug in the center of the copper with a side length of 3.5 mm. It is located in the center of a square of air and a length of 600 mm. The radiation absorption boundary is placed on the outer surface of the cube. The bottom of the base is covered with copper for grounding.

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