mmWave 5G Phased-arrays with Switchable Pattern and Polarization for Future Smartphones

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Millimeter-wave (mmWave) wireless communication is been one of the most scrutinized topics future 5G applications. Coupled with the recent introduction of 60 GHz based IEEE 802.11ad standard, significant strides have been across the digital, semiconductor and electromagnetics domain made by research institutions and industry in realizing low-latency, energy-efficient wireless networking featuring Gbps data throughput at mass-scale. The combined efforts have continued to trigger new areas of applications such as backhaul and access as well as device-to-device (D2D) links in the field of telecommunication infrastructure and consumer electronics. However, despite numerous research breakthroughs, the implementation of mmWave wireless transceivers within user equipment (UE) such as smartphones and other forms of cellular handsets remains an extremely allusive task. Considering the proliferation of smartphones in recent times, a true mmWave ecosystem remains incomplete at present. Transmitting and receiving mmWave radio signals in an efficient and economic manner via cellular handsets poses a number of extremely challenging technical hurdles.

In contrast to other wireless terminals such as laptops, setup boxes or access points, it is practically impossible to predict the position and orientation of a 5G cellular handset during the event of wireless transmission and reception. Collectively speaking, we can conclude that mmWave transceivers within 5G cellular handsets will lack a priori propagation channel knowledge despite requiring to be very robust due to channel variations. Conventional planar phased-array structures are inherently limited to hemispherical beam scanning range which will likely result in unexpected link disconnections. The effect of wave polarizations is another important factor that will contribute in the form of polarization mismatch loss factor in the wireless link budget. The selected polarization strategy affects the mmWave radio architecture and the link margin when rotational (φ,θ) alignment between the transmitter and receiver varies.

This paper demonstrates a mmWave phased-array antenna topology with switchable pattern and polarization which is integrated into a fully operating smartphone. The phased-array consisting of sixteen endfire antenna elements featuring subwavelength vertical profile and fan-beam radiation patterns are designed and integrated with the rest of the mmWave 5G radio. The advantages of combining a switched antenna beam configuration with the phased-array are experimentally investigated and evaluated using 5G system benchmarks such as data throughput as a function of antenna configuration to deduce the most effective 5G antenna configuration for future smartphones.