BER Improvement in OFDM with ZF and MMSE Equalizers Using ASTC Encoder in Different fading channels

Anupama Sanyal, Parminder Singh

ABSTRACT:
Orthogonal Frequency Division Multiplexing (OFDM) system is modelled with two different equalizers i.e. namely Zero Forcing (ZF) and Minimum Mean Square Error (MMSE), along with 32 QAM modulations are used and analyze with different channels like Rayleigh channel and Rician channel. Then orthogonal frequency division modulation with multicarrier is employed; which provides advantages like inter carrier interference (ICI) reduction; high reliability; and better performance in multi-path fading. Equalizers are adopted to remove the ISI generated in the transmitted data under various fading environments. And the results show that, ASTC with MMSE and ZFE equalizers the bit error rate (BER) performance is improved. From results are analyses that BER performance of MMSE is superior to ZFE equalizer. Now the main problem of OFDM system is PAPR. And the PAPR problem is overcome by using ASTC encoder with different equalizer and using different channels and find which equalizer performs better in the system with different channels. Therefore by reducing PAPR, there is further improvement in BER with ZF and MMSE equalizers. Thus to enhance spectral efficiency of system, the 32 QAM modulations techniques is used.

Keywords— OFDM; ASTC; ZFE; MMSE; Rayleigh Channel; Rician Channel; PAPR; ISI and ICI

I. INTRODUCTION

Fourth generation (4G) wireless technology is expected to provide high bit-rate multimedia communication capability. Nevertheless, high data rate applications require data transmission over broadband frequency selective channels; which cause severe Inter-Symbol Interference (ISI).In this high-speed wireless and mobile communications era, the concept of multi carrier transmission provides high data rates in communication channel. OFDM is a unique kind of multi carrier transmission techniques that divides the communication channel into several equally spaced frequency bands. In it the bit streams are divided into several sub streams and send the information over different sub channels. Thus a sub-carrier carrying the user message is transmitted in each band. And each sub carrier is orthogonal with other sub carrier and it is carried out by a modulation scheme. Data's are transmitted simultaneously in super imposed and parallel form. Then sub carriers are closely spaced and overlapped to gain high bandwidth efficiency [2]. The main disadvantage of OFDM is high peak to average power ratio. The peak values of some of the transmitted signals are larger than the typical values.

Those are created by the coherent summation of the OFDM subcarriers. And when N signals are combining with the same phase; they start a peak power that is N times the average power. This big peaks cause saturation in the power amplifiers; leading to intermodulation product between the subcarrier and disturbing out of band energy. At last it becomes worth while reducing PAPR. And towards this end there are many proposals such as clipping; coding and peak windowing. Therefore reduction of PAPR comes at a price of performance degradation; mainly in terms of rate and BER [5]. This paper proposes to use the ASTC codes as powerful coding techniques for OFDM standard combined with PAPR scheme. ASTC codes can for out a good solution first to overcome the disadvantage of OFDM modulations and second to keep a robustness regarding the BER performances.

Here also used different equalizer i.e. MMSE and ZFE with different channel like Rayleigh fading and Rician fading channel. In statistics and signal processing, a **minimum mean square error** (**MMSE**) estimator is an estimation method which minimizes the mean square error (MSE) of the fitted values of a dependent variable; which is a usually measure of estimator quality.

Zero Forcing Equalizer refers to a form of linear equalization algorithm used in communication systems which applies the inverse of the frequency response of the channel. And this form of equalizer was first invented by Robert Lucky. Then Zero-Forcing Equalizer applies the inverse of the channel frequency response to the getting signal; to restore the signal after the channel. This has several useful applications.

In simple word Rayleigh fading channel may be define as the channel has indirect path between sources to the receiver. Thus in Rician channel has direct path between source and receiver.

II. ASTC ENCODER AND ITS TYPES

ASTC (Algebraic Space Time Codes) as powerful coding technique for OFDM standard combined with PAPR reduction scheme. Thus ASTC to their very Algebraic- construction based on Quaternion algebra; have a full rate; full diversity; non-vanishing constant minimum determinant for increasing spectral efficiency; uniform average transmitted energy per antenna and good shaping; readily lend themselves to high data rate situations. And theses codes were invented in 2004 by obtained using division algebra. ASTC could exceed the Alamouti codes performances, thanks to its algebraic construction which guarantees three major advantages: First, a nonzero lower bound on the coding gain; which is independent of the spectral efficiency (non-vanishing determinant). Second, the shaping constraints, with an objective to make sure that the codes are energy efficient. Third, uniform average transmitted energy per antenna is also required. To spread their power regarding the bit rate and the BER performance into the selective channel case with time variation; introduce the good perfect algebraic code known as Golden codes with other tow well popular algebraic space time codes; TAST and DAST

A. Golden Code

The code was proposed in 2004; STBC comes using division algebra; which is full rate; full diversity; and has a nonzero lower bound on its coding gain; which does not depend on the constellation size. The code word is written as :

$$X_{n_i} = \frac{1}{\sqrt{5}} \begin{pmatrix} \alpha(\vartheta_{n_i}(1) + \theta\vartheta_{n_i}(2)) & \alpha(\vartheta_{n_i}(3) + \theta\vartheta_{n_i}(\\ \bar{\alpha}(\vartheta_{n_i}(3) + \bar{\theta}\vartheta_{n_i}(4)) & \bar{\alpha}(\vartheta_{n_i}(1) + \bar{\theta}\vartheta_{n_i}(\end{pmatrix} \quad (1)$$

Where $\theta = \frac{1+\sqrt{5}}{2}$ & $\bar{\theta} = \frac{1-\sqrt{5}}{2}$

& $\alpha = 1 + i - i\theta$

$\bar{\alpha} = 1 + i - i\bar{\theta}$

B. TAST Code

The TAST code is a space time algebraic code comes using the integer algebra; with rate R = Nt = 2 Symbol /uc(used code word) and diversity D = Nt × Nr = 4. Each space time layer is associated with his proper algebraic space ' in order to alleviate the problem of ISI (Inter-Symbol-Interferences). This code word is expressed as:

$$X_{n_i} = \frac{1}{\sqrt{2}} \begin{pmatrix} (\vartheta(1) + \theta\vartheta(2)) & \varphi(\vartheta(3) + \theta\vartheta(4)) \\ \varphi(\vartheta(3) + \theta\vartheta(4)) & (\vartheta(1) + \theta\vartheta(2)) \end{pmatrix} \quad (2)$$

Where

$$\theta = \exp(i\lambda)$$
$$\lambda \in \Re$$
$$\varphi = \theta^2$$

C. DAST Code

The DAST code is a 2×2 diagonal space time algebraic code obtained using the turned constellations of integer algebra, with rate 1 Symbol/uc, and full diversity. The code word is define as follows

Where

$$X_{Dast} = H_{nt.} diag(\mathrm{M}\,\vartheta_{nt})$$
$$\mathrm{M} = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & \theta \\ 1 & -\theta \end{pmatrix}$$
$$\theta = \exp(i\pi/4) \quad (3)$$

D. Time variation Representation of ASTC

As mentioned above the ASTC works under the non time variant channel assumption; which is not commonly the case. Here in fact can re-express the total code word X(Golden, Tast, Dast) to a vector $x^p_{n_i}$ of length l = 4 with p =∈ (Golden, Tast, Dast) at time (ni,ni+1) as the follows:

$$x^p_{n_i} = \frac{1}{\sqrt{5}} \begin{pmatrix} (\alpha(v(1) + \theta v(2)))_{(n_i,1)} \\ (\bar{\alpha}(v(3) + \bar{\theta} v(4)))_{(n_{i+1},1)} \\ (\alpha(v(3) + \theta v(4)))_{(n_i,2)} \\ (\bar{\alpha}(v(1) + \bar{\theta} v(2)))_{(n_{i+1},2)} \end{pmatrix} \quad x^p_{n_i} = \frac{1}{\sqrt{2}} \begin{pmatrix} ((v(1) + \theta v(2)))_{(n_i,1)} \\ (\varphi(v(3) - \theta v(4)))_{(n_{i+1},1)} \\ (\alpha(v(3) + \theta v(4)))_{(n_i,2)} \\ (\bar{\alpha}(v(1) + \bar{\theta} v(2)))_{(n_{i+1},2)} \end{pmatrix}$$

$$x^p_{n_i} = \frac{1}{\sqrt{2}} \begin{pmatrix} ((v(1) + \theta v(2)))_{(n_i,1)} \\ ((v(1) + \theta v(2)))_{(n_{i+1},1)} \\ ((-v(1) + \theta v(2)))_{(n_i,2)} \\ ((v(1) - \theta v(2)))_{(n_{i+1},2)} \end{pmatrix} \quad (4)$$

III. EQUALIZATION IN TIME DOMAIN

Considering non linear channel (or when signaling is not done according to nyquist criterion), there is a great chance that intersymbol interference occur. For linear channels, cyclic prefix is used to convert linear convolution of data into circular convolution. For both the cases, we need to use equalization. For the model used in the paper; two different equalization techniques; namely, ZF equalization and MMSE equalization both in time domain are investigated. The time domain equalizer use shorter length of cyclic prefix which does not affect efficiency of system.

A. Zero Forcing Equalizing Technique

It is a linear equalizer, which inverts the frequency response of the channel. The ZFE transfer function is the inverse of that of channel's response. Then the name Zero-Forcing; signify bringing down the ISI to zero in a noise free case. This is useful when ISI is significant compared to noise. Let the discrete time transmitted symbols, the channel response, and the set of filter coefficients are represented as s(k), h(k), and c(k) respectively as shown in Figure 4. According to the definition of ZFE algorithm we have to find filter coefficients which can mitigate the channel effects such that

$h(k)*c(k) = s(k)$ (`5)

In (1), symbol * represents circular convolution. These filter coefficients c(k) are then convolved with received time domain discrete signal y(k) to equalize y(k) as given below.

$Y_{ZF} = c(k)*y(k)$ (6)

Equation (2) can be further simplified as

$Y_{ZF} = c(k)* [S(k)*h(k)+n]$ (7)

Where n is AWGN noise in equation (7) can be further reduced to

$Y_{ZF} = s(k)+c(k)*n$ (8)

Also, we can develop the same model in frequency domain. If the channel response in frequency domain response is H[f], filter coefficients C[f] is constructed by C(f) =1/H(f). Thus combination of channel and equalizer gives a flat frequency response H(f)C(f) = 1.

B. Minimum Mean Square Equalizer

The zero-forcing equalizer; although removes ISI; may not give the best error performance for the communication system because it does not take into account noises in the system. The different equalizer that takes noises into account is the minimum mean square error (MMSE) equalizer. It is based on the mean square error (MSE) criterion. At without knowing the values of the message symbols I_k beforehand; model each symbol I_k as a random variable. Assume that the information sequence $\{I_k\}$ is WSS. We choose a linear equalizer $H_E(Z)$ to minimize the MSE between the original information symbols I_k and the output of the equalizer ^I_k:

$MSE = E[e_k^2] = E[(I_k - {}^{\wedge}I_k)^2]$ (9)

The linear MMSE equalizer can also be found iteratively. Thus first; notice that the MSE is a quadratic function of h_E. Then gradient of the MSE with respect to h_E gives the direction to change h_E for the biggest increase of the MSE. To low value of MSE; can update h_E in the direction opposite to the gradient. And this is the steepest descent algorithm. It is a stochastic steepest descent algorithm called the least mean square (LMS) algorithm.

IV. CHANNEL DESCRIPTION

In generally there are various fading channels, which includes Rician and Rayleigh and in this paper OFDM is simulated in two type of fading channels like as Rayleigh and Rician.

A. Rayleigh channel*:* In a Rayleigh fading channel model, it is assumed that that there is no direct path [4, 5, 11] between transmitter and receiver out of all multiple reflective paths. The output of such channel can be expressed as

$R(n) = \sum h(n,\tau)S(n-m) + Z(n)$ (10)

Where Z(n) is AWGN noise with zero mean and unit variance, h(n) is channel impulse response which is equal to

$h(n) = \sum \alpha(n) e^{-j\theta(n)}$ (11)

Where Į(n) and ş(n) are attenuation and phase shift for nth path. So, we summarize them for all the channel taps. The Rayleigh channel can be simulated as flat or frequency selective channel depending upon its coherence bandwidth. If coherence bandwidth is larger compared to signal bandwidth; the channel is called flat; otherwise; it is called frequency-selective. In this paper, OFDM is simulated under Rayleigh frequency-selective channel. The channel is implemented by choosing number of channel taps which should be more than cyclic prefix length. The channel h is known at the receiver.

B. Rician channel*:* The Rician fading is similar to that for Rayleigh fading, except that in Rician fading [12], a strong dominant component exists. It is dominant component can for instance is the line-of-sight wave. Specifically, in Rician model we have exhibits following properties a) the dominant wave can be a phasor sum of two or more dominant signals; for example the line of sight plus a ground reflection. It is combined signal of then mostly treated as a deterministic (fully predictable) process. b) The dominant wave can also be subject to shadow attenuation. The system model for Rician channel is same as Rayleigh channel but with difference in scaling factor.

V. RESULT DISCUSSION

In experimentally, use MATLAB simulation to get result; make model with ASTC with different channel like Rayleigh and Rician fading by using different equalizer i.e. ZFE and MMSE to remove ISI. Here also use 32 QAM modulation techniques.

The result of experimental is discussed and shown below as:

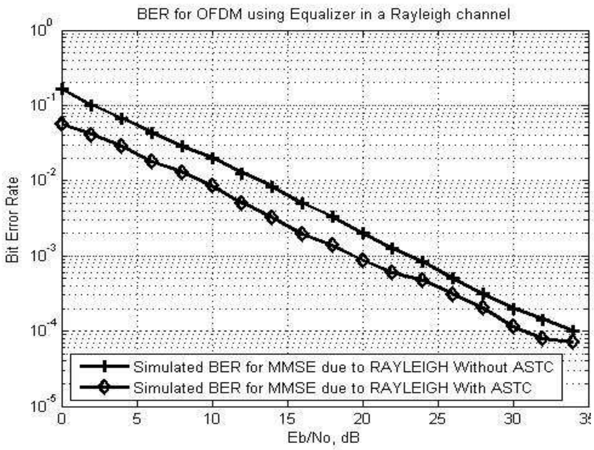

Figure 1: Comparison graph between BER and Eb/No with Rayleigh and MMSE using ASTC and without Using ASTC

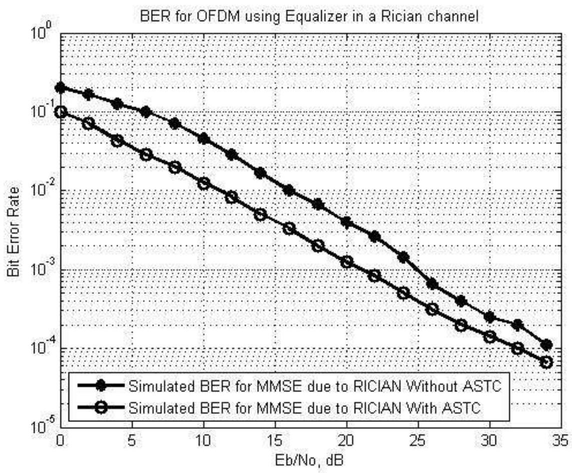

Figure 2: Comparison graph between BER and Eb/No with Rician and MMSE using ASTC and without using ASTC

Here compare graph between BER and Eb/No with Rayleigh and Rician channel with MMSE using ASTC and without using ASTC. From result find out with ASTC reduce the BER as compare to without ASTC. ASTC improve BER by reduce the PAPR value of OFDM system.

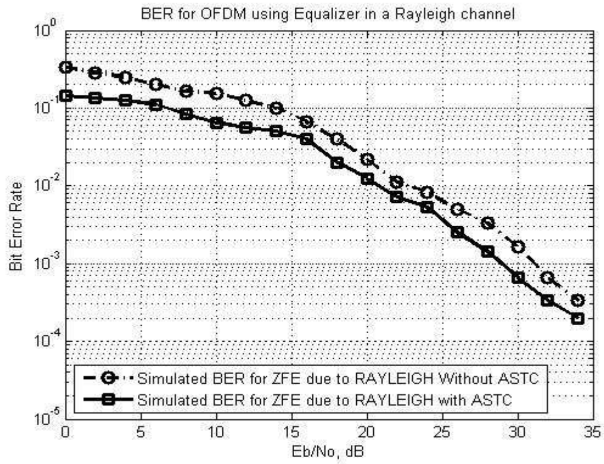

Figure 3: Comparison graph between BER and Eb/No with Rayleigh and MMSE using ASTC and without using ASTC

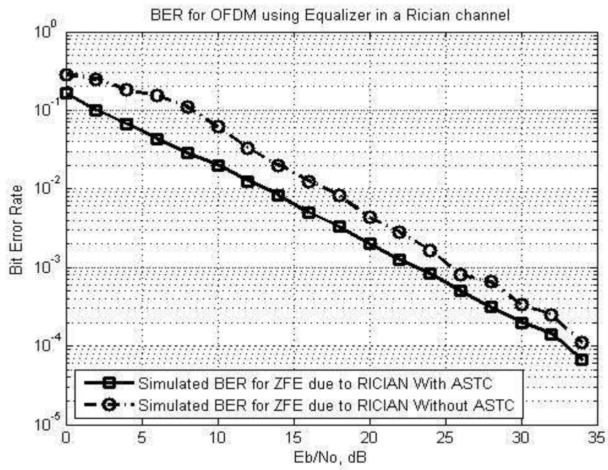

Figure 4: Comparison graph between BER and Eb/No with Rician and MMSE using ASTC and without using ASTC

In above figure compare graph between BER and Eb/No with Rayleigh and Rician channel with ZFE using ASTC and without using ASTC. From result find out with ASTC reduce the BER as compare to without ASTC. ASTC improve BER by reduce the PAPR value of OFDM system. At last find out by using ASTC encoder improve BER as compare pervious result shown in above figure without ASTC line draw.

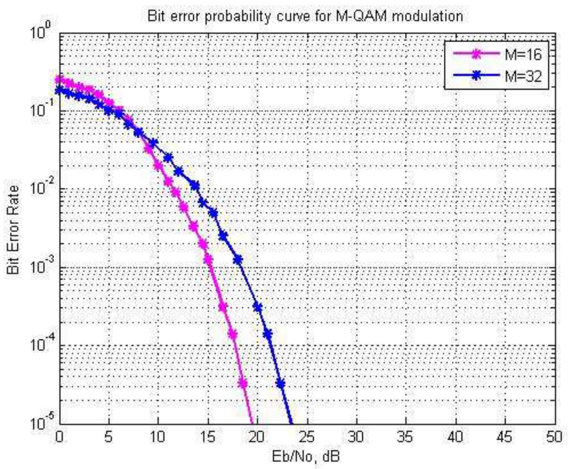

Figure 5: Compare 16 and 32 QAM modulations techniques

Here compare 16 and 32 QAM modulation technique and find out 32 QAM modulations has more spectral efficiency as compare to 16 QAM modulations. Therefore to transmit more data use 32 QAM modulations in this paper. No doubt BER increase in 32 QAM modulations but overcome this problem use ASTC encoder.

VI. CONCLUSIONS

This paper analysed that OFDM has main problem which known as PAPR. Due to this problem the system performance is reduce and power dissipation is not good which reduce the lifetime of electronics components. Many techniques require reducing PAPR problem such as clipping; clamping; Tone injection; Tone rejection and PTS &SLM coding techniques. But all these techniques have some disadvantage and limitation. Therefore it is necessary to reduce PAPR by using ASTC encoder which overcomes the limitation such as complexity, cost and decrease power efficiency. And increase spectral efficiency use 32 QAM modulations. The equalizer use here to reduce ISI.

ACKNOWLEDGEMENT

Thanks to my teachers and parents to help me. This paper dedicated to the loveable memories of my brother (Bunty) who always with me. God always bless you bhaiya with peace

REFERENCES

[1] Bhasker Gupta, Gagan Gupta, and Davinder S. Saini “BER Performance Improvement in OFDM System with ZFE and MMSE Equalizers” 978-1-4244-8679-3/11/$26.00 ©2011 IEE

[2] John Proakis, Digital communication, 4rd ed., vol. 1. Mcraw Hill: 2008.

[3] T. S. Rappaport, Wireless Communications, 2nd ed., vol.1. Pearson Education, pp. 356–376, 2002

[4] Y.Sato, “ A method of self –recovering equalization for multilevel amplitude modulation system”, IEEE Trans. on communication, vol. 23, pp.-679-682, june 1975.

[5] S. S. Sarnin, N. Kadri and A. Mahyuni, “Performance Analysis of BPSK and QPSK Using Error Correcting Code through AWGN,” in Proc. IEEE Conf, 2010 International Conference on Networking and Information Technology (ICNIT 10), pp.178-182, June 2010.

[6] W. Lindsey, “ Error probabilities for Rician fading multichannel reception of binary and N-ary signals,” IEEE Trans. Inf. Theory, Vol. 10, no. 4, pp. 339–35. 1964.

[7] Dr.S.P.Vimal,M.Kasiselvanathan and U.Saravanakumar, “A NEW SLM AND PTS SCHEMES FOR PAPR REDUCTION IN OFDM SYSTEMS” International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 11, November 2013.

[8] Sonia Singla and Vikas preet tiwana, “PAPR REDUCTION in OFDM SYSTEM USING ANT COLONY OPTIMIZATION” International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 8, August 2013.

[9] Foomooljareon, P and W.A.C. Fernando, (2002),”PAPR Reduction in OFDM Systems”, ThammasaItn. J. Sc.Tech., 7: 70-79.

[10] Bannour, Ahmed. And Ammari, Mohamed Lassaadi. and Sun,Yichuang. and Boullegue, Ridha (2011). “On the Capacity of ASTC-MIMO-OFDM System in a Correlated Rayleigh Frequency-Selective Channel” 978-1-4244-8331-0/11, 2011 IEEE

[11] Gautam, Atul. and Sharma,Manisha.(2013) “Capacity Enhancement of MIMO-OFDM System in Rayleigh Fading Channel” IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735. Volume 6, Issue 1, PP 49-58.

[12] Ahmed BANNOUR, Mohamed Lassaad AMMARI and Ridha BOUALLEGUE, “Adaptation of ASTC in a Correlated Rayleigh Frequency-Selective Fading Channels in OFDM systems with PAPR Reduction” International Journal of Wireless & Mobile Networks (IJWMN), Vol.2, No.2, May 2010

[13] J. Gao, J. Wang, and Z. Xie, “Peak to average power ratio reduction for MIMO-OFDMsystems with decomposed selected mapping,”*IJISS*, vol. 3, pp. 572–580, 2009.

[14] [7] J. C. Belfiore, G. Rekaya, and E. Viterbo, “The golden code: a 2 x 2 full-rate space-time code with non-vanishing determinants,” *IEEETrans. Inform. Theory*, vol. 13, pp. 67–75, 2004.

[15] [8] A. Bannour, M. L. Ammari, and R. Bouallegue, “Analysis of ASTC in a correlated rayleigh fading channel with imperfect channel estimation,” *International Conference on Advanced Communication Technology*, 2010.

[16] [9] G. R. ben Othman, “Nouvelles constructions algébriques de codes spatio-temporels atteignant le compromis ˇTmultiplexage-diversitéˇT,”Ph.D. dissertation, ENST, 2004.