PhD offer

At IETR (Institut d'électronique et des technologies du numérique) UMR CNRS 6164
and IEMN (Institut d'électronique, de microélectronique et de nanotechnologie) UMR CNRS 8520, France

DIRECTIONAL POWER COMBINING IN PHOTODIODE-BASED PHOTONIC TRANSMITTERS ENABLED BY ANTENNA ARRAYS

Project context

To cope with the colossal increase in data traffic, very high-speed wired (optical fibers) and wireless technologies must be developed. As for wireless communications, it is mandatory to use high frequency carriers to reach the data rates of around 100 Gbits/s foreseen for future beyond 5G networks or "6G". This thesis will explore frequency windows in the sub-THz range (100 GHz -1 THz) to achieve such high data rates in real time [1].

The development of new components (such as UTC photodiodes) is essential to increase the power generated in the "THz gap" and, hence, to compensate for the high free-space propagation losses (FSPL) in sub-THz radio links. However, an effective use of sub-THz carriers in field wireless applications (communications beyond 5G, imaging, etc) requires that the generated signals be transmitted only in directions in which they will be received. To this end, narrow (very directional) and steerable beams must be generated over a sufficiently wide field of view. The two CNRS laboratories (IETR and IEMN) involved in this project will cooperate to study the integration of UTC photodiodes (IEMN) with wideband planar antenna arrays (IETR). The developed photo-mixing arrays will rely on a coherent combination of power and also enable beam-steering. Indeed, it will be possible to control the phase of each radiating element by "true time delay" and to radiate mainly in the desired direction.

Objectives of the PhD offer

The objective is the development of photonic antenna arrays whose level of performance will go beyond the current state of the art. Two complementary concepts will be explored:

- Photomixing antennas with photonic beam formers. We will explore scalable and compact network structures capable of providing conjugate matching over a wide frequency range. Some of these concepts have already been validated by simulation [2].
- Higher gain values will be obtained by combining these photomixing antennas with advanced focusing structures (e.g. lenses or transmitting gratings) [3].

The final goal will be to propose flat antenna architectures with high gain and controllable beam for high-speed communications (backhaul/fronthaul radio links).

[1] T. Nagatsuma, G. Ducournau, and C. Renaud, "Advances in terahertz communications accelerated by photonics," *Nature Photon* 10, 371–379 (2016).

[2] A. J. Pascual, L. E. García-Muñoz, R. Sauleau and D. González-Ovejero, "Unit-cell design for antenna arrays efficiently matched to uni-travelling-carrier photodiodes," *44th Int. Conf. Infrared Millimeter THz Waves*, Paris, France, 2019, pp. 1-2.

[3] A. J. Pascual, M. Ali, T. Batté, F. Ferrero, L. Brochier, O. de Sagazan, F. van Dijk, L. E. García Muñoz, G. Carpintero Del Barrio, R. Sauleau, and D. González-Ovejero, "Photonic-enabled beam switching mm-wave antenna array," *J. Lightwave Technol.*, vol. 40, no. 3, pp. 632-639, 1 Feb.1, 2022.

Work context

This thesis is part of the electronics PEPR (*Programmes et équipements prioritaires de recherche exploratoires*), which aims to structure the French community for applications spanning the next 10 years. In this context, it is almost established that the next "6G" will play a fundamental role in the near future.

This interdisciplinary project involves 2 CNRS laboratories:

1) IETR – UMR CNRS 6164, (www.ietr.fr), with experience on electromagnetics and antenna design.
2) IEMN – UMR CNRS 8520, (https://www.iemn.fr), with expertise on THz photonics and THz electronics.

This thesis aims at bringing closer together two communities: antennas and THz photonics. The PhD student will develop fast THz transmitters with high output power (IEMN) and exploit such devices for agile and efficient radiating elements (IETR). In addition, she/he will work on the manipulation of THz waves using beam-formers to control beams at the output of the antenna system). Finally, the doctoral student will contribute to antenna testing, transmitter measurement and global front-end characterization (IEMN-IETR).

Candidate

Required education level: Master or equivalent degree in electrical engineering, photonics or physics.
Duration: 36 months.
Required background: antenna theory, microwave engineering, microwave photonics, Terahertz radiation. Knowledge of French is not required.

Deadline to apply as soon as possible (no later than December 31, 2022).

Apply at https://emploi.cnrs.fr/Offres/Doctorant/UMR6164-DAVGON-007/Default.aspx?lang=EN
To apply please submit your motivation letter, CV, and recommendation letters (optional) using the link above.

Contact persons

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All the candidatures are evaluated. However, due to the large number of applications typically received, only the short-listed candidates will be contacted.