A Novel Dual-Polarized Filtering Antenna for 5G Base Station Applications

Xuekang Liu[1], Benito Sanz-Izquierdo[1], Haiwei Zhang[2], Steven Gao[3]
[1] School of Engineering, University of Kent, Canterbury, CT2 7NT, UK
[2] Huawei Technologies Ltd, China
[3] Dept of Electronic Engineering, Chinese University of Hong Kong
Email: xl255@kent.ac.uk

***Abstract*— This study introduces a wideband and compact filtering antenna with dual-polarization for 5G base station usage. The proposed design, which combines meander lines and parasitic grid structures, achieves a broad operating bandwidth and an excellent gain suppression level in the unwanted 2/3/4G band. To verify the design concept, a phototype of the design was fabricated and tested. According to the test results, the proposed design can cover 3.16 GHz to 4.75 GHz. The isolation between the two ports exceeds 30 dB in the target n77 band (3.3-4.2 GHz). Additionally, the gain rejection level is higher than 13 dB in 1.7-2.7 GHz.**

I. Introduction

In nowadays base stations, more and more antennas working in different frequency bands are placed in a limited space to meet people's needs for communication speed and quality. However, the mutual coupling between these closely placed antennas is severe. In certain cases, this interaction can cause significant degradation of the performance of the antennas, leading to reduced efficiency and accuracy.

Filtering antenna is a good choice to resolve this issue, due to the good gain suppression level outside the operating frequency band. Recently, some methods were presented in [1]-[4] to enhance the gain suppression level of filtering antennas. However, these designs have only one polarization, which is not suitable for the use of base station application. Many dual-polarized filtering antenna were realized in [5]-[11] by employing new design principle. In [5], a three-order filtering dipole antenna was realized by the synthesis method. The fractional bandwidth of this antenna is 14.8%. The mutual coupling between the two ports is lower than -20 dB. Two filtering antennas with dual polarizations were realized in [6] and [7] by using patch antenna. Extra circuits are not introduced in these designs. The impedance bandwidths of them of filtering antennas are 29.7% and 10.1%, respectively.

In [8], a novel filtering antenna was designed by combining T-shaped resonator and PRS (partially reflecting surface). This antenna can cover a wide fractional bandwidth of 17.1% with a high port isolation of 45 dB. Additionally, the gain rejection level in unwanted frequency bands is better than 20 dB. However, the profile of this antenna is about 0.5 λ_0. Two bandwidth enhanced filtering antenna were proposed in [9] and [10] to cover the 1.7-2.7 GHz band. The radiation nulls in [9] are introduced by combining split rings, DGS, and parasitic loop. A broad fractional bandwidth of 56% with the reference of $|S_{11}| < -14$ dB is attained. However, four coaxial cables are used to form two pairs of differential feed ports. It is not suitable for PCB technology. By simply introducing two pairs of U-shaped parasitic strips around the dipole arms. A filtering antenna that is compact in size, featuring dual polarizations and wide impedance bandwidth was realized in [10].

In this study, a novel high pass filtering antenna is realized by using the meander line and parasitic grid structure. The presented design has a broad fractional bandwidth of 40%, which can cover the whole n77 band. Besides, the gain reduction level in unwanted frequency bands of this antenna is much better than the tightly coupled cross-dipole.

II. Design of Filtering antenna

A. Structure of The Antenna

The geometry of the presented wideband filtering antenna is given in Fig.1. As can be observed in Fig.1 (a), this antenna consists of three parts: the radiator, the baluns, and the reflector. The meander line arms, and parasitic grid structure are the two parts of the radiator. They are positioned on the upper and bottom part of the sub1. The meander line arms are connected to the reflector through the two baluns. The specific baluns dimensions are given in Fig.1(c). There are two Rogers 4003 substrates ($\varepsilon_r = 3.55$) substrates named Substrates 1 and 2 with the thickness of 0.305 mm and 0.508 mm in this design. The reflector with the size of 70mm × 70mm is placed on the bottom of the substrate 2. ANSYS HFSS (High Frequency Simulation Software) is used to obtain all the simulated results in this paper.

B. Performance of The Antenna

The simulated peak realized gain and $|S_{11}|$ of our design and reference antenna are depicted in Fig. 2. As seen, the presented design obtains a broad fractional bandwidth and an excellent gain-suppression level outside the operating frequency

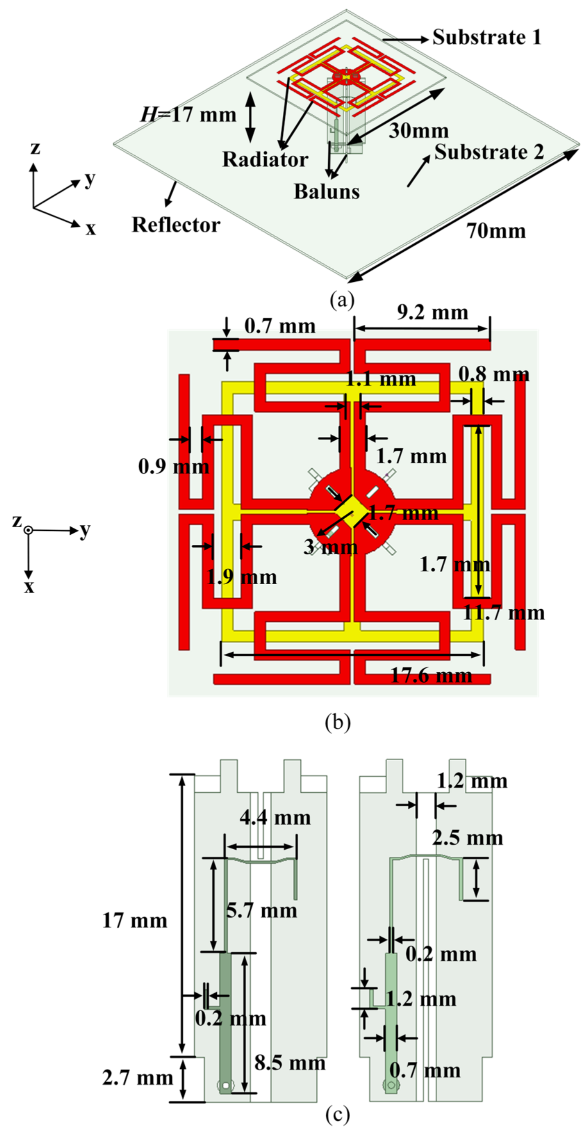

Fig. 1. Details of our design. (a) perspective and (b) top view, (c) baluns.

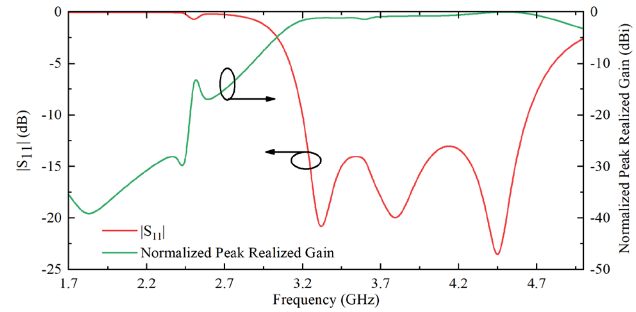

Fig. 2. Simulated $|S_{11}|$ and normalized peak realized gain.

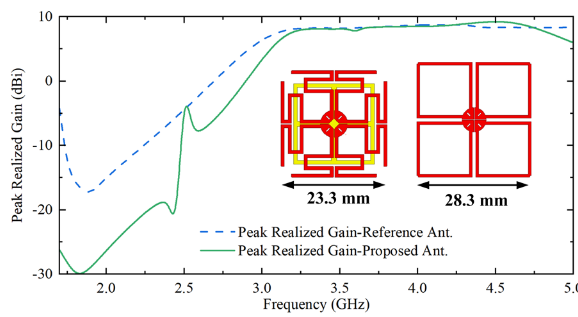

Fig. 3. Simulated peak realized gains of the presented design and tightly coupled cross dipole.

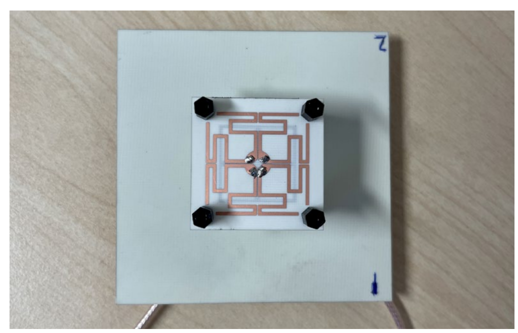

Fig. 4. Photograph of the design.

band. To demonstrate the superiority of the antenna, a traditional dual-polarized antenna is used as a reference antenna. These two antennas are the same except the radiator. As depicted in Fig. 3, the presented design has a smaller size and same gain in comparison to the reference antenna. And the simulated peak realized gain of our design is much lower than the traditional dual-polarized antenna from 1.7-2.7 GHz. It means that a low mutual coupling level can be realized when the proposed antenna is placed close to the antenna working at 1.7-2.7 GHz band. This is a very important factor in nowadays space limited base stations.

III. Results and Discussion

To confirm the validity of this design method, a model of the presented design was fabricated and evaluated through experimentation, as shown in Fig. 4. The isolation and reflection coefficients of the proposed design were obtained using Keysight P9377B VNA. The radiation performance is obtained from the anechoic chamber. As illustrated in Fig.5, the results of the measurements demonstrate that the presented design has a broad fractional bandwidth of 40% (3.16-4.75 GHz). The measured mutual coupling regarding the two input channels is smaller than -33 dB in the target working band (n77). Fig.6 presents a comparison of the measured and simulated realized gains. The slight discrepancy between the two can be attributed to several factors, including the loss of the cables, as well as the inaccuracies that can arise from the fabrication and measurement processes. The simulated gain of this antenna is around 8.5 dBi within the operating frequency band. The measured normalized radiation patterns at selected frequencies, as depicted in Fig.7, are consistent with the re-

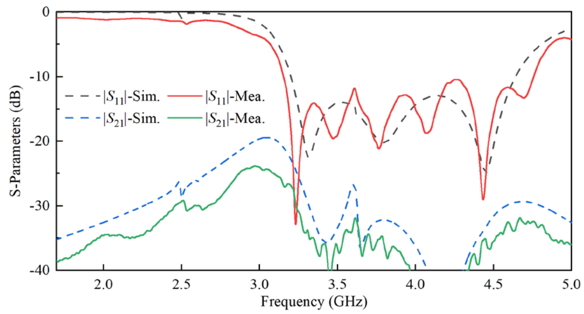

Fig. 5. Simulated and measured reflection coefficients and isolations of the proposed design.

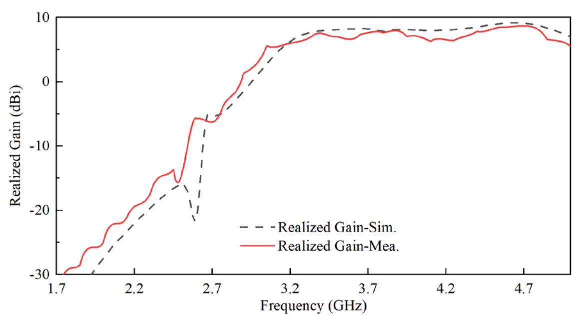

Fig. 6. Simulated and measured realized gain of this antenna.

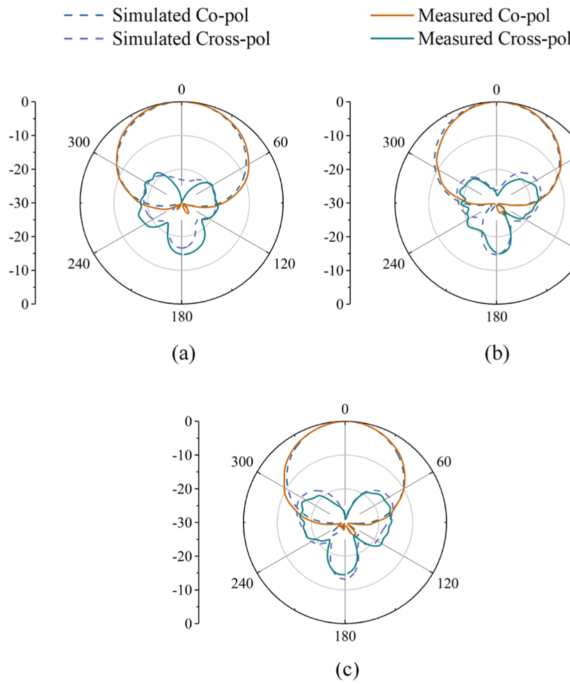

Fig. 7. Normalized radiation patterns of our design at (a) 3.3 GHz, (b) 3.9 GHz, and (c) 4.5 GHz.

sults obtained from HFSS. The half power beamwidth of this antenna is around 66°.

IV. Conclusion

A filtering antenna with compact size and dual polarization is realized by using meander line and parasitic grid structure. To confirm the design principle, a phototype of the presented design was produced and evaluated. The results of the test verified that the presented antenna could cover a wide fractional bandwidth of 40% (3.16-4.75 GHz) with a high port isolation. Besides, this antenna has a high gain suppression level of 13 dB in 2/3/4G band (1.7-2.7 GHz). Due to the above advantages, this antenna would be a suitable option for the sub-6 GHz application of 5G.

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