A Broadband Dual-polarized Capped Bow-tie 2×2 Antenna Array for 28 GHz Band in 5G Systems

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Runqi Wu, Zhengting Liu, Youwei Zhou, Xin Wang, Jungang Yin*,
College of Electrical and Information Engineering,
Hunan University, Changsha, 410082, China
yinjungang126@126.com

Jian Yang
Dept. of Electrical Engineering,
Chalmers University of Technology,
Gothenburg, S412-96, Sweden
jian.yang@chalmers.se

***Abstract*—With the development of the fifth generation (5G) communications, dual-polarization base station antennas have increasingly attracted a lot of attention. In this paper, a broadband high-efficiency dual-polarized capped bow-tie antenna array is presented. Simulation results show that the bandwidth of the proposed antenna is 24-36.8 GHz, with its return loss better than 10 dB and the stable coverage. The directivities vary from 8 to 12dBi and the relative cross-polar level is below -10dB over the most of band. It has a simple and compact structure, and is ready to be extended for large array antennas with massive MIMO performance used in 5G communications.**

Keywords—dual-polarization; capped bow-tie; 5G antennas.

I. INTRODUCTION

Concepts of the 5G communications have been proposed in recent years. The current 4G wireless communication system is not equipped to meet explosive growth in traffic demands [1]. It is important to design a base station antenna that can cover a wide frequency range and accommodates more communication standards [2]-[5]. It is reported in [6] that the directivity and matching of a bow-tie antenna, so called the capped bowtie antenna, can achieve a 3:1 band by simply adding a piece of parasitic patch director above the bowtie arms. This bow-tie-director idea can easily be extended to form an ultra-wideband 3D quasi-Yagi antenna by using multiple parasitic directors [7]. In this paper, the elemental capped bow-tie structures are configurated to realize a 2×2 dual-polarized array antenna as a candidate sub-array, readily for use of large antenna array in 5G communication systems.

II. ANTENNA DESIGN AND ANALYSES

As shown in Fig. 1, the antenna element is composed of a ground plane, 4 bow-tie dipole arms and 4 parasitic directors. 50 Ohm coaxial cables are used to feed the bow-tie dipoles as the function of baluns. The coax-to-microstrip line feeding plays an indispensable role in this antenna design both for matching and supporting. In order to matching the characteristic impedance of 50 Ohm, the formula (1)-(2) concerning microstrip line characteristic impedance are used for initial design of the coax-to-microstrip line feeding geometry [8].

$$Z_0 = \frac{\frac{120\pi}{\sqrt{\varepsilon_e}}}{\frac{W}{h} + 1.393 + 0.667\ln\left(\frac{W}{h} + 1.444\right)} \quad (1)$$

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{(\varepsilon_r - 1)}{2}\left(1 + 12\frac{h}{W}\right)^{-\frac{1}{2}} \quad (2)$$

where h is the substrate thickness, w the width of the microstrip line, ε_r dielectric constant, of the microstrip line. Z_0 is the characteristic impedance.

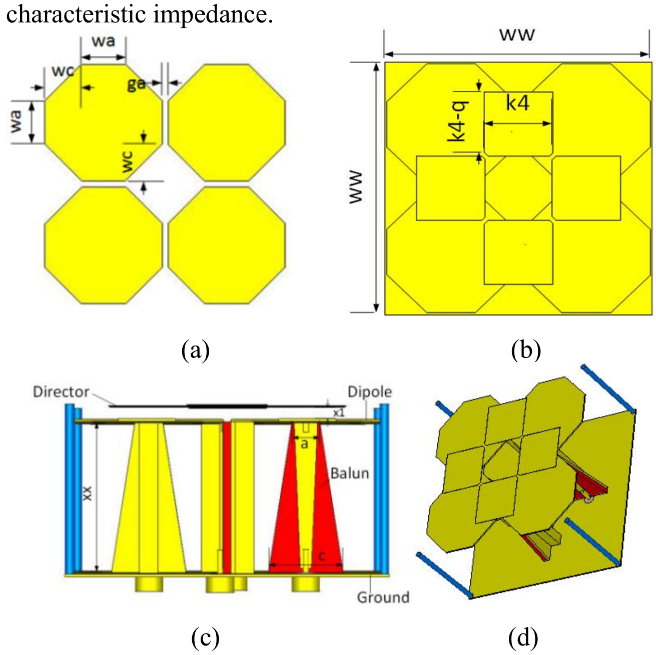

Fig. 1 (a) dipole arms, (b) top view, (c) side view, (d) 3D view

The antenna is optimized by using a genetic algorithm engine and the optimized parameters can be found in Table I. It can be observed that the proposed antenna element is much more compact than the antenna referenced in [9], while have an 8% wider bandwidth and 4 dB higher gain. Compared with antennas in [3] and [10], the proposed antenna outperforms in terms of 2 dB higher gain and 91% wider bandwidth, respectively.

TABLE I. PARAMETERS OF PROPOSED ANTENNA

Parameters	Value

ww	12.825 mm
x1	0.535 mm
xx	5.7 mm
wc	1.78 mm
k4	3.03 mm
c	2.85 mm
a	1.07 mm
q	0.09 mm
ga	0.39 mm
wa	2.14 mm
Substrate Thickness (balun)	0.39 mm
Substrate Thickness (director)	0.102mm
Relative Dielectric Constant (balun)	4.50
Relative Dielectric Constant (director)	3.48

III. SIMULATION RESULTS

Since the four coax feeding are configured in an asymmetrical manner in order to increase the isolation between ports, no symmetry plane is set up in CST simulation. The 2 ports of the same polarization are simulated respectively; when both of them are finished, the total S_{11} is then post-calculated through subtracting S_{11} by S_{21}. The calculated total S_{11} parameter of the antenna is shown in Fig. 2, and it is less than -10 dB over 24-36.8 GHz. The simulated co-polarization patterns of the proposed antenna are exhibited in Fig. 3. It can be observed from Fig. 4 that the directivities vary from 8 to 12 dBi and the relative cross-polar level is better than -10 dB over most of band.

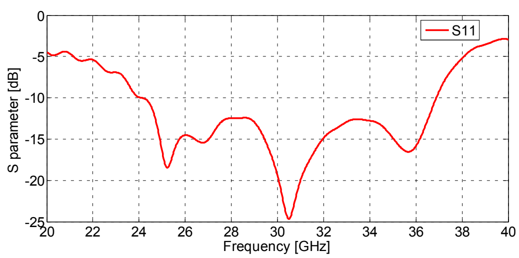

Fig. 2 Simulated and calculated $|S_{11}|$ of the proposed antenna

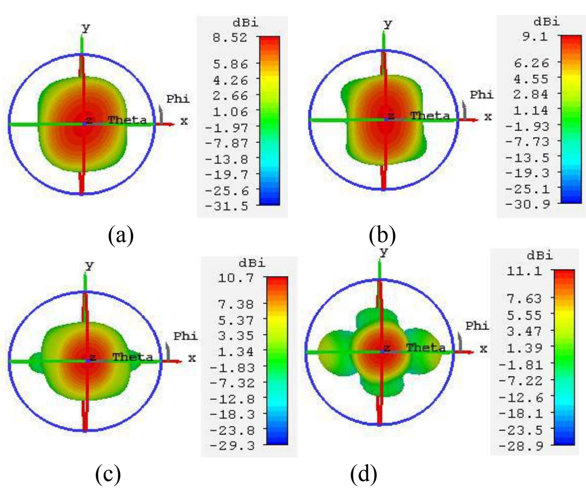

Fig. 3 Simulated co-polarization patterns of the proposed antenna at different frequencies: (a) 24 GHz; (b) 27 GHz; (c) 30 GHz; (d) 33 GHz.

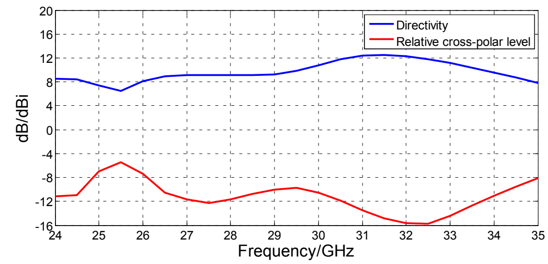

Fig. 4 Simulated co-polar directivity and relative cross-polar level of the proposed antenna.

IV. CONCLUSION

A broadband dual-polarized 2×2 capped bow-tie antenna array has been presented. The antenna can operate over 24-36.8 GHz with return loss better than 10 dB; directivities vary from 8 to 12 dBi and the relative cross-polar level is better -10dB over most of band. Compared with other dual-polarization antennas, the proposed antenna is much more compact, and readily extended to form a large antenna array for use in 5G applications.

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