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A Novel Dual-Band and High-Gain Antenna for 2G/3G Base Station

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Abstract—A dual-band and ±45° dual-polarized antenna is proposed for 2G/3G mobile communications in this paper. The proposed antenna consists of five elements for the lower band and ten elements for the upper band. Results for a single element and antenna array are presented. The front-to-back ratio is from 25 dB to 30 dB, and the axial cross polarization ratio is from 19 dB to 22 dB in a single low band unit. The dual-band array achieves a bandwidth of 15.7% (820–960 MHz) for the lower band and a bandwidth of 23.7% (1710–2170 MHz) for the upper band, covering the frequency bands required by 2G/3G systems. Simulation results show that the gains for antenna array are 15.7 dBi for the lower band and 19.1 dBi for the upper band, which is suitable for base stations applications.

1. INTRODUCTION

Base stations play a crucial role in any cellular network. The wide spread of 3G networks and wireless LANs imposes new requirements for base station antennas. Nowadays, different mobile communication systems have been designated with different frequency bands. In China, the 2G systems, such as GSM900/GSM1800, CDMA, operate in the 900 MHz (825–960 MHz) and 1800 MHz (1710–1920 MHz) bands [1], while the 3G systems, such as TD-SCDMA, WCDMA, and CDMA2000, operate in the 2 GHz (1880–2170 MHz) band [2]. Therefore, base station antennas that simultaneously cover two separated frequency bands centered at 900 MHz (820–960 MHz) and 2 GHz (1710–2170 MHz) are necessary for modern mobile communication systems that can provide 2G/3G multifunctional services. Base station antenna arrays available in the market are mainly developed on the basis of electric dipole. A variety of names can be found, including vector dipole [3], butterfly dipole [4], directed dipole [5], etc. These electric dipole arrays produce a directional radiation pattern with the use of a reflector. In general, they can acquire wide impedance bandwidth, low cross polarization, and low back radiation. The dual-polarized antennas can be roughly divided into two categories: patch antennas [6–10] and crossed-dipole antennas [11–15].

Recently, with the rapid development of mobile network capacity and the increase in the number of mobile users, China mobile communication industry will be confronted with hitherto unknown development opportunity and challenge. Therefore, wideband, low profile, high gain, dual-polarized base station antenna research has attracted wide attention from domestic and foreign studies and become a hot topic in communication industry research. The development of the base station antenna unit is the foundation of the base station array design. The main specification of the proposed dual-frequency base station antenna is summarized in Table 1.

In this paper, we propose a dual-band antenna structure with high gain. Low frequency band (820–960 MHz) is achieved by a 5-element array. The peak gain is 15.7 dB, front-to-back ratio 28 dB, axial cross polarization ratio 22 dB, and VSWR < 1.5. High frequency band (1710–2170 MHz) is achieved by a 10-element array. The peak gain is 19.1 dB, front-to-back ratio 28 dB, axial cross polarization ratio 23 dB, and VSWR < 1.5.

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Table 1. The specification of base station antenna.

Frequency Range	820–960 MHz/1710–2170 MHz
Gain	> 15 dBi
Polarization	$\pm 45°$
VSWR	< 1.5
Front-to-Back Ratio	$>= 25$ dB
Axial cross polarization ratio	$>= 15$ dB
Impedance	$50\,\Omega$
Dimension	$1570\,\text{cm} \times 200\,\text{cm} \times 100\,\text{cm}$

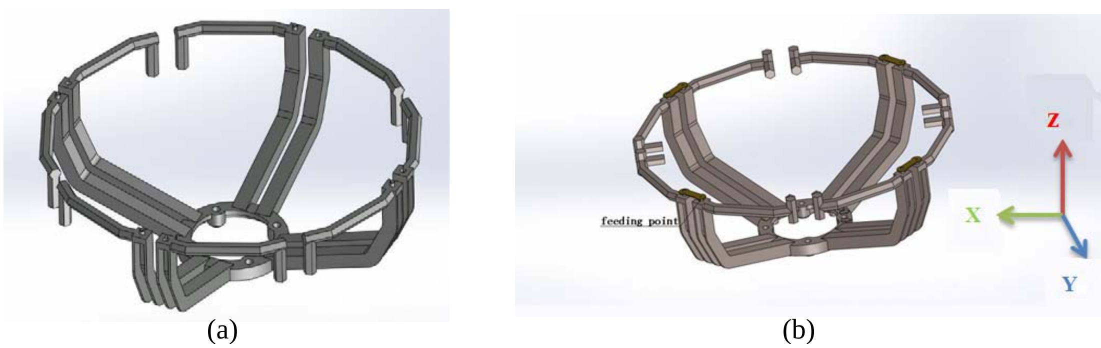

Figure 1. Configuration of (a) original and (b) novel structure.

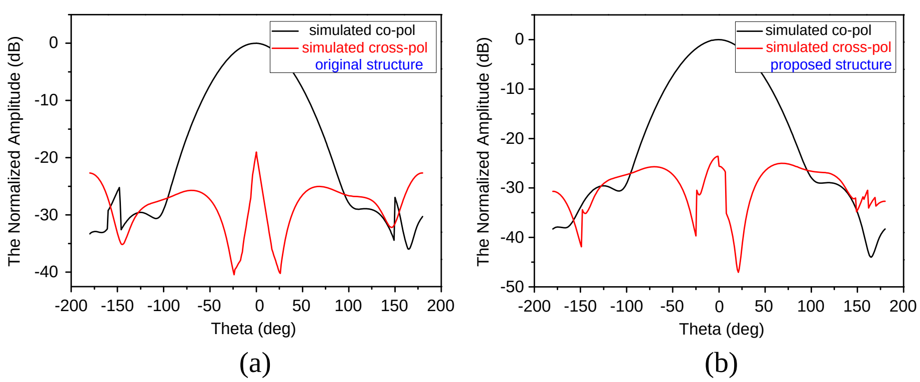

Figure 2. Simulation results, $f = 0.88$ GHz, $\varphi = -45$ deg: (a) original structure; (b) proposed structure.

2. DUAL-FREQUENCY ANTENNA UNIT CONFIGURATION

2.1. Configuration of Hemispherical Antenna

Both the original and the proposed hemispherical antenna are illustrated in Figure 1. The proposed structure increases a stub based on the original structure. There are four half-wavelength dipoles installed on the chassis of the proposed antenna. Balun uses polygon bending shape, which is from the horizontal transition to vertical direction. The profile of balun is a U-type groove. The overall antenna is approximately a hemispherical shape. Simulation of this antenna is carried out by a popular and useful commercial software, High Frequency Structure Simulator (HFSS) [14]. The simulated amplitude curves are shown in Figure 2, in which the front to back ratio is from 25 dB to 30 dB and the axial cross polarization ratio from 19 dB to 22 dB at $f = 0.88$ GHz, $\varphi = -45$ deg. The simulated VSWR of the original and novel structure is given in Figure 3. Apparently, as shown in Figure 4, the peak gain of hemispherical antenna is 9.57 dBi.

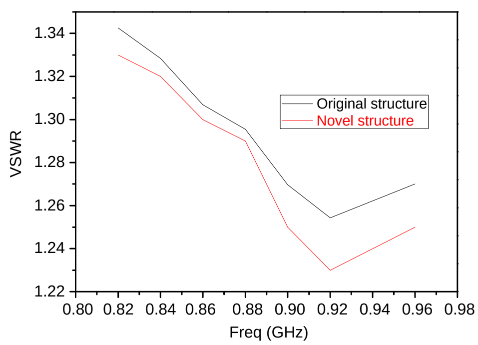

Figure 3. The simulated VSWR of the original and novel structures.

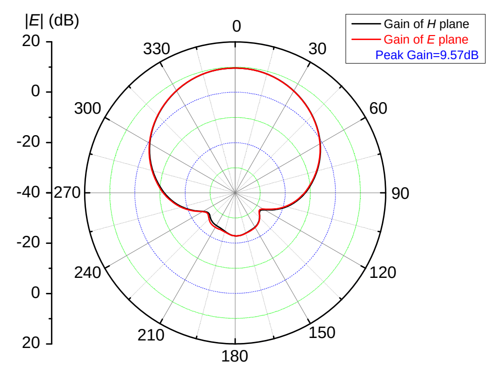

Figure 4. Radiation pattern of the hemispherical antenna.

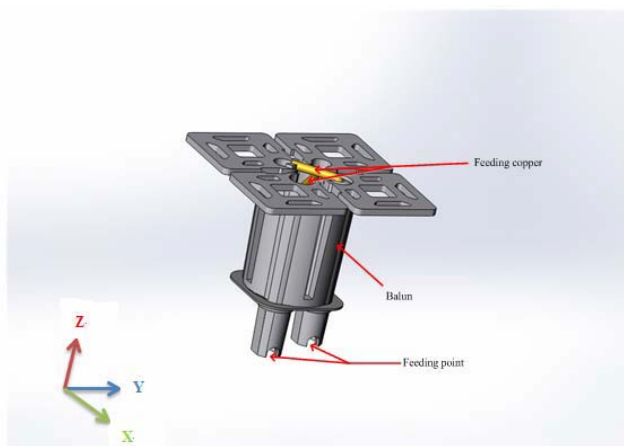

Figure 5. Configuration of the high-band antenna unit.

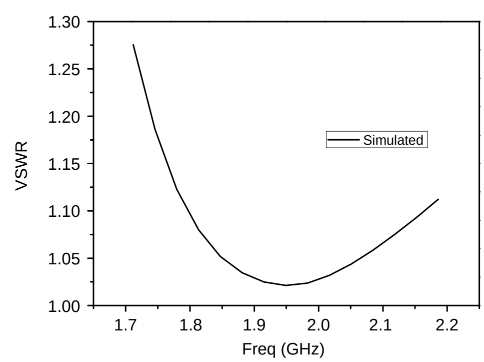

Figure 6. Simulated VSWR of the high-band antenna unit.

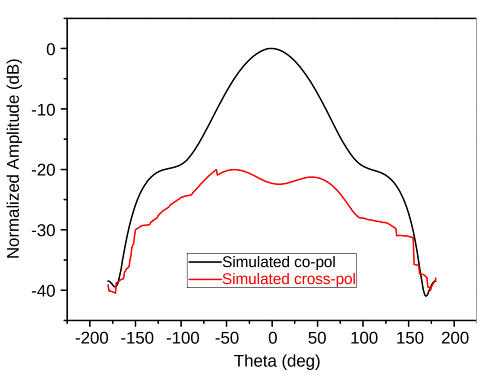

Figure 7. Simulation result, $f = 1.94$ GHz, $\varphi = -45$ deg.

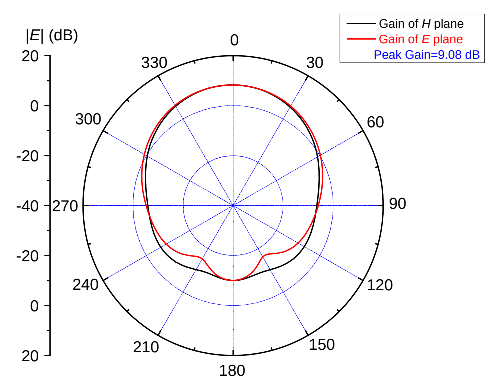

Figure 8. Radiation pattern of the high-band antenna unit.

2.2. Configuration of High Frequency Antenna

The configuration of the high-band antenna unit is shown in Figure 5. Radiator arm is a square ring type structure, which can not only expand the radiation unit band width, but also effectively reduce the weight, material and cost. Radiation arm is $\pm 45^\circ$ dual-polarization integration, using traditional half-wave dipole form. After testing the radiation unit, it is obvious that the unit has a circuit and radiation parameters with good performance. The simulated VSWR of the high-band antenna unit is given in Figure 6. The simulated amplitude curve is shown in Figure 7, in which the front-to-back ratio and axial cross polarization ratio at $f = 1.94\,\text{GHz}$, $\varphi = -45\,\text{deg}$ are near 28 dB and 22 dB, respectively. It can be seen that the peak gain of high-band antenna is 9.08 dBi in Figure 8.

3. DUAL-BAND ANTENNA ARRAY

For base station applications, the antennas need to have a high gain and narrow beam width in the vertical plane. In order to increase the antenna gain and narrow the antenna beam width, an antenna array is required. The dual-band antenna array is combined with five low-band antenna units and ten high-band units, which leads to a 5-element array for the lower band and a 10-element array for the upper band, as illustrated in Figure 9. From Figure 10, we can see that the measured and simulated VSWRs have a great agreement in frequency band. The simulated and measured amplitude curves are shown in Figure 11, from which it can be seen that two results have good agreement. From the measured curve, it is clear that the front-to-back ratio and axial cross polarization ratio are 28 dB and 22 dB at $f = 0.88\,\text{GHz}$, $\varphi = -45\,\text{deg}$, respectively. In Figure 12, we can see that the front-to-back ratio and axial cross polarization ratio are 28 dB and 23 dB at $f = 1.94\,\text{GHz}$, $\varphi = -45\,\text{deg}$. It can be seen that the peak gains of low-band antenna array and high-band antenna array are 15.7 dBi and 19.1 dBi in Figure 13 and Figure 14.

Figure 9. Prototype of the manufactured antenna array.

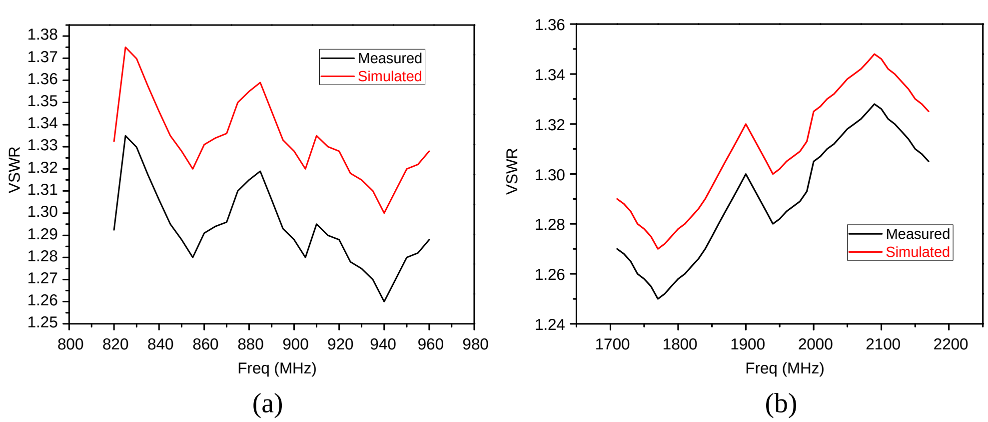

Figure 10. The measured and simulated VSWRs of the antenna array. (a) VSWR of low band. (b) VSWR of high band.

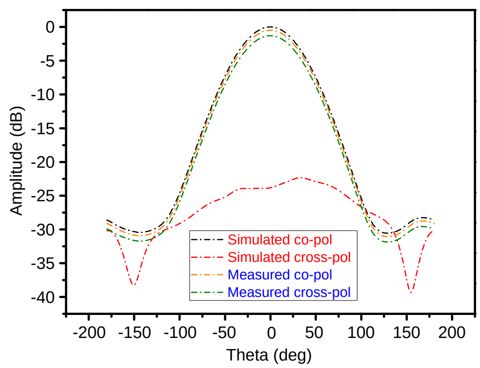

Figure 11. Comparison of simulated and measured results, $f = 0.88\,\text{GHz}$, $\varphi = -45\,\text{deg}$.

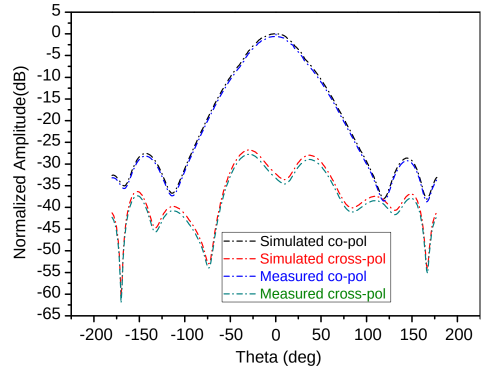

Figure 12. Comparison of simulated and measured results, $f = 1.94\,\text{GHz}$, $\varphi = -45\,\text{deg}$.

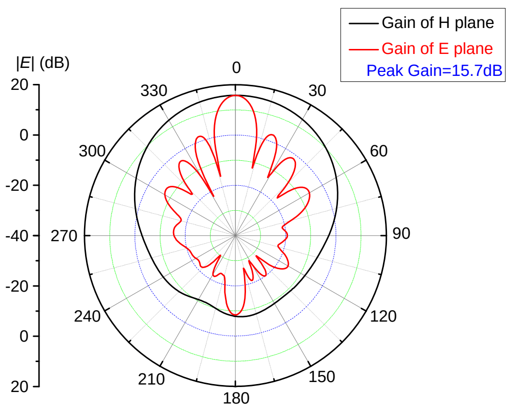

Figure 13. Radiation pattern of low band antenna array.

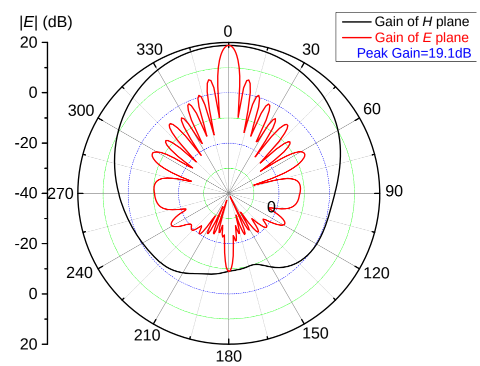

Figure 14. Radiation pattern of high-band antenna array.

4. CONCLUSION

A new antenna unit with dual-frequency bands is presented in this paper. The simulation of this antenna is carried out by a popular and useful commercial software: HFSS 14. Measuring equipment is the Agilent E5071C network analyzer. The front to back ratio is from 25 dB to 30 dB and the axial cross polarization ratio from 19 dB to 22 dB in a single low-band unit. According to measured results, it is found that the antenna array has a bandwidth and peak gain of 15.7%, 15.7 dBi, and 23.7%, 19.1 dBi at the working frequencies of 0.88 and 1.94 GHz, respectively. Good performances make it a good candidate for base station antenna design in 2G/3G communication system.

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