Low Power Millimeter Wave Beamforming Transceiver System using On-Site Coding

Elias A. Alwan, Nima Ghalichechian, and John L. Volakis
Electroscience Laboratory, ECE Department,
The Ohio State University, Columbus, Ohio, 43212,
Email: alwan.2@osu.edu

Future cellular data traffic is likely to grow 40-70% annually in the foreseeable future, implying more than 1000 times growth in wireless communications and data transfers. However, as existing cellular bands are already crowded, it is necessary to explore other bands, and more specifically, the millimeter-wave (mm-wave) band. To do so, technical challenges must be overcome. For instance, signal propagation at mm-wave frequencies is impaired by severe pathloss and shadowing. Transmit and receive beamforming with many (e.g., $\geq$32) antennas per terminal is a natural approach to overcoming this pathloss. That is, a highly directive antenna array will significantly improve the signal-to-noise ratio (SNR) to increase channel capacity. Likewise, high gain antennas will improve the spatial diversity by rejecting interference from unwanted beam directions. Therefore, as phased array antennas are capable of electronic beam steering, they are suited for future mm-wave communication systems, including 5G.

In this paper we present a complete mm-wave transceiver that enables access to the mm-wave spectrum, and therefore provides 200$\times$ more bandwidth. To do so, we propose a novel ultra-wideband tightly coupled dipole array that incorporates suitable balanced feeds. The antenna array performance is nearly optimal and has been demonstrated at Ku-band. Scanning down to 60° has also been demonstrated across a continuous 6:1 impedance bandwidth for up to 18GHz [Novak et al., IEEE AWPL, 2013]. Based on these previous efforts, we anticipate to successfully implement the proposed architecture to achieve low-loss and wideband performance in the E-band.

In addition, we present a novel beamformer architecture that channelizes all antenna array signals into a single analog-to-digital (ADC)/digital-to-analog (DAC) converter without loss of signal path identity and association with the source antenna element. This is done by introducing a novel on-site code division multiplexing (OS-CDM) technique [Alwan et al., Springer Analog Integrated Circuits and Signal Processing , 2013]. Reduction of the ADCs and DACs by a factor of 10 or more, implies dramatic power and back-end circuitry reduction, making such mm-wave transceivers practical for cellular applications.