Education News

The 2022 MTT-S Graduate Student Fellowship Awards

■ **Giovanni Crupi, Roger Kaul, Changzhi Li, and Wenquan Che**

The IEEE Microwave Theory and Technology Society (MTT-S) Graduate Student Fellowship Awards are sponsored by the MTT-S to encourage and support graduate students from around the world who are interested in pursuing the field of microwave engineering. The fellowship honorees receive an award of US$6,000, presented at the annual IEEE MTT-S International Microwave Symposium (IMS), to support their research activities. Supplemental funding is offered to support the recipients' travel to the IMS (up to maximum of US$1,000). In addition, the highest-ranked honoree is awarded the IEEE MTT-S Tom Brazil Graduate Fellowship, with an additional travel grant of US$1,000.

Twelve graduate fellowships were awarded for 2022 in the general category and two in the medical applications domain. To be eligible for these graduate fellowships, applicants must be full-time students in a recognized M.S. and/or Ph.D. degree program. Full details regarding eligibility and application requirements can be found at www.mtt.org/students. The submission deadline for the 2023 awards is 15 October 2022.

For the 2022 awards, 36 applications from 14 countries were received in the general category, and 11 applications from six nations were received in the medical area. All of the applications were excellent and represented some of the best research being conducted around the world. The overall success rate was 29.8% because of the large number of submissions. The difficult task of selecting the awardees was performed by a group of dedicated, impartial MTT-S volunteers from both industry and academia. Special thanks to the volunteers who spent many hours reviewing and grading the proposals. Davi V. Q. Rodrigues (Texas Tech University, United States) was selected for the IEEE MTT-S Tom Brazil Graduate Fellowship.

Giovanni Crupi (crupig@unime.it) is with the BIOMORF Department, University of Messina, Messina, 98125, Italy. Roger Kaul (rogerieeemtt@gmail.com) is a Senior Life Member of IEEE. Changzhi Li (changzhi.li@ttu.edu) is with Texas Tech University, Lubbock, Texas, 79409, USA. Wenquan Che (eewqche@scut.edu.cn) is with the South China University of Technology, Guangzhou, 510641, China.

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2022 Graduate Student Fellowship Awardees

Zhixian Deng

School: University of Electronic Science and Technology of China, China.

Advisor: Prof. Xun Luo.

Project topic: Multifunction receiver (Rx) array with multiple interferences suppression in CMOS technology for millimeter-wave (mm-wave) applications.

Zhixian Deng received his B.E. degree in microelectronics science and engineering from the University of Electronic Science and Technology of China, Chengdu, China, in 2019, where he is currently pursuing a Ph.D. degree in electronic science and technology. He is expected to graduate with a Ph.D. degree in June 2024. His research interests include the reconfigurable microwave/mm-wave transceiver and passive components, especially integrated circuits. He was a recipient of the IEEE IMS Student Design Competition Award from 2017 to 2019.

Project Description

Future multistandard wireless provides high data rates using the wideband mm-wave spectrum. Meanwhile, modern and future wireless applications (e.g., 5G, vehicles, and intelligent manufacturing) occupy the spectrum and make the wideband wireless systems operate in a complicated electromagnetic (EM) environment, where multiple signals will be received in practical applications. Meanwhile, the receiving signals along with the local oscillator (LO) signal will generate unpredictable intermodulation. Those receiving signals and intermodulation products located at the Rx channel (in the RF or intermediate frequency domain) will cause a significant performance degeneration in Rx systems. This research aims to achieve a multifunction mm-wave Rx array capable of suppressing multiple interference and can be reconfigured to meet the requirements in different applications. As the outcome of a proposed research plan, the multifunction Rx array will be implemented and verify for mm-wave wireless systems.

Tzu-Yuan Huang

School: Georgia Institute of Technology, United States.

Advisor: Prof. Hua Wang.

Project topic: Energy efficient, linear, and wideband mm-wave transceiver front end for next-generation wireless communication systems.

Tzu-Yuan Huang received his B.S. degree in electrical and computer engineering from the National Chiao Tung University, Hsinchu, Taiwan, in 2012 and his M.S. degree from the Graduate Institute of Communication Engineering, National Taiwan University, Taipei, Taiwan, in 2015. He is currently pursuing a Ph.D. degree in electrical engineering with the Georgia Institute of Technology, Atlanta, Georgia, United States, and he is expected to graduate in spring 2022. His current research interests include RF/mm-wave integrated circuits and systems.

Project Description

To address the highly growing data-rate demand, it is envisioned that mm-wave will be extensively employed in 5G-and-beyond communication system for increases of channel capacity and broader applicable spectra. Viable mm-wave transmitter (Tx)/power amplifier (PA) front-end solutions are required to support multi-Gb/s spectrum-efficiency-modulated signals. A corresponding large peak-to-average-power-ratio indicates that Tx/PA must demonstrate exceptional linearity to maintain signal fidelity and exceptional efficiency at power back-off (PBO). Similarly, mm-wave Rx front-end solutions should achieve high sensitivity and linearity while maintaining a wide bandwidth to proceed with high-speed signals. Our research plan aims to exploit new circuit architectures and techniques to address the mm-wave terahertz (THz) transceiver (TRx) design challenges. We propose a continuous-mode coupler balun Doherty PA covering 26–60 and 35–100 GHz with high peak power-added efficiency and substantial PBO efficiency enhancement. On the Rx side, a broadband dynamic 2D full field of view (FoV) multiple input, multiple output Rx array is proposed to support full-space signal beamforming/-tracking and perform rapid automatic spatial filtering on unknown blockers with µs low latency over full FoV.

Divya Jayasankar

School: Chalmers University of Technology, Sweden.

Advisor: Prof. Jan Stake.

Project topic: Terahertz Schottky diode harmonic mixers.

Divya Jayasankar received her M.Sc. in wireless, photonics, and space engineering from the Chalmers University of Technology, Gothenburg, Sweden, in 2019. She is currently working toward her Ph.D. degree at the Chalmers University of Technology and Research Institutes of Sweden, with an expected graduation date in 2024. Her main research interest is the development of THz Schottky diode mixers for future space missions and THz metrology. In 2021, she received the European Microwave Association's internship award and a travel grant from the Ericsson Research Foundation.

Project Description

Terahertz heterodyne receivers are indispensable tools for detecting molecular lines and, therefore, essential in planetary and atmosphere sciences. A key component for high-resolution spectroscopy is a stable LO source. Over the past decade, quantum-cascade lasers (QCL) have shown a steady performance improvement, thereby paving the way for the realization of compact THz heterodyne receivers. However, QCLs are susceptible to frequency drifts and instabilities due to cryocooler vibrations and temperature fluctuations. Hence, it is crucial to frequency stabilize the QCLs. Schottky diode mixers have a fast response time, are compact, and are ideal for QCL phase locking applications. This project aims to design Schottky diode harmonic mixers working at 3.5 and 4.7 THz for phase locking of QCLs, aiming for future space-/airborne missions.

Muhammad Ibrahim Wasiq Khan

School: Massachusetts Institute of Technology (MIT), United States.

Advisor: Prof. Ruonan Han.

Project topic: Toward battery-less THz transceivers with physical layer security for ultraminiaturized platforms.

Muhammad Ibrahim Wasiq Khan received his B.E. degree (with honors) in electrical engineering from the National University of Science and Technology (NUST), Islamabad, Pakistan, in 2012 and his M.Sc. degree in electrical engineering from the Korea Advanced Institute of Science and Technology, Daejeon, South Korea, in 2016, where he worked on THz detectors and THz imaging systems based on CMOS technology. He is currently pursuing a Ph.D. degree with the Electrical Engineering and Computer Science Department, MIT, Cambridge, Massachusetts, United States, where he is working on CMOS-based THz identification tags, THz energy-harvesting systems, and THz-orbital-angular-momentum secure transceivers. He was a recipient of the IEEE Radio Frequency Integrated Circuits (RFIC) Symposium Best Student Paper Award (First Place) in 2021. He also received the Rector's Silver Medal for his B.E. degree.

Project Description

Integrated electronics are filling up the THz gap for the last two decades, but battery-less TRxs have not been realized due to their stringent challenges. There is also a growing demand for ultralow-power, mm-size TRxs in supply chain management, authentication, microrobotics, and so on, and with the proliferation of THz-TRxs, the security of wireless links is another emerging issue. In this project, novel approaches are proposed to realize physically secure and energy-harvesting-based THz-TRxs. Specifically, a transformative physical-layer security scheme using the helical distribution of a wavefront phase (namely the orbital-angular-momentum) is employed for secure transmission. Furthermore, the circuit architectures for highly efficient CMOS THz energy harvesters are explored for wirelessly powering the TRx.

Woosol Lee

School: University of Florida, United States.

Advisor: Prof. Yong-Kyu Yoon.

Project topic: Highly efficient mm-wave-based far-field wireless power transfer (WPT) system using metaconductors (MCs) and metamaterials (MTMs).

Woosol Lee received his B.S. degree in statistical information analysis and military art and science from the Korea Military Academy, Seoul, Korea, in 2011 and his M.S. degree in network-centric warfare from the Ajou University, Suwon, Korea, in 2016. He is currently pursuing a Ph.D. degree in electrical and computer engineering at the University of Florida, Gainesville, Florida, United States. He is expected to graduate in summer 2023. His current research interests include MTMs for RF/microwave applications, WPT, and low-loss conductors for high-frequency applications.

Project Description

This project proposes a highly energy-efficient, mm-wave-based, far-field WPT system using MCs and MTMs. To achieve high end-to-end efficiency of the far-field WPT system in mm-wave, the following two approaches are proposed. First, the usage of multilayer nonferromagnetic/ferromagnetic MCs as eddy current-canceling conductors is proposed to implement all the interconnects and passive components, including Tx and Rx antennas, feeding lines, and rectifier lines. Based on the preliminary studies, the proposed MC-based Tx and Rx array antennas are expected to show at least 6-dB gain enhancement each compared with copper-based counterparts. Second, a beam-focusing MTM lens is introduced to focus and align the EM fields for high gain Tx and Rx antennas. It is highly expected that the proposed WPT system will open new possibilities for practical WPT applications with enhanced efficiency.

Harrison Lees

School: The University of Adelaide, Australia.

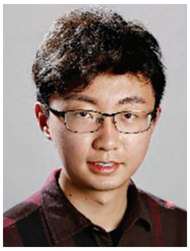
Advisor: Prof. Withawat Withayachumnankul.

Project topic: Reconfigurable integrated devices for compact terahertz systems.

Harrison Lees received his B.E. degree in electrical and electronic engineering from The University of Adelaide, Australia, in 2020. He is currently a Ph.D. candidate at the Terahertz Engineering Laboratory at the University of Adelaide under the supervision of Dr. Withawat Withayachumnankul and Dr. Daniel Headland with expected graduation in 2024. His priority research interest is terahertz-integrated silicon microphotonics for 6G communications.

Project Description

The terahertz band is commonly used to refer to EM radiation with frequency ranging from 100 GHz to 10 THz. In recent years, there has been accelerating interest in using terahertz technologies for high-speed, beyond-5G, wireless communications. Currently, integrated circuits built from all-silicon dielectric waveguides are a promising avenue for achieving these goals. However, the properties of dielectric waveguides mandate that these systems must be relatively large to avoid cross-channel interference and are inherently passive following fabrication. This project seeks to explore a variety of techniques to reduce the size and increase the flexibility of dielectric waveguides to enhance the performance and accelerate further development.



Zheng Liu

School: Princeton University, Princeton, New Jersey, United States.

Advisor: Prof. Kaushik Sengupta.

Project topic: *A* frequency agnostic beamforming system with nonuniform array geometry and wideband Tx for mm-wave wireless links.

Zheng Liu received his B.S. degree from Peking University and his M.S. degree from the University of California at Los Angeles. He is currently working toward his Ph.D. degree at Princeton University, United States. His research interests include mm-wave broadband PAs and phased-array systems. Zheng was a recipient of the IEEE IMS Best Student Paper Award (third place) in 2021 and Analog Devices Outstanding Student Designer award in 2022.

Project Description

The evolving spectral allocations in the mm-wave bands across 24–100 GHz necessitate future front ends to address multiple bands spread across the spectrum. Current phased-array systems based on uniform linear arrays are fundamentally incapable of operating across a wide range of frequencies extending beyond an octave without grating lobes. In addition, the broadband specification poses significant challenges for the PAs: a design demanding GHz channel bandwidths across multiple bands over a 3:1 mm-wave bandwidth while maintaining high linearity and efficiency. To this end, my research aims at: 1) fundamental design methodologies aiming toward a nonuniform array geometry, capable of operating across a broad range of frequencies (>3:1) and 2) novel Tx architectures using mm-wave harmonic engineering, stacked common base PA cells, and non-Foster impedance tuning to enable high PA efficiency and linearity across this wide frequency range. Such a frequency-agnostic beamforming array can fundamentally redefine the dynamics of the next generation of concurrent multiband wireless networks.

Maxim Masyukov

School: Aalto University, Finland.

Advisor: Prof. Zachary Taylor.

Project topic: Terahertz on-wafer metrology for future space applications.

Maxim Masyukov received his B.S. and M.S. degrees (both with honors) in photonics and optical information technologies from ITMO University, Russia, in 2018 and 2020, respectively. Since 2021, he has been with the Department of Electronics and Nanoengineering, Aalto University, Finland, as a Ph.D. student in radio science and engineering under the guidance of Prof. Zachary Taylor. He is expected to graduate in May 2025. His research activity is mainly oriented to different aspects of mm-wave techniques and terahertz radiation with the MilliLab, European Space Agency (ESA) external laboratory.

Project Description

Many ESA missions utilize satellite-mounted radiometers that observe various aspects of Earth and its atmosphere; thus, high-fidelity on-wafer measurements are essential for the fabrication of high-quality integrated circuits operated in free space. The focus of this research is to develop measurement techniques for device qualification, in particular on-wafer and quasi-optical measurements in the WR-2.2 (325-500-GHz) band. To address the barriers facing the frequency scaling of standard RF measurement techniques, on-wafer calibration techniques for the WR-2.2 band will be developed, including new mathematical approaches for error formalisms, simulation, and fabrication of on-wafer calibration standards for further tests using the terahertz probe station.

Mattia Mengozzi

School: University of Bologna, Italy.

Advisor: Prof. Alberto Santarelli.

Project topic: Broadband digital predistortion (DPD) of efficient multiple-input RF PAs exploiting optimization and machine learning techniques.

Mattia Mengozzi received his B.Sc. degree in computer engineering at the University of Bologna, Italy, in 2017 and received his M.Sc. in electronic engineering at the same university in 2020. He is currently pursuing a Ph.D. degree with a project focusing on microwave measurement techniques and performance optimization methods for high-efficiency 5G PAs under the supervision of Prof. Alberto Santarelli; the expected graduation date is 2024. His research interests focus on the development and validation of a new DPD technique exploiting the multiinput nature of efficient PA topologies.

Project Description

DPD is one of the most widely used techniques to compensate for nonlinear dynamic effects in RF transmitters. However, devising effective DPD strategies in the context of multiinput PAs is not straightforward. Moreover, the flexible control of multiple inputs adds degrees of freedom that could enable better linearity/efficiency tradeoffs. The project aims at investigating a new approach to DPD coefficient learning, in which they are jointly identified by a multiobjective optimization (MOO) framework maximizing a given set of contrasting figures of merit (e.g., linearity, efficiency, RF output power, and so on). To avoid the high number of measurements that would be needed to run a MOO learning procedure, the proposed algorithm is based on a surrogate model of the PA, which can be identified and refined during the learning procedure. The project targets the experimental validation of the framework on a dual-input Doherty PA.

MuhibUr Rahman

School: Polytechnique Montreal, University of Montreal, Canada.

Advisor: Prof. Ke Wu.

Project topic: Simultaneous 2D tuning using nonlinear transmission lines (NLTLs).

MuhibUr Rahman received his bachelor's degree in electrical engineering from the University of Engineering and Technology, Peshawar, Pakistan, in September 2014 and his M.S. degree in electrical engineering from the NUST, Islamabad, Pakistan, in March 2016. He is currently pursuing a Ph.D. degree in the Department of Electrical Engineering, Polytechnique Montréal, University of Montreal, Canada, under the supervision of Prof. Ke Wu, and is expected to graduate in 2023. His current research interests include NLTLs, solitons, shock waves, electron devices, ultrafast electronics, and nonreciprocal ferrite devices.

Project Description

Picosecond pulse generation, compression, and transmission are very desirable in ultrafast electronics, geophysical exploration, discharge plasma, biological electromagnetics, and future oscilloscopes. This research aims to investigate theoretical and experimental development in an NLTL along with the demonstration of simultaneous rise and fall time compression. The 2D tuning concept, including electric and magnetic tuning, is explored in NLTL, and new innovative schemes are proposed in this regard. These pulse generators are then utilized in a practical system, and the corresponding received waveform response is studied. The transceiver effect on pulse characteristics is deeply studied, and detailed ringing is analyzed. A technique will be explored as well to mitigate the ringing instead of using a conventional late-time ringing mitigation technique. Gaussian and higher derivatives of Gaussian pulses are also developed, and their capability to maintain their shape after the transmission is also explored.

Sam Razavian

School: University of California, United States.

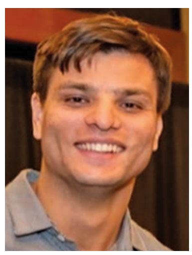
Advisor: Prof. Aydin Babakhani.

Project topic: Highly efficient integrated THz pulse and continuous wave (CW) radiators and receivers for broadband sensing, imaging, and Communication applications.

Sam Razavian received his B.Sc. degree in electrical engineering from the Sharif University of Technology, Tehran, Iran, in 2016 and his M.Sc. degree in electrical and computer engineering from the University of California, Los Angeles, California, United States, in 2019, where he is currently pursuing a Ph.D. degree, with the expected graduation date in spring 2023. He was an RFIC design intern with Qualcomm Inc., San Jose, California, United States, in 2020 and 2021. His current research focus is on mm-wave and terahertz transmitters and receivers for different applications, including broadband sensing, hyperspectral imaging, and high-speed communication. He is also a recipient of the 2021–2022 IEEE SSCS Predoctoral Achievement award.

Project Description

With the emergence of new Internet of Things and mobile applications, there has been an ever-increasing demand for high-data-rate wireless communication and high-resolution sensing. The subterahertz band offers a wide, unlicensed bandwidth that plays a critical role in the realization of the aforementioned applications. Considering that current commercial THz systems are costly and bulky, developing these systems in standard silicon technologies is vital to lower the cost. In this research, we propose a novel technique based on p-i-n diode reverse recovery to improve the power, bandwidth, and efficiency of the generated THz waves in silicon-based processes. Using the concept of reverse recovery, p-i-n diode-based pulse and CW radiators and receivers are designed that are utilized for spectroscopy, Doppler radar, and multi-Gb/s THz communication.



Davi V. Q. Rodrigues

School: Texas Tech University, United States.

Advisor: Prof. Changzhi Li.

Project topic: Toward beam-steering microwave topologies for passive sensing applications.

Davi V. Q. Rodrigues received his B.S. degree in communications engineering from the Military Institute of Engineering, Rio de Janeiro, Brazil, in 2017 and his M.S. degree in electrical engineering from Texas Tech University, Lubbock, Texas, United States, in 2021. He is currently pursuing a Ph.D. degree in electrical engineering at Texas Tech University. He is expected to graduate in August 2023. His research interests include microwave/mm-wave circuits and systems, wireless sensors for smart living and biomedical applications, and structural health monitoring based on Doppler radars. He is the recipient of the Best Student Paper Award of the 2020 IEEE MTT-S International Microwave Biomedical Conference.

Project Description

The goal of this research is to investigate, develop, and test novel beamforming microwave topologies for passive sensing applications that leverage current and next-generation Wi-Fi, Bluetooth, and WPT infrastructures to make the best use of RF radiations, spectrum, and wireless networks for ubiquitous smart homes, healthcare, and smart living. Most of the reported passive sensing systems that leverage Wi-Fi signals rely on complicated architectures for signal acquisition and processing. In this project, a passive sensing topology based on injection-locking technology will be developed to achieve robust detection of small amplitude motion (e.g., noncontact vital sign monitoring). On the other hand, three other low-complexity, low-cost, and compact microwave systems with no onboard RF oscillator will be designed for the remote recognition of large amplitude movements, such as hand gestures, physical activities, walking, and falling.

2022 Graduate Student Fellowship in Medical Applications Awardees

Behnam Arzhang

School: University of Manitoba, Canada.

Advisor: Prof. Gregory Bridges.

Project topic: Optical diffraction and dielectrophoretic analysis of cells using cytometer.

Behnam Arzhang received his B.Sc. degree (with honors) from the University of Shahre Kord, Shahre Kord, Iran, in 2010 and his first M.Sc. degree from the University of Tabriz, Tabriz, Iran, in 2012. He received his second M.Sc. degree from the Memorial University of Newfoundland, Canada, in 2019. He is currently pursuing a Ph.D. degree in electrical and computer engineering at the University of Manitoba, and he is expected to graduate in summer 2024. His recent research interests are focused on the design and development of a cytometer to analyze particles based on their dielectric properties.

Project Description

This project will examine the light-scattering properties of cells through a combination of theoretical simulations and experiments. A microfluidic channel will be used to measure the dielectric and optical properties of cells. The Mie theory technique will be used to compute the intensity of the scattering pattern of cells. The pattern will be used to generate optical data. Fluid dynamic simulation will be employed to trace particle trajectory in the channel. The height of the particle in the channel above electrodes can change based on its dielectric properties since the particle experiences the dielectrophoresis force in the microfluidic channel. The differential velocity of the incoming particle and outgoing particle can be used to define the height of the particle after electrodes in the channel or vice versa. Based on these changes, the dielectric properties of the cells' compartments can be determined.

Aditya Gupta

School: Technical University of Munich (TUM), Germany.

Advisor: Prof. Amelie Hagelauer.

Project topic: The design and implementation of energy-efficient mm-wave Tx architecture at 61 GHz in the 22-nm FDSOI fully depleted silicon-on-insulator (22FDSOI) CMOS process for the sub-mm localization of body-worn electromyography (EMG) sensor nodes.

Aditya Gupta received his B.Tech. degree in electronics and communications engineering from the Vellore Institute of Technology, India, in 2014 and his M.Sc. degree in communications engineering from TUM, Germany, in 2018. He worked as an analog/mixed-signal concept engineer in the automotive microcontrollers team at Infineon Technologies, Germany, between 2018 and 2020. He is currently pursuing a Ph.D. degree at TUM and is expected to graduate in 2025. His research interests include analog/mixed-signal and mm-wave integrated circuits design.

Project Description

In the field of medicine and psychology, the accurate analysis of physiological, behavioral states, and body functions is often required for efficient patient diagnosis and therapy. This requires both the muscle activity information and its precise location source. In this project, a 61-GHz mm-wave Tx chip is to be designed in the 22-nm FDSOI CMOS process for an extremely energy-efficient and localizable, noninvasive biomedical wireless EMG transponder. This facilitates a novel approach toward acquiring real-time surface EMG data while simultaneously achieving high-precision sub-mm accurate localization of the source muscle. The research task focuses primarily on the investigation, design, verification, and characterization of mixed-signal, energy-efficient mm-wavefront end and baseband circuits for the Tx to meet the low-power and carrier stability requirements of the transponder. In a further step, the Tx chip is to be integrated into an EMG sensor platform, which will be evaluated in a test series on probands, e.g., in the face or on legs, to analyze facial expressions and gait.

Deadlines for the 2023 IEEE MTT-S Graduate Student Fellowship Awards

In 2023, the MTT-S will sponsor up to 12 graduate fellowships in the general category and two graduate fellowships in the medical applications area. Travel supplement funds will again be available for the awardees to attend next year's IMS.

The MTT-S strongly encourages students in microwave and RF engineering to apply for the fellowships. As noted previously, the next application deadline is 15 October 2022. Please consult the detailed instructions for the graduate fellowship program at www.mtt.org/students.