An Omnidirectional Planar Coaxial Antenna with T-shaped Slot Structures

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***Abstract*—An omnidirectional planar coaxial antenna with T-shaped slot structures is proposed. In order to improve the impedance matching, the microstrip line has a gradient section. The T-shaped slots are added to improve magnetic field distribution and miniaturize the antenna. A prototype has been designed and fabricated. The measured results show that the -10 dB bandwidth of the antenna is 8.7% (0.86-0.94 GHz). In this frequency band, the antenna generates an omnidirectional radiation pattern in the E-plane. The proposed antenna has the characteristics of planar shape, light weight and easy to install.**

Keywords*—*planar coaxial antenna, omnidirectional antenna, T-shaped slots

I. Introduction

The coaxial antenna was first proposed by H. Wheeler [1]. Afterwards, many scholars conducted research on this antenna. A high-gain end-fed coaxial collinear antenna and a compact coaxial flared antenna are proposed [2][3]. Both of them have a broad bandwidth. Reference [4] realizes a leaky coaxial cable with circular polarization property. Then, a kind of microstrip coaxial collinear antenna array is designed and it has an omnidirectional radiation pattern [5]. They all achieve a good performance, but their large size limits their application scenarios. For RFID application, the antennas with planar structure and ease of installation are more attractive [6][7]. A novel planar coaxial collinear antenna with rectangular coaxial strip is presented [8]. It realizes the planarization of coaxial antennas and maintains satisfactory performance. Nevertheless, it suffers from a high profile and is inconvenient to assemble. What's more, the magnetic field distribution of the antenna is not good.

Motivated by these works, a planar coaxial antenna using the T-shaped slot structures which exhibits an omnidirectional radiation pattern is proposed in this paper. Cross-linked coaxial sections are used as the radiating elements, and microstrip line is used as feed line. To reduce the size of the antenna and improve magnetic field distribution, T-shaped slot structures are introduced. The microstrip feed line incorporates a gradient structure and a coplanar waveguide structure for better impedance matching. The measured results show that the -10 dB bandwidth of the antenna is 8.7% (0.86-0.94 GHz). The results validate the effectiveness of the proposed design approach.

II. Omnidirectional Planar Coaxial Antenna Design

A. Antenna Structure

Fig. 1 shows the geometry of the proposed planar coaxial antenna. The antenna is designed to operate around 915 MHz on a 1.6 mm FR4 substrate with a relative permittivity ε_r=4.4 and loss tangent of 0.02. It is composed of radiation elements, T-shaped slots, a microstrip feed line. The length of each radiation element is about half wavelength. The current flowing through each section lags by half a wavelength compared to the previous section, but due to the sections are cross-linked, all the sheath currents are in phase. Their amplitude of electromagnetic fields theoretically keeps the same. The shape of the radiating elements is a combination of rectangle and trapezoid, forming a gradually widening shape for improved impedance matching. The T-shaped slots are etched on both sides. The microstrip feed line is located in the center of the substrate to achieve an omnidirectional radiation pattern. The front end of microstrip feed line includes a 50 Ω CPW structure which facilitates the connection with SMA connectors. The starting point of each feed line is connected to the bottom layer of the previous section, and the end point is connected to the top layer of the following section. Moreover, the sidewalls of the radiating elements are replaced by vias. Optimized values of the structure are listed in Table I.

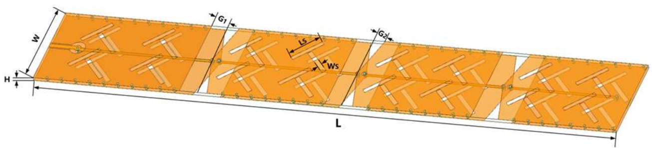


Figure 1. Geometry of the proposed planar coaxial antenna.

TABLE I

DIMENSIONS OF THE PROPOSED STRUCTURE

Parameter	W	L	H	G_1	G_2	L_s	W_s
Value(mm)	40	260	1.6	7.8	5	15	2

B. Evolution of the Proposed Coaxial Antenna

From Fig. 2, it can be seen that Antenna I has a good impedance match but the resonance is shifted towards high frequency. In order to shift the resonance frequency down without increasing the size, Antenna II introduces T-shaped slots. Slots can extend current path so that lowering the resonant frequency of the antenna. In addition, more current will leak from the outer wall which improves the magnetic field distribution. It is evident that the introducing of T-shaped slots not only lowers the resonance frequency but also obtains a better impedance matching. Then, the key parameters on the reflection coefficient are analyzed. It is seen that, the parameter G_1 has a significant impact on the reflection coefficient of the proposed antenna as shown by Fig. 3(a). As G_1 increases, the resonant frequency decreases from 1.0 GHz to 0.96 GHz. Similarly, Fig. 3(b) shows that as G_2 increases, the resonant frequency moves up from 0.81 GHz to 0.94 GHz.

C. Experimental Validation

The proposed antenna is analyzed in High Frequency Structural Simulator (HFSS). Fig. 4 shows the simulated 3D radiation pattern of the proposed antenna. It can be seen that the antenna provides an omnidirectional pattern in the E-plane. The radiation pattern is almost symmetrical about the y-axis. Measured results of S11 are exhibited in Fig. 5. The simulated

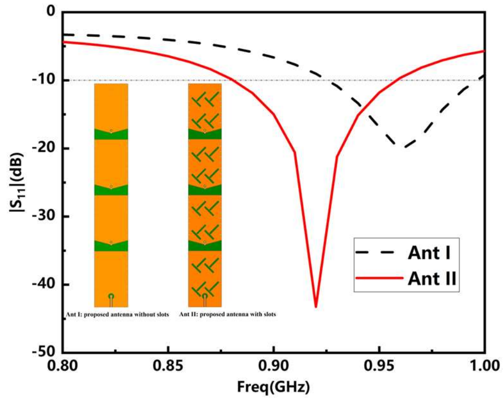
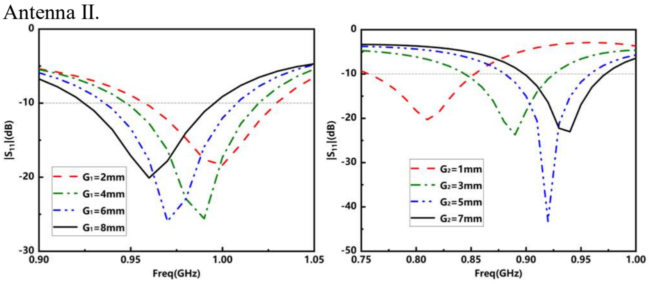


Figure 2. Comparison of simulated reflection coefficient for Antenna I and Antenna II.



(a) (b)

Figure 3. Impact of (a) varying G_1 and (b) varying G_2 on the impedance matching.

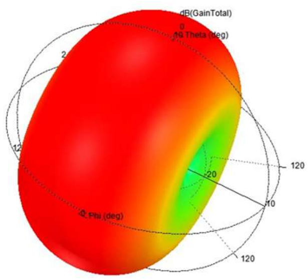


Figure 4. Simulated 3D radiation pattern at 915MHz.

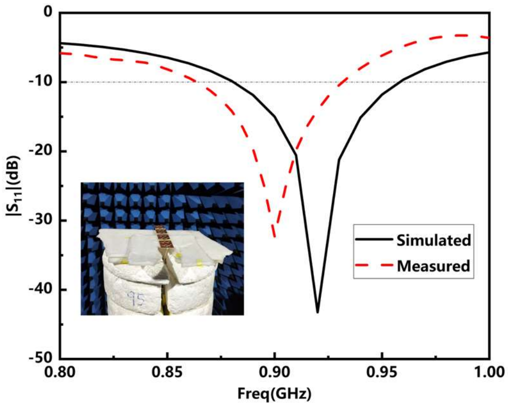
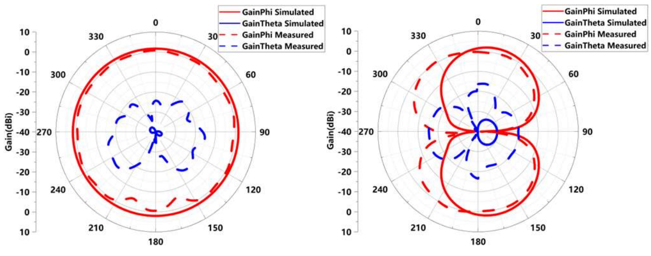


Figure 5. Simulated and measured reflection coefficient of the proposed antenna.

-10 dB bandwidth is from 0.88 GHz to 0.96 GHz while the measured one covers from 0.86 GHz to 0.94 GHz. The discrepancy between them is mainly due to fabrication error. Fig. 6 plots the 2D radiation patterns at 915 MHz. It shows again that the radiation pattern is omnidirectional in the E-plane.



(a) (b)

Figure 6. Radiation patterns of the proposed antenna at 915 MHz. (a) E-plane, (b) H-plane.

III. CONCLUSION

An omnidirectional planar coaxial antenna with T-shaped slot structures has been proposed. The antenna is fed by microstrip and comprises four radiation sections. The results show that the antenna operates in the frequency band of 0.86-0.94 GHz which almost covers the UHF RFID band and achieves an omnidirectional radiation pattern in the E-plane. The proposed antenna has the characteristics of planar configuration, light weight and easy to install. Good performance makes this antenna suitable for RFID applications, especially when installation space is relatively small.

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