Precoded MIMO Multiuser Scheme for Diversity Fairness – A Review

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Abstract — **This paper presents diversity fairness with Tomlinson-Harashima precoding, mainly focuses on receiver is equipped with single antenna wherer exists only the transmit diversity, but without any receive diversity. Presently the receive diversity due to multiple antenna at each receiver side, it is commonly assumed that the total number of receive antenna is less than or equal to that of transmit antenna. TH precoders for channels have been proposed, including zero-forcing designs, minimum mean square error (MMSE) designs. Zero forcing work which invert the frequency response of the channel and MMSE equalizer is that it does not usually eliminate ISI completely but, minimizes the total power of the noise and ISI components in the output. The latest research on this show that THP is useful to achieve better transmit diversity.**

Index Terms — **Diversity, Multiple input Multiple output (MIMO) system, Rayleigh fading channel, Tomlinson-Harashima precoder (THP).**

I. INTRODUCTION

Multiuser multiple-input multiple-output (MIMO) in wireless communication, potential for achive transmit diversity and increased channel capacity. Multiple-input multiple-output(MIMO) broadcast channels has been an extensive area of research in the last few years. With an increased interest in data throughput and quality-of-service. MIMO wireless communication systems have played a fundamental role in providing such benefits. In particular, the capacity limits of the Gaussian multiuser broadcast channel with multiple transmit antennas at the base station and multiple receive antennas at each user have captured a large amount of research in recent years[1]. Channel State Information (CSI) at the transmitter and allows reduce of fading and exploitation of transmit-receive diversity. However, if CSI is known at the transmitter, higher throughput can be attained using spatial multiplexing, which can be implemented as multibeam transmit beamforming[2].

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Tomlinson-Harashima precoding (THP) was originally proposed as a temporal non-linear pre-equalization technique for channels with inter-symbol-interference, in which it works by sequentially pre-subtracting the interference effect of previous symbols. The operation of the THP relies critically on the availability of channel state information (CSI) in order to accurately subtract the interference that otherwise would be created at each decentralized receiver. We consider the broadcast channel (BC) with Tomlinson-Harashima precoding, and its dual, the multiple access channel (MAC) with decision feedback equalization. We will obtain robust minimax designs for these non-linear multi-user transceivers for deterministically bounded channel uncertainty models[3]. Tomlinson–Harashima precoding (THP) is a non-linear technique that overcomes the limitations associated with the linear precoders and keeps the complexity low[4]. Tomlinson–Harashima precoded signals could be an efficient solution to support diversity fairness without affecting the best-ordered users. The main aim to introduce a simple technique that resolves the THP diversity unfairness and jointly exploits the transmitter's spatial diversity. The proposed scheme elaborates a single-retransmission of the generated THP downlink signal by using two complementary MUI suppression orders at the transmitter. In this way, each user receives two copies of the transmitted signal via two "diversity-complementary" channels that keep the total number of diversity degrees constant for all users. The ZF-THP is a well-known non-linear technique for the downlink that diagonalizes the MIMO wireless channel and allows simple detection at the receivers[4]. THP, the user performance depends on the multiuser interference (MUI) order and this causes a diversity unfairness to the downlink users diversity gain/order is an important performance metric[5]. Performance of unfairness is reduce by zero forcing (ZF) THP in this a diversity order is equal to one all user is used. So this approach balanced the achieved diversity gain[6]. In particular the processing matrices of the THP algorithm are designed following a minimum mean square error (MMSE) approach under a constraint on the overall transmit power. Unfortunately, the solution to this problem requires a large number of matrix inversions (equal to the number of active users) and may be unfeasible when applied to heavy-loaded systems[7].Tomlinson-Harashima precoded signal provide efficient solution to support diversity fairness without affecting the ordered users. THP signals, focuses on the coherent combination of the simultaneous without discussing fairness diversity[8].

ISSN: 2278 – 7798

II. II. TOMLINSON-HARASHIMA PRECODING

The basic idea of Tomlinson-Harashima precoding (THP) was originally proposed as a non-linear pre-equalization technique for channels with inter-symbol-interference, in which it works by orderd pre-subtracting the interference effect of previous symbols. Principle can be applied at the base station of a downlink system in which independent data symbols are transmitted to decentralized users, in which the THP pre-subtracts the interference of previously precoded symbols that are intended for other users[3]. THP operation relies critically on the availability of channel state information (CSI) in order to accurately subtract the interference that otherwise would be created at each decentralized receiver[3].basically Based on the assumption of perfect CSI at the transmitter, several different view for designing TH precoders for broadcast channels have been proposed, including zero-forcing designs, minimum mean square error (MMSE) designs[3].

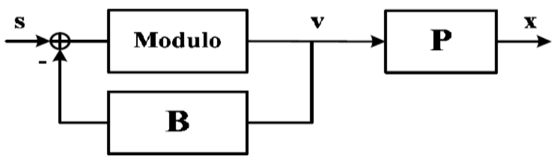

Fig. 1 Tomlinson-Harashima Transmitter[3]

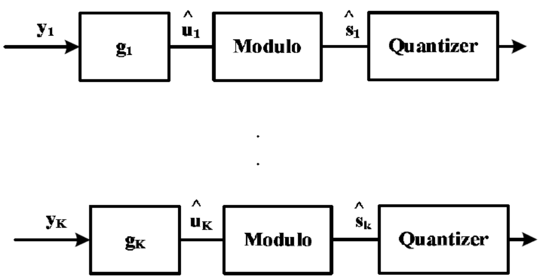

Fig. 2 Decentralized Receivers[3]

In practical downlink base station, the CSI available at the base station is generally imperfect.Particular, in systems in which each user quantizes its channel information and feeds it back to the transmitter the uncertainty in the CSI at the transmitter is mainly due to the effect of quantization errors[3]. The result mismatch between the actual CSI and the transmitter's estimate of the CSI can result in a serious degradation of the performance of the downlink[3].

EQUALIZER

Equalizer provides an approximate inverse of channel frequency response because is a digital filter. Equalization decrease to effect of ISI probability of error that occurs without suppression of ISI, noise power enhancement, reduction of ISI effects has to be balanced. In our THP zero forcing and MMSE equlizer is used[9].

ZERO FORCING EQULIZER

In communication system Zero-Forcing equlizer is a linear equlization alogorithm used, zero forcing work which invert the frequency response of the channel. Inversion of channel, Zero-Forcing equlizer applies to the recived signal, to restore the signal before the channel. Bringing down the ISI to zero in a noise free case so this is called Zero-Forcing. When ISI is signifiant compared to noise so this well use full. C(f) = 1/F(f) when channel with frequency response F(f) the zero forcing equlizer C(f). If F(f)C(f) = 1 combination of channel and equlizer gives a flat frequency response and linear phase. Input signal is multiplied by the reciprocal of this when channel response for a particular channel is A(s)[9]. Equation is

$$Y = A \cdot x + n \qquad (1)$$

To solve for x,we need to find a matriix W which satisfies
WA=I the Zero Forcing (ZF) detector for
W = (AAA)-1 AA
Where W - Equalization Matrix and
A - Channel Matrix

Note that the off diagonal elements in the matrix AAA are not zero, because the off diagonal elements are non zero in values. Zero forcing equalize performing well but is not the best equlizer[9]. It is simple way and easy to implement.BPSK Modulation use Rayleigh fading channel, the BER is defined as

$$Pb = \frac{1}{2}\left(1 - \sqrt{\frac{(\frac{Eb}{N0})}{(Eb/No)+1}}\right) \qquad (2)$$

Where
Pb - Bit ErrorRate
Eb/No -Signal to noise Ratio

MMSE (MINIMUM MEAN SQUARE ERROR) EQULIZER

A minimum mean square error (MMSE) describes the approach which minimizes the mean square error (MSE), and also describes common measure of estimator quality. Basically MMSE equalizer is that it does not usually eliminate ISI completely but, minimizes the total power of the noise and ISI components in the output. Let x is unknown random variable, and let y is known random variable[9]. Estimator x^ (y) is any function of the measurement y, than mean square error is given by

$$MSE = E\{(X\hat{}(y) - X2)\} \qquad (3)$$

Expectation is taken over both x and y. An estimator achieving minimal MSE[9]. The Minimum Mean Square Error (MMSE) approach tries to find a coefficient W which minimizes the

$$E\{[Wy-x\}[Wy-x]\ H\} \qquad (4)$$

Where W - Equalization Matrix
H - Channel Matrix and
n - Channel noise
y- Received signal.

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III. MATHEMATICAL CONCEPT

Tomlinson-Harashima precoding is a transmitter equalization technique where equalization is performed at the transmitter side.

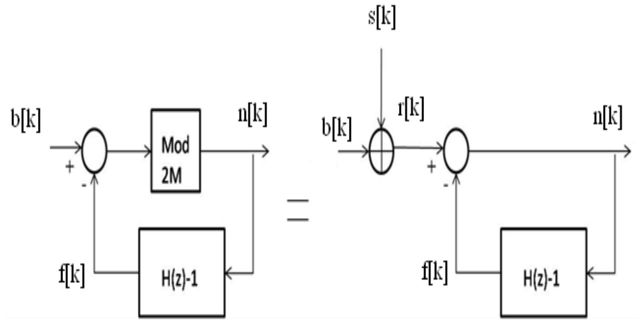

Fig. 3 Tomlinson-Harashima precoder and linearized description(6)

Tomlinsion-Harashima structure basically two ways conceived. Left part is first way show in figure sequence is b[k] that is deducted by f[k]. The f[k] is the result of filtering the output sequence n[k] and subtracted channel impulse response by one unit in the first element[6]. Result of addition is subjected by explained modulo adder, so n[k] can be obtained.

Second way to understand the TH structure is as follow: unique sequence s[k] ∈ 2MZ (Z as an integer number) added with data sequence b[K] and create an effective data sequence (EDS) r[k],so r[k] = b[k]+s[k], r[k] is then filtered with the inverse of H(z)[6].

Below shows the mathematical relationship between the sequences:

$$n[k]=b[k]+s[k]-\sum_{k=1}^{p} h[k]\cdot n[k-K]=r[k]-f[k] \qquad (5)$$

The values s[k] are selected symbol-by-symbol by the memory less modulo operation, which reduces n[k] to the interval [-M,+M][6].

Linear preequlization is an extension of THP. In THP selected the current effective data symbol, this is congruent to the current b[k], magnitude of the corresponding channel symbol n[k] is minimize[6].

Fig4 Transmission with THP, complete scheme shows below

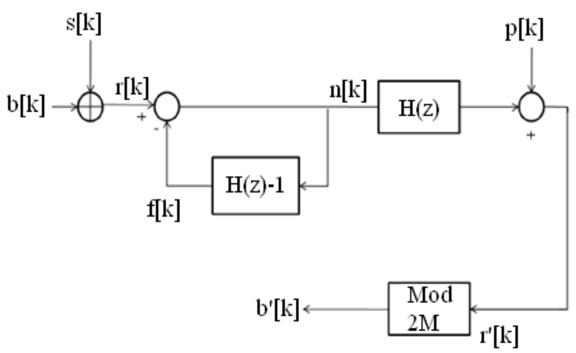

Fig4 Complete scheme for a transmission with THP[6].

$$c[k] = r'[k] = \sum_{k=0}^{p} h[k]\cdot n[k-K] + p[k] =$$
$$n[k]+\sum_{k=1}^{p} h[k]\cdot n[k-K] + p[k]=$$

$$=n[k]+f[k]+p[k] = r[k]-f[k]+f[k]+p[k] = r[k]+p[k] \qquad (6)$$

Where p[k] is a white Gaussian noise sequence.

P[k] easily deduced, that in noise is absence, p[k] recovered can be directly before the entry of last mod 2M, so out put p[k] would be reduced to range R=[-M,M] by modulo redactor without any ISI[6].

IV. SIMULATION RESULTS

In this section, we present simulation results for MIMO ZF-THP with different number of transmit and receive antenna. The bit-error-rate (BER) performance of these system was evaluated for various spectral efficiencies as a function of the average SNR per receive antenna. All performance comparisons are made for a SNR of the range from 0 to 25 db.

A) The below graph is plotted for four transmit-antenna and four receive-antenna. This system is spacilly designed for a packet size of 1000 bits using QPSK modulation in Rayleigh fading environment for signal to noise ratio ranging from 0 to 25 db.

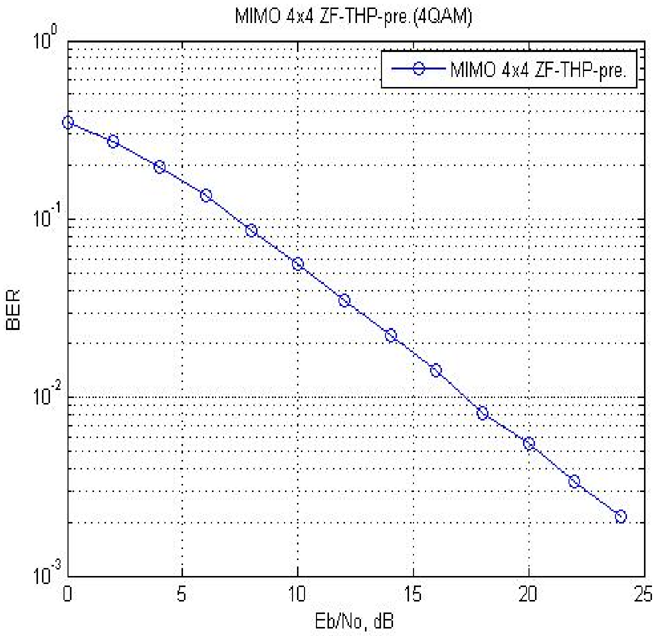

Fig. 5 BER performance of ZF-THP for four Transmitter and Four receivers antenna.

The above result shows MIMO 4×4 ZF-THP (4QAM) the BER performance of ZF-THP system for four transmitter and four receiver antennas for Rayleigh fading channel. As we can see that BER decreases exponentially with increase in SNR. The maximum value of BER is $10^{0.6}$ for SNR=0 db which decrease to $10^{-2.9}$ with SNR=25db.

B) Below graph plot the average BER for a system with four transmit and four receive antennas. Compare the performance

ISSN: 2278 – 7798

between minimum SER and BER criteria, zero-forcing TH precoder designs with BLAST ordering and no ordering.

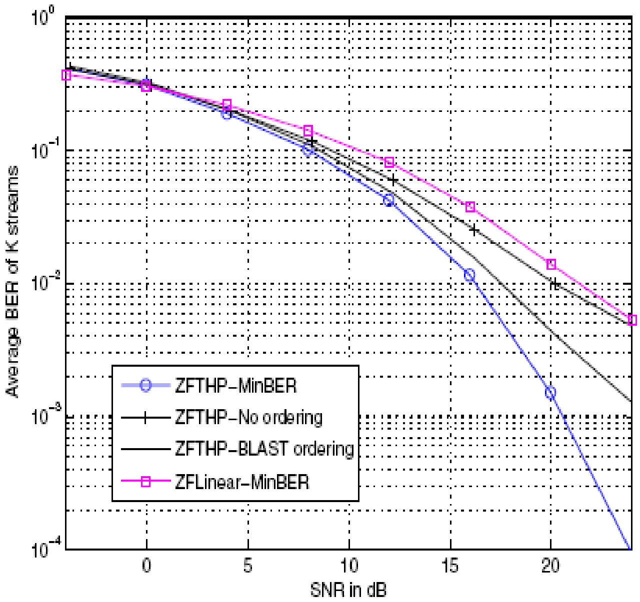

Fig. 6 Average BER performance of ZF-THP 4× 4 (16QAM) for four Transmitter and Four receivers antenna[8].

According to the above diagram, ZF Linear value of BER is $10^{0.7}$ for the initial value of SNR (SNR=0).The value of BER decreases to $10^{-2.6}$ when SNR=25 db.
In the same manner,ZF-THP MinBER value of BER is $10^{0.7}$ than value of SNR (SNR=0). The value of BER decreases to $10^{-4.0}$ when SNR=25 db.
In other two cases ZF-THP No ordering and ZF-THP Blast ordering ,value of BER in case of ZF-THP no ordering is $10^{0.7}$ with SNR (SNR=0) value of BER decreases to $10^{-2.6}$ when SNR=25 db. And ZF-THP Blast ordering value of BER is $10^{0.6}$ value of SNR is (SNR=0). BER is decreases to $10^{-3.0}$ when SNR=25 db.

V. CONCLUSION

Tomlinsion Harashima is a transmitter equalization technique, improvement on the elimination of the ISI of our channel. In this paper zero forcing equalizer used on transmitter end and signal transmit on receiver than BER is calculate after that MMSE equalizer are used on receiver side, BER performance of ZF and MMSE is compared . In this paper mainly focus on TH precoding using ZF and MMSE to achive better transmit diversity.

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ISSN: 2278 – 7798