2025 START Program
CFP Brief

THEME: **01. Wireless Communication**

SUB-THEME: **1.3. Antenna miniaturization using non-classical technologies for drastic improvement in antenna efficiencies**

Context/ Overview

Wireless sensing and communication at RF frequencies is inherently limited by size of the antenna modules. With introduction of new communication bands like 6G, the already crowded hardware infrastructure in hand-held devices is facing additional pressure to incorporate the new antenna bands. Similarly, in wearable devices, the wireless communication capability is limited to inclusion of only Bluetooth and/or Wi-Fi protocols due to additional size limitation of wearables. Yet another upcoming avenue focuses on development of IoT technologies to support next generation of connected devices. To have truly wireless capabilities in small IoT tags, wearables, AR and additional communication protocols in hand-held devices, it is essential to develop miniature antenna solutions.

Problem Statement

Antenna efficiency depends primarily on the antenna size. As the antennas get smaller, the Wheeler-Chu-Harrington limit dictates the efficiency ε as ~ $A/\lambda2$, where $A \ll \lambda2$ [1]. The current antennas in handheld devices, which are close to $0.25\lambda - 0.3\lambda$, tend to have much larger efficiencies than the small antennas, but also occupy more space. If these conventional antennas can be replaced by such infinitesimally small antennas without sacrificing the efficiency, it opens a lot of avenues for device miniaturization and inclusion of extra sensing and communication capabilities. Examples of additional capabilities can include introducing MIMO and beamforming in terminal antennas at FR1 and new 6G FR3 bands similar to the capabilities currently existing for mmWave 5G FR2 bands, having sub 1cmx1cm ambient energy harvesting IoT Tags, direct communication capabilities in wearable devices etc.

Objectives & Scope

The key objective is to explore novel technologies that go beyond classical approach to design antennas. These can include use of acoustic devices to shrink the size by multiple orders of magnitude by relying on wavelength of acoustic waves being much shorter than electromagnetic waves at same resonant frequency. Approaches that explore use of new materials and technologies like magnetic thin-films to introduce spin waves are also encouraged. The eventual goal is to develop a working prototype of a new miniaturized antenna and compare it with conventional state-of-the art antennas to show improvement in size, efficiency, beam directionality, polarization control and development of array of devices to demonstrate beamforming.

Specific Topics & focus areas*

Three main focus areas are identified to achieve the above objectives

1. **Antenna development using non-classical methods**
   Antenna operating at FR1/RF3 and/or Bluetooth bands occupying 10 times smaller size than standard antenna solution with maintaining similar efficiency and gain. Compare with standard antennas used in current commercial hand-held, wearable devices or AR and show improvement in one or more areas of antenna performance, like size, gain, cross-pol isolation, efficiency, mutual coupling etc.

Methods to tune antenna operating frequency to other bands like 900 MHz, 5 GHz, 6-8 GHz should also be developed and shown to identify use at different operating bands.

2. **Multiple polarizations**

   Developing antennas capable of supporting multiple polarizations using the same element, or showing different polarizations by arranging individual antennas units with single polarizations adjacent to each other.

3. **Array excitation**

   Develop arrays on miniaturized individual antenna units and demonstrate innovating feeding methods to be able to beamform with the antenna array or use the antenna in a MIMO configuration.

※ The topics are not limited to the above examples and the participants are encouraged to propose other original ideas.

References (optional)

[1] Pfeiffer, C., "Fundamental efficiency limits for small metallic antennas", IEEE Trans. Antennas Propag., vol. 65, 1642-1650 (2017)

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