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A Novel Wideband Filtering Antenna for Sub-6GHz 5G Base Station Application

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***Abstract*—A broadband filtering antenna is proposed in this work, which covers the whole 3.3-3.8 GHz working frequency band to meet Sub-6GHz 5G base station application. By adding loop branch and short-circuit L-shaped patch to the dipole, and loading a square parasitic ring below the dipoles, the proposed antenna achieved broadband and filtering functions. The results of simulation illustrate the proposed antenna works in a wide frequency band of 2.74-3.86 GHz ($|S_{11}|$ and $|S_{22}|$ <-18 dB), and the port isolation ($|S_{21}|$ <-23 dB). This proposed antenna has a high gain of 9.2±0.3 dB in the passband, and an out-of-band rejection of more than 14 dB is achieved at 1.70-1.88 GHz and 4.64-5 GHz.**

***Index Terms*—Filtering antenna, base station, dual polarization, decoupling.**

I. Introduction

The high-speed development of 5G communication system has been promoted by the increasing tension of frequency band resources in recent years. Therefore, 3G/4G/5G mobile communication systems will exist simultaneously for a long time, which means that a variety of antennas in different frequency bands need to be placed in the compact space of a base station. However, when antenna elements of different frequency bands are placed compactly, they will couple with each other, which will affect their radiation performance. In order to eliminate the coupling between antennas in different frequency bands, filtering antenna can be an effective candidate.

To meet the demand of filtering antenna, a traditional method is to connect the filter derectly to the antenna [1]–[3], but the additional circuit increases the complexity of the design and more space will be occupied. By adding filter circuit such as coupled stripline open-loop resonators [4] or open-circuit stepped-impedance resonators [5] to the feed structure of the antenna can also implement filtering affect, but this method will introduce additional insertion loss and reduce the efficiency of the antenna. In recent years, using resonant structure of antenna to realize filtering has become a research hotspot in the field of filtering antenna.

In this paper, a broadband dual-polarization filtering antenna without adding any filtering circuits is proposed. By loading annular branch and short-circuit L-shaped patch to the dipoles, and using parasitic loop below the dipoles, the working bandwidth of 2.74-3.86 GHz ($|S_{11}|$ and $|S_{22}|$ <-18 dB) and port isolation ($|S_{21}|$ <-23 dB) in the working band can be achieved. The proposed antenna can filter the unwanted frequency (1.7-1.88 GHz/4.64-5 GHz). In the stopband, the out of band rejection reached over 14 dB, and the gain of 9.2±0.3 dB is achieved in the passband.

II. Antenna Design

The overall structure of the proposed broadband filtering antenna is displayed in Fig. 1. This antenna consists of a substrate, two coaxial cables, a pair of Y-shaped feeding structures, a square parasitic metal ring and a metal reflector. On the underside of the substrate, the cross dipoles are orthogonally printed, and a loop branch is loaded in the middle of each dipole. The thickness of the substrate is 0.8 mm, which is made of FR4 plate with relative dielectric constant of 4.4. The outer conduct layer of the coaxial cable feeds two of the dipoles, while the inner core of the coaxial transmission line feeds the other two dipoles through a pair of Y-shaped feeds structures, which placed on the topside of substrate. The center of one Y-shaped feed wire is printed below the substrate to avoid physical overlap, as shown in Fig. 1. On the topside of substrate, two pairs of short-circuited L-shaped patches are printed and connected by a metal cylinder to a dipole patch at the bottom. The entire antenna is placed on a 0.8 mm-thick copper reflector. Square parasitic metal rings are placed below the substrate and supported by four plastic columns. In the Fig. 2, the specific parameters of the proposed filtering antenna are displayed, and Table I shows the optimized parameters.

Two transitional forms of antenna are designed (Ant 1 and 2) to help explaining the operating principle of the proposed filtering antenna, Ant 3 is the proposed antenna, as shown in Fig. 3, and then the performance of these three antennas is compared and discussed. Ant 1 only contains two pairs of cross dipoles. Based on Ant 1, Ant 2 adds a ring branch and a square parasitic metal ring, and Ant 3 adds two pairs of short-circuit L-shaped patches based on Ant 2.

Fig. 4 shows that Ant 1 has two resonance points at 2.8 GHz and 3.5 GHz. Ant 2 can introduce a resonant point at 3.8 GHz by adding a ring branch to the dipole structure and loading a parasitic metal ring below it, but the original resonant point at 3.5 GHz shifts to lower frequency in the meantime. Ant 3 stabilizes the high-frequency resonance point by adding a short-circuit L-shaped patch on the dipole, with the left shifted

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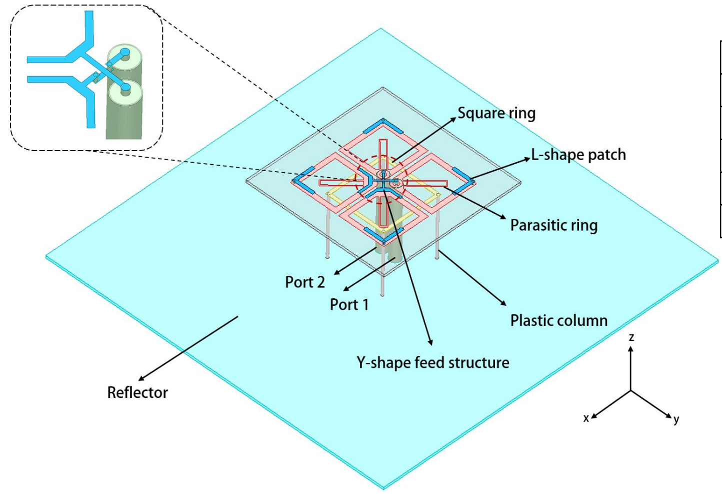
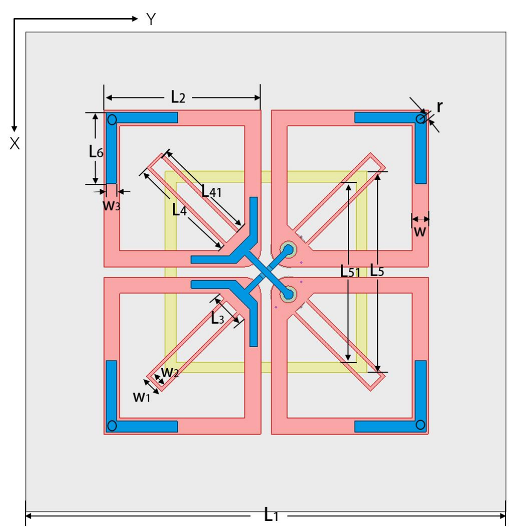
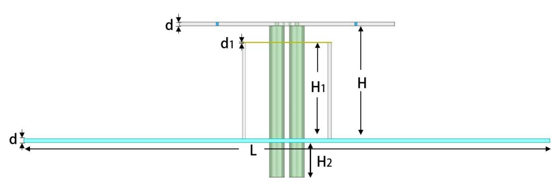


Fig. 1: 3D view of the antenna.

second resonance point returns to 3.4 GHz. Thus, Ant 3 could generate three resonance points at 2.8 GHz, 3.4 GHz and 3.8 GHz.



(a)



(b)

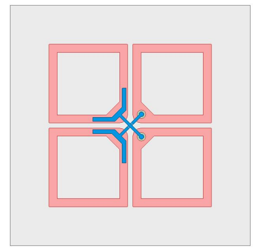
Fig. 2: (a) Top view of the antenna. (b) Side view of the antenna.

III. Simulation Result And Discussion

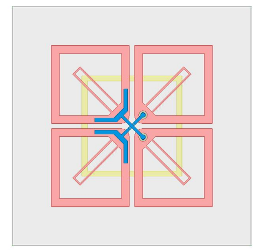
In Fig. 5, the simulated S-parameters of the proposed filtering antenna are given. The simulated antenna operating frequency band is 2.74-3.86 GHz ($|S_{11}|$ and $|S_{22}| <-18$ dB), and the isolation of the antenna is greater than 23 dB ($|S_{21}|$

TABLE I: GEOMETRIC PARAMETERS (UNIT: mm)

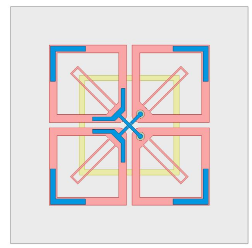
Parameter	L	L_1	L_2	L_3	L_4	L_{41}
value	110	45	14.7	3.43	10.29	10
Parameter	L_5	L_{51}	w	w_1	w_2	w_3
value	18.9	16.9	1.5	1.41	1.98	1
Parameter	H	H_1	H_2	d	d_1	
value	23.5	20	8	0.8	0.1	



(a) Ant 1



(b) Ant 2



(c) Ant 3

Fig. 3: Structures of Ant 1, Ant 2 and Ant 3.

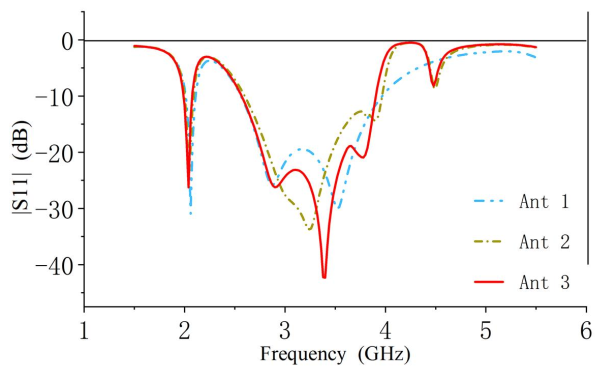


Fig. 4: S_{11} parameters of Ant 1, Ant 2 and Ant 3.

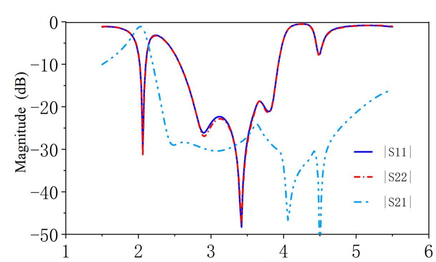


Fig. 5: All S parameters of the proposed antenna.

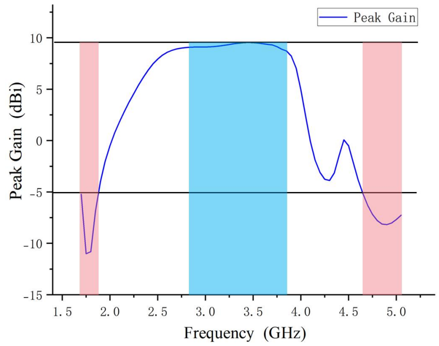
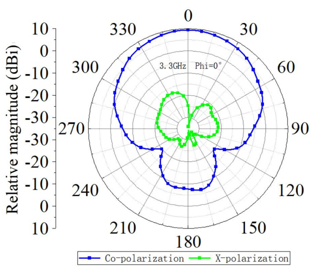
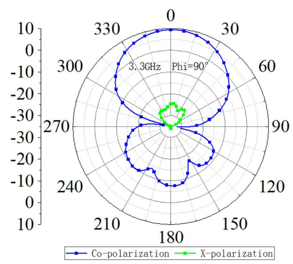


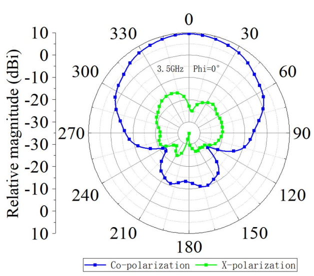
Fig. 6: Simulated peak gain of the proposed antenna.



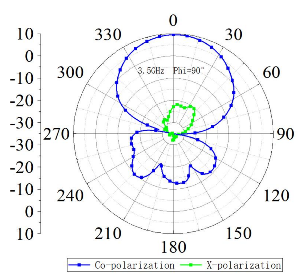
(a) 3.3 GHz Phi=0°



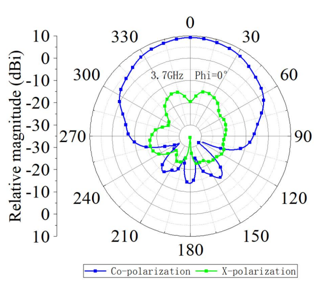
(b) 3.3 GHz Phi=90°



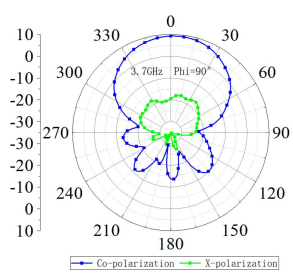
(c) 3.5 GHz Phi=0°



(d) 3.5 GHz Phi=90°



(e) 3.7 GHz Phi=0°



(f) 3.7 GHz Phi=90°

Fig. 7: The element radiation patterns at 3.3 GHz, 3.5 GHz and 3.7 GHz.

<-23 dB) in the whole operating frequency band. The peak realized gain of the proposed filtering antenna in different frequency bands is displayed in Fig. 6. It can reflect that in the operating band, the peak realized gain of the antenna can reach 9.2±0.3 dB, and the peak gain curve is flat in the passband. The out of band rejection is better than 14 dB in the range of 1.7-1.88 GHz and 4.64-5 GHz, which proves that this filtering antenna has a good filtering effect.

Fig. 7 shows the proposed antenna radiation patterns at 3.3 GHz, 3.5 GHz and 3.7 GHz. The results reflect that, for the proposed antenna, the cross-polarization isolation is greater than 28 dB in the main polarization direction. It indicates that the antenna pattern has good directivity and stability.

IV. Conclusion

The proposed broadband filtering antenna can be used in Sub-6G 5G base station application. The filtering antenna (Ant 2) first obtained a new high-frequency resonant point by loading four ring branches on the dipoles and adding a square parasitic ring below the dipoles because the original antenna (Ant 1) has only two low-frequency resonant points, meanwhile the second resonant point of Ant 1 is moved to the low frequency (Ant 2). Then, the four dipoles are combined with the four L-shaped patches (Ant 3) where four L-shaped patches are connected to the four dipoles by four shorten probes so that the resonance point in low frequency (Ant 1) is moved back to the original high frequency, and the high-frequency resonance point of Ant 2 is stabilised in high-frequency resonance point of Ant 3. Simulation results illustrate that the antenna has a wide operating frequency band of 2.74-3.86 GHz, with the reflection coefficients of $|S_{11}|$ and $|S_{22}| <-18$ dB and the port isolation $|S_{21}| <-23$ dB. In the working frequency band from 2.74 GHz to 3.86 GHz, the gain performance can reach 9.2±0.3 dB and have a flat curve. The proposed antenna (Ant 3) has an out of band rejection of more than 14 dB in the frequency bands of 1.7-1.88 GHz and 4.64-5 GHz. Therefore, filtering antenna designed in this work is a competitive choice for 5G multiband base station.

Acknowledgment

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