

A Low-Profile Dual-Polarized Dielectric Resonator Antenna for 2G/3G/4G Base Station Applications With Gain Enhancement

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Abstract—A low-profile dual-polarized dielectric resonator antenna reshaping the electric field by slotting the surface of the dielectric resonator to improve gain for use in 2G/3G/4G base stations operating from 1.7 to 2.7 GHz is presented. By stacking two different dielectric layers to expand bandwidth and implementing slot cuts on the surface of DR to improve the high-frequency gain, the antenna with low profile of $0.09\lambda_0$ can obtain an impedance bandwidth of about 50% and a peak gain of 10.2 dBi.

Index Terms—Base station antenna, low-profile antenna, wideband antenna, dual polarization, dielectric resonator antenna.

I. INTRODUCTION

In modern communication systems, dual-polarized antennas have been widely used in base stations [1], [2], [3], because dual-polarized antennas have obvious advantages in improving communication quality, anti-interference ability, spectrum utilization, and other aspects. In traditional base stations, dipole antennas have always been the main form of base station antennas due to their wide operating frequency band, simple design and processing. However, due to the requirement of a $\lambda/4$ spacing between the dipole antenna and the metal floor, the signal reflected by the metal floor can be superimposed on the dipole antenna to achieve high gain radiation, which undoubtedly increases the profile height of the antenna's spatial structure. Due to the fact that dielectric resonators can utilize high dielectric constant to achieve miniaturization and low profile, without the conductor loss and surface electromagnetic wave transmission loss of traditional metal antennas, this is undoubtedly an excellent choice for balancing antenna space structure miniaturization and low profile with antenna radiation efficiency. Stacking two or more layers of different DR has been proven to improve bandwidth and realized gain [4], [5], [6]. The newly reported work in [7] reshapes the electric field distribution by digging rectangular grooves on the side wall of the rectangular dielectric resonator, ultimately achieving a stable high gain

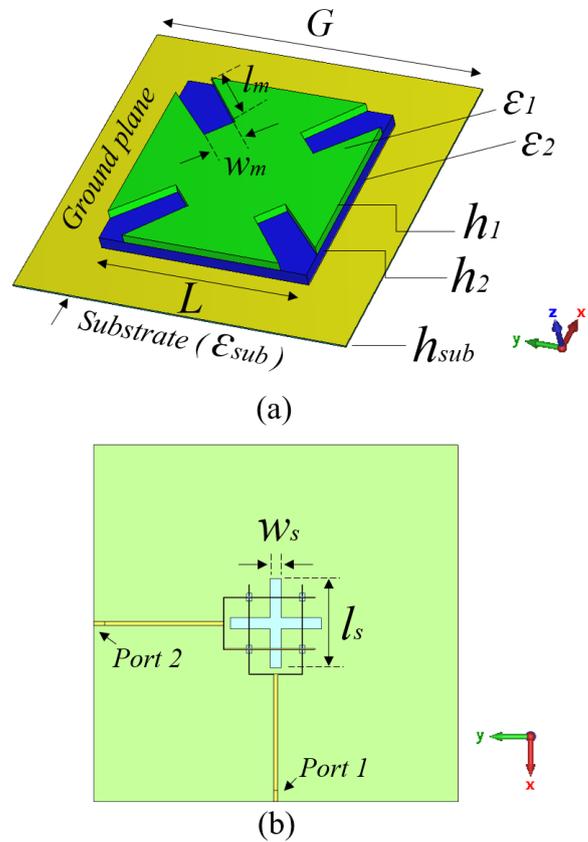


Fig. 1: Geometrical configuration of antenna. (a) 3-D view. (b) Bottom view. Design parameters: $G = 160$, $L = 100$, $l_m = 32.9$, $w_m = 12$, $l_s = 40$, $w_s = 5$, $h_1 = 4.6$, $h_2 = 6.4$, $h_{sub} = 0.813$, $\epsilon_1 = 20$, $\epsilon_2 = 2.8$ and $\epsilon_{sub} = 3.38$ (unit: mm)

of up to 12.3 dBi, but with a narrow bandwidth. Similarly, a grid dielectric resonator antenna planar array is proposed in [8], but with a bandwidth of only 10%, which is usually not suitable for use as a base station antenna.

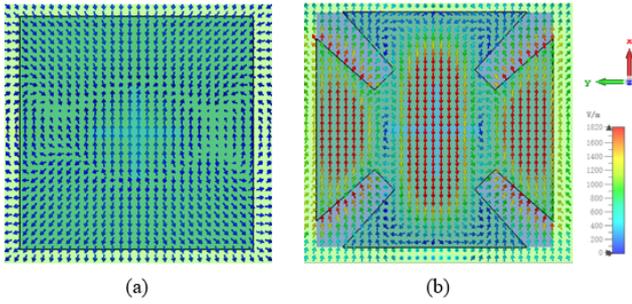


Fig. 2: Simulated resonant E-field inside the reference DRA and proposed DRA at 2.6 GHz. (a) reference DRA. (b) proposed DRA.

Therefore, this article proposes a low profile dual polarization dielectric resonator antenna that achieves a broadband of over 1.7-2.7 GHz to cover 2G (1710-1920 MHz), 3G (1880-2170 MHz), and 4G (2300-2400 and 2570-2690 MHz) cellular communication systems, suitable for 2G/3G/4G base station applications. In addition, the high-frequency gain of the antenna is improved by slotting the surface of the dielectric resonator to obtain stable radiation characteristics.

II. ANTENNA DESIGN AND WORKING THEORY

A. Antenna Design

Fig. 1 shows the configuration of the proposed antenna, which consists of two layers of different dielectric resonators and a feeding network. The dielectric layer serving as a radiator consists of a high dielectric constant top rectangular dielectric layer (20) and a low dielectric constant bottom dielectric layer (2.8). The feeding network is printed on a Rogers RO4003C substrate with a thickness of 0.813 mm, with a relative permittivity of 3.38 and a loss tangent of 0.0021. The microstrip feeder on the other side of the substrate couples energy to the dielectric resonator through a cross shaped slot and excites the radiation mode of the dielectric block. The two orthogonal excitation ports form a dual polarization performance. Due to the symmetry of the structure, the simulation results of port 1 and port 2 are similar to each other. Therefore, this article only discusses and analyzes the case where port 1 is excited.

B. Working Theory

From Fig. 2, it can be seen that the antenna mode at 2.6 GHz frequency without slots is TE_{311}^y mode, which will cause severe sidelobes in the antenna pattern and result in a significant decrease in gain. By reasonable slotting on the surface of the upper layer DR, the antenna size is reduced and the overall mode of the DR is shifted towards high frequencies. At the frequency of 2.6 GHz, the antenna mode is TE_{131}^y mode. Compared with TE_{311}^y mode, the sidelobes of TE_{131}^y mode are effectively suppressed, and the antenna

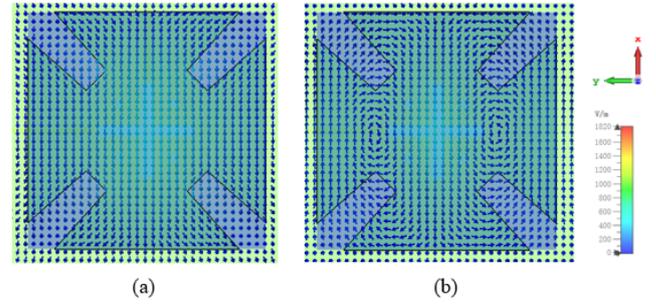


Fig. 3: Simulated resonant E-field inside the proposed DRA. (a) 2 GHz. (b) 2.4 GHz.

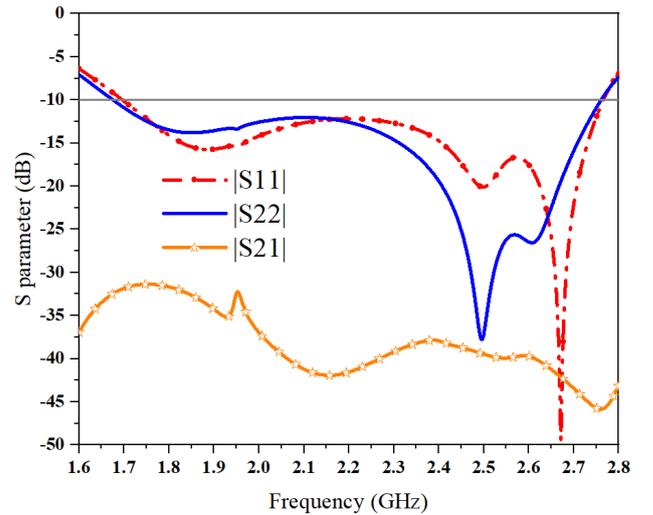


Fig. 4: Simulated S parameter of the proposed antenna.

gain is increased by more than 5 dB. It is worth noting that the antenna bandwidth after slotting is almost unaffected, and the -10 dB impedance bandwidth of the two ports has slightly shifted towards higher frequencies, still covering 1.7-2.7 GHz, which well meets the requirements of base stations operating in 1.7-2.7 GHz, and the isolation between the two ports is better than 30 dB.

III. SIMULATION RESULTS

Fig. 3 shows the electric field distribution of the proposed antenna in resonant modes at low frequency (2 GHz) and high frequency (2.4 GHz), indicating that the low frequency is TE_{111}^y mode and the high frequency is TE_{131}^y mode. Fig. 4 shows the simulated reflection coefficients of two ports, which indicate that the -10 dB impedance bandwidth of the two ports is 47.5% (from 1.70 to 2.76 GHz) and 48.6% (from 1.68 to 2.76 GHz), respectively. The proposed antenna covers the entire 2G/3G/4G base station communication frequency band. In addition, the isolation coefficient between the simulated two ports is better than 30 dB within the entire operating frequency band of the antenna, which meets the high

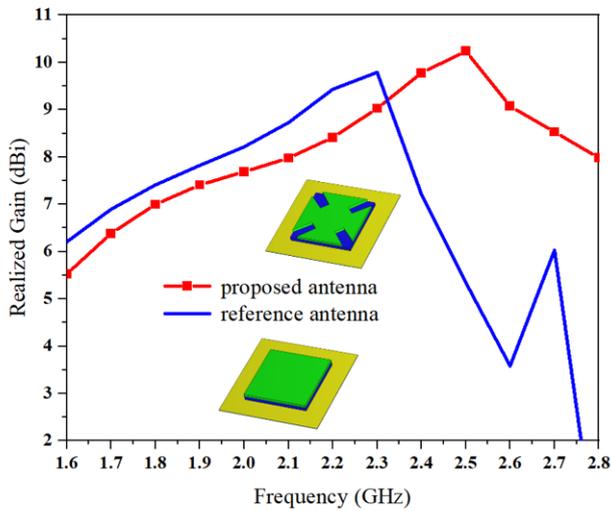


Fig. 5: Simulated realized gain of the proposed antenna and reference antenna.

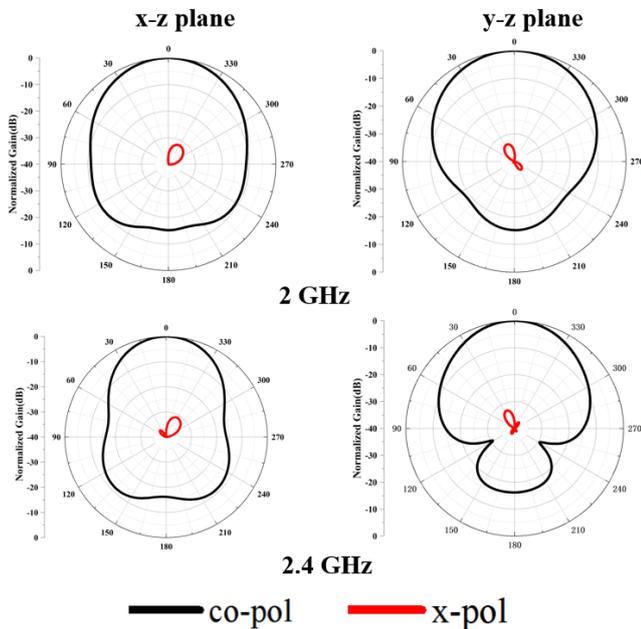


Fig. 6: Simulated radiation patterns of the proposed antenna at 2 GHz and 2.4 GHz

requirements of the base station antenna for isolation between ports. Fig. 5 shows the boresight gains of the proposed antenna and reference antenna, where the reference antenna refers to the case where there is no slotting of the upper layer DR of the antenna. Compared with the reference antenna, it is evident that the antenna with slots on the surface of the upper layer DR has achieved significant improvement in high-frequency gain, such as a gain increase of over 5 dB at 2.6 GHz, and a peak gain of up to 10.2 dBi. Fig. 6 shows the radiation patterns of the proposed antenna at 2 GHz and 2.4 GHz when port 1 is excited, indicating the stable radiation

pattern bandwidth. In addition, the antenna exhibits extremely low cross polarization characteristics at operating frequencies.

IV. CONCLUSION

This article introduces a stacked low profile dual-polarized dielectric resonator antenna, and improves high-frequency gain by slotting on the upper DR surface. From the simulation results, it can be observed that the proposed antenna operating bandwidth covers the frequency of 2G/3G/4G base station antennas and exhibits approximately 50% impedance bandwidth and a peak gain of 10.2 dBi. The isolation between two ports is better than 30 dB. With these attractive features, the proposed antenna will undoubtedly become an ideal candidate for future base station applications.

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