2021 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (APS/URSI) | 978-1-7281-4670-6/21/$31.00 ©2021 IEEE | DOI: 10.1109/APS/URSI47566.2021.9704135

A Novel Dual-Polarized 5G Base Station Filtering Antenna

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***Abstract*—In this paper, a novel dual-polarized base station filtering antenna with high selectivity is proposed. The four slots on the radiation patch and the metal block between the two ports are used to improve the port isolation. The slot lines can also adjust the resonance points of the antenna. The octagonal slot in the middle of the feed patch is used to adjust the input impedance, attaining the antenna operating band of 3.3-3.6 GHz with voltage standing wave ratio (VSWR) less than 1.5. Besides, a high out-of-band gain-suppression level (>24 dB) can also be obtained without adding any filter structure. The proposed antenna has high potential in the 5G massive multiple-input multiple-output (MIMO) applications.**

***Index Terms*—Base station antenna; dual-polarized; sub-6 GHz; filtering antenna.**

I. Introduction

Nowadays, with the rapid development of wireless communication technology, 5G sub-6 GHz band has been applied. Higher requirements for the design of base station antenna are put forward, such as low profile and high gain. Besides, as the electromagnetic environment becomes more complex, there is a great demand for antennas with high out-of-band suppression levels. Using filtering antenna can effectively reduce the mutual coupling between antennas at different frequency bands in base station. It is a common method to load filter structure on the antenna [1] – [5] when designing filtering antenna. In [1], a method to design the filtering base station antenna with square ring and cross ring structure was proposed. However, the profile is relatively high. In [2], a multi-layer 5G filter base station antenna was proposed. With a filter patch in the middle, the antenna can achieve coverage of 3.3-3.8 GHz with high selectivity.

In this paper, a base station filtering antenna without any additional filter structure is proposed. The antenna can operate in frequency bands of 3.3-3.6 GHz and achieve gain suppression of 1.7-2.1 GHz (cover 2G/ 3G/ 4G) and 4.7-5 GHz (5G). When applied to antenna arrays of different frequency bands, it can effectively reduce mutual coupling.

II. Configuration and Principles

The geometry of the proposed antenna is shown in the Fig. 1. The antenna is only composed of two layers of substrates, the upper substrate is made of FR4, of which the radiation patch is printed on the top side. The material of substrate below is Arlon AD300A and is printed with the feed patch on top and the reflector at the bottom. Between the substrates, four plastic pillars with permittivity of 3.5 and loss tangent of 0.002 are designed for supporting. The profile of the antenna is only 6.6 mm.

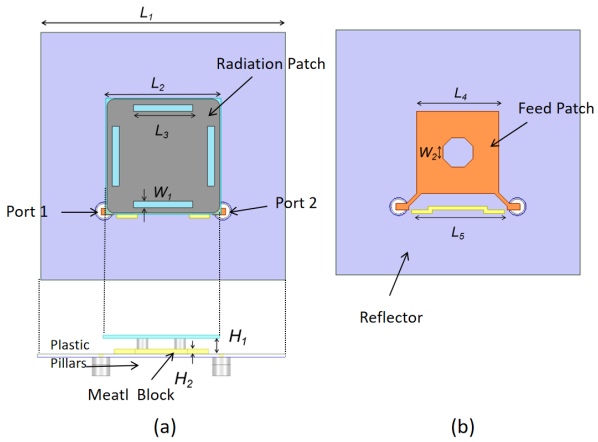

Fig. 1. Geometry of the proposed antenna. (a) Top view and side view. (b) Feed patch. (Detailed antenna parameters: L_1 = 66 mm, L_2 = 30.4 mm, L_3 = 16 mm, L_4 = 22.2 mm, L_5 = 25 mm, W_1 = 1.8 mm, W_2 = 3.3 mm, H_1 = 5 mm, H_2 = 1.3 mm.)

Four rectangle slots are cut on the edge of the radiation patch and an octagonal slot is cut in the middle of the feed patch. The feed patch excites the radiation patch by coupling, and the port 1 and port 2 can achieve $\pm$ 45°polarization respectively. A metal block was placed between the two ports to improve the isolation. The antenna is simulated and optimized in HFSS.

To get a deep insight into the working mechanism for the proposed antenna, three reference antennas were simulated by HFSS for comparison. Ant 1 has no rectangle slots, octagonal slot and isolation block. Ant 2 adds octagonal slot on the basis of Ant 1, and Ant 3 adds four rectangle slots on the basis of Ant2. These antennas' structures are shown in Fig. 2 and the simulated S parameters of these antennas are shown in the Fig. 3.

It can be seen that the octagonal slot can improve the impedance matching of the antenna and increase the antenna

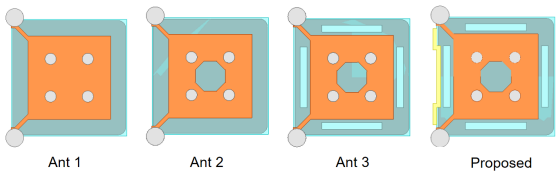

Fig. 2. Bottom view of reference antennas and proposed antenna.

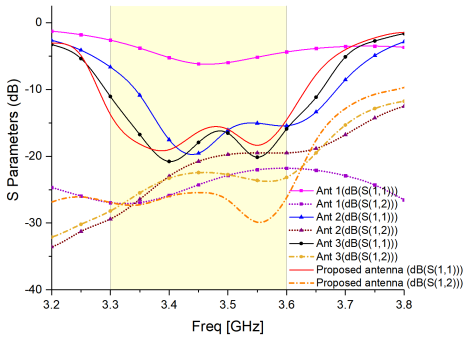

Fig. 3. Simulated S parameters of reference antennas and proposed antenna.

bandwidth. The rectangle slots and metal block can improve the port isolation from 19 dB to 26 dB. Besides, the four rectangle slots can also adjust the resonance points. By optimization of the length and width of the slot, accurate frequency coverage can be achieved.

Fig. 4 shows the current distribution of radiation patch surface when port 1 is excited in the operating bands and notch bands. At 1.8 GHz, the current on the radiation patch is very weak, resulting in a radiation null. At 4.8 GHz, antenna generates opposite surface current, and current radiation cancels with each other, thus generating another radiation null.

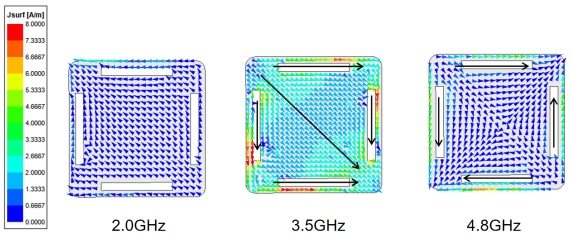

Fig. 4. Current distributions on the radiation patch at different frequencies.

The proposed antenna is fabricated and measured. The measured and simulated results are shown in Fig.5 and Fig.6, respectively. The antenna covers 3.3-3.6 GHz with VSWR <1.5. The gain in the operating band is about 7.5 dBi, while the out-of-band (1.7-2.1 GHz and 4.7-5 GHz) suppression of the gain reaches 24 dB, which achieves a good filtering performance. The antenna has a stable radiation pattern from 3.3 GHz to 3.6 GHz. The 0°cross polarization discrimination

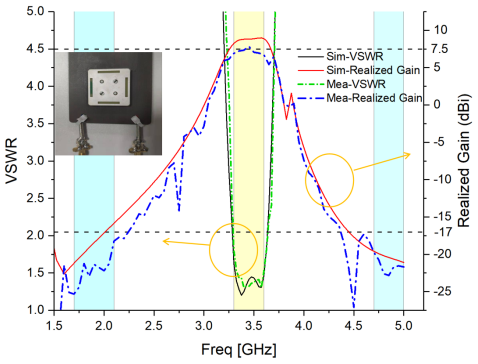

Fig. 5. Measured and simulated VSWR and realized gain.

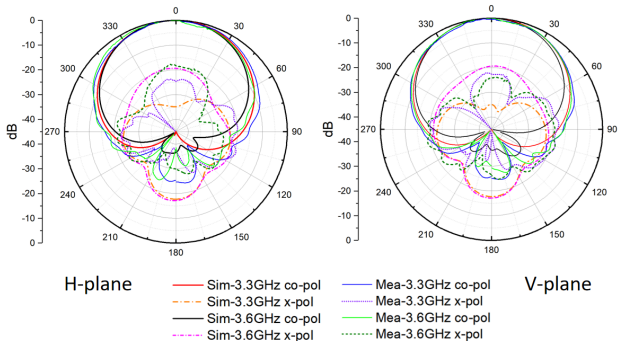

Fig. 6. Measured and simulated radiation patterns at 3.3 GHz and 3.6 GHz.

is greater than 20 dB, and the 3-dB beamwidths is about 66 ± 3°.

III. Conclusion

In this paper, a novel low profile, dual-polarized filtering antenna with volume of only 30.4 mm × 30.4 mm × 6.6 mm is proposed. The antenna has a high gain of 7.5 dBi in the operating frequency, notch bands of 1.7-2.1 GHz and 4.7-5 GHz, and the out-of-band suppression can reach 24 dB. Besides, the isolation of 26 dB, good cross polarization discrimination and 3-dB beamwidths of 66 ± 3°could also be obtained. Good performance of the proposed antenna makes it a promising candidate for 5G sub-6 GHz base station systems.

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