



MTT-S Society News

Technical Committee 24 Report 2021–2023

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The IEEE Microwave Theory and Technology Society (MTT-S) Microwave/Millimeter-wave Radar, Sensing and Array Systems Committee (TC-24) is dedicated to advancing education and research in microwave and millimeter-wave technology with a focus on system applications. The committee is deeply involved in pursuing research in precision high-frequency radar, terahertz sensing, phased arrays, digital beamforming, multiple input/multiple output (MIMO) systems, high-frequency microwave imaging techniques, and distributed microwave systems. The committee's emphasis on system applications often involves combining advanced circuit designs and microwave component technologies with system architectures, digital hardware subsystems, and appropriate signal processing approaches. Leveraging the progress in all these



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fields in intelligent ways to improve system-level capabilities is a very fertile ground for research and is rapidly evolving with new advances and implementations.

Technical Highlights

Currently led by the chair, Nils Pohl, and vice-chair, Robert Schmid, TC-24 has 14 members and three affiliate members. The committee is composed of members from academia, industry, and government research laboratories to help promote communication and collaboration across the technical community. The committee welcomed the addition of three

affiliate members in 2021 through the MTT-S affiliate member initiative [1]. The affiliate members have been actively engaged in the microwave community at conferences and through publications and also generated an overview of TC-24 for the MTT-S Technical Coordination and Future Directions Committee [2]. The following paragraphs highlight a subset of the exciting technical contributions from the committee members within the past two years. A list of the current committee members and a more extensive list of the key publications by the committee members are available on the

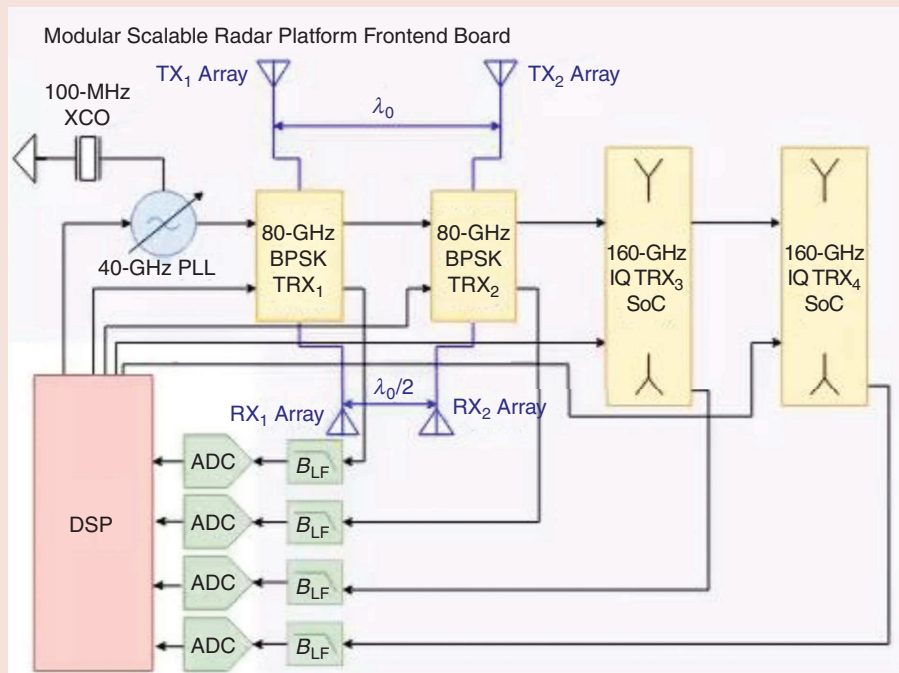
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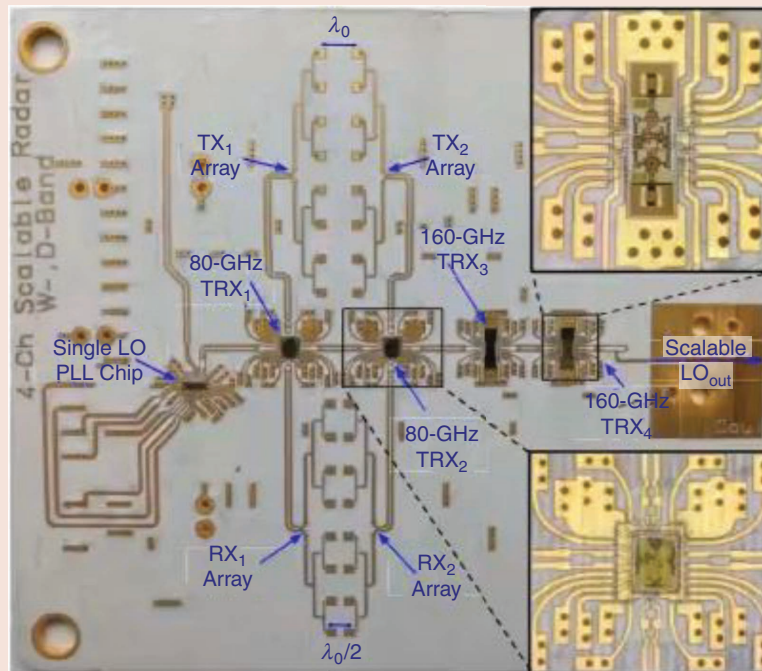
TC-24 website at <https://mtt.org/technical-committees/tc-24-microwave-mm-wave-radar-sensing-and-array-systems-committee/>.

High levels of integration and improvements in the underlying performance of CMOS and silicon-germanium (SiGe) transistors continue

to enable new opportunities for applications leveraging millimeter-wave and terahertz circuits. Fabian Lurz and his research group at the Hamburg



(a)



(b)

Figure 1. A 160-GHz and 80-GHz MIMO radar platform used for a variety of applications including remote heart rate detection. BPSK: binary phase-shift keying; PLL: phase-locked loop; SoC: system-on-chip; DSP: digital signal processor; ADC: analog-to-digital converter; LO: local oscillator; RX: receiver; CXO: crystal oscillator; TRX: transceiver; IQ: in-phase and quadrature. (Source: Taken from [6].)

University of Technology have been investigating time series-based hand gesture recognition using 60-GHz frequency-modulated continuous wave (FMCW) radar [3]. The application of remote sensing to the medical environment has continued to grow in interest, and multiple committee members have been developing new approaches and techniques to remotely sense and analyze the operation of the heart and lungs [4], [5], [6]. An example 160-GHz and 80-GHz millimeter-wave MIMO system used to measure heart rate is shown in Figure 1 [6]. In addition, Martin Vossiek was part of a large research consortium focusing on the use of terahertz sensors to provide continuous real-time data on plants and insects to better understand their health and behavior for crop yield optimization and resource management [7]. The application of terahertz sensors to environmental monitoring has several interesting opportunities that may be pursued in the near future.

Jeff Nanzer and his research group at Michigan State University have been developing concepts in the areas of distributed phased arrays and active incoherent imaging. In [8], a two-

tone waveform was used to achieve wireless synchronization on the order of picoseconds. In [9], precision internode ranging was used to change relative phase states between distributed transmitters to compensate for changes in node position such that coherent operation was maintained at a desired receiver location. In addition, an implementation of a 38-GHz 3D active incoherent microwave imaging system (3D AIM) was developed using a 24-element sparse receive array and four noise transmitters. The 3D AIM system is shown in Figure 2, along with a reconstruction of a scene with two corner reflectors [10].

Public Service and Engagement

TC-24 is actively involved in engaging the broader IEEE community and the next generation of experts in this challenging field. The members of TC-24 are significantly involved in many microwave conferences, including the International Microwave Symposium (IMS), Radio & Wireless Week (RWW), and European Microwave Week (EuMW). Alexander Koelpin was the RWW general chair in 2023, and Robert Schmid was the 2023 tech-

nical program chair of one of the colocated conferences at RWW, Silicon Monolithic Integrated Circuits in RF Systems (SiRF). A large number of the committee members participate in the technical paper review committees and also serve in conference leadership positions and as session chairs.

At IMS 2022, Fabian Lurz and Christian Damm coordinated a student design competition in collaboration with TC-4 (Microwave Passive Components and Transmission Line Structures) called “Design of a Self-Interference Cancellation Coupler.” This competition challenged student design teams to develop analog self-cancellation circuitry operating over a 250-MHz bandwidth in the 24-GHz industrial, scientific, and medical band to support monostatic radar applications. At IMS 2023, Kamel Haddadi helped organize a workshop with TC-8 (RF Nanotechnology) on “Microwave Measurements in Extreme Environments for Emerging Applications in Computing, Energy, and Life Sciences.” Nils Pohl collaborated with TC-28 (Biological Effects and Medical Applications) to create a workshop called “Radio-Frequency and mm-Wave Biomedical

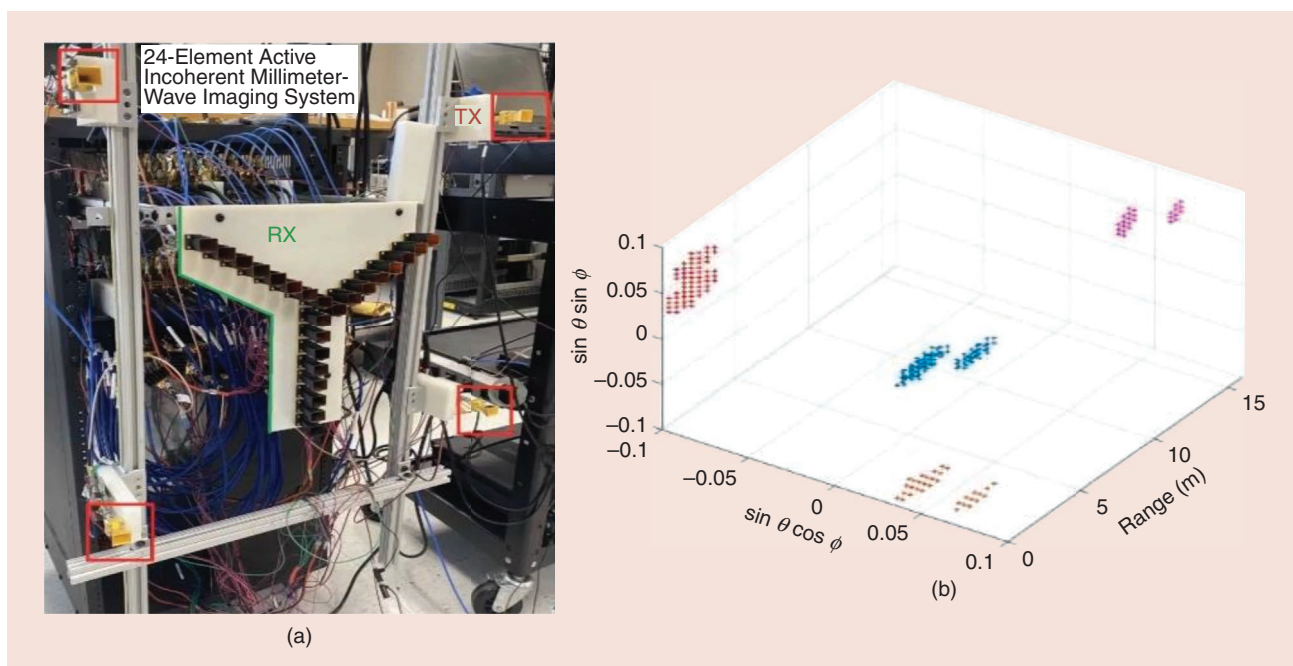


Figure 2. An AIM imaging system and a scene reconstruction of two corner reflectors shown in blue. The projection of the corner cubes in different planes is shown in red, magenta, and orange. (Source: Taken from [10].)



Figure 3. Wael Ahmad receives the 2023 IEEE Microwave Prize Award.

Radar Technologies.” Wael Ahmad, one of the TC-24 affiliate members, also served as a judge in the IMS 2023 Student Paper Competition.

Ramesh Gupta was the vice-chair of the working group that generated the mmWave and Signal Processing Chapter for the 2023 International Next Generation Roadmap [11]. The working group focused on identifying the key technical challenges that require research and investment over the next decade to support the envisioned evolution of 5G applications.

Christopher Silva is an inaugural member of the IEEE Standards Working Group P1765-OTA, Recommended Practice for Estimating the Uncertainty in Error Vector Magnitude (EVM) of Measured Digitally Modulated Signals for Wireless Communications: Conducted and Over-the-Air Hardware Verification. This group is developing a follow-on revision to the recently issued IEEE Standard 1765TM-2022 [12] in which Christopher played a significant technical lead and writing role since its June 2015 inception. The new group formed in the September 2022 time frame and is addressing the fundamental EVM distortion metric in the context of antennas of the simple through MIMO variety.

Jeff Nanzer has been presenting his research on the topic of “Distributed

Phased Arrays: Challenges and Recent Progress” as an MTT-S Distinguished Microwave Lecturer (DML) since 2022 (preview video available online [13]). As a part of the DML program, this has included numerous virtual talks to audiences across the globe as well as in-person presentations to a number of universities and local IEEE sections in Australia, the United States, and Europe.

TC-24 strongly supports RF systems activities across IEEE, including the new cosponsored hybrid publication *IEEE Transactions on Radar Systems* (TRS), which published its first articles on IEEE *Xplore* in March 2023. Martin Vossiek serves as one of the two associate editors-in-chief, and Gregory Lyons serves as the journal’s treasurer and as a member of the TRS Steering Committee that runs the journal. Gregory also serves as the MTT-S representative to the IEEE Systems Council.

Awards

TC-24 members have been recognized through a number of awards for their impact on the microwave and millimeter-wave community and for their high-quality publications. Ramesh Gupta was awarded the 2023 N. Walter Cox Award for exemplary service to the Society in the spirit of selfless dedication and cooperation.

As shown in Figure 3, Wael Ahmad was part of the team that received the 2023 annual IEEE Microwave Prize Award, recognizing their publication, “Multimode W-Band and D-Band MIMO Scalable Radar Platform,” as the most significant contribution published in the MTT-S field of interest [6]. Nils Pohl and his collaborators received the 2022 Piergiorgio L. E. Uslenghi Letters Prize Paper Award for the article “Near-Field Effects on Micrometer Accurate Ranging With Ultra-Wideband mmWave Radar,” where they applied theory from physical optics to overcome ranging errors created by using standard far-field assumptions [14]. In addition, Nils Pohl and Ruhr University Bochum collaborated with 2 π -LABS GmbH on a D-Band FMCW sensor that combined a chip with one transceiver and two additional receivers with a configurable end-launched waveguide antenna. This work resulted in the publication “Versatile 126–182-GHz UWB D-Band FMCW Radar for Industrial and Scientific Applications,” which received the 2023 IEEE Sensors Letters Best Paper Award [15].

Upcoming Activities

TC-24 looks forward to continuing to create opportunities to exchange new research developments, network across technical expertise areas, and help educate young professionals. At the time of writing this article, IMS 2024 is on the near horizon. Amir Mortazawi will be presenting in a workshop on “Multi-Functional RF Integrated Passive Components for 6G, Radar Systems, and Beyond.” Jeff Nanzer will also be presenting at an IMS 2024 workshop called “Massively Distributed MIMO as the New Paradigm in 6G—Implementation Challenges and Opportunities.” To discuss new research, collaboration, and engagement opportunities, please reach out to the TC-24 chair and vice-chair using the contact information provided on the TC-24 website [16].

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Figure 7. At the end of the panel discussion during MAPCON 2023.

There was an interesting discussion on “What Does the Future Hold for Microwave Professionals? Challenges

and Opportunities” for nearly 30 min, where the experts provided a wonderful roadmap to the young aspirants in

this field. The session ended up with a photo session with the dignitaries present in the hall (Figure 7).

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