Ultra-Wideband Arrays with Low Cost Beamforming Back-Ends

John L. Volakis
ElectroScience Laboratory, Department of Electrical and Computer Engineering
The Ohio State University, Columbus, OH
volakis.1@osu.edu

Future communication links will require higher data rates, multiple beams, and higher transmit/receive gains, in addition to smaller weight, cost, and power. With the growing interest for reduced size platforms and the requirement for ultra-wideband (UWB) performance to address multi-functionality, there is a strong need for UWB apertures to enable increased spectral efficiency, multi-functionality and security, there is a strong need for small UWB apertures, particularly at millimeter wave frequencies. Such apertures enable increased spectral efficiency, spatial multiplexing, concurrent beams at different frequencies. Furthermore, UWB arrays offer high data rates and allow for secure communication using long codes that spread across the bandwidth. An added feature will be the capability for simultaneous transmit and receive (STAR) applications.

In addition to challenges in designing small size UWB arrays, traditional antenna arrays are associated with complex electronic back-end that are typically associated with large power requirements. For UWB arrays, beamforming should also be frequency independent. However, to date, there is no technology for low power and small form factor wideband beamforming. In fact, traditional beamformers are mostly suited for narrowband or multiband operation with inherently high power requirements.

With the above in mind, this presentation introduces new concepts in beamforming concepts that overcome the aforementioned complexity and large power requirements. Among several low-cost and low-overhead UWB beanformers, we will introduce a digital beamformer that overcomes on-site code division multiplexing (OS-CDM). The latter uses coding to combine many array element signals into a single ADC. Notably, for a 64-element array, this OS-CDM approach lead to at least 60% cost and 68% power reduction, respectively, when only 8 elements are grouped together. Further, back-end wiring/pins are reduced significantly as all data processing is pushed to the processing unit. We have already demonstrated the effectiveness of the OS-CDM concept by building and testing multi-channel receivers using commercial-off-the-shelf components. Various test bench measurements were performed in an anechoic chamber using an UWB antenna array operating from 200MHz-2.5GHz for multi-beam tracking at multiple frequencies. We will also demonstrate beamforming at millimeter wave frequencies using a single aperture that operates from 25-75GHz, and even up to 90GHz. Our results verified that on-site coding has minimal or no degradation in SNR. Further, since OS-CDM is implemented at baseband, it can be easily integrated in millimeter waves transceivers.

In summary, this presentation reviews traditional beamforming approaches, and presents innovative methods for handling UWB communications. We anticipate that a combination of UWB array with OS-CDM coding and autonomous beamforming mechanisms will lead to game-changing frequency-independent down-conversion, beam steering and MIMO across large bandwidths, from MHz to millimeter wave bands. At the conference, we will discuss system evaluation and performance of these concepts using simulations and model measurements.