A Dual-polarized Magneto-electric Dipole Antenna With a Novel Feeding Structure

Yade Fang, Yufa Sun, Zuming Li
Key Lab of Intelligent Computing & Signal Processing, Ministry of Education, Anhui University
Hefei 230601, China
yadefang@126.com

***Abstract*—A novel dual-polarized magneto-electric (ME) dipole antenna is proposed for mobile communication base station. The proposed antenna utilizes coaxial lines to feed the two pairs of magneto-electric (ME) dipoles and a rectangular box-shaped reflector to enhance its stability in radiation patterns and high gain over the operating frequency. The simulated results show that a common impedance bandwidth with standing-wave ratio (SWR) ≤1.5 is from 1.68 GHz to 2.71 GHz, and port-to-port isolation is larger than 27 dB within the bandwidth. The antenna gain varies from 8.5 to 11 dBi. As an important advantage, the input impedance of antenna can be controlled within certain limits by adjusting the configurations, thus the antenna can be fed directly by coaxial cables without using impedance transformers. Besides, the antenna structure is compact and simple.**

***Keywords*—base station antenna, magneto-electric dipole, coaxial cable feed, dual polarization.**

I. INTRODUCTION

With the rapid development of wireless communication technology, higher requirements are placed on broadband unidirectional antennas. On the one hand, the antenna needs superior performance: low SWR, high isolation, high gain and low cross polarization, on the other hand, the antenna is required to be more miniaturized and more convenient for maintenance in the premise of ensuring the good performance. The ±45 °dual polarization antenna is widely used in modern wireless communication with its easy-to-implement structure and stable radiation characteristics. For the past few years, most scholars paid more attention to the research of frequency reuse and used the vertical polarization to realize the polarization diversity. Significant development in the design of dual-polarization magneto-electric dipole antennas has been observed. However, it is still difficult to achieve wide impedance bandwidth, high isolation, and low cross polarization simultaneously. Several forms of broadband base station antenna have been proposed to solve these problems [1]-[6]. Most of them chose to broaden their bandwidth by using the Γ shaped feeding line and stair-shaped feeding line. But all these techniques weaken the advantages of the magneto-electric dipole antennas: they become thick, complicated, and expensive. Two dual-polarized base station antennas proposed in [7, 8] can satisfy the application of wireless communication system. But for enhancing the gains of the antennas, the dimensions of the reflectors are enlarged.

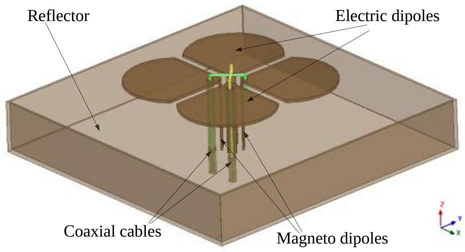

Fig. 1. Perspective view of the dual-polarized antenna.

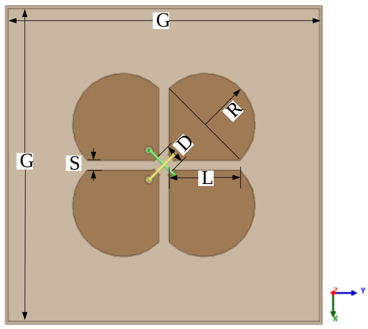

Fig. 2. Top view of the dual-polarized antenna.

The ±45 °dual-polarization magneto-electric dipole antenna proposed in this paper has good performances on the 2G/3G/LTE bands which ranges from 1.68 to 2.71GHz, and reaches normal industrial standards. What is more, the new form has a simple and compact structure and is easy to be manufactured in large scale.

II. CONFIGURATION OF ANTENNA

As shown in Fig. 1, the configuration of the proposed magneto-electric dipole antenna consists of two pairs of horizontal electric dipoles and two pairs of vertical rectangle magneto dipoles, and a square metal reflector. Fig. 2 and Fig.3

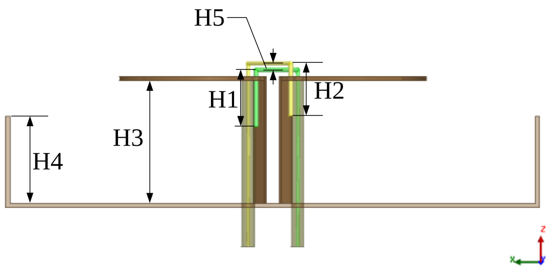

Fig. 3. Side view of the dual-polarized antenna.

show the top view and side view of the proposed antenna respectively.

A. *Magneto- electric (ME) Dipoles*

As shown in the Fig. 2, the horizontal electric dipole is a combination of an isosceles right-angled triangle and a semicircle. Just consider one of the two electric dipole pairs, the other can be viewed as parasitic element. When a dipole antenna has parasitic elements, its impedance bandwidth can be extended [7]. The design of right-angled and very close distance between electric dipoles can strengthen the degree of the coupling.

The vertical magneto dipole plays an important role in proposed antenna design. On the one hand, it is a necessary element of magneto-electric dipole antenna, on the other hand, it forms a conversion of the unbalanced transmission line to the balanced feeding structure, and simultaneously supports the electric dipoles.

B. *Coaxial Cables*

For this design, one of the most important breakthrough is to get rid of the complicated feeding structure of the magneto-electric dipole antennas. The inner cores of the coaxial cables pass through the two pairs of horizontal electric dipoles, and extend down the vertical magneto dipoles for the coupling feed. Simultaneously, the outer conductors of coaxial cables are soldered to the horizontal electric dipoles and fed directly to it. For dual polarizations, two coaxial cables are placed orthogonally, and to avoid mechanical interference, one inner core of the two coaxial cables is modified, the horizontal transmission part is H5 lower than the other. It makes little difference on its radiation pattern. By properly choosing H1 and H2, good impedance matching performances can also be obtained for port 2, which is quite similar to port 1. That is the only difference between the two pairs, thus we can easily infer that the two ports have highly symmetric performances.

C. *Reflector*

The reflector has very significant effects on the radiation characteristics of the antenna. To get a directional radiation, a metal reflector is necessary. The rectangular box-shaped reflector with dimensions of 122mm × 122mm × 28 mm is used to achieve relatively stable gain and better radiation performance over the passband.

TABLE I. DIMENSIONS FOR THE PROPOSED DUAL-POLARIZED ANTENNA.

parameters	H5	H1	H2	H3	H4
Value (mm)	1.5	13	12	28.2	20
parameters	S	D	L	G	R
Value (mm)	3.9	9	27.5	122	19.4

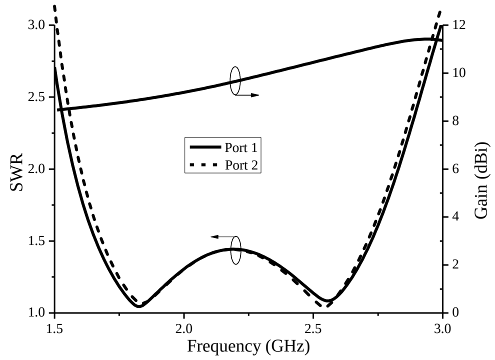

Fig. 4. Simulated SWRs and gains of the dual-polarized antenna.

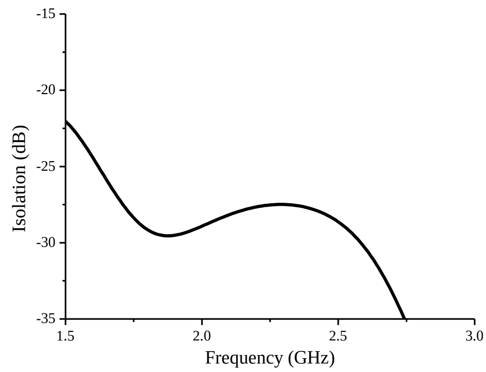

Fig. 5. Simulated isolation of the dual-polarized antenna.

By using High Frequency Structure Simulator (HFSS) software, the dimensions of the configurations are simulated and optimized, and the final optimal dimension values are listed in Table I.

III. THE RESULTS OF SIMULATION

Figure 4 depicts simulated SWRs and gains of the proposed dual-polarized antenna. It can be clearly seen that the common bandwidth of the two ports is 46.9% ranging from 1.68 to 2.71 GHz. Due to the symmetric structure, the gains of port 1 and port 2 are almost overlap. Over the operating frequency range, the simulated gains for the antenna is 10 ±1.5 dBi. Hence, the gains are relatively stable and high enough for 2G/3G/LTE base-station communications. Fig. 5 shows the isolation between the two ports. The simulated isolation between the two ports is better than 28 dB over the entire operating frequency band.

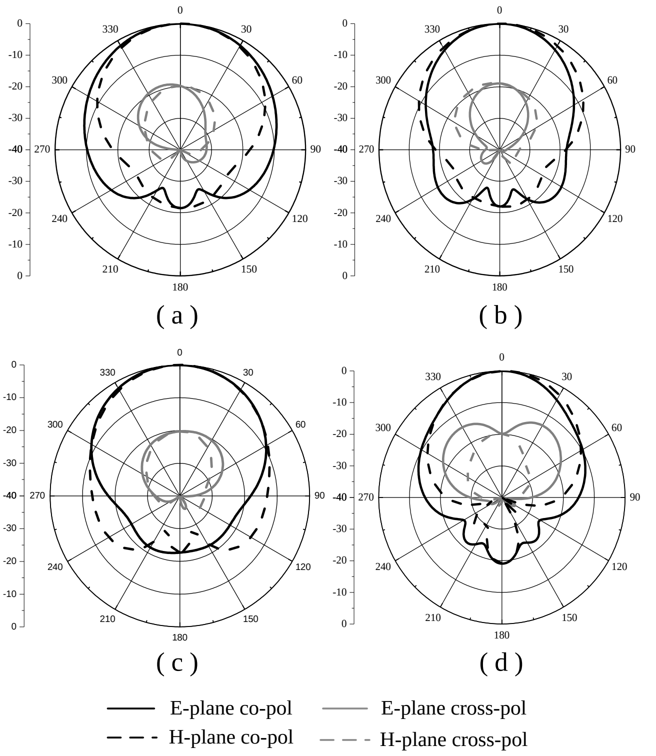

Fig. 6. Simulated radiation patterns of the dual-polarized antenna at frequencies of 1.7GHz (a), 2.0GHz (b), 2.2HGz (c) and 2.7 GHz (d).

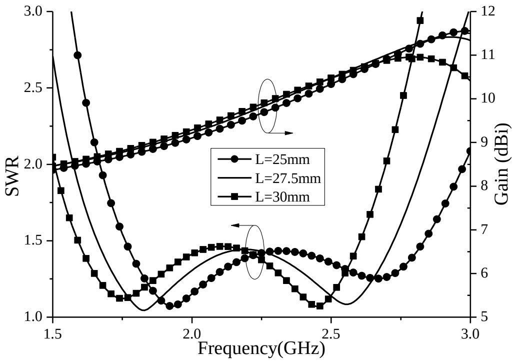

Fig. 7. Effect of L on SWR and gain.

The simulated radiation patterns of the proposed dual-polarized ME dipole antenna at frequencies of 1.7, 2.0, 2.2 and 2.7 GHz are plotted in Fig. 6, which show that the antenna has a nearly symmetric and good unidirectional radiation pattern across the entire bandwidth.

IV. Parametric Study

For a better understanding of how the dimensions of the antenna affect its performances, some parameters of the ME dipoles and the rectangular box-shaped reflector are studied by simulation. For simplicity, only port 1 is excited, because of the symmetry of the antenna. When one parameter is studied, the others are kept constant. The results provide a useful guideline for practical design.

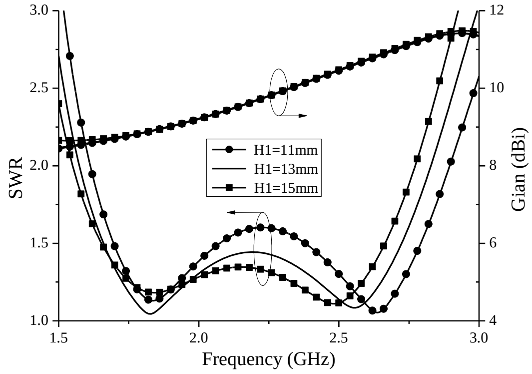

Fig. 8. Effect of H1 on SWR and gain.

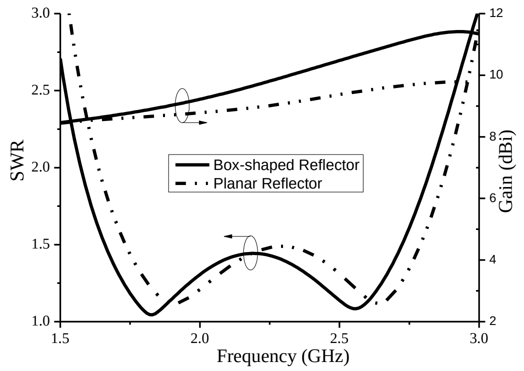

Fig. 9. Effects of reflectors on SWR and gain.

A. *Effects of the ME dipoles*

The first and the most important parameter was the length L of the horizontal portion of the planar dipole. It can be observed from Fig. 7 that the SWR is highly sensitive to the value of L. If L is increased so that the electric dipole is enlarged, the resonances are shifted to a lower frequency. However, the effect of L on the antenna gain is not significant. It can be concluded that the resonance is mainly affected by the electric dipole, and when the length of the electric dipole becomes longer, the resonant frequency obviously should move to a lower frequency according to the antenna theory. To achieve a good impedance matching, L=27.5mm was selected.

B. *Effects of the Coaxial Cables*

The second parameter studied was the length of coaxial cables, because of the symmetry of the antenna only the coaxial cable of port 1 has been simulated. Fig. 8 shows the simulated results of the SWR and gain versus H1. With the increase of the H1, the second resonant frequency of the antenna moves to a low frequency. However, the effect of H1 on antenna gain is almost negligible. For the proposed prototype, H1=13mm was chosen to achieve wide impedance bandwidth.

C. *Effects of the Reflector*

To achieve stable radiation patterns, a rectangular box-shaped reflector is necessary for a unidirectional antenna. To

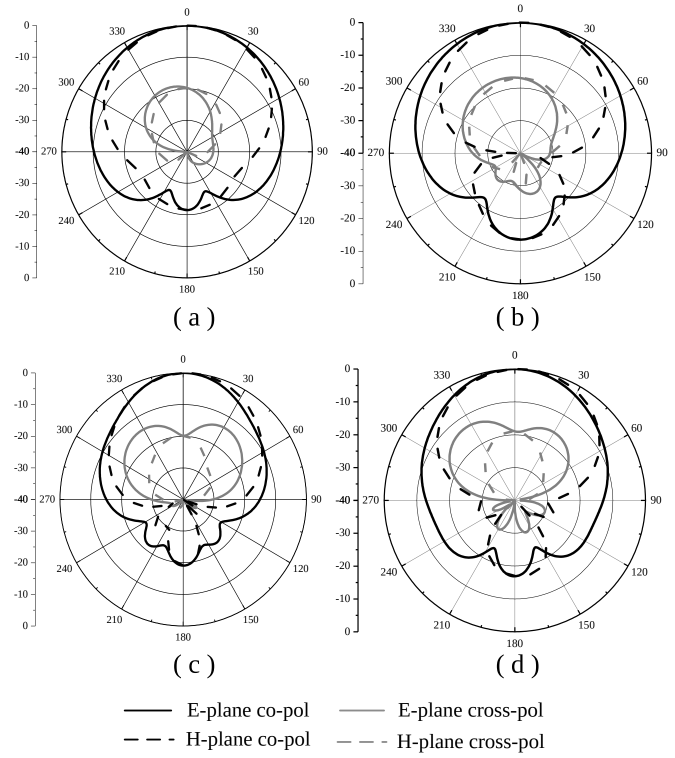

Fig. 10. Simulated radiation patterns of the dual-polarized antenna. (a) With rectangular box shaped reflector at 1.7 GHz. (b) With planar reflector at 1.7 GHz. (c) With rectangular box shaped reflector at 2.7 GHz. (d) With planar reflector at 2.7 GHz.

understand the usefulness of such a reflector, the antenna with a rectangular box-shaped reflector and a planar reflector was analyzed. As shown in Fig. 9, with a rectangular box-shaped reflector, the SWR is more stable, and the gain is much higher than the other. Fig. 10 depicts the simulated radiation patterns when port 1 is excited at 1.7 and 2.7 GHz for the dual-polarized antenna with and without metallic wall. The metallic wall suppresses both 3-dB beamwidth and back radiation. In short, the rectangular box-shaped reflector is conducive to improving the antenna performances.

V. Conclusion

A dual-polarized magneto-electric dipole antenna with coaxial cables feeding proposed for base station application is designed. According to the simulation results, the proposed antenna achieves a wide bandwidth within the 1.68-2.71GHz frequency range which can cover the DCS/PCS/3G/4G bands.

Acknodgment

This work is supported by the Notional Natural Science Foundation of China under Grant 61172020.

References

[1] B. Q. Wu, and K. M. Luk. "A Broadband Dual-Polarized Magneto-Electric Dipole Antenna With Simple Feeds," IEEE Antennas & Wireless Propagation Letters, vol. 8, no. 4, pp. 60-63, 2009.

[2] S. G. Zhou, Z. H. Peng, G. L. Huang, et al. "Design of a Novel Wideband and Dual-Polarized MagnetoElectric Dipole Antenna," IEEE Transactions on Antennas & Propagation, vol. 65, no. 5, pp. 2645-2649, 2017.

[3] L. Ge, and K. M. Luk. "A Wideband Magneto-Electric Dipole Antenna," IEEE Transactions on Antennas & Propagation, vol. 60, no.11, pp. 4987-4991, 2012.

[4] Q. Xue, S. W. Liao, and J. H. Xu. "A Differentially-Driven Dual-Polarized Magneto-Electric Dipole Antenna," IEEE Transactions on Antennas & Propagation, vol. 61, no. 1, pp.425-430, 2013.

[5] L. Siu, W. Hang, and K. M. Luk. "A Dual-Polarized Magneto-Electric Dipole With Dielectric Loading," IEEE Transactions on Antennas & Propagation, vol. 57, no.3, pp. 616-623, 2009.

[6] L. Ge, and K. M. Luk. "A Magneto-Electric Dipole Antenna With Low-Profile and Simple Structure," IEEE Antennas & Wireless Propagation Letters, vol. 12, no. 1921, pp.140-142, 2013.

[7] Z. D. Bao, Z. P. Nie, and X. Zong. "A Novel Broadband Dual-Polarization Antenna Utilizing Strong Mutual Coupling," IEEE Transactions on Antennas & Propagation, vol. 62, no.1, pp. 450-454. 2014.

[8] Z. D. Bao, Z. P. Nie, and X. Zong. "A broadband dual-polarization antenna element for wireless communication base station," IEEE Asia-Pacific Conference on Antennas and Propagation, August 27-29, 2012, Singapore.