# COMPARATIVE STUDY OF LINEAR PRE CODING

**Sk. Jagadeesh Babu[1] , A.C.Sai[2],D.Yaswanth[3], M.Vengaiah[4], K.Anil Kumar[5]**

[1]Assistant Professor, Dept.; of ECE, PBR Visvodaya Institute of Technology & Science, Kavali, Author[2,3,4,5]
2,3,4,5, UG Students, Dept.; of ECE, Visvodaya Engineering College , Kavali, AP. India. 524 201.

**Abstract** - The Linear Pre-coding techniques of Maximum Ratio Transmission (MRT) will be implementing on 5G MIMO environment. Along with the other linear pre-coding techniques such as, Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) will also be implemented and made comparison between later two techniques with proposing MRT technique and the parameters are verified through simulation. The results showed that the proposed MRT has a low bit-error rate compared with the existing techniques

**Index Terms** - LPA, Maximum Ratio Transmission, Minimum Mean Square Error, MIMO, Zero Forcing,

## I. INTRODUCTION

Linear Precoding (LP) is applied to a system to serve multiple users at a time. Linear precoding makes the Beam-Forming really optimal. LP makes users to use the resources at the same time by using certain techniques to maintain orthogonality among users thereby, reducing interference between users. It is more robust in making signal less susceptible to interference which is a major concern at 5G and MIMO environments. Based on the type of use linear precoding techniques are classified as several types, they are, Zero Forcing (ZF), Minimum Mean Square Error (MMSE), Maximum Ratio Combining or Transmission (MRT) and Block Diagonalization (BD) etc. A multiplicity [1] of autonomous terminals simultaneously transmits data streams to a compact array of antennas. The array uses imperfect channel-state information derived from transmitted pilots to extract the individual data streams. The power radiated by the terminals can be made inversely proportional to the square-root of the number of base station antennas with no reduction in performance. In contrast if perfect channel-state information were available the power could be made inversely proportional to the number of antennas. Lower capacity bounds for maximum-ratio combining (MRC), zero-forcing (ZF) and minimum mean-square error (MMSE) detection are derived. Counter intuitively, [2] the practical issues of having uncertain channel knowledge, high propagation losses, and implementing optimal non-linear precoding are solved more or less automatically by enlarging system dimensions. However, the computational precoding complexity grows with the system dimensions. For example, the close-to-optimal and relatively “antenna-efficient” regularized zero-forcing (RZF) precoding is very complicated to implement in practice, since it requires fast inversions of large matrices in every coherence period. In wireless [3] communication fading of channels is the serious cause of the received degraded signals. The effect of fading can be minimized by using various time and space domain techniques. However, space domain techniques are preferred over the others due to its advantages. In this paper, comparison of the wireless MIMO system under Almouti's and maximum ratio combining schemes is presented. Basic idea in these schemes is to transmit and receive more than one copy of the original signals. The performance of linear [4] precoding schemes in downlink Massive MIMO systems is dealt with in this paper. Linear precoding schemes are incorporated with zero forcing (ZF) and maximum ratio transmission (MRT), truncated polynomial expansion (TPE), regularized zero force (RZF) in Downlink massive MIMO systems. Massive MIMO downlink output is evaluated with linear precoding included. This paper expresses the performance of achievable sum rate linear precoding with variable signal-to-noise (SNR) ratio and achievable sum rate and several transmitter-receiver antennas, such as imperfect CSI, less complex processing and inter-user interference. Block diagonalization (BD) [5] based precoding techniques are well-known linear transmit strategies for multiuser MIMO (MU-MIMO) systems. By employing BD-type precoding algorithms at the transmit side, the MU-MIMO broadcast channel is decomposed into multiple independent parallel single user MIMO (SU-MIMO) channels and achieves the maximum diversity order at high data rates. However, due to the [6] strong low-frequency [6] penetration, in addition to the high frequency band, 5G also needs to use the low-frequency band. At the same time, 5G will also have the following key technologies:[7,8]large scale dense network (large scale distributed MIMO): this technology provides flexible 5G intensive cells. It is a transmission point composed of many inexpensive antennas, which can serve multiple users at the same time. With a large-scale. This kind of perception is all-round, and should have a comprehensive understanding of the comprehensive information based on the geographical environment and climate conditions of the location. The above dynamic management of wireless resources is realized by distributed and software defined radio.[9,10] ultra wideband spectrum: because the capacity of channel increases with the increase of bandwidth, in order to achieve the

Gbps order of magnitude communication rate required by 5G mobile communication, it should also have the continuous bandwidth of high frequency band.

## II. PROPOSED METHOD

In large-scale MIMO systems, we looked at the performance of many prominent linear precoding techniques. To facilitate expression, we used a single cell system. Use denotes the user-to-base station downlink channel matrix. We examined the performance of the primary Linear Precoding methods based on a theoretical study, performed performance simulations in real-world scene conditions, and compared the results to the theoretical predictions. In the single cell large-scale MIMO transmitter block diagram shown in Fig. 1, the base station precedes the signal and sends the signal vector to the user. S represents the original signal, and X represents the information vector sent by the sender to the user after precoding.

$$x = \sqrt{\rho}\, Ws \quad \text{----(1)}$$

$$y_k = Hx + n = \sqrt{\rho} H_k W_k S_k + n_k \quad (2)$$

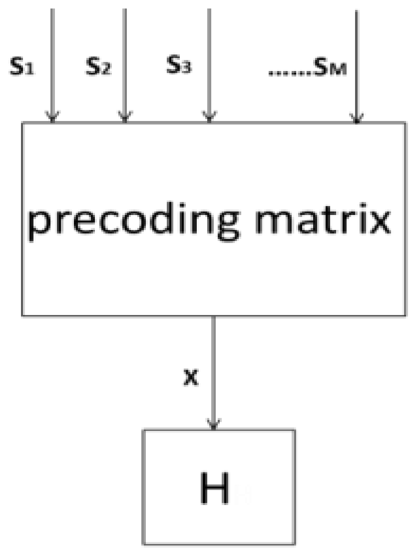



Figure.1 Single cell large-scale MIMO transmitter block diagram

### (a) Maximum Ratio Emission Precoding Algorithm

The matched filter precoding algorithm is the MRT precoding technology used in downlink. The ideal channel transmission environment is one in which the channels from the base station to the various user terminals are as independent as feasible. The efficiency of MRT precoding in large-scale MIMO systems greatly depends on this environment. Formula 3 is the expression of MRT precoding for the kth user in the cell. MRT precoding is a very basic precoding technique that increases each user's SNR while ignoring interference from other users.

$$W_K = H_k^H \quad \text{----- (3)}$$

### (b) Minimum Mean Square Error Precoding Algorithm

Zero forcing precoding scheme reduces to zero the interference from other users and ignores the effect of noise on the system. The received signal component will be weaker and the received signal to interference plus noise ratio (SINR) will be lower when the noise makes the channel matrix ill-conditioned or nearly ill-conditioned and the coefficient will be close to zero.

$$W_K = H_K^H\,(H_K H_K^H + \beta I)^{-1}$$
---(4)

**III.EXISTING METHOD**

Studied the performance of several main Linear Precoding algorithms in large-scale MIMO systems. For the convenience of expression, in a single cell system, we use indicates the downlink channel matrix from base station to user. Based on the theoretical analysis, we studied the performance of the main Linear Precoding algorithms, and made performance simulation under the actual scene conditions, and compared with the theoretical results.

$$\mathrm{x} = \sqrt{\rho}\, Ws$$
---- (5)

$$y_k = Hx + n = \sqrt{\rho} H_k W_k S_k + n_k$$
**-----(6)**

## (a) Maximum Ratio Emission Precoding Algorithm

In downlink, the MRT precoding technology is actually the matched filter precoding algorithm. The performance of MRT precoding in large-scale MIMO system depends on the channel transmission environment to a great extent, and the ideal environment is that the channels from the base station to different user terminals are as independent as possible. The expression of MRT precoding for the kth user in the cell is formula 3。MRT precoding is a very simple precoding technology, which can maximize the SNR of each user, but does not consider the interference between users.

$$W_K = H_K^H$$
---- (7)

## (b) Zero Forcing Precoding Algorithm

Zero forcing linear precoding scheme was originally proposed by Free scale Semiconductor Company. Different from the MRT precoding technology, ZERO FORCING precoding can completely remove the interference among users.

$$W_k = H_k^H (H_k H_k^H)^{-1}$$
**----(8)**

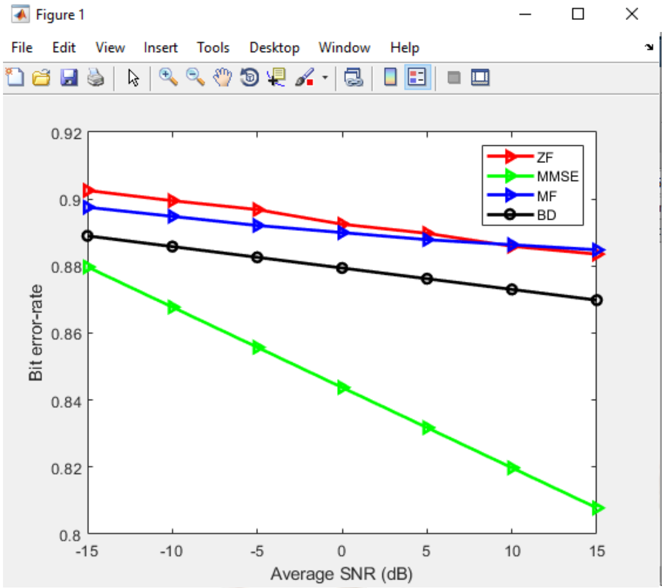
## © Minimum Mean Square Error Precoding Algorithm

Zero forcing precoding scheme reduces the interference of other users to zero, and does not consider the impact of noise on the system. When the noise causes the channel matrix to become ill conditioned or near ill conditioned, and the coefficient will be close to zero, the received signal component will be weakened, and the received signal to interference plus noise ratio (SINR) will be reduced.

$$W_K = H_K^H\,(H_K H_K^H + \beta I)^{-1}$$
**---------- (9)**

**IV.Results and Discussions**

Figure 2 shows the capacity simulation results of several Linear Precoding algorithms. It can be seen. From Figure 2 that the system capacity after ZF, MMSE and MF precoding increases with the increase of SNR, meanwhile, MMSE precoding grows the fastest, ZF and MF Secondly. At the same time, under the same SNR, it can be seen that MMSE precoding capacity is significantly better than the other two precoding. This shows that MMSE precoding can suppress the interference between users. Figure 3 is a simulation of bit error rate (BER) of ZF, MMSE and MF precoding with SNR True curve, using 4QAM modulation. It can be seen from the figure that in the case of low SNR, the bit error rate of MMSE precoding is significantly lower than the other two; with the increase of SNR, the bit error rate of each precoding method decreases gradually, MF In the environment of high SNR, ZF precoding performs well. Figure 4 that when the number of base station antennas increases, the advantages of MMSE precoding compared with ZF precoding are significantly reduced, which verifies that in the case of large-scale antennas, simple linear precoding can also have good performance.



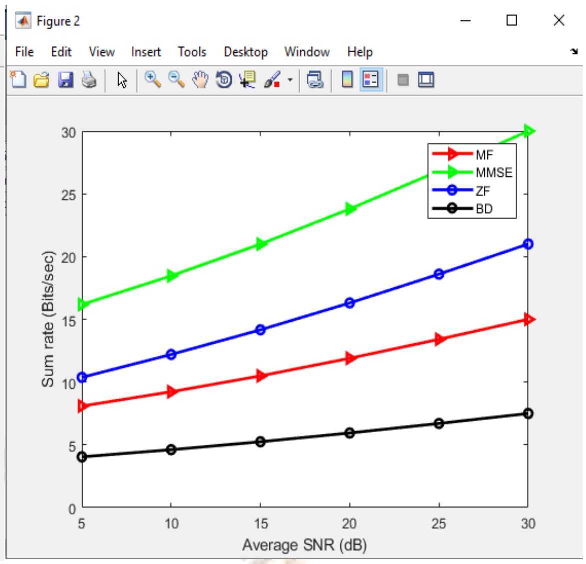




Fig. 2 Results of several linear precoding algorithms

Fig 3 Sum rate of several linear precoding algorithms

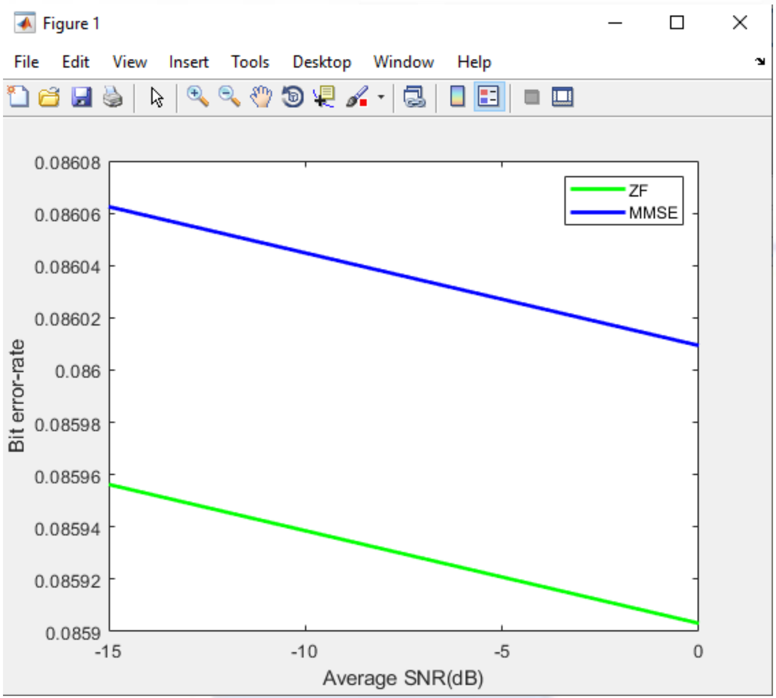



Figure 4 Bit error rate of several linear precoding algorithms

## V. CONCLUSION

Here, in this paper we implemented four of the linear pre-coding techniques and made a comparison between them. The implementation have shown that, MRT has low bit error-rate and high sum-rate among the four implemented techniques. Hence, we can finally conclude that MRT is better among the four, but, ZF and MMSE are better at high SNR environments and BD is robust and easier to implement. Finally, we can conclude that, the Block Diagonalization (BD) precoding technique is easier to implement among all the other linear precoding techniques.

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