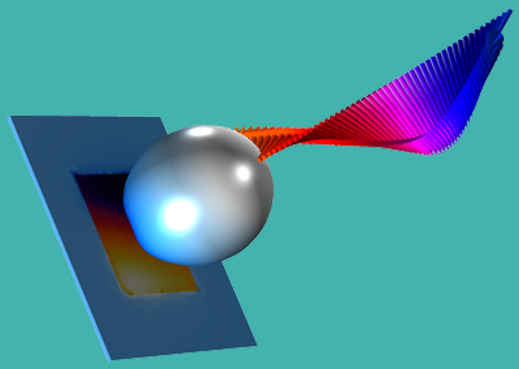

Source: COMSOL

Characteristic Modes Special Interest Group

Newsletter, Volume 2, Number 3, Sep 1, 2022

In This Issue:

Scholar Spotlight:

Jianping Zeng (Graduate Student Member, IEEE) was born in Ruijin, Jiangxi, China. He received the B.S. degree in Applied Physics from Jiangxi Normal University, in 2018. He is currently pursuing the Ph.D. degree with Fudan University, Shanghai, China.

His current research interests include antennas, characteristic mode theory, and artificial bandgap materials.

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Featured Article

"Single-Fed Triple-Mode Wideband Circularly Polarized Microstrip Antennas Using Characteristic Mode Analysis", *by Jianping Zeng et al.*

Circularly polarized (CP) antennas are widely used in wireless communication for reducing multipath interference, polarization mismatch, and the Faraday rotation effect. Microstrip patch antennas are popular candidates for realizing CP antennas owing to their low-profile and easy-integration characteristics. However, the design of a single-fed wideband CP microstrip antenna is challenging due to their inherent high-quality factor (Q) modes.

Single-fed antennas are preferred compared with complicated multi-fed CP networks. The CP bandwidth can be enhanced by using a thick and low-permittivity substrate. In this way, only one CP mode limits the further bandwidth enhancement. For wider CP bandwidth, stacked and coplanar parasitic elements are effective but suffer from large volume.

This article proposes a triple-mode concept for bandwidth enhancement of single-fed CP antennas. As shown in Fig. 1, three modes are designed. For mode pairs (1 and 2) and (2 and 3), orthogonal polarizations, equal amplitudes, and quadrature phase differences are desired. The middle mode 2 is shared by modes 1 and 3. As a result, two CP modes are formed and the CP bandwidth is significantly enhanced. Guided by this concept, a U-slot and an E-shaped CP antenna are proposed and designed with characteristic mode analysis.

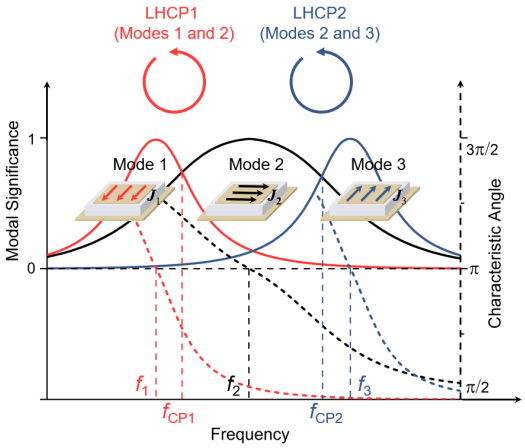

Figure 1: Triple-mode concept for wideband circular polarization.

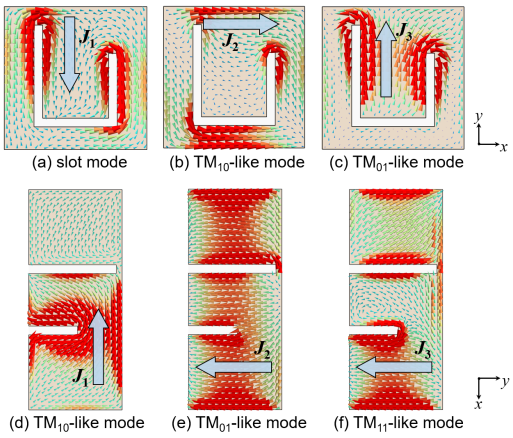

Figure 2: (a)–(c) modal currents $\mathbf{J}_1$–$\mathbf{J}_3$ of the U-slot structure. (d)–(f) modal currents $\mathbf{J}_1$–$\mathbf{J}_3$ of the E-shaped structure.

Fig. 2(a)–(c) shows the modal currents $\mathbf{J}_1$–$\mathbf{J}_3$ of the U-slot structure. In fact, modes 1–3 of the U-slot patch structure correspond to the slot mode, the TM_{10}-like mode, and the TM_{01}-like mode, respectively. At the two frequencies, the characteristic angle differences of adjacent modes are close to 90 degrees, and the modal significances of adjacent modes are similar. $\mathbf{J}_1$ and $\mathbf{J}_3$ are mainly vertically directed, and $\mathbf{J}_2$ is mainly horizontally directed. Mode 2 is shared by modes 1 and 3. Two CP modes are formed by modal current pairs $(\mathbf{J}_1+\mathbf{J}_2)$ and $(\mathbf{J}_2+\mathbf{J}_3)$.

Fig. 2(d)–(f) shows the modal currents $\mathbf{J}_1$–$\mathbf{J}_3$ of the E-shaped structure. The principle of wideband CP is similar to that of the U-slot structure. Differently, modes 1–3 of the E-shaped patch structure correspond to the TM_{10}-like mode, the TM_{01}-like mode, and TM_{11}-like mode, respectively. Moreover, mode 1 is shared by modes 2 and 3.

Experimental results show that the CP bandwidths are 21.1% (U-slot antenna) and 25.4% (E-shaped antenna), respectively. Both CP antennas have the advantages of compact size, wide bandwidth, and simple structure. For details, please refer to: J. Zeng, X. Liang, L. He, F. Guan, F. H. Lin and J. Zi, "Single-Fed Triple-Mode Wideband Circularly Polarized Microstrip Antennas Using Characteristic Mode Analysis," *IEEE Transactions on Antennas and Propagation*, vol. 70, no. 2, pp. 846–855, Feb. 2022, doi: 10.1109/TAP.2021.3111280.

News and Events

1. Some of our SIG members took the initiative to organize a Special Section on Advances in Antenna Design for Metaverse and Other Modern Smart Mobile Devices in *IEEE Open Journal on Antennas and Propagation* (OJAP). The submission deadline is 31st Oct 2022. The Guest Editorial team consists of Chi-Yuk CHIU, Zhinong YING, Yue LI and Jiang ZHU.
2. CM-SIG is successful with the proposal of the EuCAP 2023 convened session on "Characteristic Mode Analysis for Next Generation Systems and Technologies", with Dave Bekers (TNO, Netherlands) and Mahrukh Khan (The College of New Jersey, USA) being the conveners.
3. A webpage is added on our CM SIG website on awarded grants, to demonstrate CM's versatility for solving challenging research problems. Click here for details.

New Member Introduction

Bio: Jiang Xiong (Member, IEEE) received the Ph.D. degree from the Zhejiang University in China in 2010. He is now an associate professor at the Computational Electromagnetics Laboratory, University of Electronic Science and Technology of China (UESTC). His current research interests include artificial electromagnetic structures, electromagnetic metamaterials/metasurfaces, novel antennas for wireless communications, etc. **View on CMA:** As a traditional and significant constituent in the theory of electromagnetics, the CM concept and the CMA method have been playing an increasing important role in modern electromagnetic radiation and scattering applications. Recently, in UESTC, we have particularly added an introductive content for the CMA to the mandatory course "Advanced Electromagnetics Theory" for graduate students majoring in electromagnetic fields and microwave technology, radio physics, physical electronics, etc., where the basic concepts, critical techniques, and typical applications are displayed. We hope students can, with a clearer insight of the CMA based mechanism, come up with useful and high-performance microwave components and antennas in their future career in a more efficient manner, instead of merely relying on the prevalent cut-and-try process.

Summary of CMA Research: *We have recently studied a feeding algorithm for the optimized current for three canonical optimization problems in electrically small antennas (ESAs): minimum Q, maximum G/Q, and maximum G, where the characteristic modes from several types of generalized eigenvalue problem are utilized. A multi-feed solution has been proposed. Although the realization is still difficult currently, our effort is indeed a step forward towards practical implementation.*

Survey

We look forward to hearing your feedback and inputs on the CM Newsletter. Please take the time to complete the survey here: Take me to the survey.

Resources

Open Source Tools for CMA:

- FEKO-student edition
- CM MATLAB Software
- AToM Antenna Toolbox

Webinars:

- Our webinars on YouTube
- Our webinars on Bilibili
- Webinars from FEKO

Benchmarking Activity:

- Benchmarking in 2018

Available Courses:

- Courses offered by ESoA

Past Special Issues on CMA:

- July 2016 issue of IEEE Trans. Antennas Propag.
- April 2022 issue of IEEE Antennas Propag. Mag.

Past Issues of CM-SIG Newsletter:

- CM-SIG Newsletter

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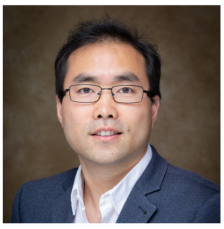

About CM-SIG: Characteristic Modes-Special Interest Group was initiated at the Special Session on CMs during the 2014, IEEE International Symposium on Antennas and Propagation in Memphis, TN, on 10 July 2014. CM-SIG was formed as a platform to promote technical activities in the field of CMs. For more information, please visit our website: http://www.characteristicmodes.org/.