Reduction of PAPR in MIMO-OFDMA System by Using Daoud Technique LDPC Codes

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Abstract— **The high peak average power ratio, PAPR and also bit error rate, BER appears the be the main disadvantage as they are viewed as important implementation issues in communication system. These two major drawbacks were considered extensively in MIMO OFDMA which can result in significant distortion. These large peaks increase the amount of intermodulation distortion resulting in an increase in the error rate. In this paper, the proposed study is based on PAPR reduction by the implementation of Low Density Parity Check, LDPC using Daoud Technique. This paper also present the significant to simulate the bit error rate, BER to provide the system with good performance and achieving maximum diversity order which will improve the whole system in terms of BER performance. Comparison of PAPR and BER is carried out for LDPC and Daoud LDPC in MIMO OFDMA. The simulation result shows that the Daoud LDPC codes gives a slight better reduction of PAPR and BER with maximum diversity order achievement when compared to conventional LDPC codes.**

Keywords- Low Density Parity Check (LDPC), Multiple Input-Multiple Output (MIMO), Orthogonal Frequency Division Multiple Access (OFDMA), Bit Error Rate (BER), Daoud LDPC.

I INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a method of encoding digital data on multiple carrier frequencies. The demand for data communication towards high data rates has increased over the last few years and will likely continue to grow. Orthogonal frequency division multiple access (OFDMA) is a version of OFDM (Orthogonal frequency division multiplexing) modulation that happens to be optimized for multiple users specifically for cell phones and other mobile devices. This technique gives a significant increase in data rates in wireless communication system.

In conjunction of its robustness to frequency selective fading, high spectral efficiency and low computational complexity, OFDMA can transform MIMO channel into a set of parallel frequency [1]. MIMO which is known as a capacity booster work perfectly with OFDMA system by enhancing the data rates in order to fulfill the future demands.

MIMO-OFDMA support both spatial multiplexing and diversity coding such as Space Time Coding and Space Time Frequency Coding. This paper used Space Time Frequency Block Coding in order to combine the advantages of MIMO and OFDMA systems. STFB coding is done across space, time and frequency to achieve maximum diversity gain. However, the main drawback of MIMO OFDMA is its high PAPR [2]. In an OFDMA system, the data is transmitted into many groups, each being modulated by a baseband QAM symbol. As a result, the amplitude of such signals can have very large value. When high peak power signals pass through power amplifier, A/D and D/A converters, peaks are distorted non- linearly because of amplifier and converters imperfections. Minimizing the PAPR allows higher average power to be transmitted for a fixed peak power, improving the overall signal to noise ratio at the receiver [3].

One code that is very close to Shannon limit was proposed by Gallager in 1962 applied to BPSK and QPSK is Low Density Parity Check. The fundamental of the research was evaluated over an additive white Gaussian noise channel and it has been shown LDPC codes have a large gain with the respect to conventional code for large packet length [4].

Recently, low density parity check (LDPC) codes have attracted much attention because of their excellent error correcting performance. Today, LDPC codes are used in most of the wireless, wired, optical, OFDMA communication systems. Low density parity check codes are a class of linear of block codes [5]. The name comes from the characteristics of their parity check matrix which contains only a few 1's in comparison to the amount of 0's. Their main advantage is that they provide a performance which is very close to the capacity for a lot of different channels and linear time complex algorithms for decoding.

In this study, the concept of coding technique is applied to the MIMO OFDMA system but also well suited for error correcting performance. The literature survey defines the usage of low density parity check codes for PAPR reduction [6]. This code shows that the theoretical values are closer to the Shannon limit and perform good role in the PAPR reduction of MIMO OFDMA system.

In this paper, the LDPC code by using Daoud technique is proposed using MATLAB to provide excellent reduction of PAPR with suitable modulation scheme along with diversity concept to achieve the great error performance with maximum diversity order. The simulation result is shown in PAPR and BER with signal to noise ratio. The comparison between conventional LDPC and LDPC Daoud technique can be summarizing by the final simulation in the simulation and result part.

II SYSTEM MODEL

MIMO is known to be a booster for a high data rate transmission. The combination between MIMO and OFDMA is very attractive and has become a most promising broadband wireless access scheme [7]. Driven by the demands to support data applications at higher throughput and spectral efficiency, orthogonal frequency division multiplexing (OFDM) based multiple access is being considered as a promising technique for the future wireless networks. OFDMA has been adopted as the downlink access technology of 3rd generation partnership project (3GPP) long term evolution (LTE) and LTE-advanced standards [8]. Based on the OFDM technique, OFDMA inherits the immunity to intra-cell interference.

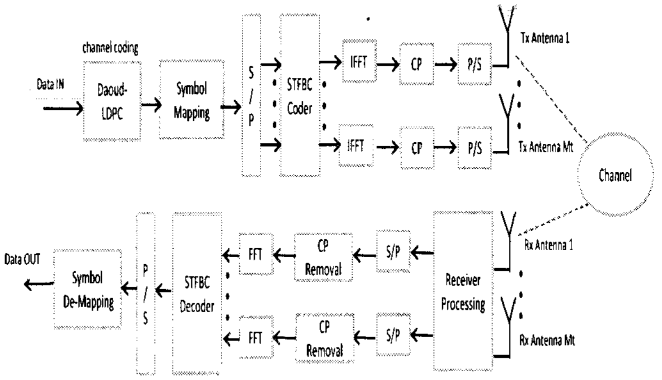

Figure1. A simplified MIMO-OFDMA transceiver block diagram.

Figure 1 shows the block diagram of transmitter and receiver of MIMO-OFDMA. The data source firstly will be encoded by forward error correction (FEC). Next, the encoded data will be modulated into digital mapping constellation by digital modulator which converts the binary data into complex number. After that, the symbol data is encoded by MIMO encoder and the parallel output then will be transmitted to OFDMA modulator. Each parallel output corresponds to each transmit antenna. At the OFDMA modulator, the symbol data is modulated by IFFT and cyclic prefix is inserted to every OFDMA symbol in order to optimize inter-symbol interference (ISI). Afterwards the output is modulated to construct analog data and up conversion process is done.

Parity check matrix	[32400x64800]
Block length	64800
Number of Info bits	32400
Number of parity bits	32400

Table 1: LDPC encoder parameter

Parity check matrix	[32400x64800]
Block length	64800
Number info bits	32400
Number parity bits	32400
Number of iterations	50

Table 2: LDPC decoder parameter

III LOW DENSITY PARITY CHECK (LDPC) CODE

LDPC code is a type of linear block codes. LDPC codes are now recognized as a good error correcting codes which achieve near Shannon limit performance [9]. LDPC codes have better block error performance than Turbo code, because the minimum distance of an LDPC code increases proportional to the code length with high probability [10]. The advantage suits well for high bit rate transmission that demand low frame error potential.

LDPC codes are using sparse parity check matrix with two different possibilities to present the codes. First is using matrix ***H*** and the second one is using graphics. The structure of LDPC is entirely expressed by the parity check matrix 'H' where 'H' is a sparse , the matrix consists of '0' and '1'. The sparse is a MxN parity check matrix where $N>M$ and $M=N-K$. The message bits are said to be 'M', the parity bits are said to be 'K' and 'N' defines the total number of bits in the encoded data. There are two classes of LDPC. One is regular and another one is irregular LDPC. This study deals with irregular LDPC in that the rows and columns of 'H' have the different weights.

The size of the parity check matrix is $P1xP2$ where $P1$ represents the size of the row and $P2$ defines the size of the column in parity check matrix. The number of 1's in a row is stated as row weight 'Wr' and the number of 1's in columns is represented as column weight, 'Wc' where Z is a zero matrix. Thus, when constructing the Parity-check matrix ***H***, all the rows of the matrix needs to be ensure are linearly independent.

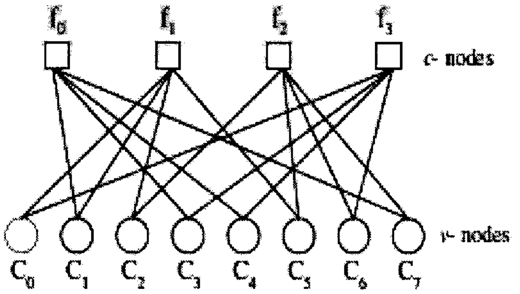

Figure 2: Tanner graph corresponding to the parity check matrix H for (8,4) code.

Figure 2 is an example of graphical representation of LDPC code from Tanner. This graph contains 2 types of nodes which is called variable nodes (v-nodes) and check nodes (c-nodes). The variable nodes correspond to the n in matrix *H* dimension while check nodes correspond to the m in matrix *H* dimension. The 8 bits of variable nodes represent codeword and check nodes consists of four parity bits.

IV PROPOSED TECHNIQUE

4.1 LDPC Daoud

For an effective encoder-decoder implementation, the parity check matrix has the approximation and has to be a block-structured matrix. There are two main factors in constructing a good LDPC code: an approximate upper triangular form with a small gap matrix, g, as possible and the block structured matrix feature. Starting from the observation in tackling these constraints, for irregular LDPC codes the variable nodes with high degree tend to converge more quickly than those with low degree. Therefore with a finite number of decoding iterations, not all the small cycles in the code bipartite graph are equally harmful. In other words, those small cycles that pass more low-degree variable nodes degrade the performance more seriously than the others. Thus, it is recommended that all small cycles should be prevented from passing too many low-degree variables nodes [11].

$$\mathbf{H} - \begin{bmatrix} \mathbf{H}_{1,1} & \mathbf{H}_{1,2} & \cdots & \mathbf{H}_{1,n} \\ \mathbf{H}_{2,1} & \mathbf{H}_{2,2} & \cdots & \mathbf{H}_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{H}_{m,1} & \mathbf{H}_{m,2} & \cdots & \mathbf{H}_{m,n} \end{bmatrix}.$$

Figure 3: The parity check matrix, H

The size of each block matrix is ***b*** x ***b***; the size of parity check matrix is ***p1*** x ***p2***, where ***p1=mb*** and ***p2=nb*** (where m and n define the size of the parity check matrix) and ***g=yb***, where y is total number of blocks in the g submatrix. The row and column weight distributions are {***wr1,wr2,...,wrn***} and {***wc1,wc2...wcn***} where ***wr1*** and ***wcj*** represent the weight of ith block rows and jth columns, respectively. The output from these parameters will provide the components of the ***p1*** x ***p2*** parity check matrix, ***H*** as in figure 3.

This matrix will be either a right cyclic shift of an identity matrix or a zero matrix. According the weight distribution of the matrix columns and rows, two different sets of weight distributions have been generated

$\{a_1, a_2, \ldots a_n\}$, where

$$a_j = wc \begin{cases} W_{cn}, & 1 \le j \le (n - m + \gamma) \\ W_{cj}, & 1 \le j \le (n - m + \gamma \le j \le n) \end{cases} \qquad (1)$$

$\{b_1, b_2, \ldots b_m\}$, where

$$a_i = \begin{cases} W_{ri} - 1, & 1 \le i \le (m - \gamma) \\ W_{ri}, & 1 \le i \le (m - \gamma + 1 \le i \le n) \end{cases} \qquad (2)$$

Starting with $j = 1$ the a_j null blocks on the *j*th block column will be replaced by a_j right cyclic shifted identity matrix.

4.2 Peak To Average Power Ratio (PAPR) Reduction Technique

In presence of large number of independently modulated sub-carriers in OFDMA systems, the peak value of the some signals can be very high as compared to the average of the whole system. The complex envelope of an OFDMA signals is an overlap of N complex oscillations with different frequencies, phases and amplitudes. As a result, we get a time domain signal with high peak to average power ratio.

These peaks may cause signal clipping at high levels and may force the amplifier in the transmitter side to work in the non linear region, thereby producing frequency components in addition to the original and results in out of band radiation. The major concept of this paper is to reduce the high peak value before the transmission is carried out [12]. The ratio of the peak to average power value is termed as peak to average power ratio.

When N signals are added with the same phase in the N-point IFFT stage to produce OFDMA symbol, they occasionally produce a high peak power equal to N times the average power. Thus, the PAPR definition can be written as

$$PAPR = 10 \log \left(\frac{Ppeak}{Pave} \right) \qquad (3)$$

Where Ppeak is the maximum power of an OFDM symbol Pave is the average power.

The average power is calculated using the formula

$$Average\ Power = \frac{Sum\ of\ magnitude\ of\ all\ the\ symbols}{No.of\ symbols} \qquad (4)$$

The complementary cumulative distribution function (CCDF) of the PAPR is one of the most frequently used methods to check how often the PAPR exceed the threshold value (Vimal and Kumar, 2011). Graph is plotted among threshold and CCDF values. The CCDF can be calculated by the relation P (PAPR>X) =1-P(PAPR<X). The fixation of threshold value range from zero to maximum value. The formula for calculating the threshold value is

$$Threshold = \frac{0{:}(Maximum\ PAPR - Minimum\ PAPR)}{Maximum\ PAPR{:}Minimum\ PAPR} \qquad (5)$$

Let the maximum value be 10, minimum value be 5. Therefore:

Threshold= 0:(10-5)/10:10= 0:0:5:10

Then, the threshold values are 0, 0.5, 1, 1.5.......10.

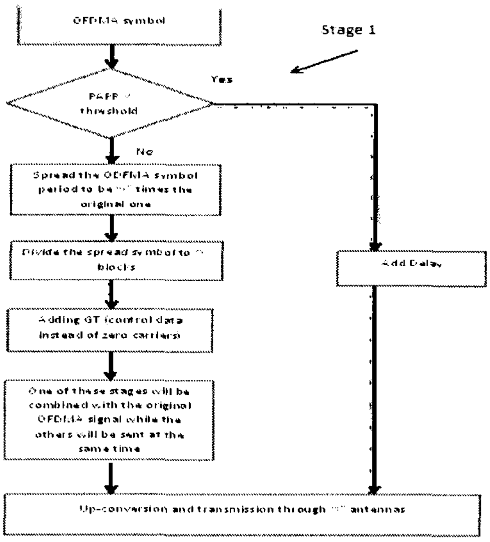

Figure 4: the flowchart of the algorithm for the proposed work

V SIMULATION AND RESULT

In this study the simulation was carried out by using MATLAB 7.10 simulation program. The simulation environment consist of the following; uniformly distributed randomly generated data sequence, two different channel coding rate, different modulation technique, IFFT size of 256 and generator polynomial g= [1 1 1 1 0 1]. The simulation also considers LDPC that has different spreading rates, two different column weights of 6 and 7, as well as the following values, m=64, n=128, b=64, γ=3 and d(*min*)=8. Performance of comparison between LDPC and Daoud LDPC schemes is shown in figure 5 for PAPR.

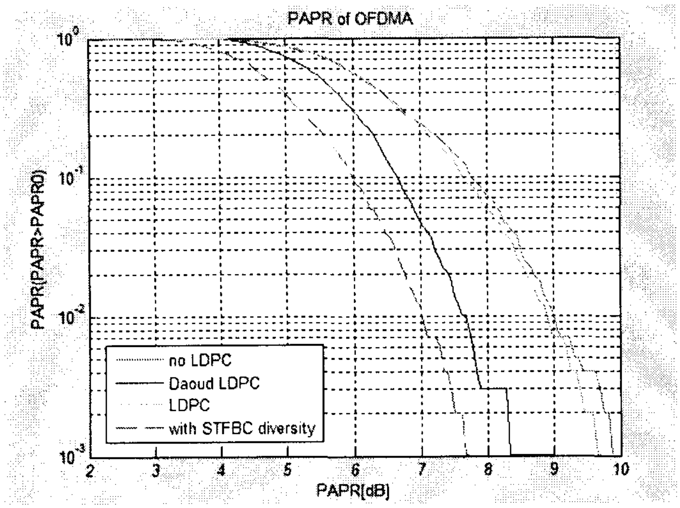

Figure 5. PAPR performance of LDPC-Daoud with MIMO OFDMA

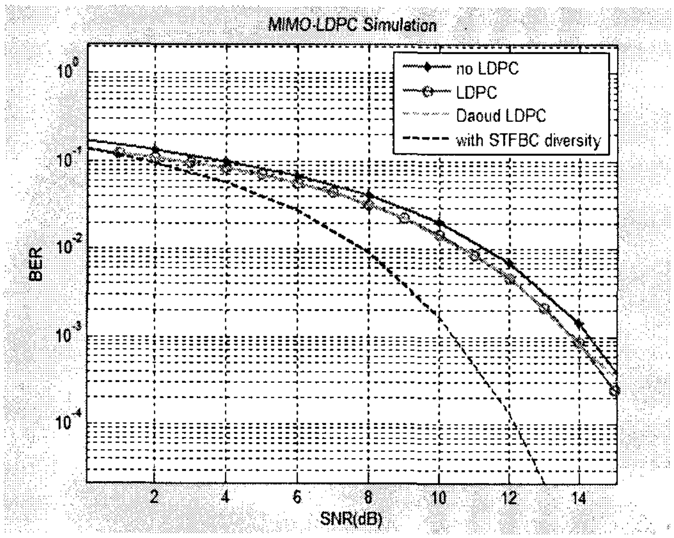

Figure 6. BER performance of LDPC-Daoud with MIMO OFDMA

The results given in figure 5 show a comparison between the PAPR with no compensation (OFDMA), PAPR compensated using LDPC coding, PAPR compensated using LDPC Daoud coding and PAPR compensated using Daoud LDPC with diversity. It is observed that MIMO using Daoud Technique in LDPC performs better than regular MIMO LDPC

O.Daoud et al. has shown that application of LDPC coding for PAPR reduction does indeed decrease the PAPR when compared to that of no compensation [13]. Comparing these results to those from the presented simulations, it can be seen that LDPC coding does indeed offer an increase in reduction of the PAPR over the conventional LDPC coding approach. Daoud LDPC shows a further decrease in PAPR from the conventional LDPC method accordingly (of course, this depends on the modulation method and the coding rate).

In the figure 5, PAPR plot shows that they exceed the threshold value. From this figures the reduction improvements are clearly shown. It can be seen that at a PAPR threshold of 10 dB, the probability of the PAPR values that exceed this threshold is reduced while using LDPC codes instead of no coding (MIMO OFDMA). The reduction of PAPR can be best compare in conventional LDPC with Daoud LDPC as we proposed. The Daoud LDPC shows a slight improvement which prove that the Daoud LDPC coding is better than the conventional LDPC where the PAPR value is bound up below than 10 dB (to be exact, it is 7.8 dB) with 1.1dB gain. With additional of STFBC diversity, the reduction of PAPR shows a great performance. However, these results are depending on spreading rate to enhance the result simulation.

In figure 6, the graph is plotted after simulation of channels at different type of coding in order to verify the result of BER. The SNR of BER is numerically obtained for no coding (MIMO OFDMA), LDPC coding, Daoud LDPC coding, and Daoud LDPC with STFBC diversity. Comparisons of these four different coding techniques show that the proposed codes of Daoud LDPC are able to achieve better result. It quantifies the reliability of the entire system including both transmitter and receiver part in the system. The plotted graph has clearly shows that the raw MIMO OFDMA coding took the last place compared to the other three different coding.

After that the MIMO OFDMA has been upgraded with LDPC coding, it enhance its performance a little bit with a pink line indicator in figure 6. Next, we tried to compare the result of conventional LDPC with the proposed Daoud LDPC and the results improved slightly better than the two previous coding. However, this enhancement depends on the value of bandwidth. From figure 6, it has been concluded that the BER of Daoud LDPC code is acceptable where the value of BER exceed 10^{-1} whereas the SNR value is above 10 dB.

VI CONCLUSION

In this paper, the Daoud LDPC technique has been proposed. The Daoud LDPC codes have been used to reduce the PAPR effectively. The result shows the response to SNR and PAPR value is convincing, where the PAPR value is 7.8 dB and the SNR value for BER is 13 dB with the use of Daoud LDPC with diversity. The result of the performance of LDPC in Daoud LDPC coding for MIMO-OFDMA could be a reference in the future development.

VII FUTURE WORK

1. Investigate the simulation of various pair of antenna in order to observe the highest performance in BER,PAPR and Maximum Diversity Order.
2. Simulate the above work using different LDPC coding in order to compare the performance of Daoud LDPC with other coding such as Quasi Cyclic LDPC, Turbo Codes, Reed Solomon Code and Convolutional Codes.
3. Further work can be extended by increasing the coding and spreading rates with different modulating scheme.

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