

# A Compact Broadband Dual-Polarized Antenna Element for 2G/3G/4G Base Station Applications

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**Abstract**—A novel broadband and slant  $\pm 45^\circ$  dual-polarized antenna element with compact structure is presented in this paper for LTE700/CDMA800/GSM900 bands applications. The proposed antenna mainly comprises of two pairs of orthogonal dipoles, four couples of baluns, an octagonal pedestal and two kinds of plastic fasteners. A square aluminum sheet is placed between adjacent dipoles to widen the impedance bandwidth of the antenna. Simulated and measured results show that the proposed antenna element has a wide impedance bandwidth of 31.60% with VSWR  $< 1.6$  from 698 to 960 MHz at both ports. High port-to-port isolation ( $< -25$  dB) and stable radiation pattern with horizontal half-power beam width (HPBW) of  $65^\circ \pm 6.4^\circ$  are achieved within the whole working band. The antenna is suitable for existing 2G/3G/4G base station applications.

**Index Terms**—broadband antenna, dual-polarized antenna, base station applications.

## I. INTRODUCTION

With the rapid development of modern mobile communication systems, base station antennas, as one of the most important parts of mobile communication systems, have received much extensive attention and achieved great progress in recent decades. Polarization diversity technology (especially slant  $\pm 45^\circ$  dual-polarization) was widely applied in base station antenna design as an effective method to improve channel capacity and combat multipath fading [1], [2]. On the other hand, base station antennas with broad impedance bandwidth to support multi-network communication systems simultaneously are preferred in modern base station applications due to its ability in saving site resources.

To satisfy these requirements, base station antennas with different configurations were investigated. Patch antennas are widely used in base station applications because of their simple manufacturing processes [3]–[6]. However, major drawbacks of these antennas include complicated construction, bulky volume and relative narrow impedance bandwidth. The dipole antenna has been studied a lot in recent years [7]–[12]. Many dipole antennas were designed as hollow bowl structure to realize embedded scheme as mentioned in [13], which helps to reduce the overall size of the antenna array. Furthermore, dipole antennas feature good electrical and mechanical characteristics and thus are good candidates for modern wireless communication systems.

In this paper, we propose a broadband dual-polarized (slant  $\pm 45^\circ$ ) base station antenna element operating over 698 to

960 MHz with VSWR  $< 1.6$ , which can fully cover LTE700 (698-806 MHz), CDMA800 (820-880 MHz) and GSM900 (880-960 MHz) bands. The antenna has the same bandwidth as [10] while with a smaller size of  $0.417\lambda_0 \times 0.417\lambda_0 \times 0.276\lambda_0$  ( $\lambda_0$  is the wavelength corresponding to the center frequency of the operating frequency band). High port-to-port isolation and stable radiation pattern are also obtained across whole working frequency band. Moreover, the antenna element features compact structure, good stability and simple fabricating process, which makes it a good candidate for 2G/3G/4G base station applications.

## II. ANTENNA CONFIGURATION

The configuration of the proposed antenna element and coordinate system are shown in Fig. 1. It consists of two pairs of orthogonal dipoles, four couples of baluns, an octagonal pedestal and two kinds of plastic fasteners. The proposed antenna has the following characteristics: 1) the two pairs of dipoles are placed orthogonally to realize dual-polarization radiation characteristic; 2) each dipole contains two identical radiating arms. Compared with [8], the radiating arms of the proposed antenna have larger radiating surface which helps to widen the impedance bandwidth; 3) the radiating arms slightly converge to the center of the antenna to reduce mutual coupling with internal antenna element (in embedded scheme); 4) a square aluminum sheet (marked by green color) is placed between two adjacent dipoles to introduce strong mutual coupling, which also broadens the impedance bandwidth of the antenna; 5) each balun is connected to a radiating arm to provide balance feed and the antenna is fed by coaxial cables directly; 6) the bottom of four couples of baluns are soldered with an octagonal pedestal, and the antenna is easy to install through the four screw holes; 7) plastic fasteners (marked by orange color) are made of polyoxymethylene (relative permittivity of 2.7 and dielectric loss tangent of 0.0023). They can fix the aluminum sheet and increase the stability of the antenna [14].

Simulated VSWR versus frequency of the antenna element with and without aluminum sheets are depicted in Fig. 2. The simulated result shows that aluminum sheets can broaden the bandwidth effectively because of strong mutual coupling is introduced between adjacent dipoles.

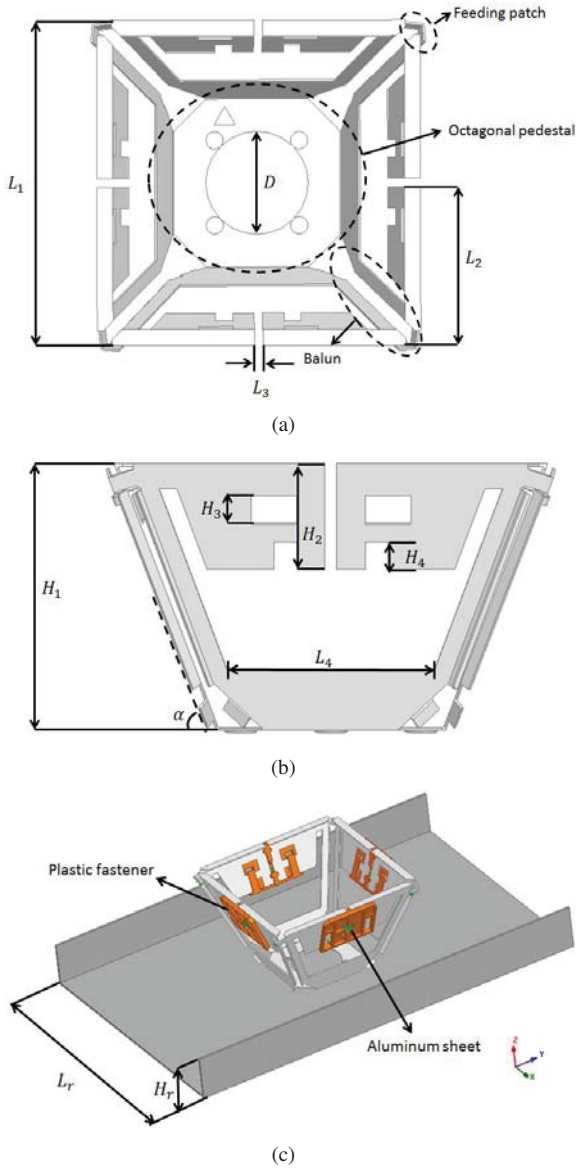


Fig. 1. The proposed antenna element. (a) top view; (b) side view; (c) full view.

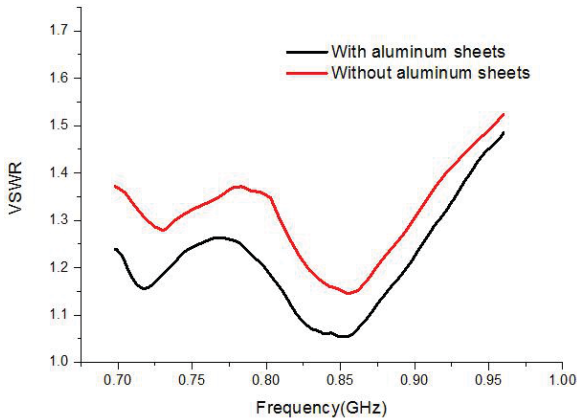


Fig. 2. Simulated VSWR with and without aluminum sheets.

TABLE I  
OPTIMIZED PARAMETERS OF THE ANTENNA ELEMENT AND THE REFLECTOR

Parameter	Value	Parameter	Value	Parameter	Value
$L_1$	151 mm	$L_2$	66 mm	$L_3$	4 mm
$L_4$	72 mm	$H_1$	100 mm	$H_2$	39 mm
$H_3$	8 mm	$H_4$	10 mm	$D$	48 mm
$L_r$	250 mm	$H_r$	40 mm	$\alpha$	$69^\circ$

An U-shape metal reflector is specifically designed to direct the antenna element radiating to desired direction and obtain stable radiation pattern. Four holes are drilled in the middle of the reflector to fix the antenna. All the optimized parameters of the antenna element and the reflector are tabulated in Table I.

### III. SIMULATION AND MEASUREMENT RESULTS

A prototype of the proposed antenna element is fabricated and tested. The front view of the antenna element is shown in Fig. 3(a), and the back view of the antenna element includes feeder line and power divider as shown in Fig. 3(b). Two face-to-face dipoles are fed in phase with equal amplitude from one port. The plastic fasteners are added onto the antenna element to increase the stability of the antenna and have little effect on radiation performance. The antenna element is measured in an anechoic chamber to get its VSWR and port-to-port isolation, and the radiation pattern is measured by far-field test system.

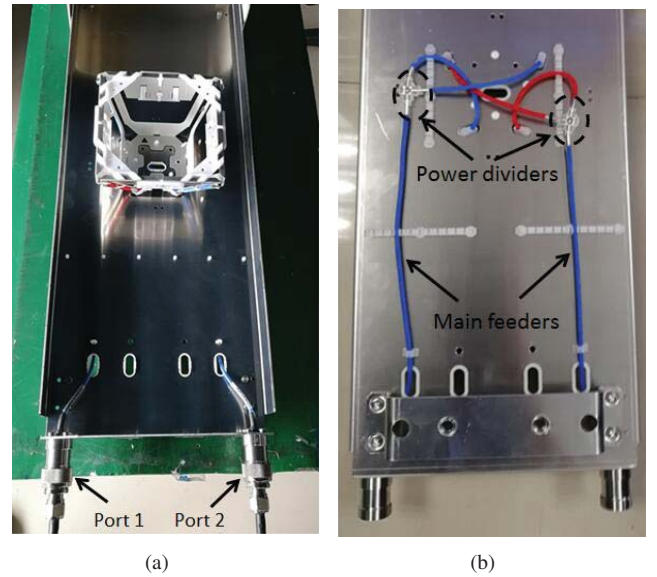


Fig. 3. A prototype of the antenna element. (a) front view; (b) back view.

Due to the differences between simulation and test environment, and the discrepancies between simulation and measurement models, a difference is observed between simulated and measured results. As shown in Fig. 4(a), simulated and measured VSWR are less than 1.6 within the whole working band. The  $S_{21}$  is less than -25 dB from 698 MHz to 960 MHz

as shown in Fig. 4(b). A similar trend between simulated and measured results is observed. Fig. 4(c) shows the simulated and measured gain of the antenna. The measured gain varies around 9 dBi, and the measured gain is larger than the simulated gain due to the loss of the coaxial cables and 7/16 DIN connectors. Considering the symmetry of the proposed antenna, only one polarization mode is presented. Measured radiation patterns of the antenna in the horizontal plane at 698 MHz, 824 MHz and 960 MHz are plotted in Fig. 5. It can be seen that the radiation patterns are stable over the entire frequency band. In addition, the horizontal HPBW is about  $65^\circ$  with variation about  $6.4^\circ$ , which is suitable for a three-sector base station application.

#### IV. CONCLUSION

A broadband and slant  $\pm 45^\circ$  dual-polarized base station antenna element with compact structure is presented in this paper. Strong mutual coupling is introduced by adding a square aluminum sheet between adjacent dipoles. Therefore, the proposed antenna has wider impedance bandwidth while with a smaller size than other dipole antennas. All the simulated and measured results demonstrated that the antenna has a wide impedance bandwidth of 31.60% with  $VSWR < 1.6$  from 698 to 960 MHz. Furthermore, high port-to-port isolation and stable radiation pattern across the entire working band are also achieved. The antenna features good electrical and mechanical characteristics and thus is suitable for 2G/3G/4G base station applications.

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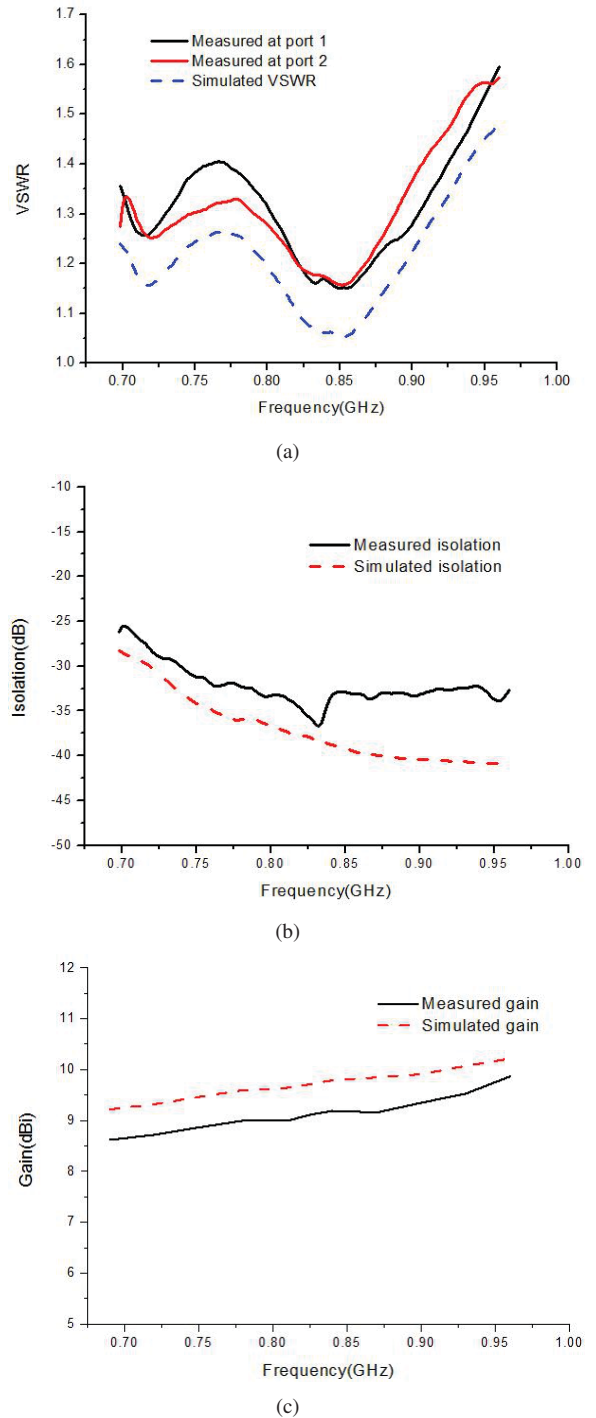
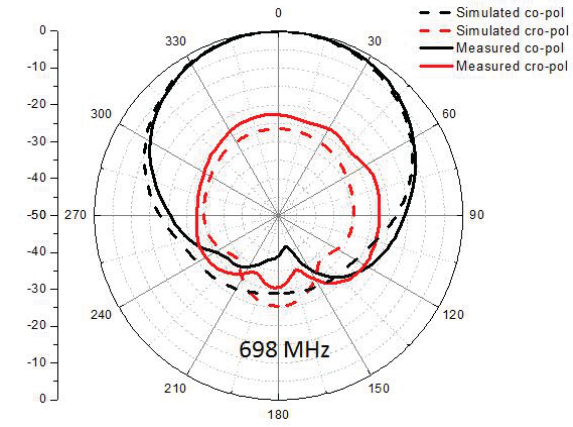
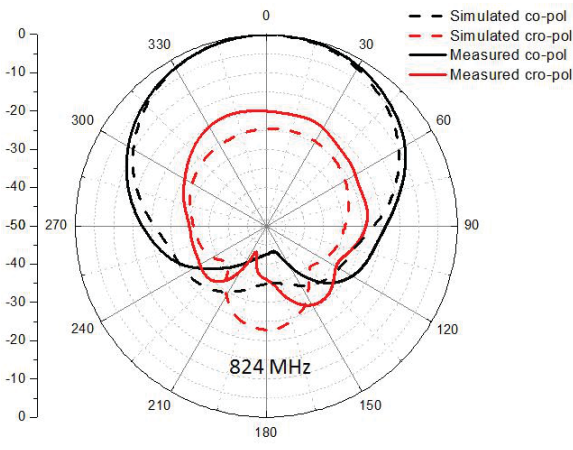


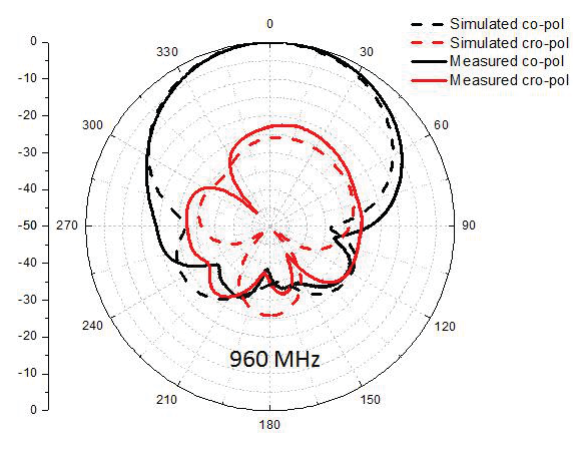
Fig. 4. Simulated and measured results of the proposed antenna: (a) VSWR, (b) Isolation ( $S_{21}$ ) and (c) Gain.



(a)



(b)



(c)

Fig. 5. Simulated and measured H-plane radiation patterns. (a)  $f=698$  MHz; (b)  $f=824$  MHz; (c)  $f=960$  MHz.

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