

Increasing Channel Capacity of Linear Array Systems with Traveling Wave Polarized Antennas

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Multiple Input Multiple Output (MIMO) antenna systems have received considerable interest due to their ability to support increased channel capacity in rich multi-path scattering environment. Recently it was proposed that the use of tri-polarized antennas can lead to a potentially three-fold increase in capacity (M. R. Andrews, *Nature*, **409**, 316-318, Jan, 2001). These tri-polarized antennas consist of multiple co-located elements which respond to different components of the incident electromagnetic field and can be employed to achieve the same effect as that of traditional MIMO systems which have spatially separated antennas.

Linear array antennas are very versatile and find a variety of applications in beam-forming and direction-of-arrival estimation. On the other hand, traveling wave antennas provide a broad-band response. In this paper, we combine the two concepts to study the benefits that tri-polarized traveling wave antennas can provide when used in linear array configuration as compared to analogous uni-polarized arrays. First, a general expression is derived for the electric-field generated by a linear array of tri-polarized traveling wave antennas in the far-field region. Then we introduce the concept of degrees of freedom and develop the tools which are used to analyze traveling wave antennas. We show that under certain conditions tri-polarized traveling wave antennas can offer a three-fold increase in the degrees of freedom when used in linear arrays as compared to an equivalent array of uni-polarized antennas only. This increase in the degrees of freedom implies the existence of three orthogonal channels under suitable scattering conditions which can be exploited to potentially lead to increase capacity at high signal-to-noise (SNR) ratio.

We then evaluate channel capacity using well known channel models in NLOS (Non-Line Of Sight) scenarios. We obtain a consistent increase in channel capacity for different number of tri-polarized antennas and array lengths. The theoretical calculation of degrees of freedom as well as channel simulations indicate that increase in capacity is possible by using tri-polarized traveling wave antennas in linear systems. Fabrication of the traveling wave antenna arrays is underway to perform channel measurements and verify if the capacity increase can be realized in practice.