Experimental Validation of Digital Beamformer Performance with Ultra-Wideband Antenna Arrays using On-Site Coding

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Many applications require high speed communication system with a single multi-functional front-end (transceiver) integrated to an ultra-wideband (UWB) aperture. Also, for realizing cognitive and software defined radio, UWB systems with digital beamforming are essential. However, there are several restrictions imposed on such systems; starting with a wideband feed network, the ability to scan down to low angles over the entire bandwidth, and building a scalable and power-efficient digital back-end for data processing. Nonetheless, advancements in digital technology and signal processing have reduced the complexity of digital beamformers.

Recently, a novel On-Site Coding Receiver (OSCR) architecture was proposed to significantly reduce the intense hardware requirement for digital beamforming [Alwan et al., IEEE APS, 2013]. OSCR was implemented by coding each antenna signal using code division multiplexing (CDM) technique. Highly orthogonal Walsh Hadamard codes were employed for coding prior to combining them for digitization. Specifically, a single ADC was employed for a group of array elements instead of having one ADC per element. At the digital back-end, full signal recovery was done by decoding with the same codes but in digital form. FPGA was used to decorrelate and recover the signals associated with each array element for beamforming. That is, it was analytically shown that OSCR reduced the number of ADCs and I/O channels by nearly a factor of 10. Hence, the size, weight, area, power and cost of the system was significantly reduced with minimal impact on receiver signal-to-noise ratio (SNR) and phase error.

At the conference, we will show four-channel OSCR system built using COTS components and in-house fabricated PCBs. Various measurements were performed in-situ and at the anechoic chamber using an UWB array to evaluate OSCR's impact on the performance. In this paper, the estimated angle of arrival obtained from measurements in the chamber will be presented (at $\theta_S = 0^0, 15^0, 30^0$ and 45^0). The goal of this experiment was to evaluate errors associated with the OSCR approach. Coherent signal combining at the digital domain for improving the SNR and signal recovery will also be addressed along with impact on performance.