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Characteristic Modes Special Interest Group

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In This Issue:

Scholar Spotlight:

Xiongying Liu (S'02–M'06) received the B.S. degree in instrument science and technology from the Changchun College of Geology, Changchun, China, in 1996 and the M.S. degree in physical electronics and the Ph.D. degree in circuits and systems both from the South China University of Technology, Guangzhou, China, in 2001 and 2004, respectively. He is currently a full professor and a Ph.D. advisor with the School of Electronics and Information Engineering, South China University of Technology.

He has authored or co-authored about 90 technical papers in refereed journals and conference proceedings. He holds 31 granted and filed Chinese patents. His current research interests include nonlinear dynamics, wearable and implantable antennas for body-centric communications, and RFID technology.

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Featured Article

"Design of Broadband Circularly Polarized All-Textile Antenna and Its Conformal Array for Wearable Devices", *by Xiongying Liu et al.*

Wearable antennas working in the 5 GHz (5.15–5.825 GHz) band have gradually caught scientists' interest since the 5 GHz band has a promising characteristic that the bandwidth is as broad as 1 GHz, enabling high data rates in the order of 10 Gb/s. Hence, they are highly favored for wireless body area network (WBAN) systems. To facilitate such WBAN systems, wearable antennas face more challenges than conventional antennas.

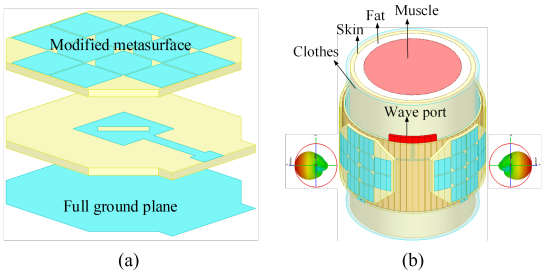

Figure 1: Configurations of (a) the proposed BCP and (b) WCAA.

Since wearable antennas operate in the vicinity of the lossy human body, the loading effect of lossy tissue has to be considered in the antenna design process. Also, to conform to the curve-shaped human body, flexible and lightweight materials such as textile, polyimide, and polydimethylsiloxane are always adopted in the design of wearable antennas. Moreover, the circularly polarized (CP) antenna is used because it radiates EM fields whose orientations rotate circularly when observed as a function of time. This allows off-body communications via CP antennas to be independent of the antenna orientations with the advantages of low polarization loss and signal attenuation.

Based on characteristic mode analysis (CMA), a broadband circularly polarized (BCP) all-textile antenna and its wearable conformal antenna array (WCAA) are investigated for body-centric communications. As demonstrated in Fig. 1(a), the proposed antenna consists of a circularly polarized (CP) microstrip patch antenna loaded with a piece of metasurface. The modal significance (MS) of the first four CMs (CM 1–CM 4) is shown in Fig. 2(a). It can be found that four modes resonate at different frequencies within the frequency band of interest. Wherein, CM 1–CM 3 are the desired mode to achieve broadband performance, and CM 4 can be ignored.

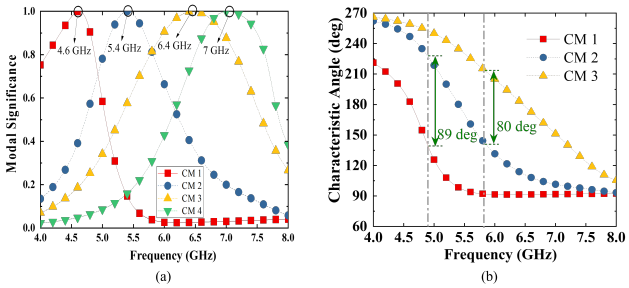

Figure 2: Modal characteristic of CM 1–CM 4. (a) MS. (b) Characteristic angle.

According to the CMA for CP antennas, the MS values of the two modes should be close to each other and relatively large, and the difference in characteristic angle is nearly 90 degrees. As observed in Fig. 2(a), CM 1 and CM 2 are dominant at 4.9 GHz. While CM 3 can be ignored at 4.9 GHz due to the low MS values. Similarly, CM 2 and CM 3 are dominant at 5.8 GHz and CM 1 can be neglected at 5.8 GHz. Moreover, according to the characteristic angle in Fig. 2(b), the CP radiation requirements can be met. Around 4.9 GHz, the magnitudes of CM 1 and CM 2 are almost the same ($MS_1 = MS_2 = 0.7$) and they have an 89-degree phase difference. Similarly, in the proximity of 5.8 GHz, the magnitudes of CM 2 and CM 3 are almost equal ($MS_1 = MS_2 = 0.81$) and they have an 80-degree phase difference on average.

Based on the proposed BCP antenna, a wearable conformal antenna array, as shown in Fig. 1(b), is developed to realize a circular array that can be worn on the human arm, while producing CP omnidirectional radiation pattern in the azimuthal plane for on- and off-body communications.

News and Events

1. The IEEE Antennas and Propagation Magazine's Special Issue on "Characteristic Modes: Into the Mainstream and the Path Beyond" published in Apr 2022 is attracting considerable attention among readers, with most of the special issue articles clocking well over 1000 full-text views. Don't miss the opportunity to read these survey articles if you haven't had the chance to do so!
2. Our Special Interest Group has reached another member milestone - with 100 member institutions from across the globe!
3. Call for papers for two special sessions on Theory and Applications of Characteristic Modes, organized by Dr. Henrik Wallén and Dr. Pasi Ylä-Oijala at Aalto University, Finland:
   - **Special Session 19:** Theory and Applications of Characteristic Modes at the URSI International Symposium on Electromagnetic Theory (EMTS 2023) in Vancouver, Canada 22–26 May 2023. Submission deadline is 15th December 2022. More details at: https://www.emts2023.org/
   - **Session B21:** Theory and Applications of Characteristic Modes at the XXXVth URSI General Assembly and Scientific Symposium (URSI GASS 2023) in Sapporo, Japan 19–26 August 2023. Submission deadline is 25th January 2023. More details at: https://www.ursi-gass2023.jp/.

New Member Introduction

Bio: Daniel Segovia Vargas (full professor at Carlos III University in Madrid and Senior Member IEEE) received the telecommunications Engineering degree from ETSIT, UPM, in 1993, the Ph.D. degree (cumlaude and awarded by COIT-Ericsson) in telecommunications engineering from ETSIT-UPM, Madrid, in 1998, with a distinction by unanimity. He has also been awarded a Doctor Honoris Causa degree from Universidad Católica San Pablo, Arequipa in Peru. His research interests include miniaturized and array and BTS antennas, metamaterial/metasurface antennas, characteristic mode analysis, implantable antennas, and THz technologies.

View on CMA: Unlike traditional approaches for antenna designs, generally based on final trial and error optimizations, the CMA provides clear physical insights into the antenna operating mechanism. This, consequently, leads to a short and fast optimization of the structure with a systematic design procedure. Specifically, when complex structures are used, CMA can reduce the problem and make it simpler. Motivated by such a fascinating tool, a few years ago, we started using it for the design and analysis of different kinds of antennas. Despite CMA has been extensively investigated, there is still much more to explore.

Summary of CMA Research: *We recently made some contributions to the design of a circularly polarized metasurface antenna with only one layer that contains both the feeding line as well as the radiating metasurface. We also applied CMA for the design process of broadband and compact dielectric resonator antennas for base station MIMO applications. Metamaterial antennas are analyzed through this tool as well.*

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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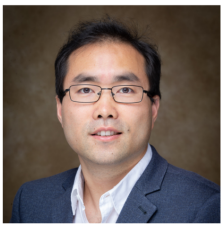

About CM-SIG: Characteristic Modes-Special Interest Group was initiated at the Special Session on CMs during the 2014, IEEE International Symposium on Antennas and Propagation in Memphis, TN, on 10 July 2014. CM-SIG was formed as a platform to promote technical activities in the field of CMs. For more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