A Differential Broadband Dual-Polarized Base Station Antenna Element for 4G And 5G Applications

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***Abstract*—In this paper, A broadband differential feed $\pm 45^\circ$ dual-polarized base station antenna element is proposed for 4G and 5G mobile communication. The proposed antenna consists of two orthogonally placed dipole, square patch and reflector, where each dipole adds six elliptical branches to broaden the bandwidth. Simulation results show that the proposed antenna element has the impedance bandwidth of 65% (1.84-3.6 GHz) within the operating band (S_{11} < -15 dB and S_{21} < -21 dB), and good radiation characteristics and high cross polarization ratio are also achieved.**

***Keywords*—broadband, differential, dual-polarized, base station antenna, 4G, 5G**

I. Introduction

With the rapid development of communication technology, the fifth generation mobile communication (5G) is expected to be commercialized in 2019, and the 5G frequency bands of various countries have been deployed, for example, 3.4-3.8 GHz used in Europe, 3.1-3.55 GHz and 3.7-4.2 GHz used in USA [1]. As for China, in order to speed up the 5G process, the Chinese Ministry of Industry and Information Technology has issued the 5G license, each operator has allocated different frequency bands, China Telecom's 5G commercial frequency is 3.4-3.5 GHz, China Unicom is 3.5-3.6 GHz, China Mobile is 2.515-2.675 GHz and 4.8-4.9 GHz, and China Broadcasting Network is 0.7 GHz. However, the commercialization of 5G will not cause the 4G network to withdrawal. For a long time, 4G and 5G will coexist. It is undoubtedly not a very good method to install a new frequency-band base station antenna on a used base station system, thus a broadband base station antennas will be utilized to cover 4G and 5G bands. In addition, base station antenna should have dual polarization characteristic to reduce the influence of multipath fading. In [2], although a broadband dual-polarized antenna is proposed, it can only operate at 1.67-2.72 GHz and not cover the 5G bands. In [3] [4], although the antennas can operate at 3.18-5.19 GHz and 3.3-4.2 GHz respectively, they can not cover the 4G band. [5] proposed a broadband base station antenna, which operates at 2.05-3.64 GHz and cover 4G and 5G bands. However its S_{11} is less than -10 dB, which does not meet the application standard of the base station antenna.

TABLE I
Detailed values of the proposed antenna

Parameter	Value(mm)	Parameter	Value(mm)
L_1	46	L_2	10
L_3	2	L_4	12.2
L_5	8.9	L_f	12.9
L_d	65	L_g	135
R_f	12.5	H_d	0.95
H	36.5	X_{gap}	1.3
Y_{gap}	2		

This paper proposes a broadband base station antenna element for LTE and 5G applications, which covers the frequency bands of 1.84-3.6 GHz. This paper is organized as follows. Section II illustrates the structure of the proposed antenna. Section III analyzes the design process. Section IV presents the simulation results. Section V draws the conclusion.

II. Configuration

Figure 1 shows the configuration of the proposed differential broadband antenna. The antenna consists of a square patch using differential feed, two pairs of orthogonally placed radiators with $\pm 45^\circ$ polarization, and reflector, where each radiator is composed of two sides of triangular, circular arc and three elliptical branches. Two pairs of radiators are printed on the bottom of dielectric substrate(with relative permittivity of $\varepsilon_r = 2.55$, and thickness of 0.95 mm), and the square patch is printed on the top of the dielectric substrate, the outer conductor of the fed coaxial cable is connected to the radiator, and the inner conductor is connected to the square patch through the dielectric substrate. The phase between two ports of each polarization is 180° out of phase. Four coaxial cables achieve differential feed in this way. All parameters of the antenna are optimized and specific values of parameters are listed in Table I.

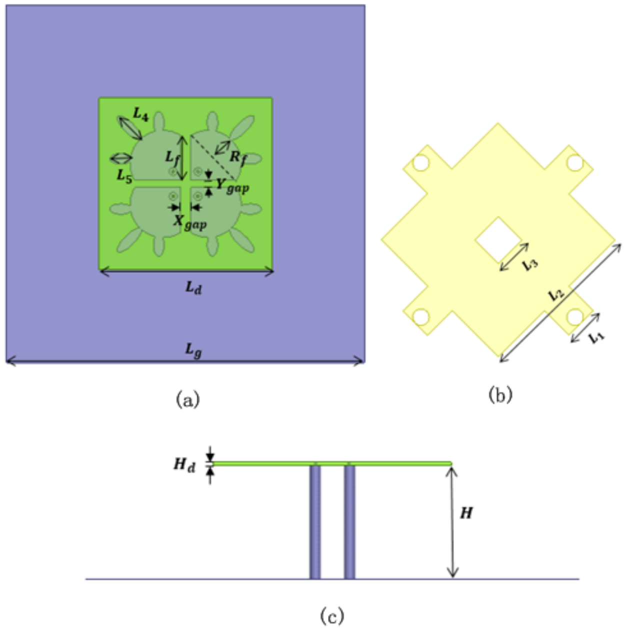

Fig. 1. The geometry of the proposed antenna: (a) Top view; (b) Feed patch; (c) Side view

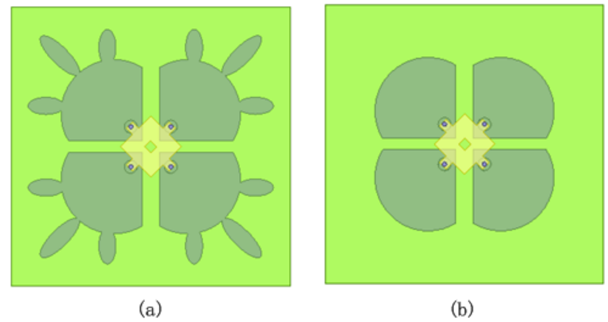

Fig. 2. The structure of the antenna with loaded ellipse and without loaded ellipse: (a) Ref1; (b) Ref2

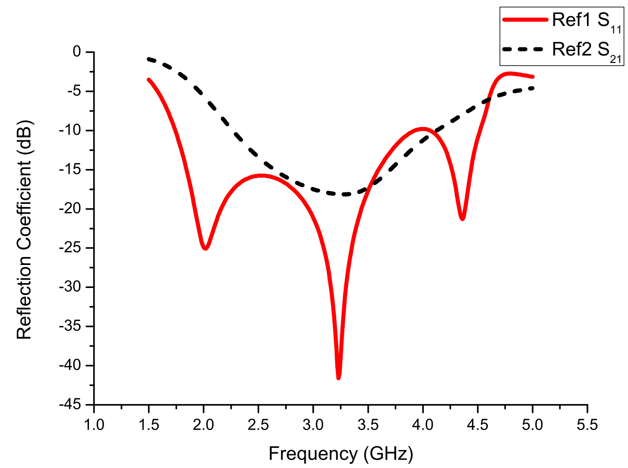

Fig. 3. Simulated reflection coefficients of the antenna Ref1 and Ref2

III. Design and Analysis

A. S parameters of Differential Dual-Polarized Antenna

For differential dual-polarized antenna elements, there are four independent ports, which are considered as dual-port networks with differential feeds, named as P_{d1} and P_{d2}. The differential reflection coefficients of differential ports P_{d1} and P_{d2} are defined as [6]. It is noted that all S_{11} in the article are S_{dd11}, and S_{21} are S_{dd21}.

$$S_{dd11} = \frac{1}{2}(S_{11} - S_{12} - S_{21} + S_{22}) \quad (1)$$

$$S_{dd22} = \frac{1}{2}(S_{33} - S_{34} - S_{43} + S_{44}) \quad (2)$$

$$S_{dd21} = \frac{1}{2}(S_{31} - S_{41} - S_{32} + S_{42}) \quad (3)$$

$$S_{dd12} = \frac{1}{2}(S_{13} - S_{14} - S_{23} + S_{24}) \quad (4)$$

B. Antenna Design

In order to analyze why the antenna is loaded with elliptical branches, Ref 1 antenna with loaded ellipse and Ref 2 antenna without loaded ellipse are designed as shown in Fig. 2. The reflection coefficients of the two structures are shown in Fig. 3. Fig. 3 shows that a resonance point of Ref 1 antenna with loaded ellipse is introduced GHz and 4.3 GHz, the the overall curve is go down gradually, and the impedance bandwidth is effectively broadened to 65% within the operating band (S_{11} <-15 dB).

C. Parameter Analysis

The influence of key parameter H on the antenna performance is analyzed as shown in Fig. 4. When other parameters are fixed, Fig. 4 shows the influence of the parameter H on the antenna performance. Due to the symmetry of the antenna structure, only the S parameters of one differential port are given. It can be seen that the parameter H has nearly no influence on the isolation in the frequency range of 1.84-3.6 GHz, but H has a great influence on the return loss. When the H increases, the higher resonant frequency shift to the lower frequency and the curve of the return loss is go down gradually in frequency band. However, the bandwidth of S_{11} < -15 dB is obviously narrowed, resulting in insufficient bandwidth. Therefore, after considering the bandwidth and the height of the radiating element, H is selected as 36.5 mm.

IV. Simulation Results

Under the optimized parameters, Fig. 5 shows the simulated S-parameter. It is observed that the antenna has broadband and high isolation, over the band of 1.84-3.6 GHz & 4.25-4.4 GHz, its S_{11}<-15 dB, and S_{21}<-21 dB. The H-plane simulated radiation patterns of the proposed antenna at 1.84 GHz, 2.7 GHz, 3.3 GHz are shown in Fig. 6, the gain are 8.2 dBi, 8.7 dBi and 5.8 dBi respectively. The reason why the

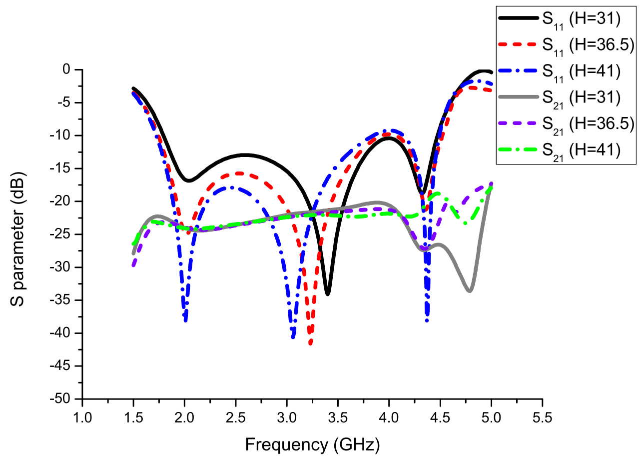

Fig. 4. Simulated S-parameters with different *H*

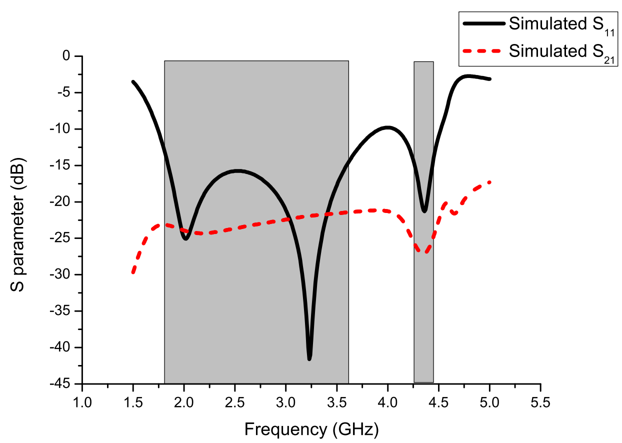

Fig. 5. The simulated S-parameters

gain is lower at 3.3 GHz may be that the distance between the reflector and the radiator is too high to enough reflect energy from the reflector. The front-to-back ratio of each frequency point is greater than 23 dB, and its axial cross-polarization is greater than 28 dB, benefiting from differential feed. Simulation results show the proposed antenna has good performance and it can operate in 4G frequency band and 5G frequency band.

V. CONCLUSION

A wide-band dual-polarized base antenna element is designed by using printed dipole with loaded elliptical branches. Simulation results show that the impedance bandwidth is as high as 65% (1.84-3.6 GHz) when S_{11} is less than -15 dB. The isolation in the frequency band is also below -21 dB, so the interference between different polarization ports is small. The gain in the 4G frequency band is about 8.4 dBi, and the gain in the 5G frequency band is about 6 dBi. Since the differential feed is used, the cross-polarization ratio is improved, and the axial cross-polarization ratio is greater than 28 dB which is much larger than that of the general base station antenna element. Structurally, although the proposed antenna uses differential feed electricity, the overall structure is simple and easy to manufacture. It is implemented by printing the radiator and the feed patch on two sides of the dielectric substrate.

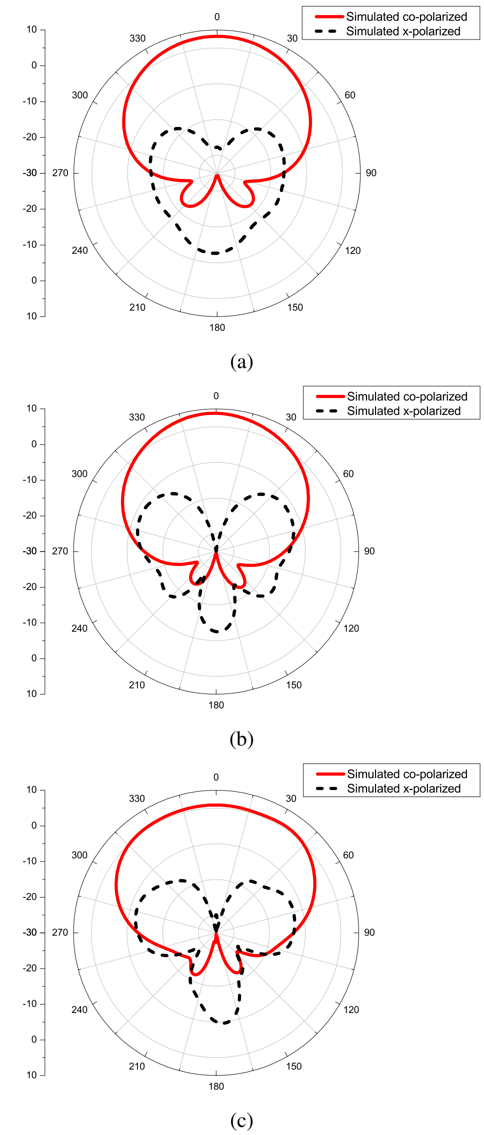

Fig. 6. Simulated gain radiation patterns in H-plane: (a) 1.84 GHz; (b) 2.7 GHz; (c) 3.3 GHz

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