PhD Project Proposal

School of Electronics, Electrical Engineering and Computer Science

& ECIT Global Research Institute

Proposed Project Title: Reconfigurable Holographic Metasurface Antennas for Dynamic Beam Synthesis and Electronic Beam Steering Applications

Principal Supervisor: Dr. Okan Yurduseven **Second Supervisor:** Prof. Vincent Fusco

Project Description

Metamaterials are artificial, sub-wavelength structures enabling electromagnetic (EM) properties that might not be possible to achieve with natural materials. Planar structures that consist of an array of these elements (or meta-atoms) are known as metasurfaces. Using metasurfaces, the control of the antenna radiated wave-fronts is possible, making these structures an excellent candidate for beam-forming applications. Although phased arrays have traditionally been the solution to this challenge, they nevertheless exhibit some limitations, including the need for a phase shifting circuit for each antenna element within the synthesized composite antenna aperture and a power amplifier to compensate for the insertion loss of these circuits. As a result, phased array antennas can exhibit a complex hardware architecture and require a considerable amount of power.

Recently, the concept of holographic metasurface antenna has gained significant traction. Using holographic metasurfaces, beam-forming is achieved by leveraging a holographic reference-wave (or guided-mode), which is modulated by the metasurface layer into a desired aperture field that produces the radiation pattern of interest in the far-field. This simple yet extremely powerful concept does not require any phase shifting circuits to achieve beamforming and, therefore, can exhibit significantly simplified system architecture on the physical layer.

A common way of modulating the radiated wave-fronts is by synthesizing a discrete surface impedance, approximating a smooth and continuous impedance function. This method has been well reported in the literature with numerous metasurface antenna prototypes are now presented. Conventionally, this technique requires creating an impedance database by means of eigenmode simulations of a single meta-atom with varying dimensions. Creating the impedance database is a time-consuming and computationally expensive process.

This project will investigate dynamic beam-forming by directly interacting the array factor (AF) of the sub-wavelength sampled metasurface aperture and the holographic guided-mode reference-wave and rely on a polarizable dipole model for the meta-atoms building the metasurface. The goal of this project is to develop novel metasurface antenna solutions by employing an array of discontinuously varying meta-elements and simple, dynamic modulation schemes, such as binary (on/off) amplitude modulation, grayscale amplitude modulation and phase modulation. The proposed project constitutes a real scientific and technological advance compared to the actual state of art in reconfigurable antennas. The success of the project guarantees a real scientific advance for the Institute of Electronics, Communications and Information Technology, with applications ranging from wireless power transfer to communications and millimetre-wave (mmW) imaging.

Job Description

- High quality research and engineering design focusing on mmWave metasurface antenna systems for communications, wireless power transfer and imaging applications.
- Development of innovative holographic concepts for mmWave metasurface antennas and dynamic beam synthesis.
- Publishing and presenting results both at international conferences and in scientific journals.
- Working towards realizing a PhD in about 3 years.
- Participation in the framework of national and European academic institutions and industry.

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