Defence Science Journal, Vol. 75, No. 3, May 2025, pp. 271-272, DOI : 10.14429/dsj.20989

Guest Editorial

Microwave, Antenna and Communication (MAC 2024)

Vijay Shanker Tripathi
Motilal Nehru National Institute of Technology Allahabad, Prayagraj - 211 004, India
E-mail: vst@mnnit.ac.in

Currently, we are witnessing a huge transformative research in the areas of microwave engineering, antenna design, and communication systems. These disciplines serve as critical foundations for building smarter, more secure, and interconnected infrastructures. With the exponential growth of wireless devices in modern society and increasing demands for reliable, efficient, and high-speed communication, researchers are being challenged to extend the boundaries of what is possible in microwave, antenna, and communication research.

Further, the integration of intelligent technologies such as artificial intelligence and Internet of Things into communication networks necessitates more sophisticated RF and microwave components and more efficient communication systems capable of managing increased data traffic in dynamic environments. Microwave frequencies (300 MHz to 300 GHz) provide substantial advantages in bandwidth, data transmission rates, and compact system design—making them ideal for applications ranging from 5G networks to satellite communications and advanced radar systems. Antennas remain crucial components that enable effective signal transmission and reception, with advancements in their design directly influencing performance metrics, operational range, and energy efficiency of communication systems.

Ongoing research in these disciplines supports innovation across multiple sectors including defense systems, aerospace technologies, autonomous vehicles, and biomedical devices such as non-invasive sensors and wireless health monitoring systems. As noted in recent IEEE standards documentation, these technological innovations not only support scientific progress but substantially contribute to quality of life improvements and economic development.

The Microwave, Antenna and Communication (MAC 2024) conference, held during October 4–6, 2024, at Hotel Rudra in Dehradun, successfully brought together researchers, industry experts, and academicians from across the country to share breakthroughs and engage in substantive technical discussions. The conference featured four dedicated tracks: Microwave Engineering, Antenna Design, Communication Systems, and Emerging Technologies and Systems. Each track highlighted the increasingly interdisciplinary nature of current research while showcasing novel methodologies, prototypes, simulations, and experimental outcomes addressing both fundamental and future-oriented challenges in RF and communication domains.

This special issue of the Defence Science Journal presents a carefully selected collection of high-impact papers representing the top 10 % of submissions presented at MAC 2024. These papers underwent rigorous peer review in accordance with IEEE publication standards and were selected based on technical merit, originality, and relevance to defense and strategic applications.

The paper titled ***"Computational-Efficient Signal Processing Solution to Frequency Quadrupler Based High-Frequency Vector Signal Generator"*** presents an enhanced modeling approach using multiscale principal component analysis and wavelet decomposition for linearizing frequency multipliers. This method improves adjacent channel power ratio and overall system efficiency, making it a valuable tool in high-frequency microwave circuit design. The results show that the proposed approach helped to have a good ACPR improvement over other models.

Next paper- *"**Minimized Four-Port MIMO Antenna for Sub-6 GHz and Satellite Applications**"* demonstrates a compact MIMO antenna leveraging split ring resonators and defected ground structures to achieve enhanced gain, high isolation, and excellent diversity performance across sub-6 GHz and satellite bands. The diversity performance matrices such as envelope correlation coefficient, diversity gain), Mean effective gain and total active reflection coefficient meet the performance criterion of the MIMO antenna. The designed four-port MIMO antennas can be used in sub-6 GHz (3.3 to 3.8 GHz) and fixed satellite television data services (10.7 to 14.5 GHz) applications.

The paper ***"Design of a 3D Printed Helical Antenna having High Gain for 2.4 GHz ISM Band Applications"*** proposes a cost-effective and efficient helical antenna fabricated using a PLA-based 3D-printed support, exhibiting 8.01 dB gain and 99 % radiation efficiency, suitable for ISM band applications.

Another contribution, *"**A Compact Dual-Band Linearly Co-Polarized Antenna Array System for In-Band Full-Duplex (IBFD) Applications**"*, features a dual-band microstrip array achieving over 45 dB isolation between ports and high broadside gain, addressing full-duplex communication requirements. At 2.4 GHz, the MPAs operate in the TM1/2,0 mode, whereas at 3.5 GHz, MPAs operates in TM1/2,2 mode. The $|S11| \leq$ -10 dB impedance bandwidth for each MPA is 2.5 % at 2.4 GHz and 2% at 3.5 GHz, with respective inter-port isolations better than 20 dB and 45 dB at the corresponding operating frequencies. Additionally, the antenna array system possesses a broadside gain of 8.3 dBi at 2.4 GHz and 9.4 dBi at 3.5 GHz.

The paper ***"A Miniaturized Self-Multiplexing Antenna for Eight Distinct sub-6 GHz 5G-NR Services for IoT Applications"*** introduces a multiport antenna using quarter-mode substrate-integrated waveguide cavities to support eight frequency bands for various 5G NR applications, with excellent port isolation and frequency tunability. The SM IoT antenna radiates at eight distinct frequency bands from 3.5 GHz to 6.7 GHz (3.46, 3.69, 4.84, 5.2, 5.88, 5.95, 6.16, 6.65 GHz) for various smart devices. The designed IoT antenna can be independently tuned to other 5G-NR services from 3.5 GHz (n78) to 7.125 GHz (n96, n104) by varying one design parameter. This SM IoT antenna also offers high inter-port isolation better than 30 dB.

Next paper with title ***"Design and Development of a Conjoined Narrow Wall Slotted Waveguide Array Antenna with Low Side Lobe Levels"*** presents an X-band slotted waveguide antenna formed by joining three precision-cut waveguide pieces, delivering low side lobes, minimal insertion loss, and excellent return loss—ideal for radar and defense systems. The fabricated prototype was tested for both bench-level measurements and radiation pattern parameters, achieving a return loss better than -34 dB, an insertion loss better than -12 dB, and a side lobe level better than -25.2 dB at 9.3 GHz.

The paper ***"Study of Multi-state Phase Gradient Surface with Single Beam Anomalous Reflection for Passive RIS Applications"*** introduces a phase gradient surface with up to five discrete states, achieving strong anomalous reflection and suppression of specular reflections by up to 12.4 dB, making it a strong candidate for passive RIS deployments in 6G networks.

The work titled ***"ML-Driven Optimization of Luneburg Lens Design"*** reports using machine learning—specifically k-means clustering—to optimize graded-index lens design, significantly simplifying fabrication while maintaining focusing accuracy and wide-angle scanning capabilities.

Another notable work, ***"A 2-bit Quad Band Reconfigurable Intelligent Surface for Modern Wireless Communications"***, showcases a RIS integrated with varactor diodes operating in four distinct frequency bands. It achieves broad beam steering with minimal scan loss and strong gain performance, offering a flexible solution for next-generation wireless systems. The feed antenna has a peak gain of 10.4 dBi at 8.4 GHz and a -10 dB impedance bandwidth of over 10 GHz. The peak gains (sidelobe levels) of the proposed RIS at 3.5 GHz, 4.5 GHz, 5.7 GHz, and 8.4 GHz are 14.6 dBi (-29 dB), 11.2 dBi (-13 dB), 16.4 dBi (-26 dB), and 17.2 dBi (-23.7 dB), respectively. Also, at 3.5 GHz, 4.5 GHz, 5.7 GHz, and 8.4 GHz, the beam steering range (scan loss) offered by the RIS are 28º (3.9 dB), 23º (2.4 dB), 70º (3 dB), and 76º (5 dB), respectively.

Another work with title "***PSO-based Resource Allocation in Cognitive Radio Ad-hoc Network***" explains PSO-based method to optimize resource allocation in Cognitive Radio Ad-hoc Networks. By tuning key parameters using NS-2 and MATLAB, their approach improves packet delivery and throughput by 22.15 %, reduces delay by 67.83 %, and boosts energy efficiency by 32.18 %.

The paper ***"Jamming Efficacy Analysis of Chaff using AI/ML"*** explores the use of machine learning algorithms such as SVM, UDC, Naïve Bayes, and Decision Tree to evaluate the effectiveness of radar jamming by chaff clouds. The study identifies optimal deployment strategies and noise conditions, showing that AI classifiers can significantly enhance jamming efficiency and suggest tactical improvements for real-world electronic countermeasure systems.

Collectively, these contributions reflect cutting-edge research and practical innovations emerging from the MAC 2024 community. They embody the conference's vision of bridging fundamental research with real-world implementations that strengthen national security capabilities and technological self-reliance.

I hope this special issue serves as a valuable resource for scientists, engineers, and practitioners engaged in advancing microwave, antenna, and communication technologies. I would like to extend my sincere gratitude to all authors for their exceptional contributions, to the reviewers for their critical insights and timely feedback, and to the organizing committee of MAC 2024 for creating a platform that fosters research excellence.