

## ABSTRACT

Rapid growth in the wireless communication technology has inspired many research and development activities for the past few years. Recent communication services continue to demand higher and higher data rate wireless communication systems. The only way to increase the rate of transmission and to improve the reliability of wireless systems is called Multiple Input Multiple Output (MIMO) in which multiple antennas are employed both at the transmitter and at the receiver side. MIMO system can be classified as single user MIMO (SU-MIMO) and multi-user MIMO (MU-MIMO).

In SU-MIMO, single user can transmit the data simultaneously on several parallel data streams, using the available transmission resources, both in time and frequency dimensions. In Multi user MIMO (MU-MIMO) multiple streams of data can be transmitted or received by different devices by sharing a single time-frequency resources to exploit multi-user diversity resulting in a significant gain over SU-MIMO. In MU-MIMO systems, the participation of multiple users in the communication increases the complexity and leads to a challenging design. When multiple users share the same channel, it is essential to keep the scalability of the system, irrespective of the non-cooperative acquisition of data.

MIMO transceiver designs rely mainly on the knowledge of channel state information (CSI) on the transmitter and receiver sides of a communication link. In most of the practical scenarios, due to the fast fading channels, the transmitter side can only have statistical (or long-term) information about the channel to achieve interference cancellation. For this purpose, at the base station, it is essential to implement a pre-processing stage, known as precoding.

Precoder uses the perfect CSIT and decouples the input signals into orthogonal spatial modes in the form of Eigen-beams to create a parallel channel. Based on CSIT, the precoder perfectly allocates power as per the

scalability of the channel. Hence, it allows more users to transmit their signals if the channel is strong and it allows few users to transmit their signals if the channel is weak. Precoders can be designed by utilizing channel information to cancel the interference at the receiver without sacrificing the diversity or the complexity of the system.

A multiple access system with full diversity can be achieved by maximum likelihood detection, but the complexity of the system increases exponentially as a function of the number of antennas, number of users, channel estimation, SNR, bandwidth efficiency and estimation of BER. The precoder used in a MIMO system must be capable of providing all these requirements. Precoding techniques are classified into linear and non-linear. The non-linear techniques such as Tomlinson-Harashima precoding (THP) and vector precoding (VP) techniques outperforms the performance of linear systems such as channel inversion, regularized channel inversion and block diagonalization and achieves very good results in multiuser broadcast channels. But, in nonlinear precoding the computational complexity also increases as a consequence of successive interference cancellation.

The main idea of the proposed work is to design a precoder which uses the channel state information of different users and allow them to transmit over orthogonal directions to reduce the interference and provide full diversity for a number of users for long distance coverage. The performance of the proposed system can be analyzed in terms of bit error rate (BER) and throughput, input SNR (Signal to Noise Ratio), diversity order. In order to avoid the performance degradation due to feedback delays of CSI, channel prediction techniques such as zero forcing (ZF), minimum mean square error (MMSE) are used. The most complex task of precoder is to recover the CSI in the presence of noise and hardware errors. The performance of the sorting algorithms such as K-best scheme, FSE, two-way sorting algorithm are used for nonlinear precoding techniques to achieve close to optimal error rate and low power consumption.

The thesis focuses on the precoding techniques such as Channel Inversion(CI), Regularized Channel Inversion (RCI), Block Diagonalization (BD), Dirty Paper Coding (DPC) and Tomlinson Harashima (THP) which are analyzed and compared effectively in MIMO OFDM Systems. The precoding techniques are designed and the performance is compared for a  $4 \times 4$  MIMO system in which 4 users with the highest channel norm values are selected. For SNR=10 dB, BER of CI is 0.13, RCI is 0.06, BD is 0.19, DPC is 0.030, and BER of THP is 0.038. The results show that, the non-linear precoding technique DPC, outperforms the linear precoding techniques such as RCI, CI and BD at the cost of complexity.

Apart from BER performance, hardware cost and complexity are the major constraint in the design of precoder. The complexity of DPC-VP is analyzed and implemented in Xilinx Virtex VI FPGA software using different detectors (K-Best, FSE) and the performance are compared in terms of power consumption. By analyzing the results, the modified Bi-orthogonal-Euclidean method is suitable to select the best child node units because, less number of slices is needed when compared with two-way sorting and K-best tree-search algorithms, which shows the performance as 33.6862% and 39.5522% respectively. Though DPC-VP provides better BER performance in FDD systems, CSI introduces unavoidable delay which increases the complexity.

In general, the complexity can be reduced by linear precoding with suitable predictors in 4G networks. In order to improve the performance of linear precoder further, low complexity aided lattice reduction MMSE (LC-LR-MMSE) precoder is designed and compared with conventional precoders such as conventional RBD and QR/SVD RBD the LC-LR-MMSE system outperforms by approximately 50%.