A Method for Bandwidth Enhancement of Cross-Dipole Antennas with Compact Configurations

Hai-Han Sun[1], Can Ding[2], He Zhu[2], and Y. Jay Guo[2]
[1]Nanyang Technological University, Singapore
[2]University of Technology Sydney, Australia
haihan.sun@ntu.edu.sg

***Abstract*— In this paper, a new method to broaden the bandwidth of dual-polarized cross-dipole antennas is presented. By connecting a thin loop to a traditional cross-dipole, additional resonant points are introduced and the bandwidth is broadened. This method does not increase the physical dimension of the antenna and has little influence on radiation performances. A loop-connected cross-dipole antenna is presented to verify the method. The bandwidth it achieves is 66.7% from 1.65 GHz to 3.30 GHz with a very compact radiator size. The antenna also has a high port isolation level and stable radiation performances, making it highly suitable for the base station application.**

Keywords*— *bandwidth enhancement; compact configuration; cross-dipole antenna; dual-polarized antenna

I. Introduction

Dual-polarized antennas have been widely used in base stations to combat multipath fading effect and improve system capacity [1]. For these antennas, wide bandwidth, good impedance matching, high isolation, and consistent radiation patterns are basic requirements. In addition, compact and simple configurations are demanded by the industry to enhance antenna's robustness, reduce fabrication complexity, and reduce mutual coupling in antenna arrays.

The cross-dipole antenna has been a very popular choice in the cellular base station industry to achieve dual-polarized radiation. The configuration is constructed as a pair of sub-dipoles oriented perpendicular to each other and backed by a reflector. Primitive cross-dipoles have the two sub-dipoles isolated from each other [2]. The bandwidths they achieve are less than 25%. To enhance the bandwidth, tightly-coupled cross-dipoles have been investigated [3], [4]. Strong mutual coupling between sub-dipoles is introduced by closely spacing the elements, and it helps broaden the bandwidth to more than 45%. The bandwidth can be further broaden to more than 60% by introducing parasitic elements such as strips and disks [5], [6], but at the expense of the radiator sizes.

In this work, a new method to broaden the bandwidth of cross-dipole antennas with a compact size is presented. By connecting an additional loop to the cross-dipole radiator in a proper way, the introduced loop becomes a part of the radiator and introduces more resonances for matching. The method is applied to a tightly-coupled cross-dipole antenna as an example. The realized antenna has a wide bandwidth of 66.7% with a compact size of $0.43 \times 0.43 \times 0.28\ \lambda_0^3$, where λ_0 is the wavelength at the middle operating frequency.

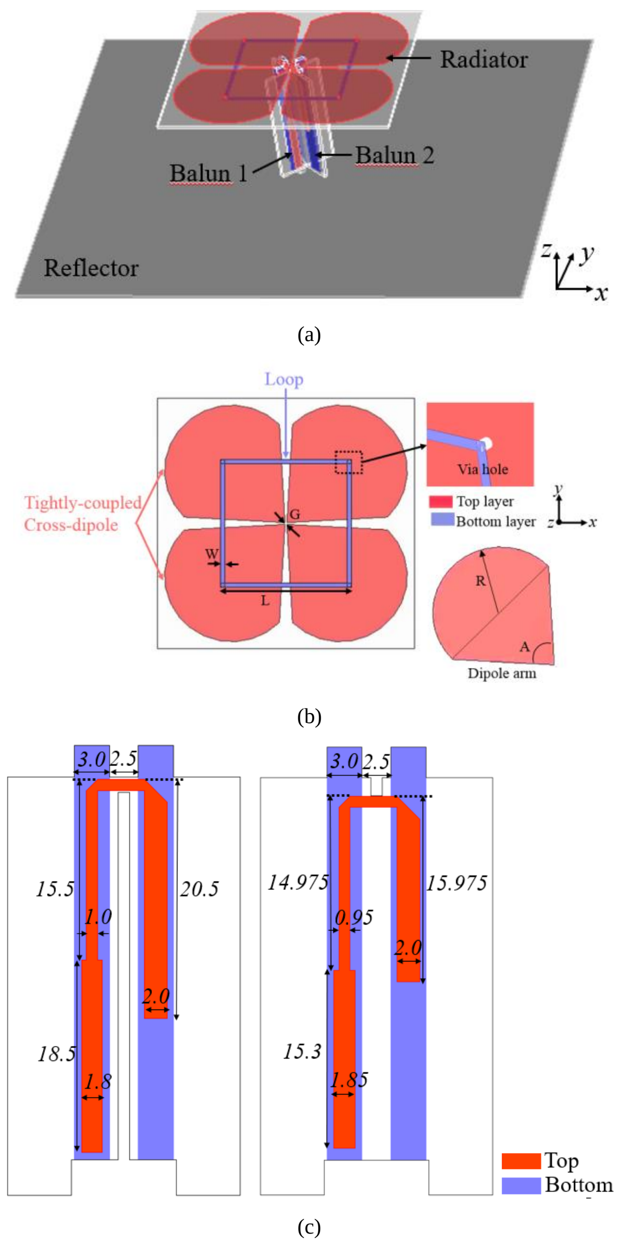

Fig. 1. (a) Perspective view of the loop-connected cross-dipole antenna. (b) Configuration of the radiator. (R = 14.4 mm, A = 83.6°, L= 28 mm, W= 0.8 mm, and G = 0.56 mm). (c) Configurations of the two baluns.

II. Configuration and Porformance of the Loop-Connected Cross-Dipole Antenna

Fig. 1 (a) shows the perspective view of the proposed antenna. The antenna consists of a loop-connected tightly-coupled cross-dipole radiator, two baluns for impedance matching and balanced feeding, and a reflector for directional radiation. A more detailed view of the radiator is shown in Fig. 1(b). The tightly-coupled cross-dipole and loop are printed on the different sides of a substrate and are connected using via holes at the four corners of the loop. By exciting the two dipoles, +45˚ or -45˚-polarized radiation can be obtained. The radiator is fed by baluns shown in Fig. 1 (c), which are designed following the guidelines in [7]. The radiator is mounted above a flat reflector with a distance of 34 mm. The substrate used in this case has a dielectric constant of 3.48 and a thickness of 0.76 mm.

The antenna is fabricated and tested. The S-parameters of the antenna are shown in Fig. 2. Both the simulated and measured results demonstrate that the antenna has a bandwidth of 66.7% from 1.65 GHz to 3.30 GHz with reflection coefficients less than -15 dB. The port isolation is more than 28 dB. The horizontal radiation patterns (in *xz*-plane) are shown in Fig. 3. The patterns are symmetrical and stable across the wide band, and the measured cross-polarization discrimination is more than 17 dB at boresight. The simulated and measured half-power beamwidth (HPBW) and the realized gain results are shown in Fig. 4. The antenna has HPBWs of 76.1˚ ± 8.5˚ and realized gains of 7.9 ± 1.0 dBi across the band. The antenna has a very compact size of $0.43 \times 0.43 \times 0.28\lambda_0^3$.

III. Conclusion

In this work, a new technique is presented to broaden the bandwidth of dual-polarized cross-dipoles with a compact size. The method relies on connecting a loop to dipole arms to introduce additional resonances. A loop-connected tightly-coupled cross-dipole antenna is presented as a demonstration. By joining loops to the dipole arms, the matching capability of radiators is improved. The antenna has a broad bandwidth of 66.7% with a very compact size. The isolation between two polarized ports has a high level above 28 dB. Simulated and measured results show that radiation performances of the antenna are stable across entire operating bands.

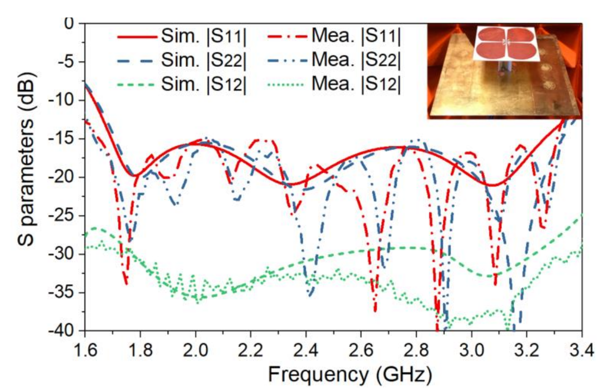

Fig. 2. S-parameters of loop-connected cross-dipole antenna.

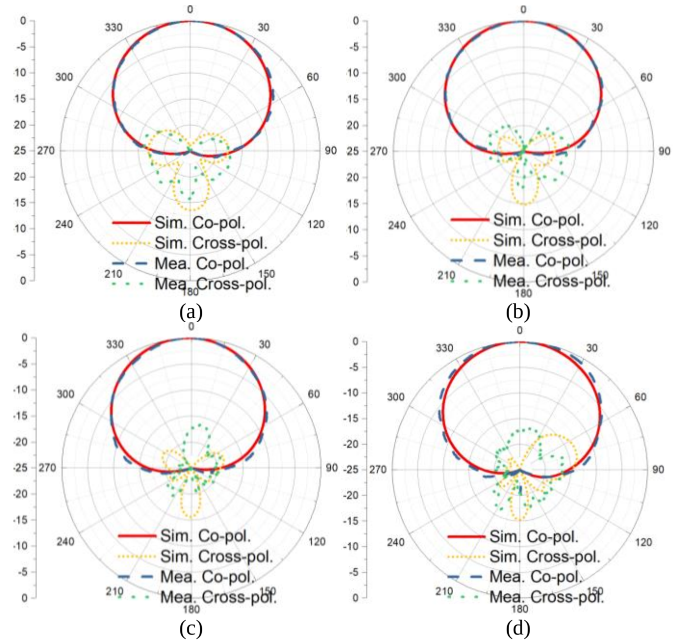

Fig. 3. Radiation patterns of the loop-connected cross-dipole antenna at (a) 1.7 GHz, (b) 2.2 GHz, (c) 2.7 GHz, and (d) 3.2 GHz.

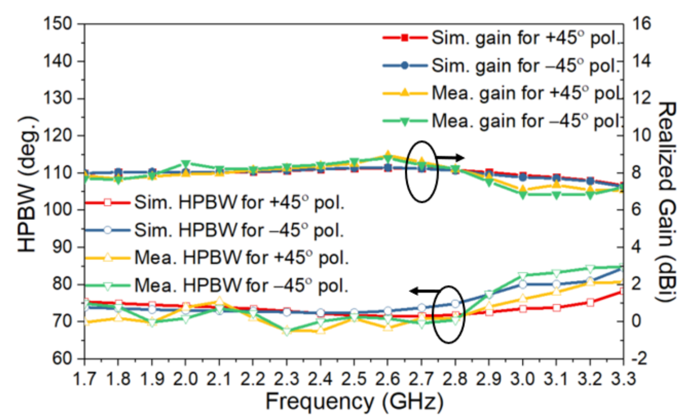

Fig. 4. HPBW and gain of the loop-connected cross-dipole antenna.

References

[1] Z. -N. Chen, and K.-M. Luk, Antennas for base stations in wireless communications, McGraw‐Hill, New York, NY, 2009.

[2] D. Su, D. Fu, T. N. C. Wang, and H. Yang, “Broadband polarization diversity base station antenna for 3G communication system,” *J. of Electromag. Waves and Appl*., vol. 22, no. 4, pp. 493 – 500, 2008.

[3] C. Ding, H. Sun, R. W. Ziolkowski and Y. J. Guo, “Simplified tightly-coupled cross-dipole arrangement for base station applications,” *IEEE Access*, vol. 5, pp. 27491-27503, Nov. 2017.

[4] Y. Cui, R. Li, and H. Fu, “A broadband dual-polarized planar antenna for 2G/3G/LTE base stations,” *IEEE Trans. Antennas Propag.*, vol. 62, no. 9, pp. 4836 - 4840, Sep. 2014.

[5] L. Wu, R. Li, Y. Qin, and Y. Cui, “Bandwidth-Enhanced broadband dual-polarized antennas for 2G/3G/4G and IMT services,” *IEEE Antennas Wirel. Propag. Lett.*, vol. 17, no. 9, pp. 1702 – 1706, Sep. 2018.

[6] Y. Cui, L. Wu, and R. Li, “Bandwidth enhancement of a broadband dual-polarized antenna for 2G/3G/4G and IMT Base Stations,” *IEEE Trans. Antennas Propag.,* vol. 66, no. 12, pp. 7368 – 7373, Dec. 2018.

[7] H. Sun, C. Ding, B. Jones and Y. J. Guo, “A wideband base station antenna element with stable radiation pattern and reduced beam squint,” *IEEE Access*, vol. 5, pp. 23022–23031, Oct. 2017.