Low Cost Power Efficient Beamformer with Element-to-Element Mixing (BEEM)

Rimon Hokayem*, John L. Volakis, and Elias A. Alwan
Department of Electrical and Computer Engineering,
Florida International University, Miami, FL, 33174

Future 5G communications links are expected to support data rates 50 times over the current 4G LTE networks. The enabling infrastructure are Radio Frequency (RF) front-ends that can handle this data increase using wideband, but also very small in size, weight, and low power (SWAP) components. As such, there is a growing interest for reduced size ultra-wideband (UWB) apertures and platforms to address multi-functionality and security. Specifically, we are interested in wideband beamforming arrays for concurrent execution of several tasks, such as communication, sensing, navigation, and mapping.

So far, communication links have primarily focused on narrowband, single-user, and single-beam interfaces. Furthermore, traditional beamformers are analog and have been mostly suited for narrowband or multiband operation with inherently high-power requirements. For UWB operation, these analog beamformers are not suited for small platforms since they require high complexity hardware and are bulky. As is the case with all UWB arrays, it is necessary to achieve low cost and low power beamforming. Hence, beamforming must be frequency independent.

In this project, we introduce a novel RF front-end with frequency independent and autonomous beamforming topology for 5G and millimeter-wave (mm-wave) technologies. The design exploits the process of indirectly mixing the signal from each array element to cancel out phase delays in a frequency independent manner and for any angle of arrival (AoA). That is, the proposed beamformer is based on element-to-element mixing (BEEM) to achieve maximum diversity and enhance receiver’s sensitivity. The proposed BEEM topology removes bulky phase shifters and local oscillators, implying substantial reduction in size, power, and cost as compared to other beamformers.

In this paper, we will present detailed evaluation of the proposed BEEM topology. More specifically, we examine the impact of element-to-element mixing on phase noise and overall antenna array gain. To do so, an incoming signal with 16-quadrature amplitude modulation (16-QAM) is considered in presence of additive white Gaussian noise. Simulations are also conducted using 8 array elements. Preliminary results show that the near theoretical 9dB gain for the 8-element array can be achieved using our system. That is, this architecture accomplishes coherence in signal combining for enhanced signal reception. More details about the BEEM topology and transceiver system analysis will be presented at the conference.