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PERFORMANCE EVOLUTION OF PAPR REDUCTION IN OFDM WITH AND WITHOUT LDPC TECHNIQUE

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ABSTRACT

The OFDM is one of the proven multicarrier modulation techniques, which provides high spectral efficiency, low implementation complexity, less vulnerability to echoes and non-linear distortion. Apart from the above advantages presently this technique is used by almost all wireless standards and above. The one major shortcoming in the implementation of this system is the high PAPR (peak-to-average power ratio) of this system. In this paper, Irregular Low-Density-Parity Check encoder is used effectively to reduce PAPR problem& improves BER. Low Density Parity Check codes (LDPC) are promising techniques to reduce the peak-to-average power ratio (PAPR) for orthogonal frequency division multiplexing (OFDM). Almost all peak-to-average power ratio reducing techniques are degrading the BER performance. The result shows that proposed system with LDPC code improves performance of BER than without LDPC coding. The performance of system is simulated by MATLAB software.

KEYWORDS: Orthogonal frequency division multiplexing (OFDM), Peak-to-average power ratio (PAPR), Irregular Low density parity check (LDPC), BER, and Complementary Cumulative Distribution Function (CCDF).

INTRODUCTION

In recent years orthogonal frequency division multiplexing (OFDM) has gained a lot of involvement in diverse digital communication applications. It is a new ensuring transmission scheme for broadband communications over a wireless channel. An orthogonal frequency division multiplexing data is transmitted simultaneously through multiple frequency bands process. It offers many advantages over single frequency transmission as high spectral efficiency, robustness to channel fading system, immunity to impulse interference, and the capability to handle frequency-selective fading without resorting to complex channel equalization schemes [1]. OFDM also uses small guard interval, and its ability to combat the ISI problem. Simple channel equalization is needed instead of complex adaptive channel equalization scheme. In the conventional serial data transmission technique, the information symbols are transmitted sequentially where each symbol occupies the entire accessible spectrum bandwidth. But in an OFDM, the information is converted to N parallel sub-channels and sent at lower rates are using frequency division multiplexing (FDM) system. The subcarrier frequency spacing is selected carefully such that each subcarrier system is located on the other subcarriers zero crossing points. This implies that there is overlapping among the subcarriers other than will not interfere with each other; they are sampled at the sub carrier frequencies [2]. Despite the fact that OFDM has a number of advantages, one of the major drawbacks of orthogonal frequency division multiplexing signal is its large envelope fluctuation, for likely resulting in large peak-to-average power ratio. When the OFDM

Signals with high peak-to-average power ratio are transmitted through a nonlinear device, a high-power amplifier (HPA) or a digital-to-analog converter, a high peak signal generates out-of-band energy and in-band distortion [3]. These degradations would seriously affect the performance of OFDM systems. In other words, when the orthogonal frequency division multiplexing signal with high peak-to-average power ratio (PAPR) system passes through a non-linear device, the signal will suffer significant nonlinear distortion. This non-linear distortion will result in in-band distortion and the out-of-band radiation. The in-band distortion causes scheme performance degradation and the out-of-band radiation causes ACI (adjacent channel interference) that affects systems working in the neighbor bands. This linear power amplifier has poor efficiency and is so expensive. Peak-to-average power ratio reduction scheme changes the formation of the orthogonal frequency division multiplexing signals with high peak-to-average power ratio (PAPR) before multicarrier modulation, e.g. coding, and LDPC.

A. Orthogonal frequency-division multiplexing *(OFDM) System*

An orthogonal frequency-division multiplexing, in some cases known as multicarrier modulation technique (MCM) or discrete multitude (DMT) is a well-known modulation technique that is tolerant to channel disturbances and impulse noise. The multi carrier modulation have been developed 1950’s by introducing two modems, the Collins complex system and the one so called Kathryn modem. The Orthogonal frequency-division multiplexing (OFDM) has remarkable properties such as bandwidth efficiently, highly flexible in terms of its adaptability to communication channels and robustness to multipath. To achieve higher spectral efficiency scheme in multicarrier method, the sub-carriers must have overlapping transmit spectra although at the same time they need to be orthogonal process to avoid complex separation and processing at the receiving end [6]. As it is stated in, the orthogonal set can be represented as such

$$\left\{\frac{1}{\sqrt{\mathrm{T_s}}}\exp^{\mathrm{j}w_{\mathrm{k}}\mathrm{t}}\ \mathrm{for\ t} \in [0,\mathrm{T_s}]\right\} \qquad (1)$$

With $w_k = w_0 + kw_s;\quad k = 0,1,\ldots,N_c - 1$

w_0 Is the lowest frequency used and w_k is the subcarrier frequency.

Instead of baseband modulator and bank of matched filters, Inverse Fast Fourier Transform and Fast Fourier Transform is efficient method of orthogonal frequency-division multiplexing system implementation.

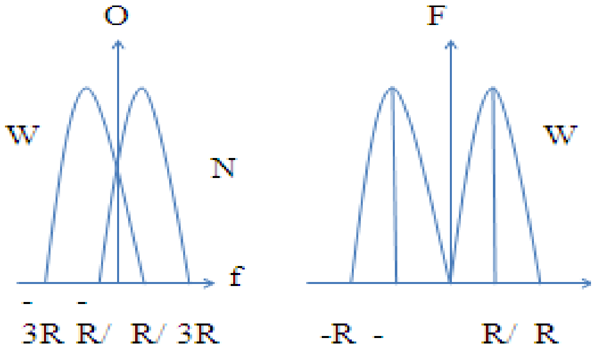

Fig. 1 Frequency Efficiency of OFDM over FDM for Two and Three Sub channels

B. Peak to Average Power Ratio (PAPR)

High Peak-to-Average Power Ratio technique has been recognized as one of the major practical problem involving orthogonal frequency-division multiplexing system modulation. Generally, the High Peak-to-Average Power Ratio (PAPR) of Orthogonal frequency-division multiplexing signals *x*(*t*) is defined as the ratio period amongst the maximum instantaneous power and its average power during an Orthogonal frequency-division multiplexing symbol.

$$PAPR = 10log10\frac{P_{peak}}{P_{av}}s(2)$$

Where $\mathrm{P_{peak}}$ and $\mathrm{P_{av}}$ can be compute as:

$$Ppeak = max|x(t)|2 \qquad (3)$$

$$P_{av} = \frac{1}{T}\int_0^T |x(t)|^2 dt$$

Hence, the High Peak-to-Average Power Ratio is expressed as:

$$PAPR = 10log10 \frac{max\,|x(t)|^2}{\frac{1}{T}\int_0^T |x(t)|^2 dt} \quad (4)$$

When N sinusoids add, the peak magnitude would have a value of N; the average might be quite low due to the destructive interference amongst the sinusoids. High Peak-to-Average Power Ratio (PAPR) signals are usually undesirable for it usually strains the analog circuitry. For power amplifier has High Peak-to-Average Power Ratio, signals would require a large range of dynamic linearity since the analog circuits which usually results in expensive devices and high power utilization with lower efficiency [1].

In orthogonal frequency-division multiplexing technique, some input sequences would be resulted in higher High Peak-to-Average Power Ratio than others. Which mean, input sequence that require all such carriers to transmit data their maximum amplitudes would certainly result in a high output High Peak-to-Average Power Ratio. Thus by limiting the possible input sequences to a smallest sub set, should be possible to obtain output signals with a guaranteed low output Peak-to-Average Power Ratio.

High Peak-to-Average Power Ratio (PAPR) system could cause problems when the signal is applied to transmitter which contains non-linear components such as High Power amplifier in the Transmitter chain. The Peak-to-Average Power Ratio system has the worst case value which depends on the no of subscribers N. The non-linear effects on the transmitted orthogonal frequency-division multiplexing symbols are spectral spreading, inter-modulation and changing the signal constellation [4].

In the complementary cumulative distribution function is the distribution of Peak-to-Average Power Ratio technique and has stochastic characteristics. Complementary cumulative distribution function of Peak-to-Average Power Ratio (PAPR) scheme is defined as the probability that the PAPR (Peak-to-Average Power Ratio) of the OFDM (orthogonal frequency-division multiplexing) symbols exceeds a given threshold A such as

$$CCDF = 1 - Pr(PAPR \geq A) \quad (5)$$

C. Low Density Parity Check codes (LDPC)

In this part, we briefly introduce the basic principle and notations of Low Density Parity Check codes. For further reading see. LDPC codes are linear block codes whose parity-check matrix H has the favorable property of being sparse. Contains only a low number of non-zero elements. In the tanner graphs of such codes are bipartite graphs containing two different kinds of nodes, code nodes and check nodes. A (n, k) Low Density Parity Check codes (LDPC) is thus represented by a m x n parity-check matrix H, where m=n-k symbol, is the number of redundancy of the coding techniques. We can then distinguish regular from irregular Low Density Parity Check codes (LDPC), depending on the degree distribution of code nodes and check nodes. A regular scheme means that these distributions are constant along rows and column, and are usually represented through the notation. For such a code, the number of non-zero elements is thus given either through $n * dv \ or \ m * dc$, leading to the following code rate relation [9].

$$Rc = 1 - (m/n) = 1 - (dv/dc). \quad (6)$$

The decoding of Low Density Parity Check codes is relying on the Belief-Propagation Algorithm framework extensively discussed in literature. These involve two major steps, the check node update and the bit node update. Where intrinsic values from the channel feed first bit nodes, then extrinsic information is processed and forwarded to check nodes, that themselves will produce new extrinsic information relying on parity-check constraints, in feeding their connected bit nodes.

C.1Ldpc code representation

The LDPC code can be described by two forms firstly by matrices or secondly by graphical representation.

C.1.1Matrix representation

The matrix is parity check matrix with m x n for a (8, 4) code.

$$H = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Fig. 2 Matrix representation

C.1.2 Graphical representation

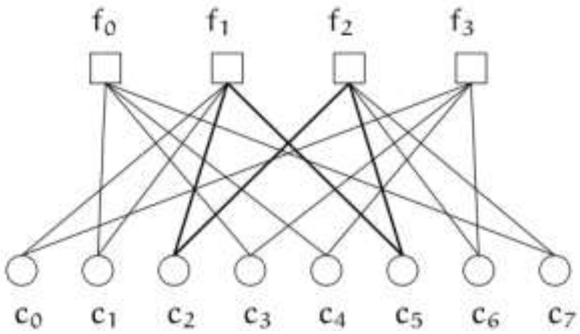

Fig. 3 Tanner graph related to matrix representation

C.2Construction of LDPC code

For associate degree of nodes of every set irregular LDPC choose some distribution method. For construction of irregular LDPC, the initial step involves choosing a profile that describes the required column of every weight and therefore the preferred rows of every weight. During second step it includes construction methodology of LDPC code. The insertion of edges between the vertices that satisfy the constraint.

C.2.1 LDPC Encoding

Low-density parity-check (LDPC) codes have been adapted by high-speed communication systems to their close to Shannon limit error-correcting capability. So as to attain the desired bit error rate (BER), longer LDPC codes with higher code rate are measured. As within the case of block codes, we tend to outline generator of matrix (*G*) and parity check matrix (*H*). In order to achieve a systematic Low-density parity-check code *G* must be in the following form:

G [I*k P*]

Where I*k* is an identity matrix and P defines the parity bits. to solve for the G matrix. And the H matrix is often in an arbitrary format, it must be converted into echelon canonical form here in some cases, a code may be specified by only the H matrix and it becomes necessary

H= [-PT In-k]

Where In−k is an identity matrix and defines the parity Bits [10]. Typically, encoding consists of using the G matrix to compute the parity bits and decode consists of using the H matrix and soft-decision decoding. This conversion can be accomplished by the assistance of a computer program. The G matrix can be observed by inspection. In the encoding stage, the main task is identifying the fixed bits position. As we know, in the systematic LDPC codes, the value of the transmission codeword is the same with the value of the H matrix's message word. So we can fix some codeword bits in the encoder's codeword. [11]

C.2.2Decoding process in LDPC technique

Hard decision decoding involves Bit-flipping algorithm as well as the soft decision decoding involves Sum-product and Min sum algorithms. Here bit flipping algorithm is discussed below: The list of bits contained in a parity-check equation creates a parity check set. Odd-even check set tree is usually a representation of redundancy check kick in a tree structure. Each line rising because of this node represents one of many parity-check sets containing d. Another nodes bit through these parity-check sets are represented from the nodes on the first tier in the tree. The lines rising from tier 1 to tier 2 of the tree represent the other parity-check sets containing the bits on tier 1.The nodes on tier 2 represent the opposite bits in those odd-even check sets.

SIMULATION AND RESULT

The software has been developed to simulate the orthogonal frequency-division multiplexing (OFDM) transmission and Peak-to-Average Power Ratio (PAPR) reduction technique is evaluated on same test bench. In the following parameter are taken during simulation.

Table. 1. Simulation Parameter

S.N	**Parameter**	**Specification value**
1.	FFT size	64
2.	Number of Symbol	$3*10^4$
3.	code Rate	1/2
4.	Modulation technique	QAM-64
5.	SNR range	0-30
6.	CP length	1/4
7.	Channel Model	Rayleigh
8.	Size of parity check matrix in ldpc code	8*4
9.	Total no of bit in code word	8
10.	No. of information bit in code word	4
11.	No .of parity bits in code word	4

The Peak-to-Average Power Ratio (PAPR) results of every symbol for with and without LDPC are shown in Fig.4. Improvement in Maximum PAPR is clearly visible from graph.

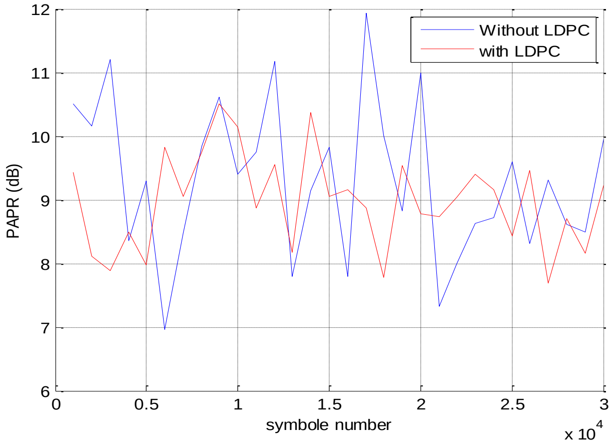

Fig. 4. An OFDM symbol (in k), with and without LDPC containing 64 subcarriers using QAM modulation

Apart from maximum PAPR value, mean PAPR is also improved and given in table 2.

Table. 2. PAPR improvement using LDPC

SN.	**TECHNIQUE**	**PAPR(DB)**
1.	Ofdm without Ldpc	9.3006
2.	Ofdm with Ldpc	8.9772

The CCDF vs. PAPR is shown in the fig.5. From the figure 5 it is clear that the only 5% symbol having PAPR higher the 10.5db with LDPC where as in without LDPC 20% symbol having more than 10.5db value of PAPR.

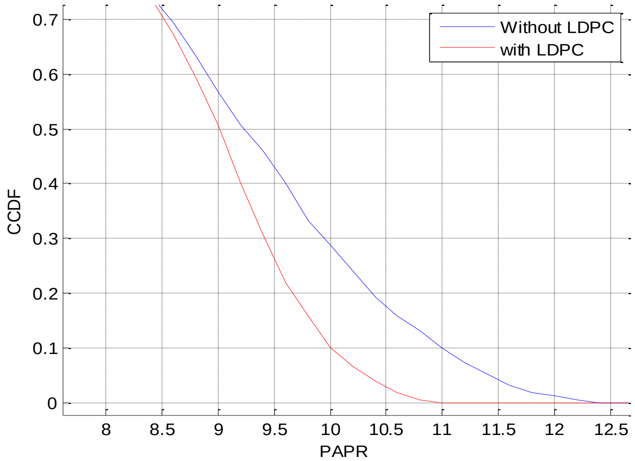

Fig.5 PAPR reduction using QAM 64

The LDPC code is FEC code hence it also improve the BER result which is shown in fig. 6.

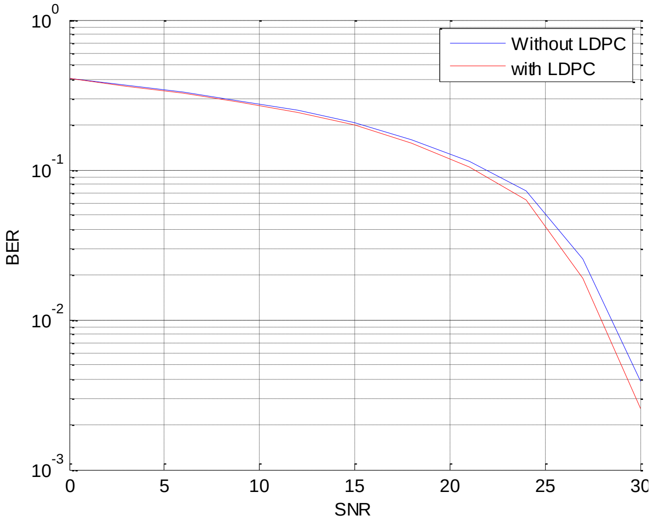

Fig. 6.Simulated BER Vs SNR of OFDM with& without LDPC code

The numerical results are also in given in the table 3.

Table. 3. BER improvement using LDPC

S.N.	SNR(dB)	BER without Ldpc	BER with Ldpc
1.	0	0.4105	0.4041
2.	3	0.3692	0.3605
3.	6	0.3289	0.3223
4.	9	0.2893	0.2834
5.	12	0.2497	0.2429
6.	15	0.2064	0.2000
7.	18	0.1592	0.1515
8.	21	0.1136	0.1048

9.	24	0.07184	0.06342
10.	27	0.02557	0.01887
11.	30	0.003846	0.002564

CONCLUSION

The use of LDPC code is demonstrated in the paper for reducing the PAPR and simultaneously the BER. The - 0.5 db improvement has been observed in mean value of PAPR, however maximum PAPR is reduced by 2db. The BER performance is maintained (for 10^{-3}) with reduced SNR by
-1.5db.

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