Antenna Design Considerations for 5G Millimeter-Wave Cellular Communications

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As the shortage of frequency spectrum limit the data capacity in cellular networks, the millimeter-wave (mmWave) frequency band has been considered as a possible candidate for 5G communication. Although the use of mmWave frequency bands introduces severe path loss between the transceivers, its larger bandwidth enables users to experience several Gbps mobile data rates with can be used for real time 4K video streaming, virtual and augmented reality, etc.

To overcome the significant path loss in mmWave bands, array antennas are used to improve the overall link budget. The improvement in link budget is higher when larger number of antenna elements are used in the antenna array which in turn require larger design area inside the handset. However, the possible design area of mmWave antenna is limited by other parameters of the handset like battery capacity, design, and rigidity. Achieving higher gain in the limited space is one of the main difficulties in mmWave antenna design

Another design considerations for mmWave antenna is the effect of the phone case. The mmWave antenna is surrounded by the phone case which affects the return loss and the radiation pattern of the antenna (W. Hong et al., IEEE Trans. Antennas Propag., 65, 6250-6261, 2017). As various materials like plastic, glass, metal, etc. may be adapted for the phone case, intensive studies on the phone case effects on the mmWave antenna are needed. Based on these study, the frequency detuning effects caused by the relative permittivity of the phone case must be included in antenna design and also the antenna surrounding structure needs to be optimized in order to enhance the antenna performance in integrated environment.

The metallic components around the mmWave antenna also have significant effects on the radiation pattern of the antenna. In comparison to the frequency spectrum below 3 GHz where the handset antennas usually have dipole-like radiations patterns, the use of mmWave spectrum in handset may have shadow regions because the mmWave antennas partially surrounded by metallic components e. g. display panel, phone case, etc. As the mmWave propagation has strong LOS components, it is susceptible to blockage which causes network reliability degradation. To reduce the shadow regions, the mmWave antenna module can be placed away from the metallic components thereby increasing spherical coverage of the handset.

Achieving dual-polarized antenna is also an important design goal because 5G mmWave system can realize MIMO system with polarization diversity. To achieve highly efficient mmWave dual polarized antenna, the antenna position should be determined considering the effects of the surrounding components. When the antenna is not placed in an optimal location, the polarization purity will decrease. As a results, it will increase the coupling between antenna ports and decrease the data throughput of the network.