Theme: 6G communication systems

- Sub Theme: Physical layer and hardware component innovation for upper mmWave and THz technology.

It is inspiring to note that the Federal Communications Commission (FCC) opened the spectrum between 95 GHz and 3,000 GHz for experimental use and unlicensed applications, to encourage the development of new wireless communication technologies. Moreover, the discussions on use cases and deployment scenarios for 5G NR systems operating beyond 52.6 GHz bands have already begun, to be included in 3GPP Release 16. Following this trend, it is inevitable to utilize the terahertz (THz) bands (0.1 to 10 THz) for future wireless systems. In these bands, an enormous amount of bandwidth is available, which can facilitate Tbps speeds in the future 6G systems.

However, to realize stable THz communications in practice, several challenges need to be addressed. We are seeking innovative solutions to enable the use of upper mmWave and THz communications, and which falls under one of the following major topics:

1) Waveform design and Beamforming algorithms and architecture.
   a. Waveform design which supports GHz-wide channels with low overhead and enables high-spectral efficiency. At the same time, it is adapted to mitigate some of the hardware limitations (e.g., low PAPR, susceptibility to phase-noise).
   b. Novel techniques to achieve MIMO order > 2 at THz frequencies in a near LoS environment. THz links are expected to be mainly dominated by LoS or reflected paths. Such near LoS links will not have sufficient multipath to allow high order MIMO such as order of 8 and above. Some prototypes based on LoS MIMO and OAM were developed in recent years for backhaul
links, however, these technologies require large spacing between the antennas and are unsuitable for a handheld mobile UE form factor. Therefore, new approaches need to be identified that are suitable for mobile devices with small form factor.

c. Beamforming algorithms and methods in light of adding THz hardware limitations, or introducing intelligent reflective surfaces (see topic 2) in the system.

2) Antenna and lenses design

a. Design of wide-band (and multi-band) antenna arrays. It is important to utilize the vast spectrum available in upper mmWave and THz and claim the advantage of Tbps communications in small form factor devices.
b. Design of feasible intelligent reflective surfaces. These surfaces are expected to play an important role in improving the system capacity at THz, as they can manipulate the direction-of-propagation and polarization among other signal parameters to improve the channels between transmitters and receivers.
c. Novel antenna solutions that can generate high gain with wide beam steering capability. Lens or reflector antenna can generate high gain but there is a limitation of beam steering angle. Phase array can support beam steering but large number of array (and RF chain) is needed to generate high gain.

3) RFIC and photonics

a. Entering THz arena, one of the fundamental changes is how to overcome large free space path loss which is proportional to the square of the frequency. Based on Friis’ formula, antenna aperture holds the key to increase the EIRP. Therefore, 2D beamforming antenna array is a must to have feature for THz applications. However, a fundamental physics challenge is that above 100GHz, existing RFIC physical sizes exceed $\lambda/2$, which makes it impossible to implement a 2D beamforming antenna array. We are looking for Antenna-electronics co-designs architecture THz front-end technologies which break this physical barrier. Solicited proposals
include, but not limited to, novel packaging technology for efficient wireless power transfer between THz antennas and RFICs, antenna-electronics co-design for high dynamic range D-band receivers with noise cancelation and for high power back off efficiency transmitters. The solutions also need to be low profile, small form factor, low cost and easy to manufacture at large volume.

b. Electronics and photonics devices for THz communications. Some initiatives in photonics managed to reduce LO phase-noise significantly, also photonics-based transmit devices are more mature than electronics in covering 1-10THz. We are looking for solutions which push the boundaries of electronics into the THz region, reduce the cost of photonics, or integrate electronics and photonics devices into single package or even a single IC.

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

※ Funding: Up to USD $150,000 per year