A Low-Profile Dual-Polarized Stacked Patch Antenna for Micro-Base-Station Applications

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***Abstract*—This paper presents a low-profile dual-polarized stacked patch antenna for micro-base-station applications. The proposed antenna includes three antenna elements, where each element consists of two rectangular patches, substrate and reflector. By introducing dual-feed technique, dual-polarization characteristic is achieved. The bandwidth is improved by couple patch. Measured results show that the proposed antenna can operate in 1710 to 1980 MHz (impedance bandwidth of 14.6%) with S_{11}<-15 dB, and has stable radiation pattern with half-power beamwidth (HPBW) of 65°±5° at H plane and stability gain of 12 dBi. In addition, the total height of the antenna is only 0.083λ. The proposed antenna with the compact structure, low-profile and stable gain is very suitable for micro-base-station applications.**

***Index Terms*—dual-polarized, patch, low-profile, micro base station.**

I. Introduction

With the rapid development of mobile communication systems, users have grown dramatically. The area covered by macro base station has been unable to meet the requirements of users, and further there are dead spots due to resistance, fading and shielding of electromagnetic wave or busy traffic resulting from uneven coverage. Thus the depth of coverage has become a key factor in the performance of mobile networks. Due to the flexible deployment and capacity expansion of micro base stations, micro base stations are widely used in densely populated areas (cities). Stacked patch antenna is greatly suitable for micro base station applications due to their merits such as low-profile, light weight, easily fabrication and assembly. Moreover, in order to overcome multi-path fading, the base station antenna with dual-polarized characteristic is required. In [1], a dual-polarized antenna with metallic isolator was presented to obtain high isolation, however the impedance bandwidth with S_{11}<-10 dB is 14% at lower band and the antenna gain is only 4 dBi. In [2], a high port isolation antenna was proposed by generated 180° phase differences. A microstrip array antenna was proposed in [3], and the impedance bandwidth is only 7.7% with complicated feed network. The ultrawideband patch antenna was proposed in [4], while its gain is very low. A stacked patch antenna with high profile was proposed in [5]. This mentioned antennas are of complicated structures, low gain and narrow-band, thus it's not suitable for micro base station applications.

In this paper, a low-profile dual-polarized antenna with high gain is proposed. The impedance bandwidth of the proposed antenna is 14.6% from 1710 to 1980 MHz and its gain is 12 dBi. The proposed antenna is simulated in commercial software HFSS and the prototype is fabricated and measured. The measured results show a good agreement with simulated results. In addition, it has the advantages of simple structure, low-profile, high gain, high reliability, good radiation performance and simple feed network. Compared to those traditional patch antennas, the proposed antenna is more suitable for micro-base-station applications.

This paper is organized as follows. Section II illustrates the structure of the proposed antenna. Section III analyzes the simulated and measured results. Section IV draws the conclusion.

II. Antenna Design

The configuration of the proposed antenna element is depicted in Fig. 1, which consists of rectangular patch, substrate and U-shape metal reflector, with dimensions of 110×110 mm^2 and the height of 13.5 mm (0.083λ, λ is the free space wavelength at the center frequency). The FR4 epoxy substrate with relative permittivity (ϵ_r) of 4.4 and thickness of 1.5 mm is chosen for the lower layer, and a rectangular radiating patch is etched on the top of the FR4 substrate. The other path is placed in the top of FR4 substrate with height of 12 mm, which can broader the impedance bandwidth, and the middle area is filled with air. The upper patch is supported by four plastic posts in the practical model fabrication. It is noted that one ground plane is inserted the bottom of the feed substrate with the same dimensions (40×40 mm^2) of the substrate. When the lower patch is fed by the straight coaxial probes, the upper patch is excited due to the electromagnetic coupling with the lower patch. The simulated S_{11} and S_{12} in several coupling distances are shown in Fig. 2. When the return loss and the isolation are simultaneously considered, the best coupling distance is H_2=12 mm as shown in Fig. 2. The detailed parameters of the proposed antenna are described in Table I. In order to get good radiation with wide HPBW and stable gain, the U-shape metal reflector is added. The two ports are fed by coaxial cables to obtain dual-polarization characteristic. The simulated patterns for each antenna element are shown in

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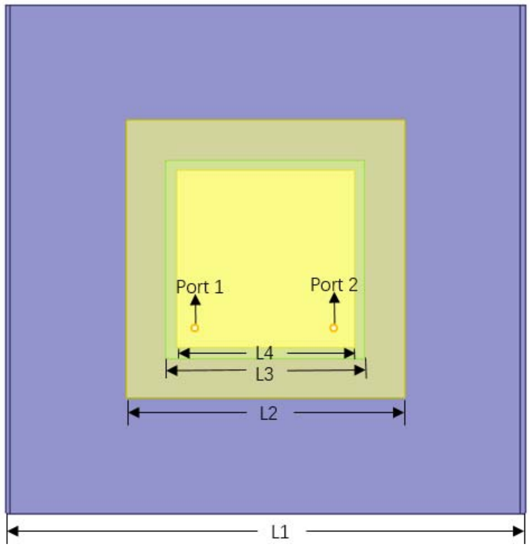


(a)

(b)

Fig. 1. Geometry of proposed stacked patch antenna (a) top view (b) side view

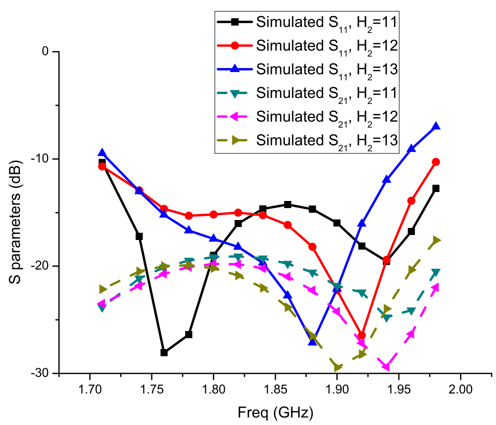
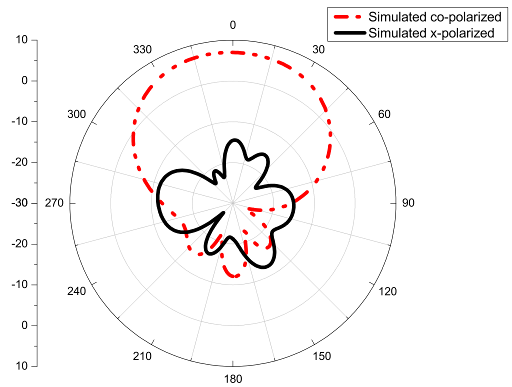


Fig. 2. Parameter optimization of H_2

TABLE I
TYPICAL VALUES OF THE THE PROPOSED ANTENNA ELEMENT PARAMETERS

Parameter	Value (mm)
L_1	110
L_2	60
L_3	40
L_4	38
H_1	10
H_2	12

Fig. 3. Since the performance of the single antenna element cannot meet requirements of the base station, three antenna elements are used to construct an antenna array to get good radiation characteristics. The simulation model of the proposed antenna is shown in Fig. 4.



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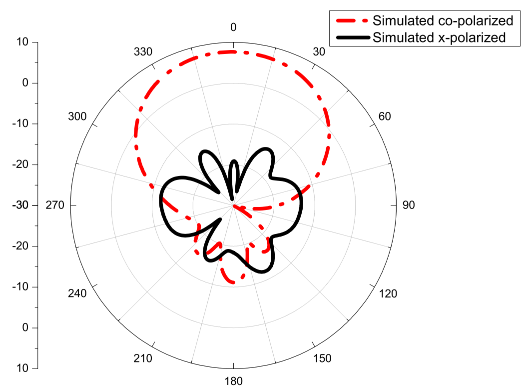

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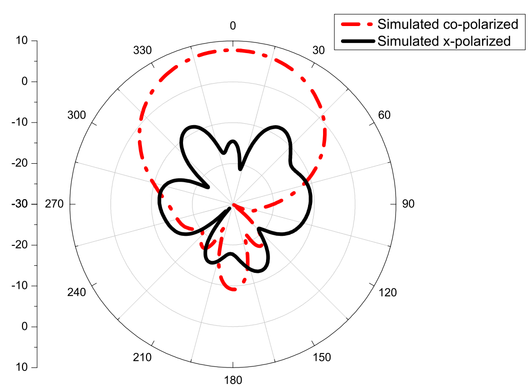


(c)

Fig. 3. Simulated H-plane radiation patterns of the proposed antenna element excited at Port1 (a)f=1710 MHz (b)f=1845 MHz (c)f=1980 MHz

III. RESULTS AND DISCUSSION

Fig. 5 shows the simulated and measured return losses and isolation for the proposed antenna. It can be seen that both

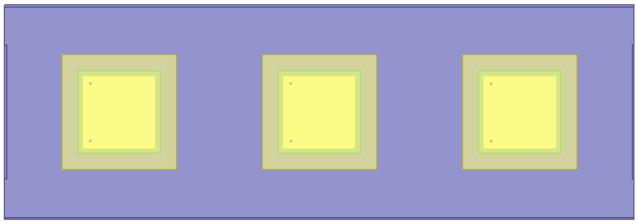


Fig. 4. Simulation model of the proposed antenna

simulated and measured S_{11} values are less than -15 dB from 1710 to 1980 MHz, and the isolation S_{12} values are less than -22 dB. Although there are some differences between the simulated and measured results, which are caused by discrepancies between simulation and measurement models, there is a similar trend between simulated and measured results. A prototype of the proposed antenna is shown in Fig. 6. Because the proposed antenna has symmetrical radiation patterns in both horizontal plane and vertical plane, only the radiation patterns of the antenna excited at port 1 are plotted, and the simulated and measured patterns at 1710 MHz, 1845 MHz and 1980 MHz are shown in Fig. 7. It is worth pointing out that all the radiation characteristics are the direction with maximum gain. It can be seen from Fig. 7 that the HPBWs are stable through the entire frequency band with 65° in H-plane, and the peak gain of 12 dBi is obtained.

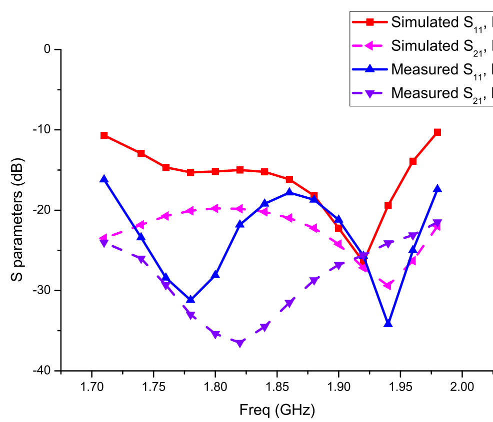


Fig. 5. Simulated and measured S parameters

IV. Conclusion

A low-profile dual-polarized stacked patch antenna was designed and measured. In the frequency range from 1710 to 1980 MHz, the return loss of the antenna is more than 15 dB, and the port isolation and the HPBW can meet practical micro base station requirements. The proposed antenna is of easily power-divider feed network. Due to its low-profile, high gain, high reliability, good radiation pattern and easily fabrication, it's very attractive for micro-base-station applications.

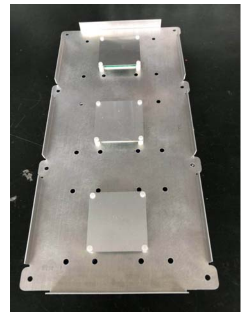
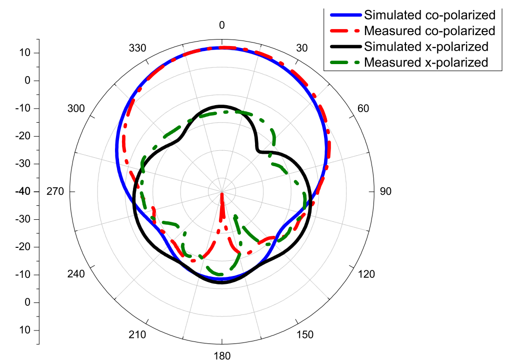


Fig. 6. A prototype of the proposed antenna



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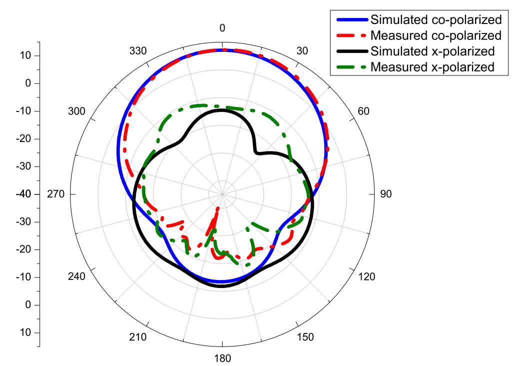

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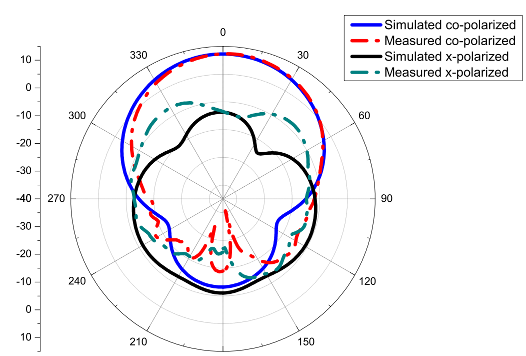

(c)

Fig. 7. Simulated and measured H-plane radiation patterns of the proposed antenna excited at Port1 (a)f=1710 MHz (b)f=1845 MHz (c)f=1980 MHz

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