UNC CHARLOTTE
The WILLIAM STATES LEE COLLEGE of ENGINEERING

UNC Charlotte – Lee College of Engineering Senior Design Program
Company Information

Company Name	*University of North Carolina at Charlotte*	**Date Submitted**	*05/11/2021*
Project Title	*Dynamically Steerable Metasurface Antennas Using Piezoelectric Actuators* **(UNCC_ECE_PI**	**Planned Starting Semester**	Fall 2021

Personnel

The table below provides an estimate of student's needs.

Discipline	Number	Discipline	Number
Mechanical		Electrical	2-4
Computer	1	Systems	
Other			

Company and Project Overview:

The project will be developed in the electromagnetic laboratory in the Electrical and Computer Engineering Department at the University of North Carolina at Charlotte under the supervision of the Principal Investigator (PI) Prof. Mario Junior Mencagli. The PI has an experience of about seven years on several aspects of wave-matter interaction related to metamaterials and

metasurfaces (MTSs). Among these aspects, emerging MTS antennas have represented one of the principal research interests of the PI. MTS antennas have witnessed remarkable development over the last few years. Key advantages they offer include their lightweight and ultra-thin form factor and ability to beam shape, provide multiple directive beams, and offer polarization control. However the current proposed project solutions do not offer any radiation pattern configurability, which is crucial capability for antennas compatible with future communication systems. In the propose project the students will investigate novel MTS antennas with beam steering capabilities under the supervision of the PI.

Project Requirements:

The objective of this project is to develop novel dynamically steerable antenna technology for mass-market interactive applications, including Internet of Things (IoT) and Machine to Machine (M2M) terminals. This project combines the emerging MTS antennas with piezoelectric actuators. The MTS-antenna operating principle is based on transforming a cylindrical (planar) surface wave, excited by a central (lateral) co-planar feed, into a radiative wave, called a leaky wave, through spatially modulated surface impedance. Tuning the spatial profile of such surface impedance enables steering the pointing angle.

This project investigates a novel type of MTSs that allows complete control of the space-varying

surface impedance providing beam steering capabilities. The proposed MTS consists of an array of metallic elements printed on a thin dielectric substrate placed over a ground plane. By tuning the distance between the substrate and the ground plane, the surface impedance spatial profile can be controlled, and as a result the antenna pointing angle can be steered. The tuning is achieved through a very few piezoelectric actuators supporting the ground plane, which allow a significant displacement under a DC bias. Prototypes of the proposed steerable antenna technology will be manufactured and tested using Additive Manufacturing techniques.

Students will compare theoretical and experimental data related to the performance of the designed antenna (gain, directivity, and efficiency), by simulating the chosen design parameters, manufacturing, and testing the MTS antenna. A verification testing protocol will need to be developed and implemented to ensure the desired operation of the antenna.

Expected Deliverables/Results:

- Design methodology of MTS antennas with piezoelectric actuators;
- Full wave simulations using commercial software (Ansys HFSS, Comsol) of the antenna system;
- Realization of the design MTS antenna with various 3D printing materials;
- Comparison of numerical and experimental results.

Disposition of Deliverables at the End of the Project:

- Present the findings at top-notch conferences on engineering (Eur. Conf. Antennas Propaga., Eur. Microw. Conf., IEEE Int. Microw. Symp., IEEE Int. Antennas Propaga.).
- The foreseen scientific results from this collaboration have the potential of leading to publication in Word-class high impact journals such as IEEE Trans. Antennas Propag., and IEEE Trans. Microw. Theory Tech.
- Deliver working modulated MTS antenna at Expo.

List here any specific skills, requirements, specific courses, knowledge needed or suggested:

- Interest in conducting research on electromagnetic MTSs related to radiative systems;
- Suggested Pre/Co-Requisites.: ECGR 3121 Intro to Electromagnetic Fields, ECGR 3122 Electromagnetic Waves, ECGR 4121 Antennas, and ECGR 4090 Metamaterials and Metasurfaces.