A Dual-Band Millimeter-Wave Antenna for 5G Mobile Applications

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***Abstract*—In this work, a microstrip antenna suitable for broadband millimeter wave mobile communication is proposed. The microstrip antenna is fed by a coplanar waveguide (CPW) structure with a matching port connected to a 50-Ω resistor. The operating bandwidth of the antenna is able to cover both the 28 GHz and the 39 GHz bands for 5G millimeter wave applications. In addition, an eight-element array is developed and studied. Results show that the array can cover the beamwidth from -30° to 30° in *yoz*-plane, which can meet the beamforming requirement for the 5G wireless communications.**

Keywords—dual-band; microstrip antenna; millimeter wave antenna; beamforming.

I. Introduction

The fifth-generation (5G) wireless communication antennas have aroused more and more attention in recent years. Millimeter-wave (mmW) antenna system is one of the vital components for the 5G communication due to its high-speed data transmission rate and low latency. Lots of researches focus on this topic and several mmW antennas are also proposed [1]-[6]. Particularly, a notch antenna and an aperture-coupled patch antenna have been proposed to operating at mmW frequencies of the 5G networks in [1]. Furthermore, a low-complexity metallic tapered slot antenna covering 24.25-28.35 GHz band is proposed in [2]. The beamforming characteristic is studied in the paper while the bandwidth can only be applied to work for the 28 GHz band. Another broadband antenna for 5G mmW applications mentioned in [3] uses a U-slot resonator in the ground to achieve a wider bandwidth. However, the bandwidth is not sufficient to cover either the 28 GHz or 39 GHz mmW bands. The antenna proposed in [5] shifts the resonating frequency to 38.6 GHz and 70 GHz. Currently, there are seldom antennas can cover the 28 GHz and 39 GHz bands simultaneously. From this point of view, the main object of the work is to promote a dual-band mmW antenna for 5G mobile devices.

The antenna with a dual-band or broadband characteristic would be of great significance in the 5G mobile communications. In this work, a dual-band mmW microstrip antenna is proposed with a small size of 4×9.45×0.26 mm^3. The beamforming characteristic is also studied by simulation to verify the antenna element is a good candidate for terminal devices.

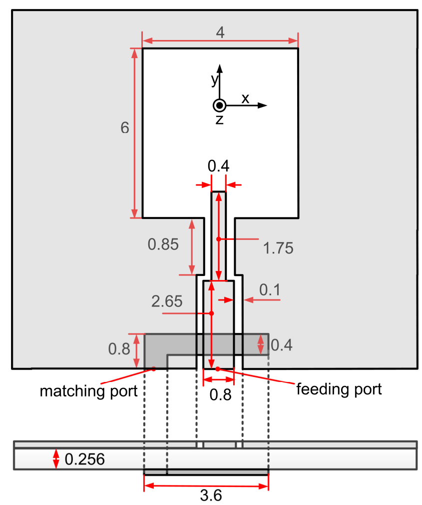

Fig. 1. Configuration of the antenna.

II. Antenna Structure

The configuration of the antenna element is shown in Fig. 1. The antenna is composed of three layers where a 0.256 mm thick dielectric substrate (ε_r=4.4) is located at the middle while the top layer and the bottom layer are both copper layers. The bottom layer is highlighted in dark gray color and that of the top layer is in light gray color. A 50-Ω resistor is connected to the edge of the bottom layer acting as a matching port as shown in Fig. 1. The strip at bottom layer is 3.6 mm long. The coupling effect between the top layer and the bottom strip helps the antenna to generate a broadband input impedance characteristic. An aperture is opened at the top layer with an area of 4 × 6 mm^2. The feeding structure of the antenna is integrated with two strips: the one near to the feeding port is 2.65 mm long with a width of 0.8 mm; and another strip near the slot has a size of 1.75× 0.4 mm^2. A coplanar waveguide (CPW) structure is utilized to feed the antenna at top layer. The distance between the feeding strip and the coplanar ground plane is 0.1 mm. All the abovementioned parameters are studied and optimized by CST Microwave Studio®.

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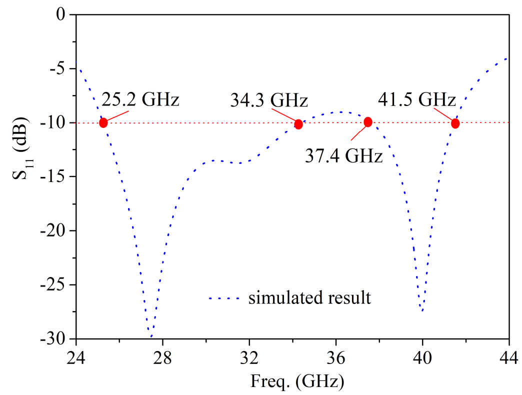
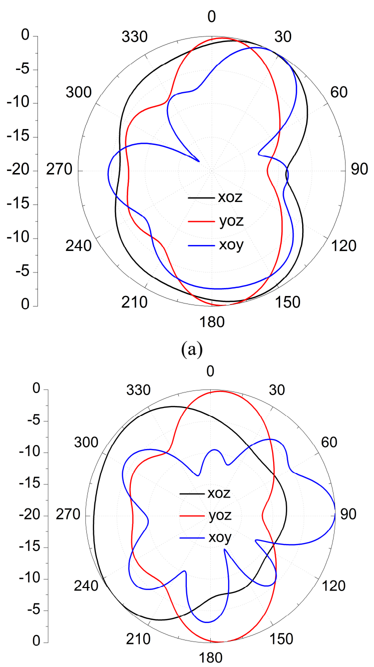


Fig. 2. Simulated S_{11} result.



(a)

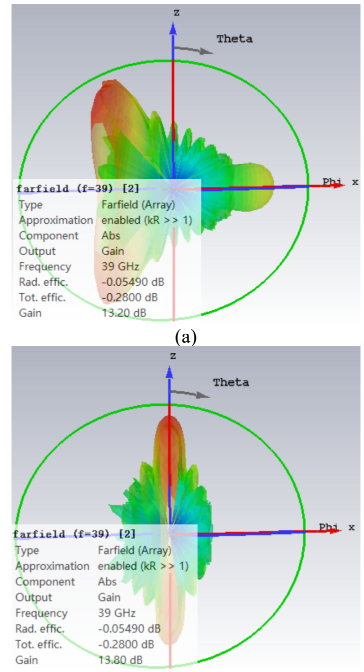
(b)

Fig. 3. Simulated radiation pattern results: (a) at 28GHz; (b) at 39GHz.

III. Resluts

The simulated S_{11} result is presented in Fig. 2. The bandwidth with S_{11}<-10 dB is ranging from 25.2 GHz to 34.5 GHz and from 37.5 GHz to 41.5 GHz, which is wide enough to cover the 5G mmW 28 GHz and 39GHz bands. The radiation pattern for both 28GHz and 39GHz are demonstrated in Fig. 3 and the realized gains are 2.3 dBi and 4.8 dBi respectively.

To verify the proposed antenna is a good candidate for mobile communication, the beamforming characteristic is also studied by simulation. An 8-element array along the *x*-axis is analyzed. The distance between the adjacent elements is 5 mm. When the adjacent elements have a 110° phase shift, the main lobe of the array radiation pattern is shown in Fig. 4(a); and that with a 0° phase shift is shown in Fig. 4(b). According to



(a)

(b)

Fig. 4. Radiation pattern for 8-element array at 39GHz: (a) 110° phase shift for the adjacent elements; (b) 0° phase shift for the adjacent elements.

Fig. 4, the main lobe of the radiation pattern is able to shift significantly with a stable realized gain by adjusting the phase difference among the antenna elements. The simulated gain of the 8-element array at 39 GHz is up to 13.8 dBi, which is potentially sufficient to apply in the 5G mmW communication.

IV. Conclusion

The propsed antenna has broadband characteristic to cover both 28GHz and 39GHz bands for 5G communication. An 8-element array is also studied to verify the proposed antenna can be a good candicate for terminal device applications.

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