ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3, Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering, Madurai, Tamil Nadu, India

An Inter Block Interference Nulling Algorithm Based on Tomlinson–Harashima Precoding for LTE-A Systems

S.Yamini [#1], K.Kavitha [*2]

Department Of ECE, K.L.N College Of Information Technology, Madurai, TamilNadu, India

Department Of ECE, K.L.N College Of Information Technology, Madurai, TamilNadu, India

ABSTRACT— In Long Term Evolution-Advanced (LTE-A) systems the Inter Block Interference(IBI) disrupts the flow of signal from source to destination either in uplink or downlink channels. To mitigate the inter block interference and to increase the performance, two transmission antennas are used and layer mapping and precoding process are involved. In this paper the Tomlinson-Harashima precoding (THP) procedure is proposed to null the Inter Block Interference(IBI) in the LTE-A system of transmits antennas (n_t) and receive antennas (n_r) with insufficient cyclic prefix(CP). The proposed scheme can eliminate the IBI with higher bandwidth efficiency. Experimental results are presented to illustrate the performance of the proposed method, demonstrating clearly superior performance of the new technique in term of the BER.

KEYWORDS— LTE-A, Precoding, Interference Block Interference, Tomlinson-Harashima precoder(THP),BER.

I. INTRODUCTION

The Long Term Evolution-Advanced (LTE-A) system is the milestone in the telecommunication field. The 3rd Generation Partnership Project(3GPP) Long Term Evolution Release 10[1] is named as LTE-A system. This paper is a result of mitigation of interference in the LTE-A system by implementing the Tomlinson-Harashima Precoding and about the LTE-A system. The system supports the Multiple Input Multiple Output (MIMO) [2] transmission hence its uses the Reference Signal(RS) in order to obtain high data rate at the receiver. In MIMO systems the Interference is eliminated using the insertion of the Cyclic Prefix and Zero Padded Methods are used. It helps to eliminate the effect of Inter Block Interference(IBI) and Inter Carrier Interference(ICI).But it is different in LTE and LTE-A system. Where LTE-A system makes the User Equipment(UE) able to transmit four multiple unique parts of data. The difference between LTE and LTE-A is that, LTE support per UE(1×2) where LTE-A supports four layers of transmission(4×4) with the four receiver antenna. The issues occur in MIMO transmissions are reduced by the LTE-A system the same OFDM scheme is used here. In MIMO [7] the CP length matters a lot during the transmission over the sub channel, hence its length is to be equal to that of the impulse response of the channel ie Channel Impulse Response (CIR).To improve the performance of the system by reducing the IBI in the case of the insufficient CP [3] during the transmission is studied.

The nulling of interference in LTE-A system using the Tomlinson-Harashima Precoding is proposed. The new precoding scheme eliminates the IBI than the zero padding or addition of the CP when the receive antenna is no more than the transmit antenna ($n_r \le n_t$).

The organization of the paper is as follows .The LTE-Advanced model is introduced in section II. Reference Signal(RS) is explained in section III. Tomlinson-Harashima precoding scheme is explained in section IV. The Simulation results with discussions is illustrated in section V and the Conclusion is presented in section VI.

Some notations in this paper is follows: y(i) denotes the ith entry of a vector y. v represents the CP length , k is the order of the CIR, N represents the number of subcarriers, $h_{i,j}$ denotes the vector matrix

II. LTE ADVANCED MODEL

The design of LTE-A system is given in this chapter where the transmitter structure is also presented on the 3GPP LTE advanced standard [1].

A. *Transmitter*

The structure of the transmitter holds the code generator where the information bits are generated and then cyclic redundancy bits are calculated and added. The output is segmented to code blocks which is followed by turbo coder. For the suitable code the rate matching process is to be done. Then its multiplexed and interleaved to get one stream of information called code word. The LTE-A system generates the two different code words.

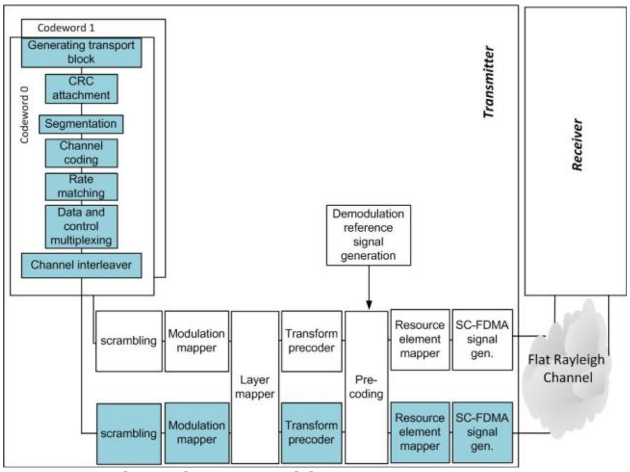

Fig. 1: LTE advanced system Model

The difference between LTE and LTE-A is the addition of Layer mapping and Precoding. The LTE-A system has both white and blue blocks. Hence two different streams can be mapped in to layers. The layer mapper divides the layer to four layers. The precoding block provides the high link capacity and efficient transmission.

To have efficient transmission the transmitter sends the symbols by inserting the reference symbol which have pre-defined amplitude and phase. Radio Channel carries signal from transmitter to receiver.

B. Receiver

The receives signal is processed at the receiver with the inverse order of blocks in the transmitter. Then in order to minimize the undesirable effect LTE-A uses the signal detection and channel estimation schemes at the receiver. LTE-A's receiver acknowledges the transmitter for the received signal when its receives correctly and calculates its BER.

III. Reference Signal For LTE-A System

The RS is of pre defined signal is inserted with the signal to be transmitted for its accurate flow. At the reception Demodulation Reference Signal (DRMS) holds the importance for channel estimation during data reception. In this paper symbols in the slots of either uplink or downlink DRMS depends on insufficient cyclic Prefix(CP) than the normal CP. The huge amount of reference signal sequence is used to support the large number of UE. Hence the sequences are cyclic shifted.

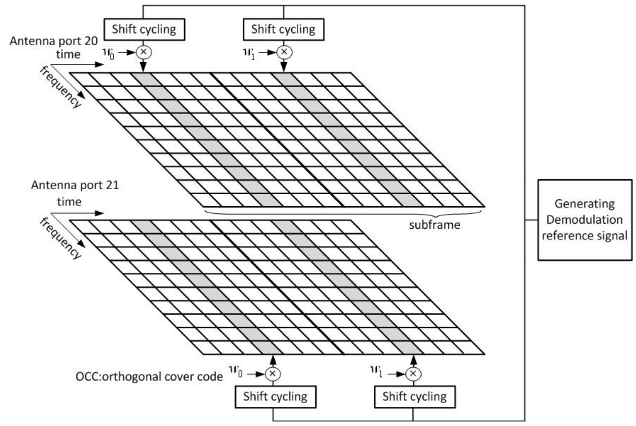

Fig. 2: Design of pilot pattern in a (2×2) MIMO SC-OFDM.

In LTE-A system multiple antennas to enhance the DRMS. The usage of multiple antennas defines the generation of the Orthogonal RS using different phase rotations cyclic shifts. Hence by this cyclic shifts of the base sequence generates the DRMS for the different layers. The orthogonal cover codes(OCC) are used to get two different RS with in sub frame.

IV. Tomlinson-Harashima Precoding

The input transformation matrix is preprocessed such preprocessing technique is known as precoding. The THP scheme is used to suppress the ICI and IBI in LTE-A system, the CSI used here is only partial or no CSI. As it requires the partial CSI it is non linear in nature. The property of ICI coefficient matrix is of unitary, conjugate odd symmetry. The THP matrix (Q) is designed. Hence it consist of the feed forward filter to calculate the successively transmitted signal. Y(i) =Q. y(i)

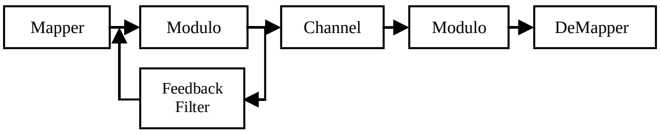

Fig. 3: Tomlinson - Harashima Precoder

The modulo arithmetic feedback is used at the transmitter is used as non linear and modulo used at the receiver is as the slicer. The modulo process is used for the addition of the signal. The channel matrix and the feedback matrix comes under the Zero Forcing case hence the transmit power will be constant.

A. Algorithm

In the case of LTE-A consider the Input matrix as $n_t \times n_r$ hence the channel matrix be $G(l)$.Hence the CP of length v is added and sent through the THP. Here the Zero Force Type decision feedback equalizer is used to eliminate the interference it gives better result than using the channel independent precoder. The signal that is transmitted along the channel is transmitted over the filter and its value have been calculated. Consider the feedback matrix as S(i,j) and the transmitted symbol is of y(i) , initially feedback structure expands the signal and performs modulo operation. The modulo operation is which $2\sqrt{m}$ is addition of real and imaginary term of the vector is done. Where

$$y(i) \in (-\sqrt{M}, \sqrt{M}]$$

Its requires the only the partial CSI and the matrix(S) gets feed forward to the receiver. Hence the over all channel matrix is about

$$G(l) = S^H Z$$

Where S is unitary matrix and Z is the triangular matrix.

In the case of different frequency offset, Since there requires the factorization of the channel matrix instead the filter is designed in the THP so that mismatch among the frequency offset, feedback errors and delay are avoided. As the drawbacks where reduced, the BER is reduced and the performance of the system gets increased even in the case of insufficient CP with receive antenna is not more than transmit antenna.

B. *Advantages*

- ICI is eliminated
- Increases the Throughput
- Requirement of partial CSI at the transmitter.
- Implemented in ISI channel.
- Presence of feedback filter

V. Simulation Results And Discussion

In this section we present the simulation results Of LTE-A system on comparison with MIMO-OFDM system with insufficient CP. The graph is plotted over BER vs SNR at the receiver.

In Fig.4 ,The analysis of the BER is done using the existing precoding system known as Channel independent precoding with the proposed Tomlinson –Harashima Precoding is done using MIMO-ODFM system, it depicts the system performance with precoder where it requires the complete CSI even though the information is sent with the insufficient CP.

Consider the data block size of length and different CP length are sent. When CP length (v) is 0,8,12,16 the independent information block will be 56,60,62,64 accordingly v = k = M here M denotes the block size. The other methods to achieve the better performance rather than channel independent precoding, the performance upgradation is also achieved by the Zero Padding scheme [9] in the case of multipath propagation. The full spatial diversity code is observed with the maximum likelihood detectors[10].

In the MIMO case four transmit and the four receive antenna is to set the transmitted block size is 32 and the order of the channel is 12.In this case two CP length is considered v= 6,v= 12. The independent information symbols is transmitted and its observed over the graph.

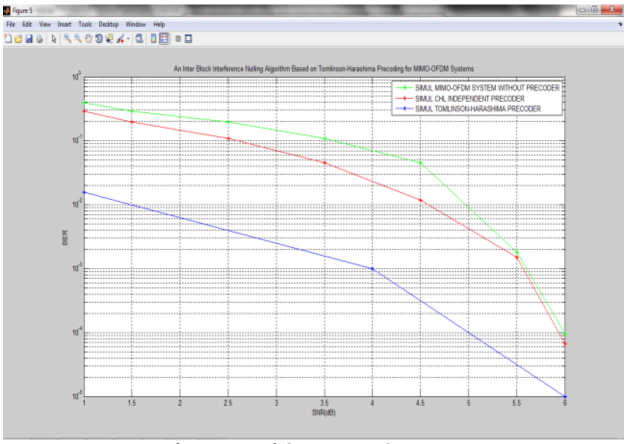

Fig.4 BER performance of the THP in the MIMO-OFDM system

The Proposed THP is implied in the system, the bottom blue line indicates the performance of the TH precoding scheme with the insufficient CP. This plot gives the comparison between the performance of the existing system and the proposed precoding system.

The nonlinear model of THP is used here, the BER level is minimized and as well as the SNR rate becomes low comparing to the existing channel independent precoding system.

For the LTE-A system the simulation Parameters are given. The results of simulations obtained with the LTE simulator supporting the LTE advanced features with the parameters setup.

TABLE I

SIMULATION PARAMETERS

Parameters	**Values**
Bandwidth	1,20 MHz
FFT Size	512
Input Block Size	16
CP Length	20
Channel model	Rayleigh,pedA,vehA
Modulation	OFDM

In Fig. 5 The performance of THP in LTE-A system is showed in comparison with the normal precoding scheme. The Throughput is 20% increased comparing to the channel independent precoder.

The THP shows the better performance than the Channel Independent precoder in LTE-A system. The line below the red line indicates the performance of THP in LTE-A system. Its simulation parameters are defined the bandwidth used here is of 20 MHz. The OFDM modulation scheme is used , the analysis is plotted against the BER vs SNR.

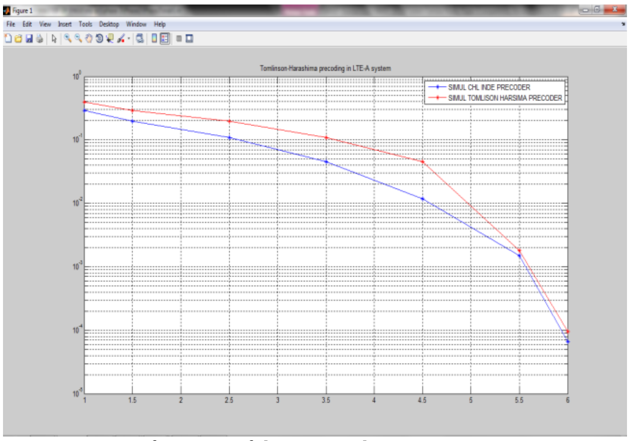

Fig. 5 : BER performance of the THP in the LTE-A system

VI. CONCLUSION

In this paper the new Interference nulling algorithm Tomlinson-Harashima precoding is proposed for LTE-A systems with insufficient CP. It is shown that its efficient than the channel independent precoding scheme LTE-A systems, when transmit antenna is more than the receive antenna ($n_r \le n_t$). The resulting algorithm uses the Tomlinson – Harashima precoder to null the IBI and ICI. It eliminates the interference and performance is analyzed in terms of Bit Error Rate.

For the future research, the work can be extended by placing the channel shortening filters for better performance.

ACKNOWLEDGMENT

I express my heart full thanks and profound sincere gratitude to Ms.K.Kavitha,M.E.,(Ph.D.) **,** Assistant Professor, Department of Electronics and Communication Engineering, K.L.N College of Information Technology, Pottapalayam , for her thoughtful comments , valuable suggestions and timely help and support .

REFERENCES

[1] 3GPP TS 36.211 Version 10.7.0. Technical spe- ci_cation group radio access network; Physi-cal Channels and Modulation. In: 3GPP: 3rd Generation Partnership Project [online]. 2013.Available at: http://www.3gpp.org/ftp/Specs/htmlinfo/36211.html.

[2] SAWAHASHI, M., Y. KISHIYAMA, H. TAOKA, M. TANNO and T. NAKAMURA. Broadband Radio Access: LTE and LTE-Advanced. In: In-ternational Symposium on Intelligent Signal Processing and Communication Systems, 2009. IS-PACS 2009. Kanazawa: IEEE, 2009, pp. 224{227. ISBN 978-1-4244-5015-2. DOI: 10.1109/IS-PACS.2009.5383862.

[3] J.-B. Lim, C.-H. Choi, and G.-H. Im, *"MIMO-OFDM with insufficient cyclic prefix," IEEE Commun. Lett.*, vol. 10, pp. 356–358, May 2006.

[4] X. Sun, L. J. Cimini, L. J. Greenstein, and D. S. Chan, *"ICI/ISI aware beamforming for MIMO-OFDM wireless system,"* in *Proc. 2009 Conf. Inf. Sciences Syst.*, pp. 103–107.

[5] Zhiqiang Liu and T.C. Yang , " *On the design of cyclic prefix length of Time reversed OFDM," IEEE Trans .Wireless Commun.*,vol.11,No.10,Oct 2012.

[6] Y. Fu, C. Tellambura, and W. A. Krzymien, *"Transmitter precoding for ICI reduction in closed-loop MIMO OFDM systems," IEEE Trans. Veh. Technol.*, vol. 56, no. 1, pp. 115–125, Jan. 2007.

[7] Yuansheng Jin and Xiang-Gen, *"An Interference nulling based channel independent precoding for MIMO-OFDM systems with insufficient cyclic prefix," IEEE Trans. Commun.*, vol.61, No.1, Jan 2013.

[8] A. Stamoulis, S. N. Diggavi, and A. Al-Dhahir, *"Intercarrier interference in MIMO OFDM," IEEE Trans. Signal Process.*, vol. 50, no. 10, pp. 2451–2464, Oct. 2002.

[9] C. Tepedelenlioglu, "*Low complexity linear equalizers with maximum multipath diversity for zero-padded transmissions,"* in *Proc. 2003 Int. Conf. Acoustics, Speech, Signal Process.*, vol. IV, pp. 636–639.

[10] K. Sathananthan and C. Tellambura, "*Partial transmit sequence and selected mapping schemes to reduce ICI in OFDM systems*," *IEEE Commun. Lett.*, vol. 6, no. 48, pp. 313–315, Aug. 2004.

[11] Y. Zhao and S.-G. Haggman, "*Intercarrier interference self-cancellation scheme for OFDM mobile communication systems," IEEE Trans. Commun.*, vol. 49, no. 7, pp. 1185–1191, Jul. 2001.

[12] J. Liu, J.-K. Zhang, and K. M. Wong, *"Full-diversity codes for MISO systems equipped with linear or ML detectors," IEEE Trans. Inf. Theory*, vol. 54, pp. 4511–4527, Oct. 2008.

[13] C.-J. Park and G.-H. Im, "*Efficient DMT/OFDM transmission with insufficient cyclic prefix," IEEE Commun. Lett.*, vol. 8, pp. 576–578,Sep. 2004.

[14] SESIA, S., I. TOUFIK and M. BAKER. LTE{the UMTS long term evolution: from theory to practice. 2nd ed. Hoboken: Wiley, 2011. ISBN 978-047-0660-256.

[15] TRANTER, William H. Principles of communication systems simulation with wireless applications.Upper Saddle River: Prentice Hall, 2003. ISBN01-349-4790-8.

[16] KHOSHNEVIS, A., S. YAMADA, Z. YIN and S. CHOUDHURY. Resource allocation and encoding for channel quality indicator (CQI) and CQI collided with uplink acknowledgment/negative acknowledgment [patent]. USA. US 0088533 A1,12/902,109. Issued 7.5.2013.

[17] M. Grossmann, C. Schneider, and R. S. Thoma, "*Turbo equalisation for MIMO-OFDM transmission with insufficient guard interval,"* in *Proc. 2006 International Zurich Seminar Commun.*, pp. 114–117.