

Precoders For Mimo-Ofdm System

Roopa Johny¹, Noble C Kurian²

P G Student, Dept. of ECE, Sree Narayana Gurukulam College of Engineering, Mahatma Gandhi University, Kerala, India

Assistant professor, Dept. of ECE, Sree Narayana Gurukulam college of Engineering, Mahatma Gandhi University, Kerala, India

Abstract :MIMO-OFDM technologies are widely used in mobile multimedia communication systems. The low peak to average power requirement in number of application has led to the use of insufficient cyclic prefix in OFDM. This will reduce the data rate of the system. To attain high data rate which is one of the major advantage of OFDM system, precoders are used. Precoding is a generalized beamforming multistream transmission method that helps to bit error rate performance of MIMO-OFDM system. The objective of this paper is to study various precoding methods in MIMO-OFDM systems. Here we have studied unoptimal precoding methods such as precoding using modulo operation, precoding using interference alignment method and optimal precoding method using channel information. The study shows that all the precoding methods reduces the ISI but the precoding using channel information helps in reducing receiver complexity and helps in increasing BER.

Keywords - MIMO-Multi input Multi output, OFDM-orthogonal frequency division multiplexing, CP-cyclic prefix ISI-Inter Symbol Interference

I. INTRODUCTION

MIMO-OFDM is one of the effective method used widely in wireless communication system. The high data rate and bandwidth efficiency of OFDM along with diversity technique has led to the use of this technology in many advanced wireless communication systems. The MIMO-OFDM technique is used as the air interface in 4G/LTE and 5G technology.

The high data rate is attained by the use of cyclic prefix in OFDM system. If the cyclic prefix is greater than the channel length then the effect of inter symbol interference can be reduced. But in most case in-order to reduce the peak to average power ratio (PAPR) of MIMO-OFDM system, insufficient cyclic prefix is used [1] which in turn will result in Inter Symbol Interference (ISI) and thus reduces the data rate. In order to increase the data rate one of the system precoders are used. Therefore this paper deals with different precoding techniques used in MIMO-OFDM system.

The remaining part of the paper is divided as follows, section 1: Basic Concept of Precoding. Section 2: BER Comparison. Section 3: Conclusion

II. BASIC CONCEPT OF PRECODING

Precoding is a conventional beamforming method used to support multi-stream data transmission in multi antenna communication. In single stream beam forming using multiple antenna the same input signal emitted from all the antennas are multiplied by certain weighing factor (phase and gain) and is transmitted such that the signal power is transmitted at the receiver side. But when multiple antennas are used at the receiver side this method cannot maximize the signal strength at all antennas. Thus to maximize the signal strength at the receiver side we are using multistream transmission.

In point to point communication the concept of precoding is in such a way that multiple data stream is emitted from multiple antennas after multiplying by specific weighing factor ie: phase and gain. In multi-user communication system, each data stream is intended for each user and each user signal is precoded to maximize the signal strength at the receiver side. Precoding can be done in two ways 1) unoptimal precoding 2) optimal precoding.

2.1 Un-optimal precoding

In unoptimal precoding method the channel state information is not required at the transmitter side for transmission. The weights are assigned to the transmitted signal with out using any channel side information. The common unoptimal precoding method used is based on interference alignment.

Interference Alignment method: Here the input information is multiplied by the precoding matrix before the OFDM modulation [7]. The rank of the precoder matrix is increased by zero padding. So that the input information when multiplied by the precoding matrix aligns the signal and the interference to disjoint sets. In MIMO-OFDM system with precoder, the input information $\vec{S}(m)$ is multiplied by precoder matrix P and then is OFDM modulated. The out from the precoder matrix for the m-th OFDM block is given as $\vec{X}(m) = P\vec{S}(m)$. The design of precoder matrix is given as $Q \triangleq \bar{W}P$. The precoding matrix is obtained by multiplying Q with $\bar{W}^{-1} = W_N^{-1} \otimes I_{N_t}$, where W_N^{-1} is the discrete Fourier transform matrix. At the receiver side the interference can be removed by zero forcing operation.

Such a precoder matrix is not an optimal precoder matrix ie: no channel side information is used here.

2.2 Optimal precoder design

Optimal precoding method uses the complete channel side information at the transmitter in order to do the precoding. The precoding weights applied to the transmitted signal contains all channel information. This precoding methods helps in avoiding the effect of inter symbol interference (ISI).

The information bits are first transmitted through a precoding matrix [8]. The precoding matrix is designed in such a way that it maximizes the cost function. The cost function considered is

$$\min_{Q_u} \mathcal{F}_o \left(\left[\frac{1}{\sigma_s^2} I + Q_u^H R_c Q_u \right]^{-1} \right) \tag{1}$$

s. t. $tr\{Q_u Q_u^H\} \leq P_T$

Here the cost function is the lower bound of the minimum mean square equalizer at the receiver side. Thus the precoder is designed using the channel information which is given as feedback to the receiver side.

III. Ber Comparison

The unoptimal and optimal precoding methods discussed above helps in increasing the data rate of the system but since unoptimal precoder is designed without the channel side information the chance of increasing the data rate in the case of using insufficient cyclic prefix is less. In this case the complete channel side information is needed at the receiver to overcome the effect of ISI caused due to in-sufficient cyclic prefix. This effect can be achieved by using the optimal precoder design. The BER obtained for both the precoder is shown below.

Methods	SNR	BER
MIMO-OFDM	25 dB	0.0000001
Interference alignment method.	25 dB	0.000008
Precoder with channel information	25 dB	0.00005

Table 3.1 : BER comparison of precoder

IV. CONCLUSION

MIMO-OFDM is a widely used technology in wireless communication. In order to increase the data rate of the system precoding methods are used the generally used precoding methods are unoptimal precoding and optimal precoding. Even though both the precoding methods are effective in increasing the data rate, optimal precoder design is more effective in increasing the data rate as well as mitigate the effect of ISI. Thus we conclude that the precoder design with channel information is more effect method among all precoding methods.

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Roopa Johnny received B.Tech Degree in Electronics and Communications engineering From Kerala University, Kerala, India in 2013. Currently pursuing M.Tech in Communication Engineering from Sree Narayana G, Kerala, India. Her areas of interest include wireless communication.



Noble C Kurian: Assistant Professor in the Department of Electronics and Communication Engineering, SNGCE, Kerala, India. Secured M.Tech degree in Electronics and Communication Engineering (Optoelectronics and Optical communication) and PGDHRM are secured from University of Kerala, Kariavattom Campus. He started his career as lecturer and then served as Project Trainee at BARC, Department of atomic energy, Mumbai. He executed many projects in instrumentation field when worked as Optical engineer at Bengaluru. He has been working at SNGCE since December 2009. He published papers in

several national journals.