Progress In Electromagnetics Research Letters, Vol. 101, 165–171, 2021

A 5.4 GHz Dual-Polarized Printed AMOS Antenna

Wen Luo and Yanfei Li*

Abstract—A novel dual-polarized printed AMOS antenna with high isolation operating at 5.4 GHz is proposed. The horizontal and vertical polarizations have similar radiation patterns in horizontal plane with the HPBW over 90°. In the frequency range of 5.2 GHz–5.6 GHz, the vertical polarization antenna and horizontal antenna have the gain above 7.4 dB and 10 dB, respectively. The S_{21} between the two input ports of the dual-polarized AMOS antenna is lower than −40 dB.

1. INTRODUCTION

Recently, with the development of 5G wireless communication, as the vital equipment of radio frequency (RF) front end, antennas with high gain and wide beam draw great interest from researchers [1]. Furthermore, the complexity of the electromagnetic environment requires the antenna to have the characteristics of multi-polarization and be omnidirectional. So multi-polarization and omnidirectional antennas become a research hotspot. Directional dual-polarized antennas with high gain are designed and proposed by many researchers [2–5]. These antennas include two polarization parts, for example vertical polarization and horizontal polarization or two orthogonally horizontal polarizations. However, the dual-polarized antennas with similar radiation patterns in the required plane still need to be further investigated.

Franklin antenna is proposed by Franklin in 1920's [6]. Since then, Franklin antenna has been investigated by many researchers. The Franklin antenna has many advantages, such as light weight and low profile [7, 8]. AMOS antenna is achieved by placing a Franklin antenna array in front of a narrow conducting reflector plane, which makes the vertical polarization Franklin antenna achieve directional radiation pattern in the horizontal plane. Several AMOS antennas can form a horizontal or vertical omnidirectional antenna with high gain and low side lobe. Nowadays, AMOS antenna is widely used in the construction of mobile communication base station, and the printed AMOS dipole array can improve the radiation characteristic [9–13]. In [13], a printed dual-polarization log-periodic antenna is proposed, whose structure is simple and easy to manufacture using printed technology.

In this paper, based on the structure of Franklin antenna array, a novel dual-polarized printed AMOS antenna with similar radiation patterns in the horizontal plane is proposed. The simulation and measurement results show that the dual-polarization AMOS antenna has a high isolation and wide beam in the horizontal plane.

2. AMOS ANTENNA ARRAY CONFIGURATION

The currents distributions of Franklin antennas are discussed here to show the design idea of the dual-polarized AMOS antenna. The horizontally polarized antenna is designed by using a rhombus structure, as shown in Fig. 1(a), and the current components along z direction on the two sides of the antenna are opposite, which makes the generated electric fields cancelled, while the current components along

Received 23 May 2021, Accepted 8 December 2021, Scheduled 26 December 2021
* Corresponding author: Yanfei Li (liyanfei@cuc.edu.cn).
The authors are with the Information Engineering School, Communication University of China, China.

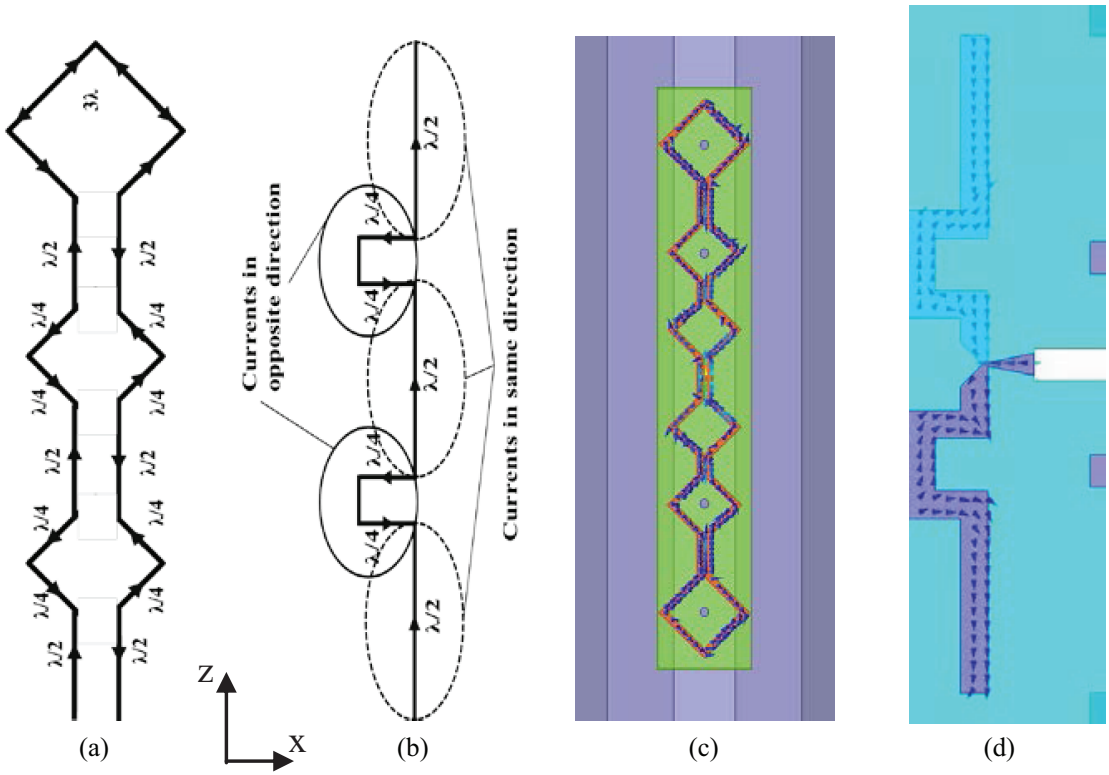

Figure 1. Franklin collinear antenna: (a) Rhombus structure: the vertical components of the current are cancelled and the horizontal components of the current are remained; (b) Linear structure; simulation current distributions of AMOS: (c) Horizontal polarized antenna; (d) Vertical polarized antenna.

x direction will radiate the horizontal polarized wave. The vertically polarized antenna is designed by using the collinear Franklin structure, as shown in Fig. 1(b), and currents are in opposite direction, which will suppress the electromagnetic radiation since the electric fields are cancelled. The remaining currents are in the same direction, which will work as dipoles to form a vertically polarized antenna array.

The dual-polarized Franklin antenna is composed of a combination of the linear collinear antenna Franklin antenna and rhombus collinear Franklin antenna, as shown in Fig. 2 and Fig. 3. The reflectors are added behind the dual-polarized Franklin antenna to construct the dual-polarized AMOS antenna array. The configurations and dimensions of the dual-polarized AMOS antennas are shown in Fig. 2. The reflector of the horizontal AMOS is a bending structure with a shape of "W" as shown in Fig. 2(b), which can make the half power beamwidth (HPBW) over 90° in XOY plane. The reflector of the vertical polarized AMOS is a plane copper as shown in Fig. 2(c) and Fig. 2(d).

3. SIMULATED AND MEASURED RESULTS

Considering that the printed antenna has accurate size, stable structure and is suitable for mass production, a dual-polarized printed AMOS antenna is designed and fabricated in this paper, as shown in Fig. 3(a). The antennas are printed on an F4B substrate, with a dielectric constant of 4.4 and loss tangent of 0.025. The reflectors made of copper are added behind the two antennas to form AMOS antennas. Simulation current distributions of the AMOS antennas are shown in Figs. 1(c) and (d), which are similar to the theoretical analysis of the Franklin antennas.

Unbalanced feeding structure will lead to the asymmetric dipoles of two sides and different current distributions, as well as deflected radiation patterns. A balun was introduced to avoid this case and achieved constant impedance over a wide range of frequency. Each AMOS antenna has a balanced feed

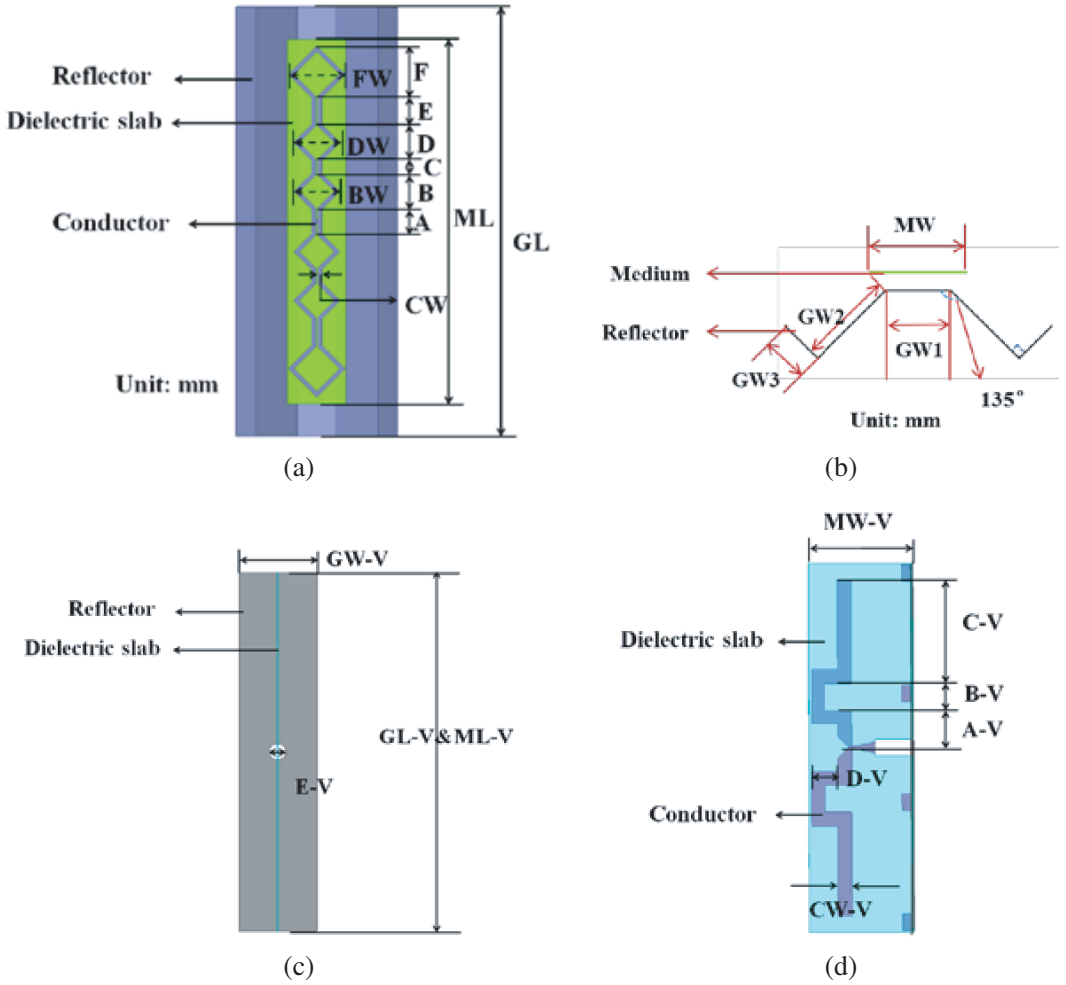

Figure 2. AMOS antenna configuration: (a) Front view, and (b) side view of horizontal polarized AMOS; (c) Front view, and (d) side view of vertical polarized AMOS. Dimensions: A = 12.6 mm, B = 18.5 mm, BW = 23.5 mm, C = 6.3 mm, CW = 2 mm, D = 19 mm, DW = 24 mm, E = 13.3 mm, F = 25.6 mm, FW = 29 mm, MW = 30 mm, ML = 186.8 mm, GW1 = 20 mm, GW2 = 30 mm, GW3 = 15 mm, GL = 220 mm, Gt = 1 mm, A-V = 11.32 mm, B-V = 8.2 mm, C-V = 30.9 mm, CW-V = 4.2 mm, D-V = 7.9 mm, E-V = 5 mm, MW-V = 30.2 mm, ML-V = 110 mm, GW-V = 24 mm, GL-V = 110 mm.

structure formed by using a quarter-wave coaxial cable. As shown in Fig. 3(c), the two arms of the vertically polarized AMOS antenna are printed on two sides of the dielectric slab, and the quarter-wave coaxial cable is connected to the two arms directly. The horizontally polarized AMOS antenna is printed on one side of the dielectric slab, and the quarter-wave coaxial cable is connected to the two paralleled conductors, as shown in Fig. 3(d).

Figure 4(a) shows the simulated and measured S_{11} and S_{21} of the dual-polarized printed AMOS antennas. Ports 1 and 2 are the input ports of the horizontal and vertical antennas, respectively. The measured S_{11} and S_{22} below -10 dB are 5.25 GHz to 6 GHz and 5 GHz to 5.6 GHz, respectively. The measured S_{21} is lower than -40 dB during the whole working frequency range. The measured gains of horizontal and vertical polarizations are larger than 10 dB and 7.4 dB, respectively in the whole bandwidth as shown in Fig. 4(b).

The simulated and measured radiation patterns in XOY (horizontal) and YOZ (vertical) planes at the frequencies of 5.2 GHz, 5.4 GHz, and 5.6 GHz are shown in Fig. 5. The HPBWs of simulated and measured radiation patterns for the horizontal polarized AMOS antenna in XOY plane at 5.4 GHz are

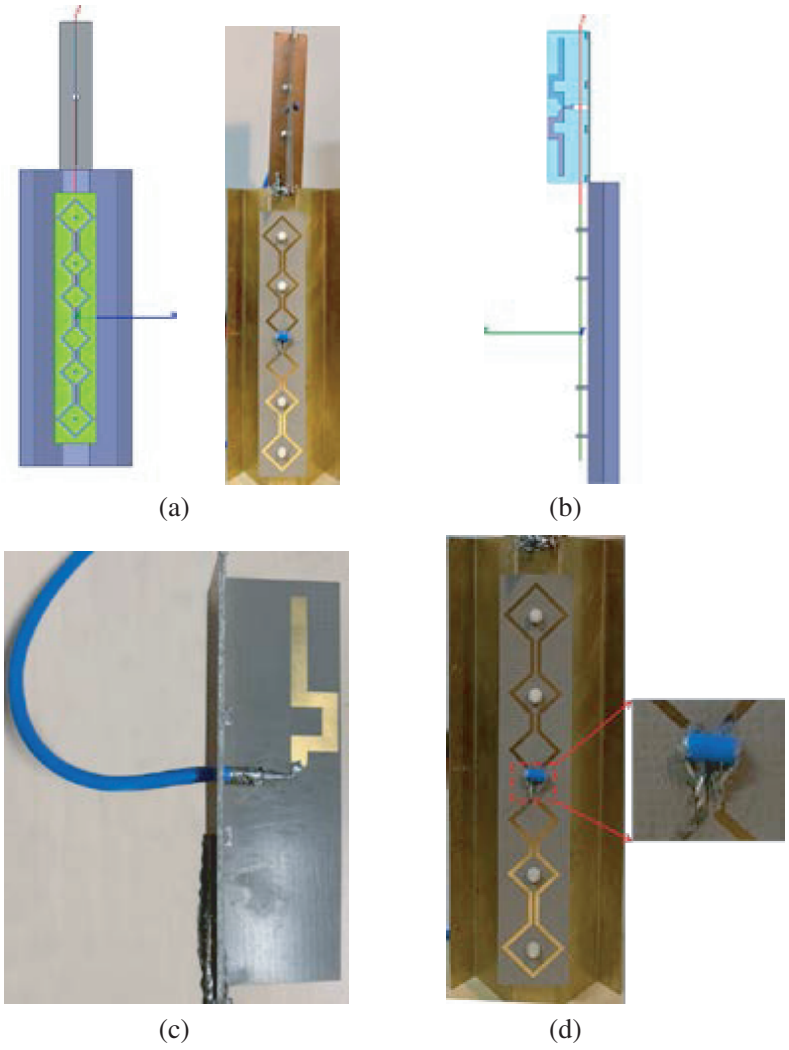

Figure 3. Dual-polarized AMOS antenna: (a) Front view and (b) side view; Fabricated AMOS antennas: (c) Vertical polarized and (d) horizontal polarized.

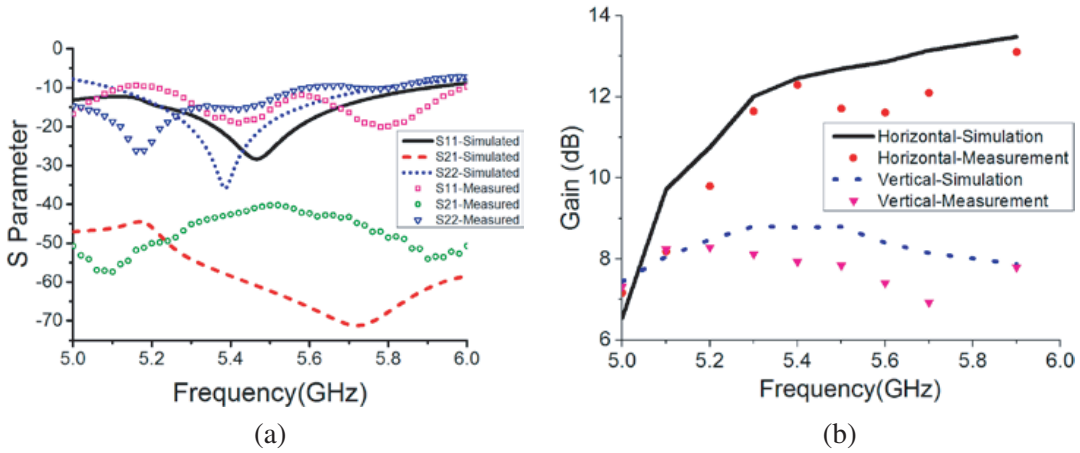

Figure 4. Simulations and measurements results: (a) S parameters; (b) Gain.

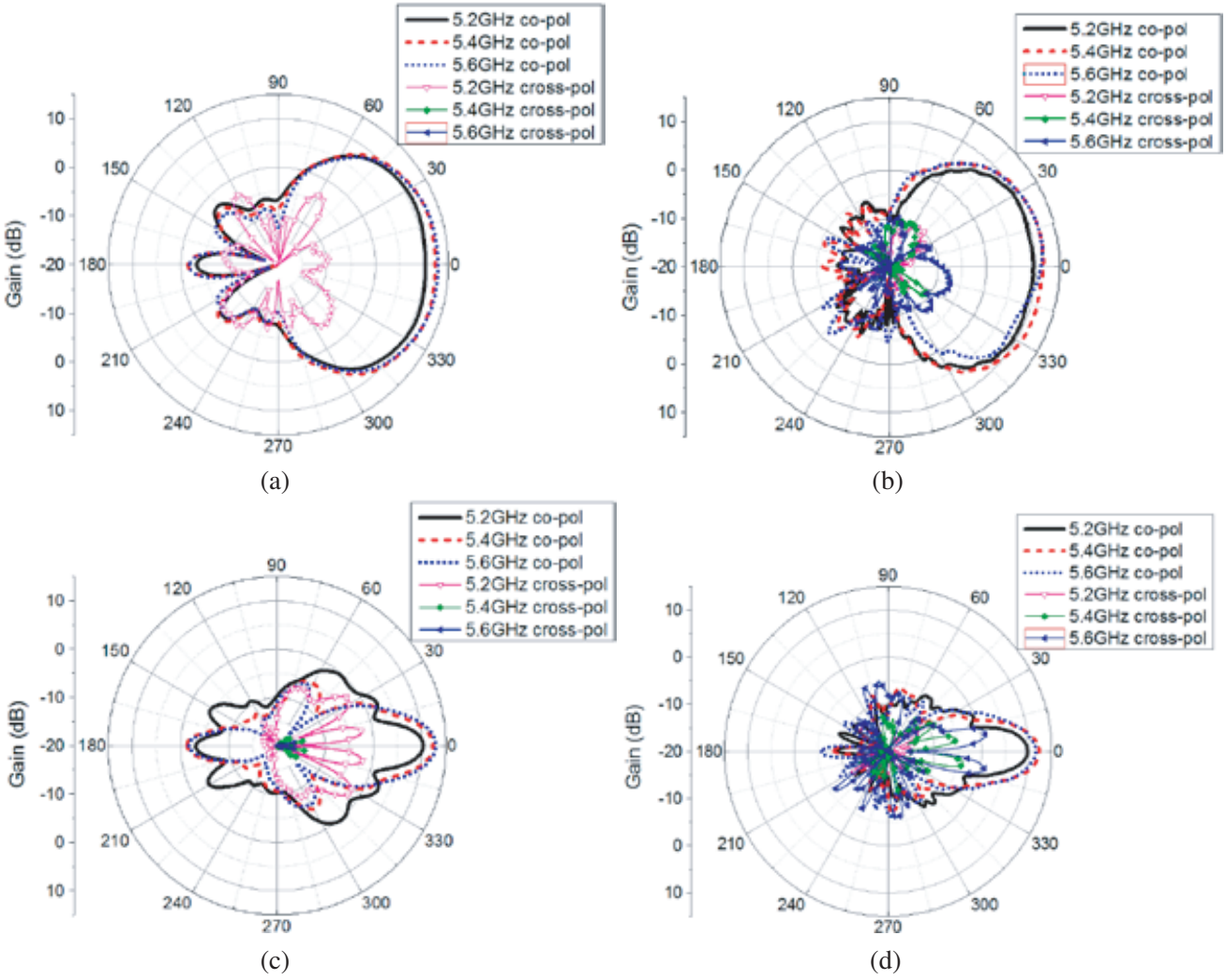

Figure 5. Radiation patterns of horizontal polarized AMOS antenna at 5.2 GHz, 5.4 GHz and 5.6 GHz. (a) Simulated in XOY plane; (b) Measured in XOY plane; (c) Simulated in YOZ plane; (d) Measured in YOZ plane.

98° and 92°, respectively.

Figure 6 shows the simulated and measured radiation patterns in XOY (horizontal) and YOZ (vertical) plane of the vertically polarized AMOS antenna at frequencies of 5.2 GHz, 5.4 GHz, and 5.6 GHz. The HPBWs of simulated and measured radiation patterns in XOY plane at 5.4 GHz are 102°

Table 1. Comparison of dual-polarized antenna parameters.

Antenna Structure	Center frequency f_0 (GHz)	Horizontal antenna		Vertical antenna		Isolation between two polarization antenna (°)
		Gain (dBi)	HBPW (°)	Gain (dBi)	HBPW (°)	
Ref. [3]	2.3	7–8.1	≈ 65	7–8.1	≈ 65	35 dB
Ref. [11]	1.5	> 10	≈ 50	> 10	≈ 50	–
This work	5.4	> 12	> 90°	> 7.4	> 90°	40 dB

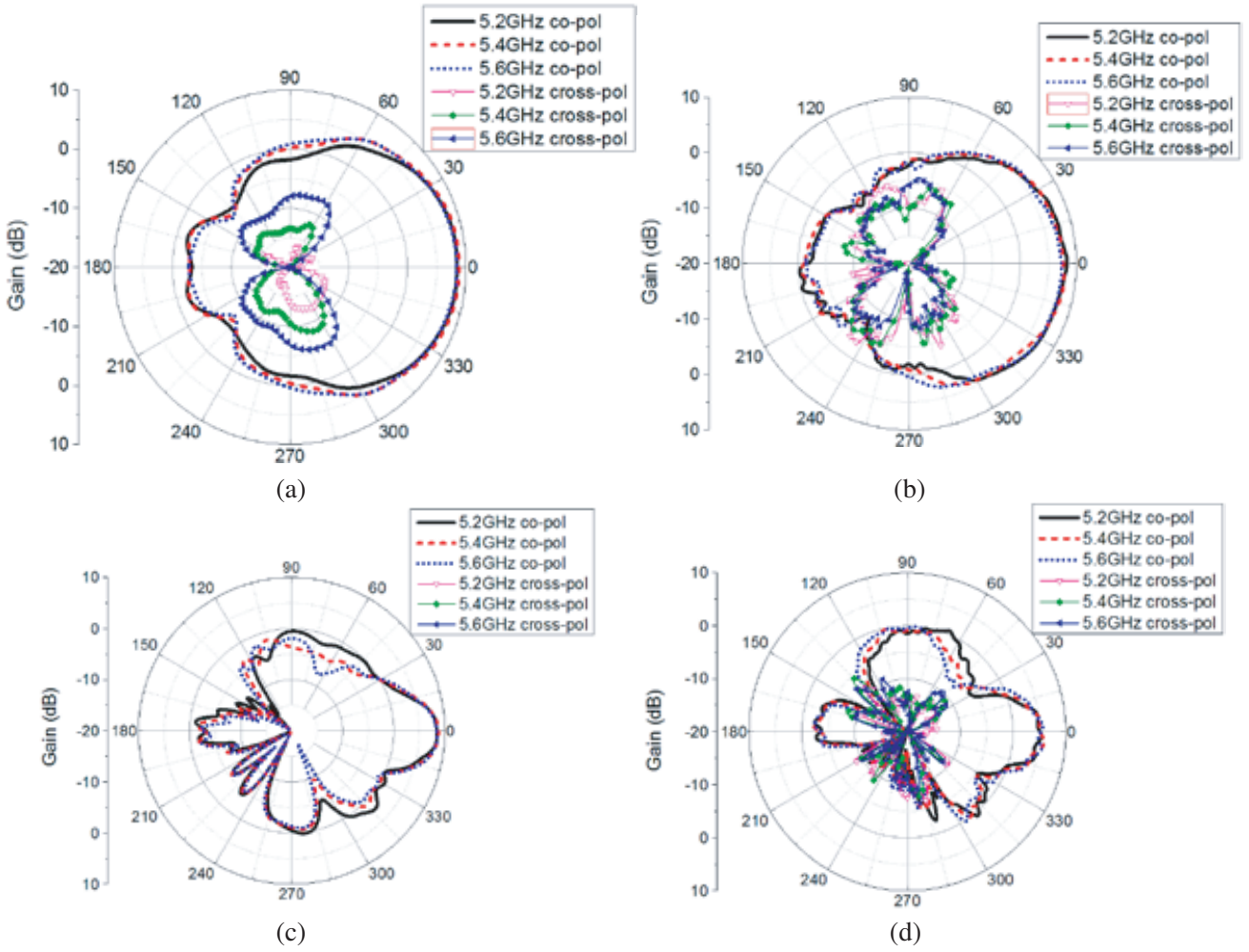

Figure 6. Radiation patterns of vertical polarized AMOS antenna: (a) Simulated in XOY plane; (b) Measured in XOY plane; (c) Simulated in YOZ plane; (d) Measured in YOZ plane.

and 99°, respectively. Table 1 lists the performance comparison between the proposed antenna and antennas in reference. The proposed antenna has a wider HBPW, higher gain, and better isolation between two polarization ports.

4. CONCLUSION

Based on the Franklin antenna array theory, a novel dual-polarized printed AMOS antenna with high isolation and high gain operating in 5.2 GHz–5.6 GHz frequency range is proposed. Simulated and measured results have proven that the dual-polarization AMOS antenna has good radiation performance. The measured radiation patterns show that the HPBWs of both polarizations are larger than 90°. The S_{21} of the two polarizations is lower than -40 dB in the whole bandwidth.

ACKNOWLEDGMENT

This work is supported by a grant from National Key Technology R&D Program of China under contract No. 2015BAK05B01 and No. 2015BAK05B01-1. The authors would like to thank Dr. Qingxin Guo and Dongdong Zeng for the measurement as well as the reviewers and the associate editor for their assistance with improving this paper by their valuable feedback on our manuscript.

REFERENCES

1. Wang, L., H.-C. Yang, and Y. Li, "Design of a new printed dipole antenna using in high latitudes for Inmarsat," *IEEE Antennas and Wireless Propagation Letters*, Vol. 10, 358–360, 2011.
2. Jie, S. and L. Kwaiman, "Wideband linearly-polarized and circularly-polarized aperture-coupled magneto-electric dipole antennas fed by microstrip line with electromagnetic bandgap surface," *IEEE Access*, Vol. 7, 43084–43091, 2019.
3. Gou, Y., S. Yang, J. Li, and Z. Nie, "A compact dual-polarized printed dipole antenna with high isolation for wideband base station applications," *IEEE Transactions on antennas and propagation*, Vol. 62, No. 8, 4392–4395, August 2014.
4. Zhou, Z., S. Yang, and Z. Nie, "A novel broadband printed dipole antenna with low cross-polarization," *IEEE Transactions on antennas and propagation*, Vol. 55, No. 11, 3091–3093, November 2019.
5. Wang, Y. and L. Y. Zhou, "Design of a dual-polarization log-periodic antenna (LPDA) in PCB," *2019 Photonics & Electromagnetics Research Symposium*, 2393–2397, 2019.
6. Jasik, H., *Antenna Engineering Handbook*, Fourth Edition, Chapter 4, McGraw-Hill, 2007.
7. Nishimura, S., K. Nakano, and T. Makimoto, "Franklin type microstrip line antenna," *1979 Antennas and Propagation Society International Symposium*, Vol. 17, 134–137, 1979.
8. Chang, S. H., W. J. Liao, K. W. Peng, and C. Y. Hsieh, "A Franklin array antenna for wireless charging applications," *PIERS Online*, Vol. 6, No. 4, 340–344, 2010.
9. Nakano, H., N. Odachi, H. Mimaki, and J. Yamauchi, "An array of Franklin and Bruce antennas," *IEEE Antennas and Propagation Society International Symposium 1996 Digest*, Vol. 2, 1130–1133, 1996.
10. Lin, W. and R. W. Ziolkowski, "Compact high directivity, omnidirectional circularly polarized antenna array," *IEEE Transactions on Antennas and Propagation*, Vol. 67, No. 7, 4537–4547, July 2019.
11. Rohani, B. B. and A. Hiroyuki, "A low profile directional antenna with dual polarization for channel capacity enhancement," *2015 IEEE International RF and Microwave Conference (RFM)*, 79–82, 2015.
12. Solbach, K., "Microstrip-Franklin antenna," *IEEE Transactions on Antennas and Propagation*, Vol. 30, No. 4, 773–775, July 1982.
13. Hamouz, P., P. Hazdra, M. Polivka, M. Capek, and M. Mazanek, "Radiation efficiency and Q factor study of Franklin antenna using the theory of characteristic modes," *Proceedings of the 5th European Conference on Antennas and Propagation (EUCAP)*, 1974–1977, 2011.