A Novel Base Station Antenna Operating in the 0.68-1 GHz Frequency Range

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***Abstract*—This paper presents a novel patch dipole for middle-low-band base stations, the operating frequency band covers the golden band (700 MHz Band). The proposed dipole includes a pair of U-shaped microstrip lines and rectangular patches. The U-shaped microstrip line drives the rectangular patch by capacitive coupling, which greatly expands the operating bandwidth without increasing the antenna size. As the simulation results indicate, in the operating frequency band of 0.68-1 GHz, the reflection coefficients $|S_{11}|$ of the proposed antenna are less than -10 dB, the gain and H-plane HPBW of this antenna reaches 9.2±0.7 dBi and 63.5°±6° respectively. The H-plane and V-plane radiation patterns are symmetrical and stable.**

***Index Terms*—Base station antenna, 700 MHz band, broad-band antenna.**

I. Introduction

The 700 MHz frequency band is known as the golden frequency band for the development of mobile communications due to its advantages such as low signal propagation loss, wide-coverage, strong penetration, and low networking cost. Recently, the 700 MHz band has become the main force for the comprehensive coverage of 5G base stations [1]. Therefore, it is significant for base station antennas to expand this frequency band. In [2] and [3], a dual-band antenna was proposed to expand the channel capacity, but unfortunately, the 700 MHz band is not included. A dipole working at 0.67-0.98 GHz was proposed in [4]. This antenna expands the operating bandwidth by loading a resonator beside the dipole, but the size of the antenna and the degree of processing difficulty are increased.

In this paper, a novel dipole covering the 0.68-1 GHz frequency band is proposed. The adoption of capacitive coupling technology greatly improves the impedance matching without increasing the size of the antenna. The proposed antenna also has the advantages of easy processing and low cost. It is very suitable for integration with high-frequency antenna arrays to expand frequency coverage and accelerate the development of 5G communication systems.

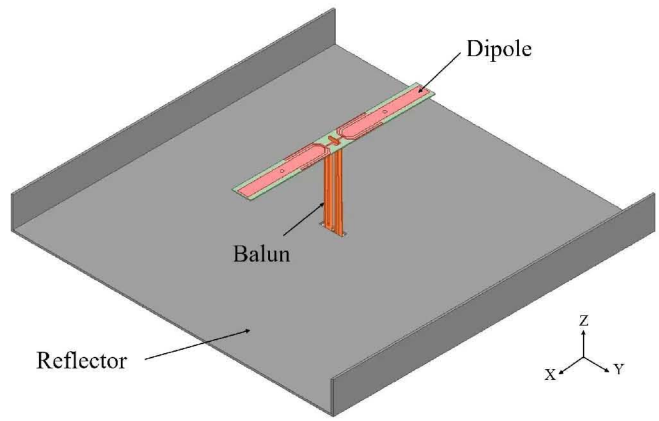
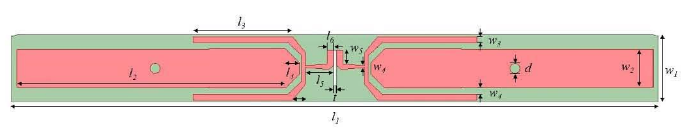
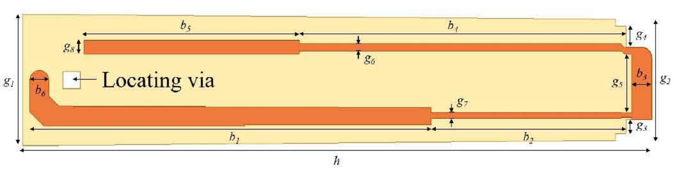


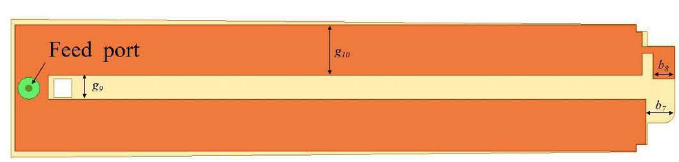
Fig. 1. Perspective view of the proposed antenna.



(a)



(b)



(c)

Fig. 2. The geometry structure of the (a) dipole, and the (b)(c) balun.

II. Related Work

The dipole antenna is one of the earliest used and simplest antenna structure, which is widely applied to radio communications. A dipole consists of two symmetrical arms and the ends of arms near the center are connected to the feeder, it can be regarded as the evolution of open two-conductor line. In the cellular mobile communication system, a large number of dipole antennas are adopted by base stations, so the research on dipoles has obvious significance.

A wideband matching method for center-fed full-wavelength dipole was first proposed in [5]. This method designs a ladder-shaped bandpass filter composed of a triple-tuned circuit, which is connected to a quarter-wavelength impedance converter to form a wideband feed structure. This dipole antenna is used in a base station with the operating frequency band of 698-960 MHz. Compared with the traditional half-wavelength dipole, the full-wavelength dipole has better radiation characteristics and bandwidth performance. In recent years, dual-polarized antennas designed by crossed dipoles have been widely used in base stations. A dual-polarized shared-dipole antenna for 1.7-2.7 GHz has been designed for base station applications in [6]. Different from traditional crossed dipoles, the two polarizations of this antenna can share the arms of the dipoles, thus the size of the antenna is significantly reduced. In order to reduce the profile of the dual-polarized dipole, an artificial magnetic conductor with a 90° reflection phase bandwidth of 1.64-2.88 GHz was employed in [7]. Compared with an antenna using conventional electrical conductor reflector, the profile height of this dual-polarized dipole designed for 1.7-2.7 GHz base stations has been reduced from 36 mm to 18 mm. Significantly high port isolation and low cross polarization were achieved in [8], because the vector synthesis technology was used in the design of a novel dipole antenna. This vector synthetic dipole is possessing the property of port isolation greater than 30 dB and the cross polarization less than -25 dB in the 690-960 MHz band. In addition, the common aperture combination of this antenna and another upper band antenna can extremely save the base station space while covering the 2/3/4G frequency band. In order to improve the integration and multi-functionality of base station antennas, filtering antenna has become one of research highlights in recent years. [9] proposed a method of designing a printed filtering dipole antenna. One arm of this dipole is designed as a half-wavelength resonator of the bandpass filter, and another arm is printed on the reverse side of the substrate, so filtering and radiation functions are realized simultaneously. Then, on this basis, a dual-polarized filtering dipole antenna operating in the 0.94-1.08 GHz band is designed, which has great potential in base station applications.

III. Antenna Design

It is indicated in Fig. 1 that the proposed base station antenna consists of a patch dipole, a balun (balanced-to-unbalanced converter), and a metal reflector. The dipole is printed on an FR4 substrate with a size of 195 mm × 20 mm × 0.8 mm, as demonstrated in Fig. 2(a). It consists of two symmetrical radiating arms, each arm includes a U-shaped microstrip line and a rectangular patch. The length of the radiating arm is about 0.25λ, where λ is the wavelength of the center operating frequency (850 MHz). The U-shaped microstrip line connected to the feed structure excites the rectangular patch through capacitive coupling, which greatly expands the operating bandwidth of the antenna. In order to further improve impedance matching, a circular slot with diameter of 3 mm is designed in the center of each rectangular patch.

TABLE I
Geometric Parameters (unit: mm)

PRM	l_1	l_2	l_3	l_4	l_5	l_6	t	w_1
Value	195	81	28.5	4.2	6.5	2	0.8	20
PRM	w_2	w_3	w_4	w_5	b_1	b_2	b_3	b_4
Value	11.4	1.8	2	4.1	58	27.5	3	47.2
PRM	b_5	b_6	b_7	b_8	g_1	g_2	g_3	g_4
Value	31.1	2.8	4.4	2.9	19	17.5	2	3
PRM	g_5	g_6	g_7	g_8	g_9	g_{10}	d	h
Value	8.55	1.1	0.85	2	3.2	72	35	91

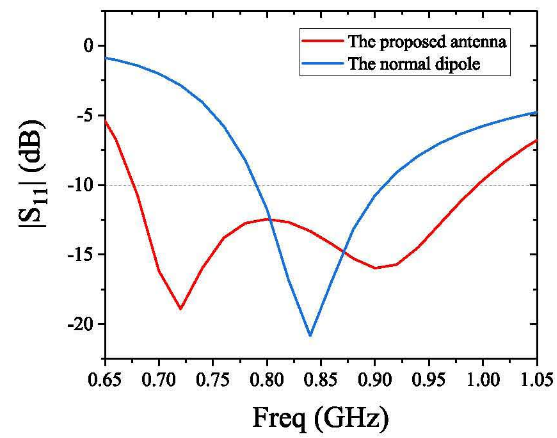


Fig. 3. The S-parameters of the normal dipole and the proposed antenna.

A balun is employed to solve the problem of impedance mismatch between the coaxial feeder and the presented dipole. The balun was printed on a Rogers R03003 substrate with the dielectric constant of 3, the loss tangent of 0.0013, and the thickness of 0.8 mm. The geometric structures of both sides of this balun are given in Fig. 2(b) and Fig. 2(c), respectively. The geometric parameters are summarized in detail in Table I.

IV. Simulated Results

The electromagnetic characteristics of the presented antenna are analyzed and verified by simulation software Ansys HFSS. The S-parameters of the proposed antenna and the normal dipole are given in Fig. 3. The reflection coefficient $|S_{11}|$ of the proposed antenna is less than -10 dB in the frequency band from 0.68-1 GHz. Different from the normal dipole, the capacitive coupling between the U-shaped microstrip line and the rectangular patch enables the antenna to generate multiple resonance modes near the center frequency. Therefore, the operating bandwidth is greatly expanded. As illustrated in Fig. 4 and Fig. 5, the gain and the H-plane half-power beamwidth (HPBW) changes smoothly. It can be seen that in the operating frequency band of this antenna, the gain is 9.2±0.7 dBi and

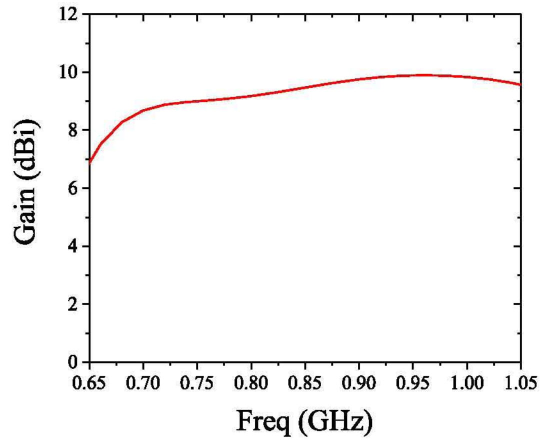


Fig. 4. The simulated gain of the proposed antenna.

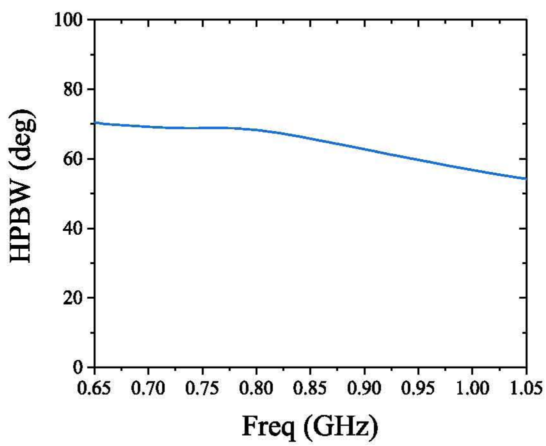


Fig. 5. The HPBW at H-plane of the proposed antenna.

the HPBW is $63.5^{\circ}\pm6^{\circ}$. The H-plane and V-plane radiation patterns of the presented antenna at 0.7 GHz, 0.8 GHz, 0.9 GHz and 1 GHz are demonstrated in Fig. 6. Symmetry and stability have been achieved in these radiation patterns.

V. Conclusion

A novel base station antenna is proposed in this paper for middle-low-band base stations. This antenna consists of a patch dipole, a balun, and a metal reflector. The dipole includes a pair of U-shaped microstrip lines and rectangular patches. The U-shaped microstrip line drives the rectangular patch by capacitive coupling, which greatly improves the impedance matching. As the simulation results indicate, in the operating frequency band from 0.68-1 GHz, the reflection coefficients $|S_{11}|$ of the proposed antenna are less than -10 dB, the gain and H-plane HPBW of this antenna reaches 9.2±0.7 dBi and $63.5^{\circ}\pm6^{\circ}$, respectively. The H-plane and V-plane radiation patterns are symmetrical and stable. The proposed antenna has great potential in advancing the coverage of 5G base stations.

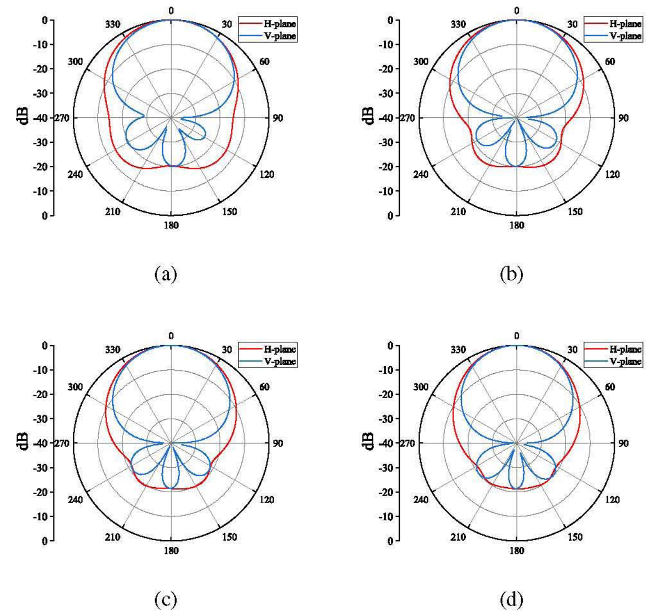


Fig. 6. The radiation patterns at (a) 0.7, (b) 0.8, (c) 0.9, and (d) 1 GHz.

Acknowledgment

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