A Coplanar Waveguide Fed Tri-Band Antenna Based on Circular Ring Structure

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Abstract*—A compact coplanar waveguide fed tri-band planar antenna based on circular ring structure is designed and simulated with a size of 25.6×25.6×1.6mm^3. This antenna system is composed of four closed circular ring structures, a microstrip feedline, and a planar ground structure, in which each adjacent ring is connected by a small rectangular patch into a closed integral structure. The -10dB impedance bandwidth of the radiation patch is 110MHz(2.44-2.55GHz), 370MHz(3.11-3.48GHz) and 2010MHz(4.04-6.05GHz) and the corresponding center frequency is 2.53GHz,3.37GHz and 5.23GHz respectively. By using trident microstrip feed line and the modified ground structure to from a better impedance match. The radiation pattern of the antenna has consistent omnidirectional, and dipole characteristics at each resonant frequency, which has useful performance for Worldwide Interoperability for Microwave Access and Wireless Local Area Network applications.

Keywords—circular rings; CPW-Fed; Tri-Band; Trident feed line structure

I. INTRODUCTION

Nowadays, with the rapid development of aerospace technology, more demands are proposed on wireless communication technologies and equipment, such as miniaturization, light weight, and multi-band transmission. The first problem that needs to be solved is the waveguide system [1]-[3]. The coplanar waveguide system is easy to realize miniaturization, multi-band, and widening of the bandwidth, due to the advantages of low radiation loss, small parasitic parameters, high integration [4].

In this paper, the designed planar antenna uses the structure of coaxial inner and outer metal circular rings connected by rectangular metal patches to realize the miniaturization and tri-band. Meanwhile, the antenna system increases the stability of the input current and the generation of the frequency points by using trigeminal feed line [5]. Finally, by using a modified ground structure with rectangular slots to achieve the better impedance matching between the microstrip feed line and ground [6]-[7].

II. ANTENNA DESIGN

The geometry of the designed antenna is shown in Fig.1 (a). The radiation patch is composed of three parts: a 50Ω coplanar waveguide microstrip feed line, a trident microstrip feed line and circular rings from bottom to top. The modified grounds are evenly distributed on the patch. The structure 1 and 2 shaped coplanar structure.

The section structure of the antenna is shown in Fig.1 (b). The Substrate of antenna is 25.6×25.6×1.5mm^3 FR-4 material with dielectric constant (ε_r) of 4.4.

Controlling the frequency point and bandwidth of the antenna by adjusting the variable W_1. Then, the feed width (W_f) and gap width (S_3) will be adjusted in order to achieve better impedance matching of 50 ohm. The trident microstrip feed line and the modified ground structure also make the impedance matching of the antenna system better [4]. The above variables and structures are all simulated in the design process by using software HFSS 13.0. The final optimized parameters are shown in TABLE I.

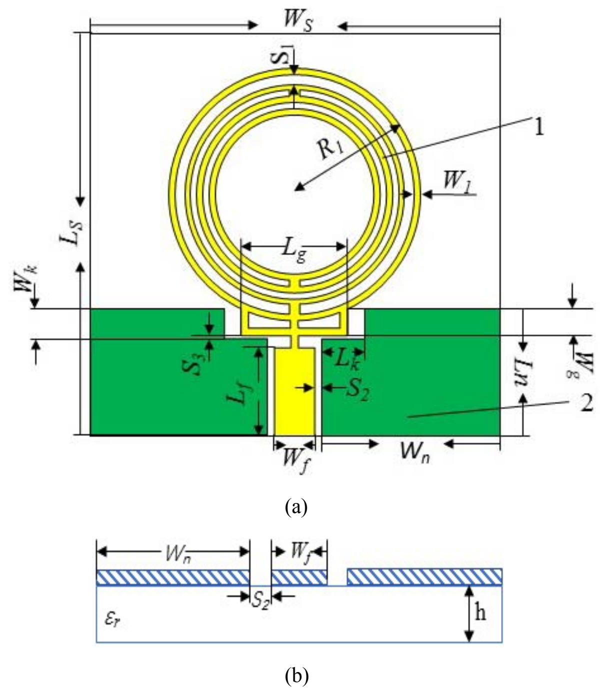

Fig. 1. Designed antenna geometry structure. (a) vertical viewing, (b) side viewing.

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TABLE I. DIMENSIONS OF THE PROPOSED ANTENNA (UNIT:MM)

Dimension	W_s	L_s	L_n	W_n
size	25.6	25.6	7.02	11.31
Dimension	L_f	W_f	L_k	W_k
size	4.91	2.2	1.5	1.34
Dimension	L_g	W_g	R_1	W_1
size	5.0	0.95	7.79	0.5
Dimension	S_1	S_2	S_3	h
size	0.8	0.4	0.4	1.5

III. RESULTS AND DISCUSSION

Simulations are performed by Software HFSS 13.0. The curve in Fig.2 shows the return loss characteristic of the antenna. It is obvious that the proposed antenna offers the bandwidth of 110MHz (2.44-2.55GHz), 370MHz (3.11-3.48GHz), 2010MHz (4.04-6.05GHz) with resonance frequencies of 2.53GHz, 3.37GHz and 5.23GHz, respectively.

The curve in Fig.3 shows the voltage standing wave characteristic of the antenna. In each frequency bandwidth, the value of VSWR is less than 2, which is the effective wave bandwidth. And in each resonance frequency, the value of VSWR both are closed to 1, which shows the better impedance matching of the antenna.

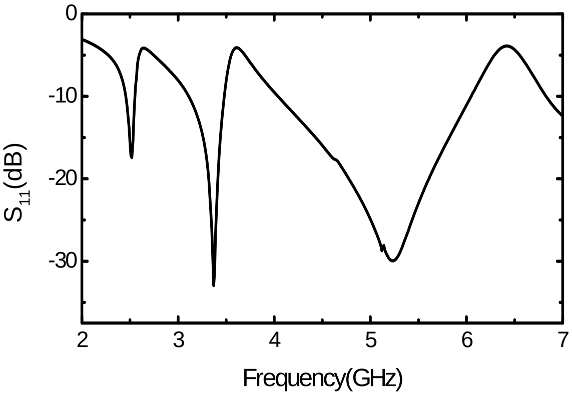

Fig. 2. Simulated return loss of the proposed antenna.

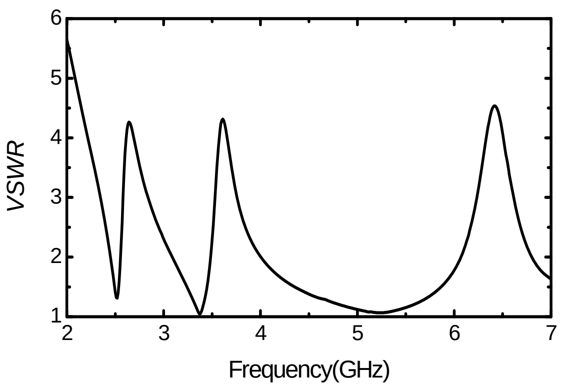

Fig. 3. Simulated voltage standing wave ratio of the proposed antenna.

The far field radiation pattern of proposed antenna is shown in Fig.4(a), 4(b) and 4(c). It can be seen from the Figure that dipole characteristic is got from the E-plane and an omnidirectional pattern is got from the H-plane.

In order to achieve a wider bandwidth and better impedance matching. Variables W_1, W_f, and trident feed line structure are simulated.

The effect of the width of the outer circular ring(W_1) is shown in Fig.5. The width W_1 is varied from 0.4mm to 0.6mm in steps of 0.1mm. It can be seen from the curve that W_1=0.5mm provides the wider bandwidth and better impedance matching at 5.23GHz frequency band.

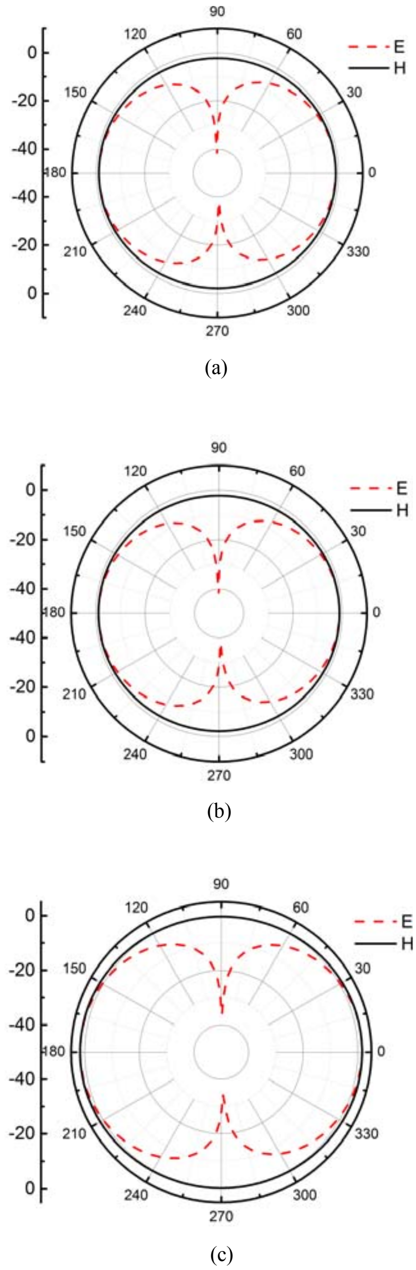

Fig. 4. Far field radiation patterns (a)2.53GHz, (b)3.37GHz, (c)5.23GHz.

The parametric study on feed width (W_f) is shown in Fig.6. It is inferred, for W_f=2.2mm offers better impedance matching.

At last, the effect of the trident feed line structure is shown in Fig.7. This structure offers a better impedance matching for each resonant frequency can be obtained in the curve.

A photograph of the fabricated prototype on an FR4 substrate type is shown in Fig.8.

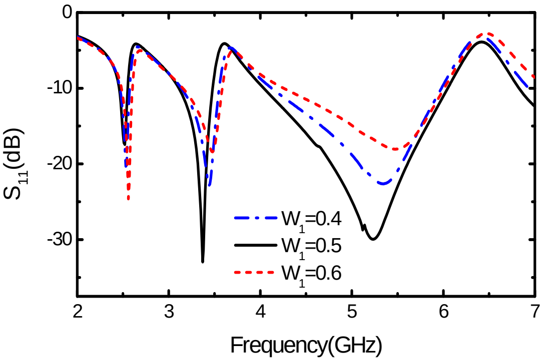

Fig. 5. Simulated return loss characteristics for variable W_1.

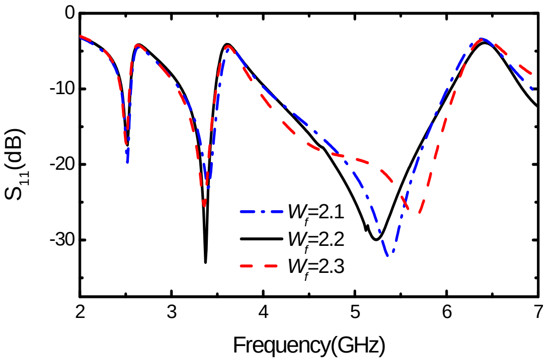

Fig. 6. Simulated return loss characteristics for variable W_f.

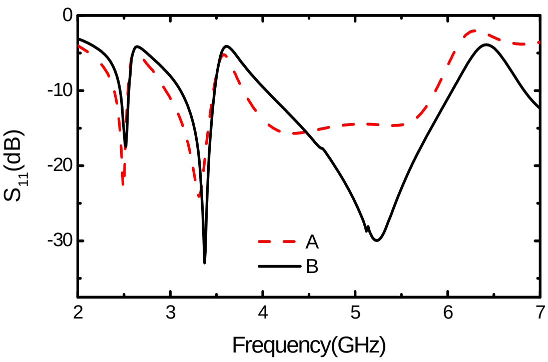

Fig. 7. Simulated return loss characteristics for trident feed line structure. A: without trident feed line structure, B: trident feed line structure.

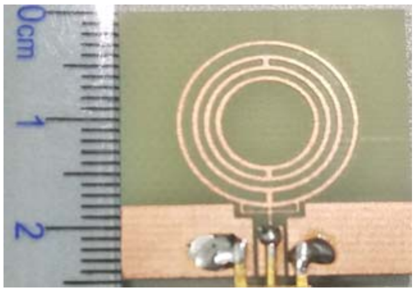

Fig. 8. Photograph of the fabricated prototype.

IV. Conclusion

A new coplanar waveguide fed tri-band antenna structure is proposed in this paper. The designed antenna adopts circular rings, trident feed line and a modified ground structure to achieve tri-band structure, better impedance matching and effective bandwidth, and make antenna has the advantages of small in size, easy integration, low radiation loss. But, due to the large amount of the rings, the structure of the designed antenna looks complicated. The bandwidth of antenna is 2.44-2.55GHz, 3.11-3.48GHz, and 4.04-6.05GHz, respectively, which has a great practical significance for WiMAX and WLAN applications.

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