Introduction to the IEEE JOURNAL OF MICROWAVES

PETER H. SIEGEL 1,2,3 (Life Fellow, IEEE)
(Special Issue Editorial)

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ABSTRACT The new IEEE JOURNAL OF MICROWAVES serves to be a broad-scope publication serving the whole of the microwave community, both within and beyond the IEEE. This opening article outlines our philosophy and content, presents our editorial team, and introduces our special Inaugural Issue.

Microwaves Everywhere

"CMB: Hiding in Plain Sight"

PETER H. SIEGEL 1,2,3 (Life Fellow, IEEE)
(Special Feature Paper)

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ABSTRACT This article is the first in a continuing series of general interest papers on the applications of microwave technologies and their impact on society. The microwave-based techniques for analyzing and interpreting the sample content of each issue are highlighted, including the use of microwave techniques in remote sensing, medical imaging, and environmental monitoring, as well as in the development of new technologies and applications.

Microwave Pioneers: John C. Mather

“A Singular Purpose”

PETER H. SIEGEL 1,2,3 (Life Fellow, IEEE)
(Special Feature Paper)

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ABSTRACT This article is the first in a continuing series of biographical articles on individuals who have made significant contributions to microwave science, technology, and applications over the course of their careers. This article focuses on Dr. John C. Mather, recipient of the 2006 Nobel Prize in Physics, for his contributions to the first measurement of the cosmic microwave background (CMB) blackbody spectrum and the development of balloon-based CMB anisotropy surveys. This article highlights Mather’s work on the development of balloon-based CMB anisotropy surveys and his contributions to the understanding of the early universe.

Instrumentation for THz Spectroscopy in the Laboratory and in Space

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ABSTRACT Spectroscopic measurements in the millimeter, submillimeter, or THz range, with resolutions exceeding a MHz, provide high spectral selectivity, broad bandwidth, and tunability. Due to the high gain and low noise properties involved in the transition, multiple features are observable in many physical systems, and such measurements dominate the scientific discovery of molecules in space and contribute significantly to remote sensing of the Earth and planetary bodies. In this article, we review advances in the use of THz spectrometers in the laboratory and in space, and discuss the current status and the future of THz spectroscopy as it pertains to the human condition.

Innovative RFID Sensors for Internet of Things Applications

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ABSTRACT Radio-Frequency Identification (RFID) devices are among the most versatile and cost-effective solutions for Internet of Things (IoT) applications, such as logistics and consumer electronics. In this article, we present a comprehensive review of recent advances in RFID technology, focusing on the key features and applications of RFID sensors. We discuss the main challenges and opportunities associated with RFID-based IoT applications, and provide a roadmap for future research directions.

On the Shoulders of Giants: Reflections on the Creators and Users of Radio

TOM LEHIN

(Special Invited Editorial)

University of Oxford, Oxford, UK

ABSTRACT This special section contains a collection of articles on the history of radio, focusing on the contributions of key figures in the field. The articles cover a range of topics, including the development of radio technology, the role of radio in society, and the impact of radio on the arts and sciences. The section aims to provide readers with a deeper understanding of the history of radio and its importance in shaping our modern world.

Sensing of Life Activities at the Human-Microwave Frontier

CHANGZHI LIU 1,2 (Senior Member, IEEE), VICTOR M. LUBAECE 1,2 (Fellow, IEEE), OLGA BORIC-LUBAECE 1,2 (Fellow, IEEE), and JENISHAM LIN 1,2 (Fellow, IEEE)

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ABSTRACT Modern microwave radar technologies and systems are becoming increasingly important for healthcare, security, and human-machine interface by remote sensing of human life activities. This paper reviews the developments in the past decade on the sensing front-end, transponder tag, and leveraging of other wireless infrastructures such as Wi-Fi. Based on the state-of-the-art engineering technologies, several emerging applications will be discussed, including continuous authentication, behavior recognition, human-to-human localization, occupancy sensing, blood pressure monitoring, and sleep monitoring. As radio frequency spectrum becomes a scarce resource, the allocation of activity sensing bands with other wireless infrastructures will be discussed. Several future research directions will be laid out to solve the challenges for ubiquitous deployment of these sensing technologies at the human-microwave frontier.
Implementation Challenges and Opportunities in Beyond-5G and 6G Communication

ULF GUSTAVSSON1, JIL FRENCH2, CHRISTIAN FAGER3 (Senior Member, IEEE), THOMAS ERIKSSON4 (Senior Member, IEEE), HERBERT ZIRATH5 (Member, IEEE), FRANK DELECLERCQ6 (Senior Member, IEEE), CHRISTOPH STEINBEHVER1 (Senior Member, IEEE), AURINO PARISINI7 (Senior Member, IEEE), RICCARDO CORREIA8 (Member, IEEE), JIAO NUNO MACIA1 (Member, IEEE), DANIEL BELLO1, and NOORI DORGE CUVALU9 (Member, IEEE)

ABSTRACT As 5G New Radio (NR) is being rolled out, research effort is being focused on the evolution of what is to come in the post-5G era. In order to meet the diverse requirements of future wireless communication in terms of increased capacity and reduced latency, technologies such as distributed massive Multi-Input Multi-Output (MIMO), sub-mmWave and Terahertz spectrum become technology components of interest. Furthermore, the demands on connectivity, anywhere and anytime, non-cellular satellite networks will be needed, which brings about challenges both in terms of implementation as well as deployment. Finally, scaling up massive Internet of Things (IoT), energy harvesting and Simultaneous Wireless Information and Power Transfer (SWIPT) is forecasted to become important enablers when deploying a large amount of small, low-power radios. In this paper, we will discuss some of the important opportunities these technologies bring and the challenges faced by the microwave and wireless communication communities.

The Role of Millimeter-Wave Technologies in 5G/6G Wireless Communications

WEI HONG1,2 (Fellow, IEEE), ZHI MIAO JANG3 (Member, IEEE), CHAO YU4 (Member, IEEE), DEBIN RAO1 (Fellow, IEEE), JIN HANG REN1 (Member, IEEE), JUNG GIU9 (Graduate Student Member, IEEE), YUN HU10 (Member, IEEE), LE BRIAN11 (Member, IEEE), YULING ZHANG12 (Member, IEEE), ZHE CHEN13 (Member, IEEE), JINHENG ZHAO1 (Member, IEEE), ZHOU ZHANG14 (Member, IEEE), YAHAN ZHENG15 (Member, IEEE), SHANZHENG HAN16 (Senior Member, IEEE), and FAN YAO17 (Member, IEEE), GUANQING YANG18, ZHANG-CHENG HAO19 (Senior Member, IEEE), and YAN TI JI20 (Member, IEEE)

ABSTRACT Ever since the deployment of the first-generation of mobile telecommunications, wireless communication technologies have evolved at a dramatically fast pace over the past four decades. The upcoming fifth-generation (5G) holds a great promise in providing an ultra-fast data rate, a very low latency, and a significantly improved spectral efficiency by exploiting the millimeter-wave spectrum for the first time in mobile communication infrastructures. In the years beyond 2020, newly emerged data-hungry applications and the greatly expanded wireless network will call for the sixth-generation (6G) communication that represents a significant upgrade from the 5G network—covering almost the entire surface of the earth and the outer space. In both the 5G and future 6G networks, millimeter-wave technologies will play an important role in accomplishing the envisioned network performance and communication tasks. In this paper, the relevant millimeter-wave enabling technologies are reviewed; they include the recent developments on the system architectures of active beamforming arrays, beamforming-enabled circuits, antennas for base stations and user terminals, system measurement and calibration, and channel characterization. The requirements of each task for future 6G communication are also briefly discussed.

Packaging and Antenna Integration for Silicon-Based Millimeter-Wave Phased Arrays: 5G and Beyond

XIAOXIONG GU1 (Senior Member, IEEE), DUXIANG LIU2 (Fellow, IEEE), and BODHISHITA SADHU1 (Senior Member, IEEE)

ABSTRACT This article reviews current research and development as well as future opportunities for packaging and antenna integration technologies for silicon-based millimeter-wave phased arrays in emerging communication applications. Impediments of silicon-based multi-chip phased arrays beyond 100 GHz are discussed, with emphasis on array architectures for scaling, antenna interconnection options, substrate materials and process, antenna design, and IC-package co-design. Opportunities and challenges to support phased array applications beyond 300 GHz are then presented, including emerging packaging architectures, interconnection characterization requirements, thermal management approaches, heterogeneous integration of multifunctional chips, and novel antenna technologies.

Automotive Radar—From First Efforts to Future Systems

CHRISTIAN WALTHER1 (Senior Member, IEEE), JUERGEN HAHN2 (Senior Member, IEEE), and WOLFGANG MIRZEL3 (Fellow, IEEE)

ABSTRACT Although the beginning of research on automotive radar sensors goes back to the 1960s, automotive radar has remained one of the main drivers of innovation in millimeter-wave technology over the past two decades. Today, millions of sensors are installed in new cars, which was made possible by inexpensive and mature millimeter wave technology. The technology maturity, in turn, enables research to be carried out on systems that are considerably more advanced than machines available just a few years ago. The focus of research has thus shifted from purely hardware-oriented and device-level topics to sophisticated automotive radar systems and RF signal-processing topics. This opens up new research topics such as digital modulation schemes in acquiring the maximum possible information from a single signal. In this paper, we sketch the path from the very beginning through the stages of the art with examples of single and multiple-input multiple-output (MIMO) antenna arrays and mature assembly and interconnect concepts to today’s key research topics of automotive radar.

RF Systems Design for Simultaneous Wireless Information and Power Transfer (SWIPT) in Automation and Transportation

DIEGO MOSOTTI1 (Senior Member, IEEE), MAZEN SHANAWANY2, GHULAM MURATA3, GIACOMO PAUOLINI4 (Graduate Student Member, IEEE), and ALESSANDRO COSPILO5 (Senior Member, IEEE)

ABSTRACT This work presents some recent solutions that exploit the wireless power transfer (WPT) technology for remote powering vehicles and machinery tools. Such technology is currently experiencing unprecedented interests in non-traditional RF/nearhouse sectors fields, such the industrial automation and the railway transportation safety. Near-field microscopic coupling solutions are presented showing, in order to satisfy efficiency performances for broad ranges of operating conditions, the maximal electromagnetic design of the entire WPT system, from the energy source to the receiver load, needs to be carried out. This technology can be combined with wireless data transfer thus realizing integrated systems able to simultaneously control the energy transfer and the transmission of data. The adopted operating frequencies are in the MHz range, which is why recently considered for this kind of applications. In particular this work focuses on three different systems: the first one demonstrates the constant powering of the most industrial chains at 6.78 MHz, regardless of the relative position of the transmitter and the receiver sub-system; the second one presents a novel design of a full wireless transportation system adopting a high efficiency GaN-based transmitter designed to keep its performance over a wide range of loading conditions; the last one consists of the simultaneous wireless power and data transfer, in a rotating machinery tool, automatically controlled by the powering system based on the coexistence of frequency diverse inductive and capacitive couplings.
Microwave Photic Array Radars

SHILOONG PIN (Senior Member, IEEE), XINGWEI YE (Student Member, IEEE), YAMBI ZHAHNG (Member, IEEE), AND FANZKHECH ONG (Senior Member, IEEE)

ABSTRACT Pulsed array radars have remarkable advantages over radars with single-element antenna in terms of agility, flexibility, robustness, and reconfigurability. Current phase-electrical phased array radar face challenges when operating with a large frequency usable range and with wide instantaneous bandwidth. Microwave photons, which allows wide bandwidth, fast frequency response, low transmission loss, and immunity to electromagnetic interference, is a promising solution to cope with issues faced by phase electronics. In this paper, we introduce a general architecture of microwave photonic radar array systems and review the recent advancement of optical beamforming networks. The key elements for modeling the response of the true time delay (TTD) and board-phase-casting are presented and discussed. Two typical array antenna structures are introduced, i.e., microwave photonic phase shifter based array and optical true time delay based array, of which the principle and typical implementations are described. High-resolution inverse synthetic aperture radar (ISAR) imaging is also realized based on a microwave photonic array radar. The possibility of on-chip integration of the microwave photonic array radar is discussed.

Microwave Imaging in Security—Two Decades of Innovation

SHERIF S. AHMED (Invited Paper)

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ABSTRACT The microwave spectrum is one of the most valuable natural resource used nowadays in communication, navigation, and remote sensing. With over a century of heritage, imaging with electromagnetic waves had been puzzling researchers and engineers alike. When science and technology advanced enough, early imaging solutions at the lower end of the microwave spectrum were revealed. Airborne synthetic aperture radars (SAR), and later spaceborne SAR, were first to evolve. With their unprecedented capabilities in earth observation and reconnaissance, researchers became even more eager to extend SAR imaging to higher frequencies and for different applications. The last two decades have provided a wealth of theoretical, experimental, and technological advancements and innovations to re-ignite microwave technologies for present and future applications. Microwave signals can potentially sense clothing and reveal concealed threats, e.g., explosives and weapons, without imposing any health risks or side effects. This paper presents a historical overview of this evolution and highlights the latest advances in security microwave imaging.

Micrometer Sensing With Microwaves: Precise Radar Systems for Innovative Measurement Applications

FABIAN NICHOL (Student Member, IEEE), BENEDICT SCHEINER (Student Member, IEEE), TORSTEN REINIG (Student Member, IEEE), ROBERT WEGEL (Fellow, IEEE), AND ALEXANDER KOELPZ (Senior Member, IEEE)

Invited Paper

Abstract Radar sensors have been widely used to estimate speed and displacement of remote targets. A novel market for contactless radar sensing is emerging in the field of automation and process analysis, where non-destructive testing and evaluation methods are needed. Here, radar systems offer various advantages over conventional sensors since they enable the contactless, continuous, and cost-effective measurement of static or dynamic ranges. These features can be used for vibration and vital sign characterization. Advances in microwave technology, especially integration density, and the development of novel algorithms keep boosting the performance of the systems. After introducing the most common operation principles, such as unmodulated and frequency-modulated continuous-wave radar, different delay line and pulse compression techniques are described in detail. These include the sheet thickness monitoring of metallic, and the measurement of the ground speed of vehicles with the latest approaches. Example low-power radar systems are presented and show the limits in terms of power consumption while still offering a high measurement precision.

History and Innovation of Wireless Power Transfer via Microwaves

NAORI SHINODA (Senior Member, IEEE)

Invited Paper

Abstract Wireless power transfer (WPT) has a long history of over 100 years since the first experiment conducted by Nikola Tesla. However, the most interesting innovation of WPT was born in the 21st century. In this decade, near-field WPT commercialization was advanced, and we now use many near-field WPT products, e.g., wireless chargers for smartphones and electric vehicles. In the next decade, we can expect the development of far-field WPT via microwaves, through which we can drive Internet of Things (IoT) sensors without batteries based on transmitted or ambient microwave power. We can charge mobile phones with microwave power. When we focus microwave power on a target by beam forming technology, we can transmit higher power to fly drones or ships to the earth. In the future, with the development of microwave-based WPT, radio regulations suitable for each country need to be discussed. In this paper, I review the history, innovation, and status of the radio regulations of WPT via microwaves with the classification of wide-band WPT, including harvesting, and narrow-band WPT.

Russian Gyrotrons: Achievements and Trends

ALEXANDER G. LUTOK (Senior Member, IEEE), GREGORY C. DROSNOM (Member, IEEE), AND MIKHAIL T. GLAVON (Member, IEEE)

Invited Paper

Abstract The last decade has contributed to the rapid progress in the gyrotron development. Megawatt-class, continuous wave gyrotrons are employed as high-power millimeter wave sources for electron cyclotron heating (ECH) and current drive in tokamaks and stellarators. The progress in gyrotron development pushes ECH from a minor to a major heating method. Also, gyrotron-based technological components successfully employed in electroncyclotron resonance ion source, for microwave ceramic sintering and diamond disk polishing. The paper describes the main features of high frequency gyrotrons. Some data about pulsed and CW wave, working in the terahertz frequency range, are given. These gyrotrons operate at specific combinations of very low voltage and beam current, demonstrate an extremely narrow frequency spectrum or wide frequency tuning. Although is important with the classical microwave tubes the gyrotrons are characterized by greater volume and weight due to the presence of bulky parts (such as superconducting magnets and massive collectors where the energy of the spent electron beam is deposited) they can easily be embedded in a hospitable and laboratory equipment (e.g., spectroscopy, technological systems, etc.). All these advantageous features have opened the road to many new and prospective applications of gyrotrons.

Microwave and Millimeter Wave Power Beaming

CHRISTOPHER T. RODENBECK (Senior Member, IEEE), PAUL J. IRFRO (Senior Member, IEEE), BEHRN K. STRASSER (Fellow, IEEE), PAUL E. HAUGEN (Member, IEEE), JAMES M. FINCHARD (Senior Member, IEEE), HOORIAN KASEM (Senior Member, IEEE), NAOHI KOIYAMA (Senior Member, IEEE), AND AARON P. SLOE (Invited Paper)

Invited Paper

Abstract Power beaming is the efficient point-to-point transfer of electrical energy across free space by a directive electromagnetic beam. This paper clarifies the basic principles of power beaming in simple terms, and proposes a benchmarking methodology for improving the comparative assessment of power beaming systems and technology. An in-depth historical overview tracing the worldwide progress in microwave and millimeter wave (mmWave) experimental demonstrations over the past 60 years shows clear evidence of a significant increase in activity during the last 5 years. In addition, a review of progress in scalable antenna arrays for the reception of microwave power beaming shows sufficient maturity for new research to initiate on the generation of realistic system impacts in support of industrial applications. A review of key enabling topics including spectrum management and safety indicates the need for additional technical solutions and international cooperation. Results reported in this paper include: 1) data from the first indoor flight test of a solar-to-RF “windmill module,” 2) the completion of multiple US indoor flight demonstrations completed at 56/95GHz, and 3) a 100kW mmWave power beaming treatment demonstrating demonstrator human life safety.
Carver Mead: “It’s All About Thinking.”
A Personal Account Leading up to the First Microwave Transistor
PETER H. SIEGEL* (Life Fellow, IEEE)

(Special Series Paper)

SiGe HBTs and BiCMOS Technology for Present and Future Millimeter-Wave Systems
THOMAS ZIMMER*† (Senior Member, IEEE), JOSEF BÖCK‡, FRED BUCHLI§, PASCAL CHEVALIER=Moulin (Member, IEEE), MICHAEL COLLINS*, BÖRJE DEBALLIE*, RÜDIGER DENZ (Member, IEEE), PHILIPPE DEROUET, SEBASTIAN FLEISCHER*, CHRISTOPHE GAUDRIE*, HALOTHAN GHANIYA†, HANS HEINRICH†, ALPER KARAKUZELI§, TIM MAHMOOD, MARC MARTAINE‡, KOVACS, CAROLINE MAYER, MICHAEL MOELLER, ANNIKA MUHLER, HANS-PETER NAGEL, PHILIP SALGÀ*, ROBERT SCHMID*, KARINA SCHEIDT*, KARSTEN SCHUL, WOLFGANG TEMPEL, LUKAS WISSEIBRAND, AND THOMAS ZIVKOV

CNTFET Technology for RF Applications: Review and Future Perspective
MARTIN HARTMANN*†, JASCH CARES‡, JAN MARSHACK, CHRISTOPHER RUTHERFORD*, DAVEY WANG*, LI DING*, LIAN-MING PENG‡, MARTIN CLAUS§, AND MICHAEL SCHROEDER* (Senior Member, IEEE)

Emerging Trends in Techniques and Technology as Applied to Filter Design
RICHARD V. SNYDER*† (Life Fellow, IEEE), GIUSEPPE MACCHIarello*† (Fellow, IEEE), SIMONE BASTIOLI‡, (Senior Member, IEEE), AND CRISTIANO TOMASSINI§ (Senior Member, IEEE)

Substrate Integrated Transmission Lines: Review and Applications
KE MO*† (Fellow, IEEE), MAURIZIO BOZI‡ (Fellow, IEEE), AND NELSON J. G. FORSECA*§ (Senior Member, IEEE)

Millimeter-Wave Power Amplifier Integrated Circuits for High Dynamic Range Signals
HUA WANG*† (Senior Member, IEEE), PETER M. ABREUCK‡ (Fellow, IEEE), AND CHRISTIAN FISCHER* (Senior Member, IEEE)
Connecting Chips With More Than 100 GHz Bandwidth

WOLFGANG HEINBRECHT (Fellow, IEEE), MARUH BOUTSAINE (Fellow, IEEE), SIDHARTH SINGH (Fellow, IEEE), FRANZ-JOSEF SCHMÜCKLE (Member, IEEE), RAFAEL DOBNER (Member, IEEE), VIKTOR KROGER (Senior Member, IEEE), AND NILS BEHRENS (Member, IEEE)

(Invited Paper)

Wolfgang Heinbrecht (Fellow, IEEE), Senior Member IEEE, NIKTAEHUN, Daejeon 34141, South Korea
Rafael Dobner, Siemens Corporate Technology, Munich, Germany
Viktor Kroger, Siemens Corporate Technology, Munich, Germany
Nil H. Behrens (Fellow, IEEE), Member, IEEE, Siemens Corporate Technology, Munich, Germany

ABSTRACT We give a broad overview of the history of microwave superconductivity and explore the technological developments that have followed from the unique electrodynamic properties of superconductors. Their low loss properties enable resonators with high quality factors that can nevertheless handle extremely high current densities. This in turn enables superconducting filter designs, high performance filters, and analog electronics, including metamaterials, with extreme performance. The macroscopic quantum properties have enabled new generations of ultra-high speed digital computing and extraordinarily sensitive detectors. The macroscopic quantum properties of microwave superconducting chips have enabled large-scale quantum computers, which at their heart are essentially microwave-based quantum engines. We celebrate the rich history of microwave superconductivity and look to the promising future of this exciting branch of microwave technology.

Microwave Superconductivity

STEVEN M. ANGLADE (Member, IEEE)

(Invited Paper)

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ABSTRACT We give a broad overview of the history of microwave superconductivity and explore the technological developments that have followed from the unique electrodynamic properties of superconductors. Their low loss properties enable resonators with high quality factors that can nevertheless handle extremely high current densities. This in turn enables superconducting filter designs, high performance filters, and analog electronics, including metamaterials, with extreme performance. The macroscopic quantum properties have enabled new generations of ultra-high speed digital computing and extraordinarily sensitive detectors. The macroscopic quantum properties of microwave superconducting chips have enabled large-scale quantum computers, which at their heart are essentially microwave-based quantum engines. We celebrate the rich history of microwave superconductivity and look to the promising future of this exciting branch of microwave technology.

Microwaves in Quantum Computing

JOSEPH C. BARDIN (Senior Member, IEEE), DANIEL K. SLUCHTER (Senior Member, IEEE), AND DAVID D. REILLY (Senior Member, IEEE)

(Invited Paper)

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ABSTRACT Quantum information processing systems rely on a broad range of microwave technologies and large-scale development of microwave devices and circuits is needed to enable the operation of these quantum devices. Here we review the use of microwave circuits and systems in quantum computing, with specific reference to three leading quantum computing platforms: trapped atomic qubits, spin qubits in semiconductors, and superconducting qubits. We highlight some of the recent advances in these areas through the use of microwave systems, and discuss how quantum computing applications have pushed the frontiers of microwave technology in some areas. We also describe open microwave engineering challenges for the construction of large-scale, fault-tolerant quantum computers.

Microwave Magnetics and Considerations for Systems Design

MONTAGGIOI (Member, IEEE), SCOTT J. GILLETTE (Member, IEEE), MAHIMA SHURLA (Member, IEEE), PIOTR KULIK (Member, IEEE), AND ANTONY L. G. GILLET (Senior Member, IEEE)

(Invited Paper)

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ABSTRACT The adoption of non-linear magnetic devices in Radio Frequency (RF) systems has been relatively slow due to their unique characteristics that do not lend themselves well to traditional design tools and methodologies. Hence we present the practical considerations in employing such devices in modern RF system design with an emphasis on real-world implications in performance and adaptability in addition to the common design methodology that has been adopted to account for their unique behavior. Specifically, this article begins with presenting how a standalone nonlinear device such as a Frequency Selective Limiter (FSL) can enable a higher-level subsystem such as the Frequency Selective Canceller (FSC). This section sheds light on the importance of characterizing the behavior of an FSL and how this behavior is different from other more traditional RF components such as a PIN Diode Limiter, as explained in the second part of the article. Lastly, a Magnetostrictive Wave (MSW) delay line that leverages the recent advancements in non-linear magnetic device design is introduced in order to provide an attractive alternative to traditional delay lines. A more comprehensive understanding of system-level performance benefits and device-level functionality will undoubtedly facilitate the widespread deployment of non-linear magnetic devices to help mitigate spectrum congestion challenges faced by modern and future RF systems.
Non-Magnetic Non-Reciprocal Microwave Components—State of the Art and Future Directions

ARAVIND NAGULU (Student Member, IEEE), and HARISH KRISHNASWAMY (Member, IEEE)

On the Benefits of Glide Symmetries for Microwave Devices

OSCAR QUEVEDO-TERUEL (Senior Member, IEEE), QIAO CHEN (Member, IEEE), FRANCISCO MEZA (Fellow, IEEE), NELSON L. G. FONSECA (Senior Member, IEEE), and GUIDO VELIBRID (Senior Member, IEEE)

Sommerfeld Integrals and Their Relation to the Development of Planar Microwave Devices

JUAN B. MOSIG (Life Fellow, IEEE), and KREYSZOTF A. MICHAELSKY (Life Fellow, IEEE)

Advanced RF and Microwave Design Optimization: A Journey and a Vision of Future Trends

JOSÉ E. RAYAN-SÁNCHEZ (Senior Member, IEEE), LORI KESSLER KOZEL (Senior Member, IEEE), and JOHN W. BRANDER (Life Fellow, IEEE)

Simulation and Automated Modeling of Microwave Circuits: State-of-the-Art and Emerging Trends

QI-JUN ZHANG (Fellow, IEEE), EMAD GAO (Member, IEEE), BERNARD NOUFI (Member, IEEE), ABHINAV NA (Member, IEEE), and MICHEL KHALIL (Life Fellow, IEEE)

Supply Modulation Behavior of a Doherty Power Amplifier

DAN FISHELLER (Member, IEEE), ROY O. POPOVIĆ (Fellow, IEEE), and TAYLOR BARTON (Senior Member, IEEE)