Millimeter-Wave Beamforming Receiver Fabrication Challenges

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To match the rapid growth of mobile data traffic, 5^{th} (5G) and 6^{th} (6G) generation wireless systems will rely on millimeter-wave (mm-Wave) frequencies, exploiting the large contiguous bandwidth in these bands. A challenge is to overcome the large mm-wave losses, implying digital beamforming across large bandwidths. Beamforming will provide for the needed gain to deliver high data rate wiht low latency and fewer errors. Concurrently, a significant reduction in size, weight, power and cost (SWaP-C) are critical requirements for the 5G/6G multichannel wireless systems by employing antenna arrays.

Towards this, a novel receiver architecture using code division multiplexing technique is presented. This architecture is referred to as On-Site Coding Receiver (OSCR) and employs spreading codes to significantly reduce analog and digital baseband hardware costs and power requirements by almost 96%. An 8-channel OSCR was simulated and fabricated to demonstrate the OSCR beamformer benefits. The circuit schematic and layout was generated using a commercial PCB design software, and the OSCR boards design required of routing digital and RF signals with bias lines for active components. To do so, the board was fabricated using 6-layers, providing rigidity to the structure and routing ease. Thru vias were placed throughout the board to ensure proper grounding and avoid shorting and substrate losses.

In carrying out the design and fabrication, the major design challenges were: 1) maintaining consistency and symmetry in the signal traces, 2) thickness and spacing between the trace lengths, and 3) ensuring proper charaterisitic impedance along the traces. The code traces were realized as differential pairs to maintain signal integrity and desired impedance. It was also ensured that the RF signals at the OSCR inputs were to have the same trace lengths and thickness as they directly affect propagation delay between the channels. It is crucial for all 8-encoded signals to reach the digital-end with the latency for decoding without errors. After decoding and all 8-traces were then combined to a single output for the digital end for phase assignment and beamforming. At the conference, we will present the design, fabrication and measurement of the mm-Wave based 8-channel OSCR system.