Dual-Port Endfire Millimeter Wave Reconfigurable Antenna with Optimized Pixel Surface

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***Abstract*—A dual-port 1×2 antenna array incorporating a parasitic pixel surface in front of the array is proposed. By optimizing the pixel surface, different radiation patterns can be provided by each port. To demonstrate the effectiveness of the approach, a dual-port design, with patterns directed to 112° and 66° and gains of 7.87 dBi and 6.95 dBi respectively at 28 GHz, is provided. A feature of the design is that no RF switches are needed in the pixel surface. The proposed antenna array can be suitable for future fifth-generation (5G) wireless communication systems.**

I. Introduction

Pattern reconfigurable antennas are required in fifth-generation (5G) communication devices to enhance performance at millimeter wave (mmWave) frequencies [1], [2]. Pattern reconfigurable antennas can provide radiation beams that can scan and track signals from different directions [3]. Beam scanning capability can be achieved in the antennas by using conventional phased arrays or RF switches to change the antenna structure. The different methods have their own advantages and disadvantages.

In this paper, we propose a dual-port endfire reconfigurable antenna for mmWave bands that incorporates a pixel surface. Compared to existing pixel antennas [3], [4], the proposed antenna does not need RF switches inside the pixel surface. We optimize the pixel surface to find a fixed structure which can achieve beam scanning capability by using different ports. After optimization, the dual-port antenna can operate from 27-29 GHz with reflection coefficients lower than -12 dB and provide radiation patterns pointing to 112° and 66° for port 1 and 2 respectively.

II. Antenna Design

Fig. 1 illustrates the geometry of the proposed dual-port endfire mmWave antenna with the pixel surface. The antenna is printed on two sides of a Rogers RT/duroid 5880 substrate with a thickness of 0.508mm (shown in grey). As shown in Fig. 1, the antenna consists of two half-wavelength dipoles (shown in orange) with a rectangular ground (shown in blue) located at the back side of the substrate and a parasitic pixel surface (shown in orange) in front of the dipoles. There are 3×10 squares (pixel) to form the pixel surface. Two adjacent pixels can be connected with a metal wire, achieving various connection combinations inside the pixel surface. The potential

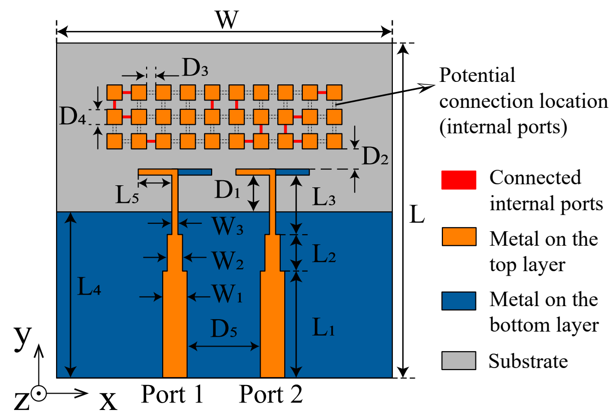

Fig. 1. Geometry of the proposed dual-port antenna where the dimensions are L=22mm, L_1=7mm, L_2=2.4mm, L_3=3.9mm, L_4=10.9mm, L_5=2.2mm, W=22mm, W_1=1.6mm, W_2=1mm, W_3=0.4mm, D_1=2.4mm, D_2=1.3mm, D_3=0.6mm, D_4=1mm, D_5=4.8mm.

connections between two pixels can be regarded as internal ports, while the two feeding ports of the dipole antenna can be regarded as external ports. When all the pixels are unconnected, we can excite two dipole antennas independently and the simulated results are shown in Fig. 2. With the unconnected surface each antenna can operate from 25-30.5 GHz, and the largest realized gains are 4.8 dB when port 1 is excited and 4.7 dB when port 2 is excited.

The antenna array with the pixel surface can be regarded as a multiport network. The S-parameters and radiation patterns can be analyzed by the internal multiport method (IMPM) [3], [5]. As shown in Fig. 1, in this design, there are 2 external feed ports and 47 internal ports. Based on previous analysis [3], [4], [5], we can optimize the connection combinations of all the internal ports to achieve desirable characteristics. Our objective in this work is to obtain two different radiation patterns when each port is excited with peak gains located at around 60° and 120° while exhibiting low mutual coupling between the ports.

III. Simulation Results

After optimization, the states of each internal port inside the pixel surface are finalized. As shown in Fig. 1, some of the

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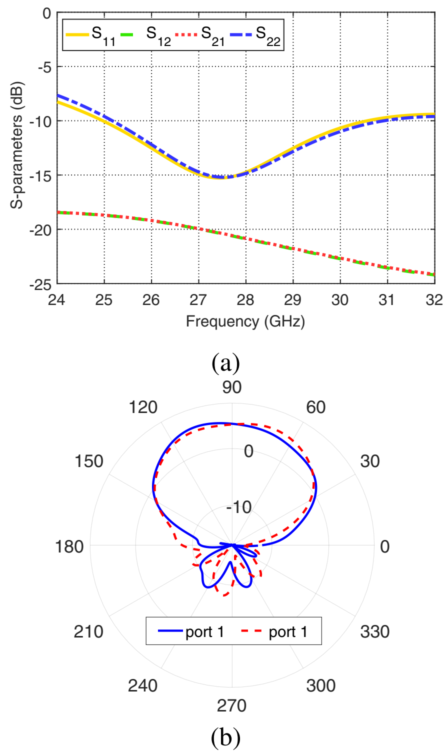

Fig. 2. Simulated results when all pixels are unconnected. (a) S-parameters. (b) Radiation patterns in xy-plane at 28 GHz.

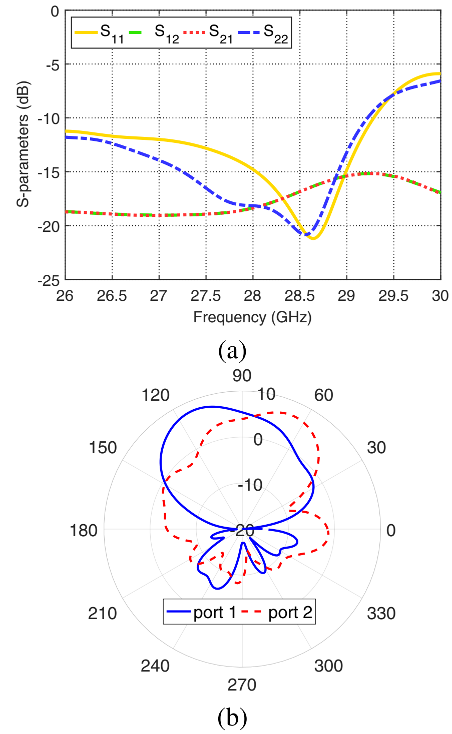

Fig. 3. The simulated results of the optimized dual-port antenna. (a) S-parameters. (b) Radiation patterns in the xy-plane at 28 GHz.

pixels are connected with a metal wire (red rectangular) and others remain unconnected.

Fig. 3 shows the simulated results of the proposed antenna array with the optimized pixel surface. With the fixed optimized connection combination inside the pixel surface, the two antenna ports can operate independently. When each port is excited separately, both antennas operate from 27-29 GHz with reflection coefficients lower than -12 dB as shown in Fig. 3(a). The coupling between the two ports is lower than -15 dB. As shown in Fig. 3(b), the radiation beam points to 112° in the xy-plane at 28 GHz when port 1 is excited, and the largest realized gain is 7.87 dB. When port 2 is excited, the beam points to 66° in the xy-plane at 28 GHz, and the largest realized gain is 6.95 dB. Table I provides details of the beam directions and realized gains at different frequencies.

TABLE I
BEAM DIRECTION (IN xy-PLANE) AND REALIZED GAIN AT DIFFERENT FREQUENCIES

Excited port	Port 1		Port 2	
	Direction	Gain	Direction	Gain
27 GHz	114°	6.51 dBi	62°	6.57 dBi
27.5 GHz	113°	7.13 dBi	64°	7.06 dBi
28 GHz	112°	7.87 dBi	66°	6.95 dBi
28.5 GHz	112°	8.79 dBi	68°	7.79 dBi
29 GHz	111°	9.04 dBi	69°	8.18 dBi

IV. CONCLUSIONS

In this paper, a dual-port endfire mmWave pattern reconfigurable antenna array with a pixel surface is proposed. After optimization, the dual-port antenna array can operate from 27-29 GHz with reflection coefficients lower than -12 dB and provide radiation patterns pointing to 112° and 66° for port 1 and 2 respectively. The proposed antenna can be a promising candidate for future 5G mmWave communication.

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