Millimeter-Wave RF Front-ends For 5G Applications

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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 support this data increase are wideband, adaptable, very small in size and weight, and of low power (SWAP). As such, there is a growing interest for reduced size ultra-wideband apertures and platforms to address multi-functionality and security. Furthermore, ultra-wideband (UWB) arrays offer high data rates and enables operations across large bandwidths. Also, beamforming allows for versatility and concurrent execution of several tasks, such as communication, sensing, navigation, and mapping. Undoubtedly, increasing bandwidth and spatial diversity antenna systems will lead the way for future 5G systems. However, due to increased consumer demand, additional but discontinuous frequency bands are likely to be allocated for commercial use. As a result, only a small percentage of the RF spectrum will be assigned to US departments and agencies, contributing to an increasingly fragmented and congested spectrum. This necessitates the migration to the relatively unused bandwidth available in the millimeter-wave (mm-wave) regime (30-300 GHz).

So far, communication links have been focused on narrowband, single-user, and single-beam interfaces. This is because technology for low power wideband beamforming is still nonexistent. In fact, 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.

To address the above requirements, we present a novel UWB RF front-end with autonomous beamforming for massive MIMO applications in the mm-wave bands. Our architecture brings forward the following innovations, including: (a) UWB mm-wave aperture fabricated via standard, low cost, Printed Circuit Board (PCB) techniques, co-integrated with a wideband feeding netowrk, (b) a new concept for frequency independent beamforming to eliminate bulky RF components, and (c) hardware and power reduction using a novel on-site code division multiplexing (OS-CDM) of antenna element signals. The latter has been shown to substantially reduce the costly and power-hungry analog-to-digital converters (ADC) needed for digital beamforming by $> 80\%$ as compared to traditional digital beamforming (Alwan et al., IEEE Access, 2014). Indeed, this hybrid beamforming approach promises game-changing performance for a new class of hardware-reduced, low cost, and power efficient transceivers. In the conference, we will present a proof-of-concept of our system to demonstrate 1) beamforming/scanning, 2) multi-user capability, 3) interference rejection, and 4) coding gain.