PhD Position

Human exposure assessment at mmWave 5G frequencies: novel approach based on artificial electromagnetic skin

Research fields: millimeter waves, 5G and beyond, microwave modeling and systems, electromagnetic dosimetry, antennas and probes, tissue-equivalent models

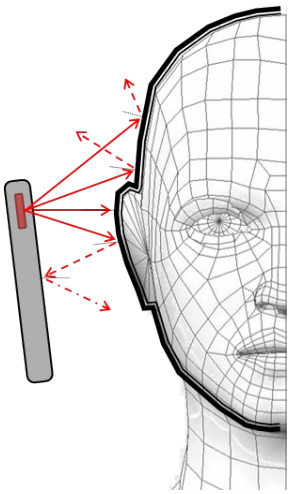
Research laboratory: IETR - Institut d'Electronique et des Technologies du Numérique (www.ietr.fr), UMR CNRS 6164, Rennes, France

Offer type: PhD position (36 months scholarship)

Hiring institution: University of Rennes

Application deadline: May 15, 2023

Expected starting date: October 01, 2023



PhD research project

Context

The growing need for low-latency and high-data-rate wireless communications leads to development of next generation heterogeneous cellular mobile networks. The sub-6GHz microwave spectrum does not allow to achieve the target performance indicators, thus pushing the wireless industry towards higher frequencies, including millimeter-wave (mmWave) bands. The deployment of the mmWave 5G networks has already started worldwide. In Europe, the goal is to have all metropolitan cities and major transport axes covered by 2025.

The systematic and continuous expansion of the 5G mobile networks will make human exposure to mmWave radiation ubiquitous worldwide. The use-case scenarios, where a mobile device is operating in vicinity of the human body (like phone call or browsing), involve bidirectional interaction of radiating devices with the human head and hand, both in terms of the body impact on the wireless device performance, as well as in terms of the user exposure. Under near-field exposure conditions, the strong interaction between the device (e.g. smartphone, tablet) and human may result in locally high exposure levels caused by localized absorption of the mmWave radiation.

Due to the upcoming mass deployment of 5G networks, the accurate assessment of user exposure constitutes a major public concern, as well as an obstacle for certification of emerging 5G mmWave devices. Because of the physical limitations, the conventional 3G/4G dosimetry and compliance testing techniques employed below 10 GHz cannot be directly scaled to higher frequencies. Currently, there is a strong need for new dosimetry techniques for accurate exposure control in realistic 5G use-case scenarios, taking into account the antenna / human body interaction.

Objectives

This PhD project will contribute to the development of a novel approach and advanced technology for realistic, fast, and accurate dosimetry and user exposure control at 5G/6G frequencies above 10 GHz, accounting for the impact of the antenna/human body interactions.

Work description

The PhD student will perform research on a conceptually new approach for user exposure assessment, addressing the fundamental challenges in terms of accurate, realistic, and fast dosimetry measurements at 5G frequencies above 10 GHz. The research tasks will include design, optimization and prototyping of a novel solid tissue-equivalent phantom (i.e. artificial electromagnetic skin) with electromagnetic (EM) scattering characteristics optimized for 5G dosimetry, overcoming intrinsic limitations of existing 3G/4G solutions. Different design principles (e.g. multi-layer frequency selective and metasurface structures) and potential of fabrication methods (e.g. molding and 3D printing) will be investigated. An array of EM sensors will be designed and integrated into the phantom. The system architecture will be optimized (lattice type and antenna array) to maximize the field measurement accuracy, sensitivity and spatial resolution, while minimizing the complexity of the system. The power density will be measured using the infrared imaging approach. The dosimetric quantities will be retrieved employing a multi-physics back-propagation method. Finally, the PhD student will contribute to building of a proof-of-concept prototype comprising 5G phantom structure with sensors, which will be integrated with a sensor-based robotic arm for manipulating a wireless device under test.

References

[1] A. R. Guraliuc, M. Zhadobov, O. De Sagazan, R. Sauleau. Solid phantom for body-centric propagation measurements at 60 GHz. *IEEE Transactions on Microwave Theory and Techniques*, 62(6), pp. 1373–1380, Mai 2014.

[2] A. Guraliuc, M. Zhadobov, R. Sauleau, L. Marnat, L. Dussopt. Near-field user exposure in forthcoming 5G scenarios in the 60-GHz band. *IEEE Transactions on Antennas and Propagation*, 65(12), pp. 6606–6615, Dec. 2017.

[3] M. Ziane, M. Zhadobov, R. Sauleau. High-resolution power density measurement technique in the near-field accounting for antenna/body coupling at millimeter waves. *IEEE Antennas and Wireless Propagation Letters*, 20(11), pp. 2151-2155, Nov. 2021.

Research environment

The PhD student will join Electromagnetic Waves in Complex Media (eWAVES, www.ietr.fr/eWAVES) research team of the IETR. Our research activities in biomedical electromagnetics cover a wide spectrum of fundamental and applied research spreading from multi-physics and multi-scale modeling to advanced technologies for body-centric wireless communications. The team was at the origin of pioneer innovations in biomedical electromagnetics, including the first mmWave tissue-equivalent phantoms, novel reflectivity-based surface phantom concept, new broadband multi-physics characterization technique for Debye-type materials, innovative mmWave textile antennas for smart clothing, and the first mmWave reverberation chamber. We have a broad network of EU and international collaborators. The PhD project will benefit from the advanced numerical methods and state-of-the-art equipment / measurement facilities of IETR (anechoic chamber up to 500 GHz, near-field characterization, high-resolution 3D printing, multi-physics dosimetry, etc.).

Candidate

We seek for engaged and motivated candidates with a MS or equivalent degree in electromagnetics, electrical engineering or electronics. The required skills and qualifications are:

- Strong background in electromagnetics, analytical/numerical modeling, and microwave engineering.
- Knowledge of numerical modeling and experience with commercial or open-source numerical solvers (e.g. COMSOL, CST, SIM4LIFE), programming skills (e.g. MATLAB).
- Knowledge about wireless communication and 5G technologies would be appreciated.
- Fluency in English (speaking and technical writing).

How to apply

Supervisors: Dr. Maxim ZHADOBOV, Dr. Artem BORISKIN, Dr. Massinissa ZIANE, Prof. Ronan SAULEAU.

To apply please send your CV, transcripts, motivation letter, and reference letters (optional) to:

⇒ Dr. Maxim ZHADOBOV, CNRS (maxim.zhadobov@univ-rennes.fr)

⇒ Prof. Ronan SAULEAU, University of Rennes (ronan.sauleau@univ-rennes.fr)