LI Ronglin, ZHANG Yueping, MA Jianguo

Editorial: Special Topic on Antennas and RF Technologies for 5G/B5G Mobile Communications

Guest Editor

LI Ronglin received the B. S. degree in electrical engineering from Xi'an Jiaotong University, China in 1983, and the M. S. and Ph. D. degrees in electrical engineering from Chongqing University, China in 1990 and 1994, respectively. From 1983 to 1987, he worked as an assistant electrical engineer at Yunnan Electric Power Research Institute, China. From 1994 to 1996, he was a postdoctoral research fellow with Zhejiang University, China. In 1997, he visited Hosei University, Japan, as an HIF (Hosei International Fund) Research Fellow. In 1998, he became a professor with Zhejiang University. In 1999, he visited the University of Utah, USA, as a research associate. In 2000, he worked as a research fellow at the Queen's University of Belfast, UK. Since 2001, he has been a research scientist with Georgia Institute of Technology, USA. He is now an Endowed Professor with the South China University of Technology, China. Dr. LI has published more than 200 papers in refereed journals and conference proceedings, and authored three book chapters. His current research interests include new design techniques for antennas in mobile and satellite communication systems, phased arrays and smart antennas for radar applications, wireless sensors and RFID technology, electromagnetics, and information theory.

Guest Editor

ZHANG Yueping is a full professor with the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, a distinguished lecturer of the IEEE Antennas and Propagation Society (IEEE AP-S), a member of the IEEE AP-S Paper Award Committee, and a Fellow of IEEE. Dr. ZHANG has published numerous papers, including two invited and one regular papers in the *Proceedings of the IEEE* and one invited paper in the *IEEE Transactions on Antennas and Propagation*. He is the first and only Chinese radio scientist who has managed to publish an article on radio history in the English learned journal, *IEEE Antennas and Propagation Magazine*. He received the prestigious 2012 IEEE AP-S Schelkunoff Prize Paper Award. Prof. ZHANG holds seven US patents. He has made pioneering and significant contributions to the development of Antenna-in-Package (AiP) technology for which he received the 2020 IEEE AP-S Kraus Antenna Award. His current research interests include the development of Antenna-on-Chip (AoC) technology for Very Large Scale Antenna Integration (VLSAI) and characterization of chip-scale propagation channels at terahertz for Wireless Chip Area Network (WCAN).

Guest Editor

MA Jianguo received the B. S. degree from Lanzhou University, China in 1982, and the Ph. D. degree in engineering from the University of Duisburg-Essen, Germany in 1996. He was with the Technical University of Nova Scotia, Canada, as a post-doctor fellow from 1996 to 1997. From 1997 to 2005, he was with Nanyang Technological University (NTU), Singapore, as a faculty member, where he was also the Founding Director of the Center for Integrated Circuits and Systems, NTU. From 2006 to 2009, he was with the University of Electronic Science and Technology of China. From 2009 to 2016, he was the dean of the School of Electronic Information Engineering, Tianjin University, China. Now he is with Guangdong University of Technology, China. His current research interests include microwave electronics, RFIC applications for wireless networks, RF device characterization and modeling, and Terahertz microelectronic systems. As a co-inventor, he holds 44 granted international patents from UK and USA and more than 50 granted invention patents from China. Dr. MA is the vice chair for Standard Committee of IEEE CRFID and a member of the IEEE MTT-S Publication Committee. He was a member of the Editorial Board of the *Proceedings of the IEEE* in 2013 – 2018 and a member of the IEEE University Program Ad Hoc Committee from 2010 to 2013. He served as an associate editor for *IEEE Microwave and Wireless Components Letters* in 2003 – 2005 and has been an associate editor for *IEEE Microwave Magazine* since 2018. Dr. MA is the Editor-in-Chief for *IEEE Transactions on Microwave Theory and Techniques*. He is a Fellow of IEEE.

The 5G mobile communication systems are being deployed worldwide and China has been a global leader in the new technology. The number of base stations for 5G mobile communications is increasing by more than ten thousand every week in China. By the end of this year, about 500 000 base stations will be built up nationwide, covering more than 300 cities. The beyond 5G (B5G) mobile systems with enhanced transmission technologies are also being developed and attracting much attention. The emerging millimeter wave (mmW) and massive multiple-input multiple-output (MIMO) technologies are expected to become key enabling technologies for 5G/B5G mobile communications. In China, the mmW bands 24.75 – 27.5 GHz and 37 – 42.5 GHz have been allocated for future 5G/B5G trials and it is anticipated that the 5G/B5G mobile communication systems based on mmW massive MIMO technologies will be ready for commercial use in 2022. As the key components in these communication systems, antennas and RF front ends play an important role in implementing ubiquitous connection among hundreds of different devices in 5G/B5G networks.

DOI: 10.12142/ZTECOM.202003001

Citation (IEEE Format): R. L. Li, Y. P. Zhang, and J. G. Ma, "Editorial: special topic on antennas and RF technologies for 5G/B5G mobile communications," *ZTE Communications*, vol. 18, no. 3, pp. 01 – 02, Sept. 2020. doi: 10.12142/ZTECOM.202003001.

In this special issue, we have collected seven papers concerning antennas and RF technologies for 5G/B5G mobile communications. Beamforming and multibeam are crucial technologies for mmW massive MIMO based 5G/B5G applications. Leaky-wave antennas (LWAs) are very suitable for beamforming in mmW bands. The paper "Leaky-Wave Antennas for 5G/B5G Mobile Communication Systems: A Survey" by HE et al. presents an overview of LWAs for 5G/B5G mobile communication systems. Classification and design methods of LWAs are introduced. The latest research progress of LWAs for 5G/B5G mobile communication systems is demonstrated. Challenges and future research directions of LWAs are discussed. Low loss, simple structure and broadband for beamforming LWAs are also essential for 5G/B5G mobile communication systems. Multibeam base station antennas are required to meet the increasing demands for higher data rates in 5G/B5G networks. In the paper "Multibeam Antenna Based on Butler Matrix for 3G/LTE/5G/B5G Base Station Applications", YE et al. propose a compact dual-band dual-polarized two-beam antenna array and a wideband dual-polarized two-beam antenna array for base-station applications. The dual-band dual-polarized two-beam antenna array is formed by two interleaved sub-arrays and two individual beamforming networks for different frequency operation. The wideband two-beam antenna array is composed of three 4 × 2 subarrays and two beam-forming networks. The proposed methods can easily be extended to the design of other multibeam base-station antenna arrays. Moreover, the paper "A Novel 28 GHz Phased Array Antenna for 5G Mobile Communications" by LI et al. presents a phased array antenna consisting of 16 × 16 patch elements. The antenna integrated with a wave control circuit can perform real-time beam scanning by reconfiguring the phase of an antenna unit. A prototype of the antenna is fabricated and measured to demonstrate the feasibility of this approach. The phased array has the advantages of low power consumption, low cost, and conformal geometry, suitable for base stations in B5G mmW mobile communication systems.

Antenna-in-package (AiP) technology has been widely adopted in mmW bands. It is believed that AiP technology may provide ultimate antenna solutions to 5G/B5G devices in the lower mmW bands. The paper "Design of Millimeter-Wave Antenna-in-Package (AiP) for 5G NR" by CHANG et al. discusses the design of mmW AiP for 5G spectrum. The system architectures and design considerations for 5G phased arrays are presented. Beamforming IC and up/down converter chips, fabrication technologies and materials, antenna and transition design, and feeding networks and filters design are described. A 4×4 low temperature co-fired ceramic (LTCC) unit AiP module for the 5G band (27.5 – 28.35 GHz) is designed and manufactured. A larger 8×8 array is also demonstrated by tiling up to four-unit modules on one single motherboard. The key design considerations of the beamforming antenna array are low loss, compact system and small size. In the paper "Integrated 3D Fan-out Package of RF Microsystem and Antenna for 5G Communications", XIA et al. investigate a three-dimensional (3D) fan-out packaging method for the integration of 5G communication RF microsystem and antennas. Through the double-sided wiring technology on the glass wafer, the fabrication of 5G antenna arrays is realized. A slot coupling antenna for 5G communications is fabricated on a 12-inch glass wafer. The antenna can operate at 60 GHz with a maximum gain of 6 dBi, which implies a feasible solution to the 3D fan-out integration of RF microsystem and antennas for 5G communications. Such a 3D fan-out integrated prototype is designed and manufactured.

Electronic design automation (EDA) software that can accurately simulate antennas, radio chips and microwave components is essential for 5G technologies. The paper "Electromagnetic Simulation with 3D FEM for Design Automation in 5G Era" by BALEWSKI et al. reviews challenges facing commercial tools for design of wireless devices where electromagnetic effects have to be taken into account. The focus is on simulation software based on finite-element method (FEM). Novel computational techniques based on FEM are introduced into state-of-the-art EDA software to accelerate numerical analysis, as well as to enable optimization, sensitivity analysis and interactive design tuning based on the rigorous electromagnetic model of a device. Several of these new techniques, helping to mitigate the most challenging issues related to FEM based simulation, are highlighted. It is demonstrated that these new computational techniques can significantly reduce the time needed for design closure with the acceleration rates reaching factors as large as tens or even over one hundred.

The paper "Robust Digital Predistortion for LTE/5G Power Amplifiers Utilizing Negative Feedback Iteration" by LIU et al. proposes a robust digital predistortion (DPD) technique utilizing negative feedback iteration for linearizing power amplifiers. Different from the conventional direct learning and indirect learning structure, the proposed DPD suggests a two-step method to identify the predistortion. A negative feedback-based iteration is used to estimate the optimal DPD signal. The corresponding DPD parameters are extracted by forward modeling with the input signal and optimal DPD signal. The iteration can be applied to both single-band and dual-band PAs, which will achieve superior linear performance than conventional direct learning DPD while having a relatively low computational complexity.

We would like to thank all the authors for their valuable contributions and all the reviewers for their timely and constructive comments on the submitted manuscripts. We hope that this special issue is informative and useful for all readers.