Executive Summary

Debatosh Guha
Professor, Institute of Radio Physics and Electronics, University of Calcutta, 92, A P C Road, Kolkata-700094

1. Title of the Project: **Development of Metasurface Enabled Multifunction Antennas for Medical and 5G Applications**

2. Date of Start of the Project: **February 01, 2020**

3. Aims and Objectives: The work basically aims development of unconventional surface geometries for printed antenna structures which would behave as metasurface, i.e., with unconventional surface impedance. This would help in achieving several advantageous features which are indeed well-known long-standing challenges. They are basically for advanced communication front-ends including those required for the 5G systems. The primary novelty is focused to use the limited available area onboard in view of portable hardware management. The objective revolves around introduction of suitable geometry such that it results in better impedance value for each surface. The objective of this project also includes developments of scientific basis of the designs based on thorough physical insight which would help in extending as well as translation of the technology to industrial applications.

4. Significant achievements (not more than 500 words to include List of patents, publications, prototype, deployment etc.)

The work has been targeted towards (i) generating new technological concepts and insights; and (ii) applying to 5G communications. The results obtained focusing to (i) have been published in IEEE Transactions and Letters through 3 technical articles. The subsequent developments have already been planned and are under progress.

Significant results:
(i) Metasurface based antenna design:
This work addresses a practical issue of excess backside radiation from the DGS (defected ground structure) integrated microstrip antennas, commonly used in 5G massive MIMO. This is applicable in both sub-6 and millimeter wave domains. Defects or slots on ground plane (GP) suppresses H-plane

XP fields. These strategic slots cause leakage of XP fields towards backside of the antenna. This work, for the first time, explores the physical insight behind this phenomenon with an aim to find a solution. Engineering on the backside of the GP has been conceived and systematically developed in the form of a metasurface

(ii) Metallodielectric boundary condition conceived for new antenna design:
Microstrip antenna and arrays are widely applicable in most of the communication domains including 5G and medical applications. Such geometries have been suffering from an inherent issue like its cross-polarized radiations, the source being identified as a weakly coupled higher order mode namely TM_{02}. Discrimination of this said mode by minimally tampering the boundary condition of the element has been addressed in this work. The magnetic wall across each non-radiating edge has been transformed into a composite boundary. Metallodielectric configuration has been successfully conceived and employed.

(iii) Novel Subarray for 5G Massive MIMO applications:
In the new era of 5G wireless communications, the antenna engineers have been exploring newer antenna units for realizing massive MIMO. High compactness along with simpler feed networks and high gain are the main targets.
Keeping this in view a compact subarray using hybrid metal-dielectric combination has been explored. A pair of dielectric resonator antennas (DRAs) are fed with identical phase and polarization by a resonant microstrip patch sharing a common grounded substrate. The elegance of the structure is to maintain the resonance features of the individual patch and DRA elements resulting in a large radiating aperture and improved gain. The new idea has been tested using the available facility in C-band. It promises 9.5-12.5 dBi gain indicating 5 dB improvement on average compared to that of the individual elements. Accurate deployment required for effective feeding of the DRAs in the subarray and the subarray side-lobe-level dependence on its aperture fields has been discussed. A comprehensive design guideline has been presented to enable one in accurately designing it in any specified frequency within the given limit.

List of publications:
[1] C. Kumar and D. Guha, "Higher Mode Discrimination in a Rectangular Patch: New Insight Leading to Improved Design with Consistently Low Cross-Polar Radiations," ***IEEE Transactions on Antennas and Propagation***, vol. 69, no. 2, pp. 708-714, Feb. 2021, doi: 10.1109/TAP.2020.3016506.

[2] C. Kumar and D. Guha, "Mitigating Backside Radiation Issues of Defected Ground Structure Integrated Microstrip Patches," ***IEEE Antennas and Wireless Propagation Letters***, vol. 19, no. 12, pp. 2502-2506, Dec. 2020, doi: 10.1109/LAWP.2020.3037219.

[3] C. Sarkar, D. Guha and C. Kumar, "Hybrid Subarray Using a New Concept of Feed for Advanced Antenna and Array Designs," ***IEEE Transactions on Antennas and Propagation***, Dec. 2020, doi: 10.1109/TAP.2020.3044671.

5. Concluding remarks:
We have satisfactorily progressed to meet our objectives partially and we sincerely thank INAE and DST for extending their support through Abdul Kalam Technology Innovation National fellowship.