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Design dual band microstrip antenna for RFID application

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Abstract. The research, simulation and design dual band antenna which operates at 900MHz and 2.45GHz are conducted. FR4-epoxy substrate is chosen with thickness h = 1.5mm, $\varepsilon_r = 4.4$. Dual band can be achieved by using different methods of impedance's matching for single antenna which is originally designed at 900MHz. Some dual band RFID structures are discussed in this paper.

Keywords: dual band antenna, RFID antenna, impedance matching.

1. Introduction

It is not new concept, however recent years, Radio Frequency Identification (RFID) is used widely. Nowadays, RFID usually operates at 125 kHz - 135 kHz (LF), 13.56MHz (HF), 420MHz - 460MHz, 860MHz - 960MHz (UHF), 2.45GHz, 5.8GHz (ISM) [1-4].

However depending on the using purposes, some applications need small structure, others require multipurpose tags or tags can be used in different environments. Therefore reduction size of antenna and combination multi antennas are requested [5].

In this aspect, dual band antennas are one of the best solutions. The combination of frequencies usually is between 900MHz and 2.45GHz or 13.56MHz and 900MHz. In fact, so far many structures have been studied. For example, designing two antennas on the same substrate or using a rectangular patch or H-shape patch with coaxial feeder and shorting pin. Other structures like slot antennas with L – shape or U – shape structures can be used too.

In this paper, we propose new approach to achieve dual band from single antenna by matching impedance method. We chose dual antenna which operate at 900MHz and 2.45GHz to design, simulate and manufacture.

2. Design and simulation

It should be noted that any antenna always has more than one resonant frequency. It depends on feeder or matching impedance. Normally, it is not difficult to find first resonant frequency. As a dipole, with length of arm approximates $\lambda/2$, we can consider first resonant frequency [6]. The applications only use one frequency on tags usually ignore other positions.

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But in this paper we want to have good second resonant frequency by this theory. We will begin with an antenna which operates at 900MHz, then using matching impedance to find second resonant frequency 2.45GHz. Although we add stubs on original antenna can reduce or change position of first frequency, but we can control this change by adjust position, size step by step very carefully, sometime we need to adjust a little width of elements of original design.

This paper examines two types of impedance matching. One uses stub to match impedance, while other one matches impedance by slots. All of design use substrate of FR-4 epoxy with thickness 1.5mm, ε = 4.4.

In first type of matching, we examine two kinds of antenna. The first one is showed Fig. 1.

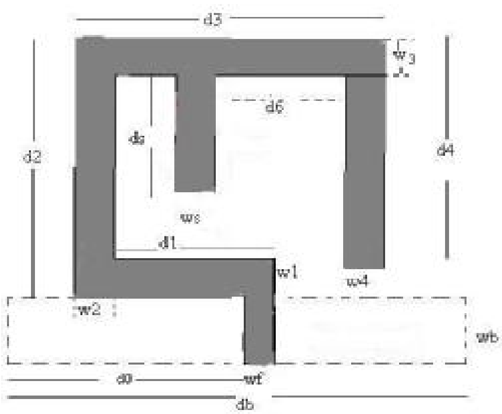

Fig 1.

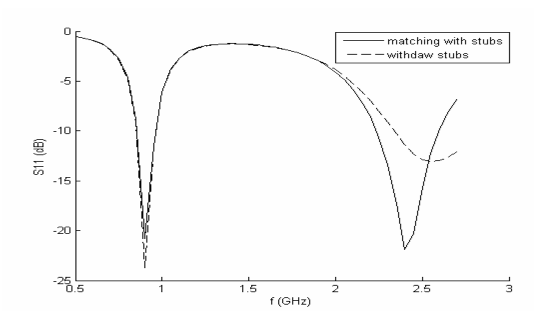

Fig 2.

We started antenna operate at 900MHz which is designed as rectangular meander with microstrip line 50Ω. The length and width of antenna is calculated by Ansoft Designer. Detail size of this antenna: Width: w1 = w2 = w3 = w4 = 4mm; Length: d0 = 25 mm, d1 = 16 mm, d2 = 28mm, d3 = 31mm, d4 = 25mm, d5 = 13mm; Stub has width ws = 4mm and length ds = 13mm.

Ground plane coincides with bottom side, width and length of ground plane wg, dg equal 8 mm, 50 mm respectively. Result of simulation is plotted at Fig. 2.

Figure 2 is a result of simulation for two above cases. When antenna has not stubs (red line), it only operate well at 900MHz, while at 2.45GHz, S11 value is worsen. When the stubs are added, at 900MHz, there is a litter change of S11 values, while at 2.45GHz, it is strongly better.

Second of type matching: matching by slot. Continuously using rectangular meander antenna. We keep bottom side, add rectangular patch into center antenna on top side. Distance between each edge of patch and antenna is adjusted to match impedance. In the paper, this distance is 1mm. Then we add an L-shape slot into center rectangular patch. Now our antenna has shape as figure 5. It looks like an o'clock. Fortunately, when we change position, size, angle of "hands of o'clock", we can match impedance better.

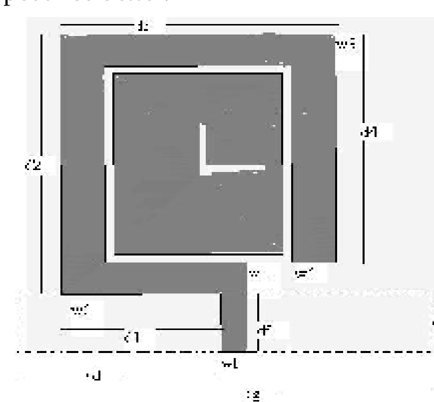

Fig 3.

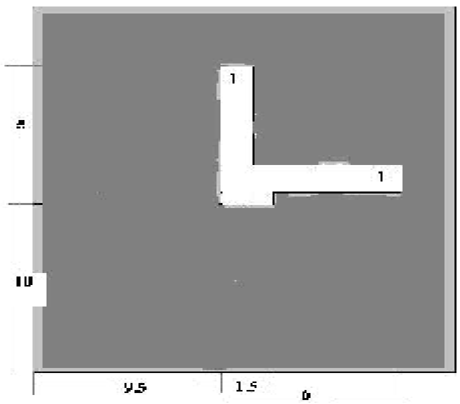

Fig. 4. Size of L – slot.

The size of this design: w1 = w3 = 4mm, w2=w4 =5mm, d1 = 18mm, d2 = 33mm, d3 = 31mm, d4 = 29mm, width of microstrip line wf = 3 mm, df = 8mm. Ground plane on bottom side with wg = 8mm, dg = 50mm. Distance d between feed point to edge of ground plane is d = 25mm. Rectangular patch has size 19mm x 23 mm, width of slots is 1 mm.

We also check some other shapes of “hands of o’clock” too. Fig. 5 shows two antennas which are similar to antenna at Fig. 3 and have different rectangular patch. Results are compared at Fig. 6.

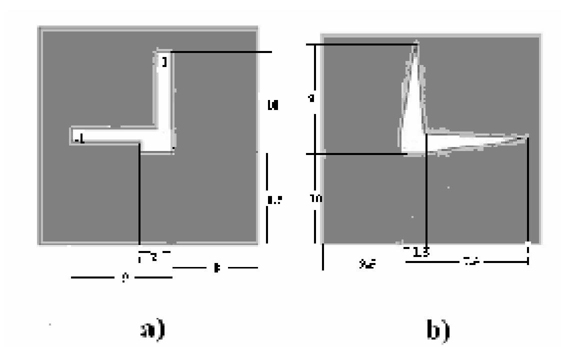

Fig 5.

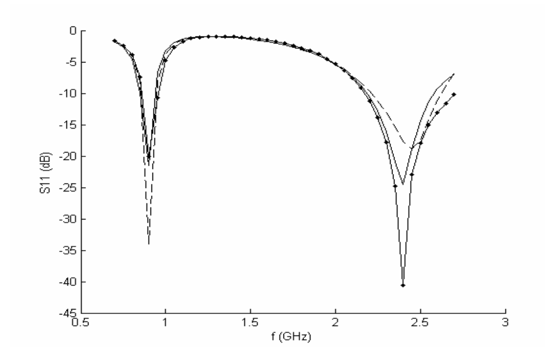

Fig 6.

Dash line as result of simulation antenna at Figure 4, solid line is result of antenna at Figure. 5 (a) and result of antenna at Figure 5(b) is remains.

At this type, when using rectangular patch not only give good result at frequency 2.45GHz but also improving matching impedance at 900MHz.

3. Measurement result

Measurement results are analyzed by Network Analyzer. S11 parameter was displayed and compared with simulation. We also consider radiation pattern at 900MHz and 2.45GHz.

For the first design. (The design uses stub).

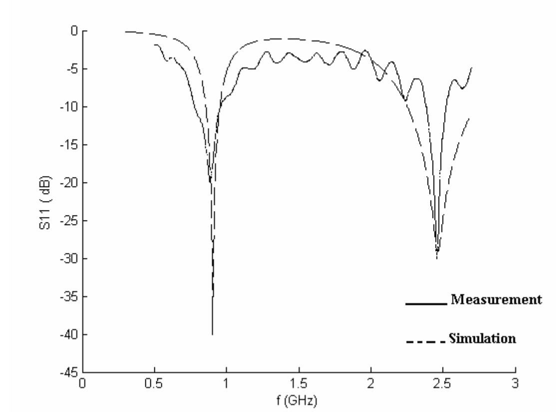

Fig. 7. S11 parameter.

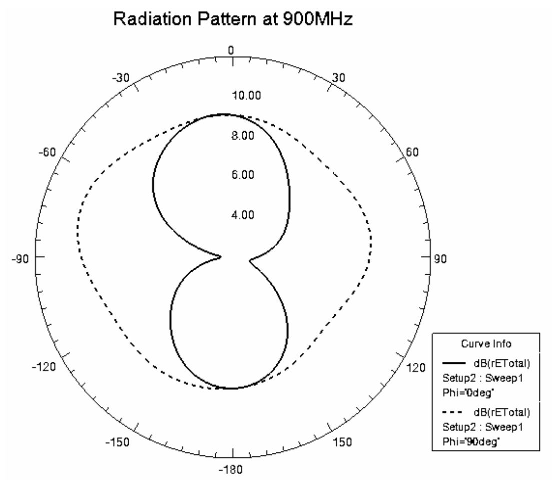

Fig. 8. Radiation pattern at 900MHz.

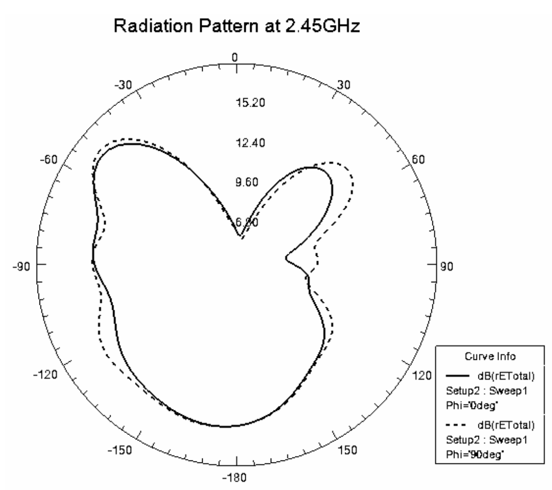

Fig. 9. Radiation pattern at 2.45GHz.

For the second design (The design uses slots).

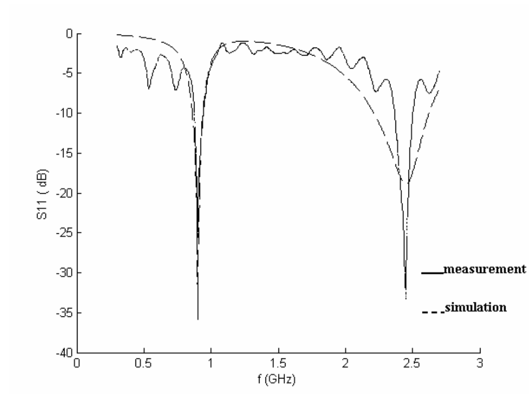

Fig. 10. S11 parameter.

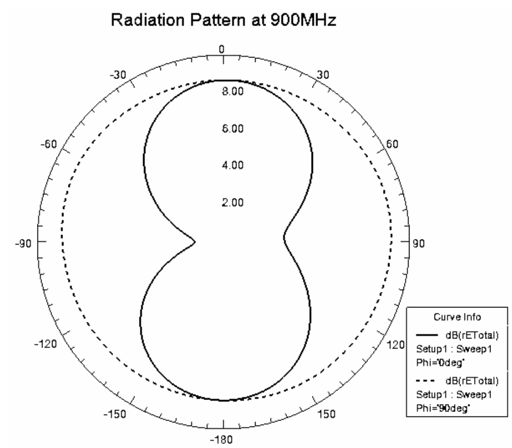

Fig. 11. Radiation pattern at 900MHz.

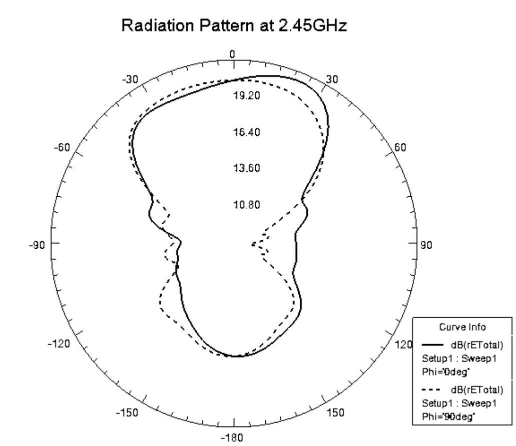

Fig. 12. Radiation pattern at 2.45GHz.

Measurement result is as good as we expect at position of resonant frequency. Although, S11 values are different. With antenna's S11 value usually equals -8dB to -10dB, it means SWR is smaller 2.5, all result of simulation or measurement are close -20dB to -30dB. So these results are in good agreement. Another problem, bandwidth is not quite large. At both 900MHz and 2.45GHz under level of -10dB, measured bandwidth is above 100MHz (100 ÷ 150M), while in simulation at 2.45GHz it is bigger (about 440MHz). However, it should be noted that RFID systems usually operate with small bandwidth as 100MHz bandwidth at 900MHz frequency (860MHz – 960MHz). For this reasons, we can accept this results. Another issue is that at 2.4GHz measurement result is deeper than simulation one, while the bandwidth of measurement result is worse than simulation one. The reason is that the real FR-4 permeability is not exact as in theory ($\varepsilon = 4.4$) and the prototype is not well manufactured.

4. Conclusion

This design is quite simple and not difficult to perform. Measurement result is a litter bit difference than simulation one. But the structure has small dimension and therefore it is found wide application in reality.

Acknowledgements

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Thiết kế anten mạch dải đa băng cho ứng dụng RFID

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Nghiên cứu, thiết kế và mô phỏng anten đa băng hoạt động ở băng tần 900 MHz và 2.45 GHz. Anten được thiết kế trên tấm FR-4 với độ dày 1.5mm và hằng số điện môi là 4.4. Đa băng có thể được tạo nên nhờ việc sử dụng các phương thức phối hợp trở kháng khác nhau của các anten đơn ban đầu được thiết kế ở tần số 900 MHz. Một vài cấu trúc anten đa băng RFID sẽ được đưa ra thảo luận trong bài báo này.