Exploiting Polarization diversity in Massive MIMO systems using Hyper-Complex Variables

ABSTRACT:

Space time coding has been combined with other diversity schemes, i.e. polarisation, to achieve increased diversity gains. Also, designing codes with higher code rates has been a desired aim but the complexity of the receiver has always limited this freedom. Higher code rates result in greater computational complexity of the receiver by limiting it to coupled decoding. Future of wireless communication systems lies in integration of diverse technologies to support multitudes of applications and optimise the performance of the underlying communication model. 5G aims to promise higher bandwidth, data rates, coverage, efficiency in terms of cost and energy with reduced latency. The efficient design techniques of space time block codes \((STBCs)\) has shown supportive results in providing better diversity gains. This has been a motivation behind the studies and investigation of the quaternion algebra to support the design of codes with higher code rates aiming at linear and decoupled decoders at the receiving side. Quaternion orthogonal designs \((QODs)\) have been proposed where they have been derived mostly from their complex domain orthogonal codes. This surely has provided an insight into the benefits of using QODs to achieve higher code rates but the main motivation has remained the use of dual-polarised antennas that are designed using two orthogonal polarizations. There are effects of cross polarization across the orthogonal polarization of the dual-polarised antennas that are measured and balanced through adjustment of the cross polar discrimination. The real essence of adding the polarisation diversity to the coding designs still remained unexplored.

Our research will address this research gap and present a thorough analysis of using higher dimensional variables not only to achieve efficient code designs with higher code rates but also investigate mechanisms to optimize the receiver design. Based on these aims, this research has two major focuses. First has been the impact of using quaternion designs with dual-polarised antennas that consist of two independent polarizations coupled together to support data streams that are orthogonal to each other. The underlying channel between the dual-polarized transmit and receive antennas is studied when the pure QODs are transmitted. These QODs provide promising diversity gains and shows comparative code rates similar to the state-of-the-art Alamouti codes. This has been done not only to design codes with higher code rates but also to exploit the polarization diversity independently. Secondly, this research work will target the simplification and computational efficiency of the receivers by aiming for linear and decoupled decoders. The use of quaternion codes support decoupled decoding at the receiver that improves the computational efficiency drastically. As an application of this work, quaternionic channel-based modulation has been discussed that fully exploits the polarization diversity without considerable limitations on the transmit and receiver dimensions. The design of wireless communication systems using pure QODs transmitted using dual-polarized antennas will open new horizons of research. It will support higher data rates and improved receiver efficiency, that are the two main targets of the future generations of wireless systems.