Variation in data rate communication systems with improved OFDM-MIMO technology by using the LDPC code

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Abstract-The fast evolution of global mobile communication demands high speed data rate transmission via satellites, which requires spectral efficient modulation technique and power efficient forward-error correction [19]. The main objective of any communication system is error free transmission with maximum possible data rate[8]. Noisy communication channels are having major problems in data transmission. To avoid this problem we can use the channel coding along with the appropriate modulation scheme. So that Channels are having modulation and channel coding for the same objective of producing the appropriate signal waveforms to cope with the noisy channel. Today LDPC are the most required channel linear block codes and provides the best performance in noisy channels like AWGN and Rayleigh channel. Along with suitable modulation schemes like QAM and MPSK etc. Under the fading conditions we can further improve the performance by applying the concept of diversity analysis. The performance of LDPC codes like any other code is measured in terms of BER, FER and Girth Test[20]. LDPC codes were ignored for long time, but now they are used mostly in all error correcting schemes and also used more than the turbo codes because these code having the better error correcting performance as well as these code are more satiable for parallel implementation. These facts are possible because of the iterations are available for decoding schemes and also the parallel decoding structures and message passing algorithms [6] etc. These days LDPC codes are used in mostly for Wireless, Wired, Optical, OFDM, communication systems.4G wireless, Satellite Communication and Digital Television lies with LDPC codes[9],[10]. LDPC codes could be used in magnetic storage devices because of their better decoding performance compared to other error correction codes. In this paper we worked to improve the error performance of the LDPC codes under extremely noisy channel conditions for different data applications with the suitable modulation schemes. Multiple input and multiple output technology is applied to solve the poor signal reception problem. Performance of the high speed data rate communication channel is improved by using the LDPC Encoder.

Key words: PAPR, LDPC, AWGN, QPSK, BPSK, QAM, OFDM, MIMO, Diversity concept, Message passing Algorithm.

1. INTRODUCTION

Low density parity check codes have gained recently a lot of interest due to their excellent for error correcting performance [23] and these codes are also having very high parallel decoding schemes [1]. These codes are a verity of the linear block codes [2]. Despite of substantial progress in the asymptotical analysis of LDPC codes, design of good codes of short and moderate length still remains an open problem. The main reason for this is that density evolution, the most widely use LDPC code analysis tool, allows one to obtain only very high-level information about the ensemble of codes, such as node degree distribution of the associated Tanner graph. However, this ignores the important properties of finite-length codes, such as stopping sets and minimum distance. Furthermore, compact representation of code parity check matrix is needed in order to implement LDPC coding in a practical system. On the other hand, most of the existing algebraic LDPC code design techniques lead to structured LDPC codes, which are regular and inherently lack the capacity approaching behavior.

Recently, low-density parity-check (LDPC) codes have most attraction because of their excellent performance for error correcting and highly parallelizable decoding scheme. LDPC having the characteristics they contains only a few 1's in comparison to the amount of 0's. LDPC provide a performance which is very closer to the capacity for a lot of different channels and linear time complex algorithms for decoding. This is the main advantage of LDPC code. These LDPC code are used or best suited for implementation as the parallelism for data transmission [4],[5]. Low-density parity-check code is an error correcting code. LDPC codes are also called as Gallager codes because Mr. Robert G. Gallager first found that codes. LDPC was the first code to allow data transmission rates close to the theoretical maximum limit.

The performance of the LDPC code is measured in terms of block error probability or frame error probability [7] or bit error probability. The following specifications are used for the LDPC code parity check matrix.

A parity check matrix is having the r- row and n column binary matrix. Where k=n-r.

The columns represents the code word digits and the rows represents the equations.

Graphical description of the parity equation is the best method to understand the decoding of the LDPC codes.

There are two types of nodes available in the graph : bit nodes and the parity nodes

There is a 1 in the i-th row and j-th column if and only if the i-th code digit is contained in the j-th equation.

Every parity node represents the parity equation and every bit node represents the code symbols.

There is a line drawn between a bit node and a parity node if and only if that bit is involved in that parity equation.

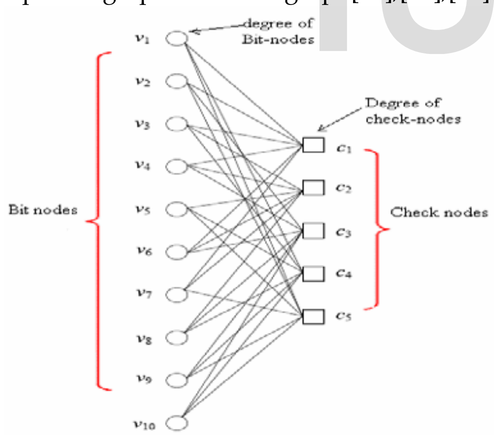
Very few 1's should be in the each row and column and expected to the large minimum distance.

2. Designed system module using LDPC code

The main objective of this paper to calculate the communication system in AWGN channel bit error rate

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

The above matrix having the number of 1's in each rows are 6 and number of 1's in each column is 3.this matrix is not a sparse matrix because it can be represented by using the bipartite graph or tanner graph[11],[12],[13] and [14].



(**Fig1.** Bipartite graph of a regular (3,6) LDPC code of length 10)

In the above graph the nodes v1, v2…..V9 are called the bit nodes and also called the variable nodes where as node c1,c2….c5 are called the check nodes. The graph is constructed by using the following specification as number of bits nodes should be equals to number of column available in the H matrix where as the number of check

(BER) performance by using the LDPC code.BER is used to evaluate the performance of the communication channel

The linear block codes having the following parity check matrix where H is used in Decoder side. The valid codeword satisfy the below equation

$$x.H^T = 0$$

The generator matrix is related to the H matrix is given as

$$G.H^T = 0$$

[2]The main LDPC codes are the regular codes are having the number same number of 1's in every row and every column. The LDPC code are the Varity of the linear block codes with sparse parity check matrices.

The following H matrix is having the rate-1/2, and length-10 regular LDPC code.

nodes should be equals the number of rows in the parity check matrix or H matrix.

Let the emanated edges from the variables node is having the degree d_v and the number of edges emanating from the check no is d_c then the rate of the (d_v, d_c) regular LDPC code is given by the following equation.

$R_{c=}(1 - d_v / d_c)$

The number of 1's in the parity check matrix H is N.dv, while the total number of elements in H is N^2.Rc, where N is the length of the code. When N is increasing, the number of 1's is increased linearly so that reason total number of elements also increases as per the quadric equation. Hence, for large code length N the parity check matrix is sparse. Parity check matrix is important because it is having sparse characteristic [2] , there is relations between a variable node and a check node by using the available number of 1's in parity check matrix. In the decoder side this quantity determines the complexity we also use this relation on the decoder side to decode the codeword.

Iterative decoding of LDPC code

The objective of this paper is to reduce the complexity of the decoding process. This process should me more effective when we explicit the long code in the some sub-codes like the LDPC codes. This schemes is provides very effective computational process on the decoding side because complexity is very slowly increased with increasing the code length at fixed code length. Normal parity check matrix having the approximately same numbers of 0's and 1's but LDPC parity check matrix having very few numbers

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of 1's as compare to numbers of 0's due to this reason this is called as the low density parity check, due to this Tanner graph is also having the low density at its edges [16],[17] hence H has the low density of 1's. The complexity of the decoding side is directly depends on the density of code. So that the designer try to design the density of the code as low as possible so that the LDPC code algorithm is designed with low density.

Message passing algorithm

Messages are probabilities (or likelihood) of \1" or \0" been transmitted which should be exchanged along the edges of the graph and the computations are performed[1].

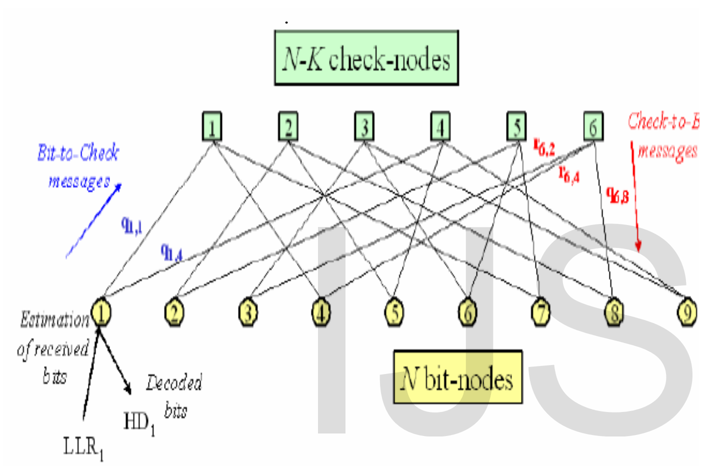

Fig 2: Illustration of message –passing algorithm

There are Two stages of message passing.
Probabilities of bit nodes.
Probabilities of check nodes.

[18] In message-passing algorithm, messages are exchanged along the edges of the graph, and computations are performed at the nodes, as shown in Fig. 2. Each message represents an estimate of the bit associated with the edge carrying the message. These decoders can be understood by focusing on one bit as follows:

Assume that bits of the LDPC code words are transmitted over the communication channel but transmition some bits are corrupted due to that corruption 1 becomes 0 and vice versa. Each bit node should check the arrived bit at the receiver corresponding to that one which should be transmitted from the equivalent node at the transmitter. If error will occur or not it will asks to all the neighbors check node what the bit's value should be. Each neighboring check nodes then asks to other and this will performed by using modulo 2 sum of that value. In order to improve the performances repeat this iterative method correspondingly.

Designed Architecture of LDPC Decoder

[1], [15] Gallager design a block diagram to simply the message passing algorithm. [21] LDPC decoders are low floor decoders.
He guessed from the Fig. 3 that a parallel computer can be simply instrumented requiring principally a number of proportional to modulo 2 adders, n analog adders, non-linear circuits and amplifiers to approximate the function F(β).

However, evaluating the sum in the log-probability domain requires a combination of exponential and logarithmic functions. In order to simplify the implementation, the computation can be near about the maximum value of the input operands that should be followed by an additive correction factor determined by a table lookup, as illustrated in the Fig. 4.

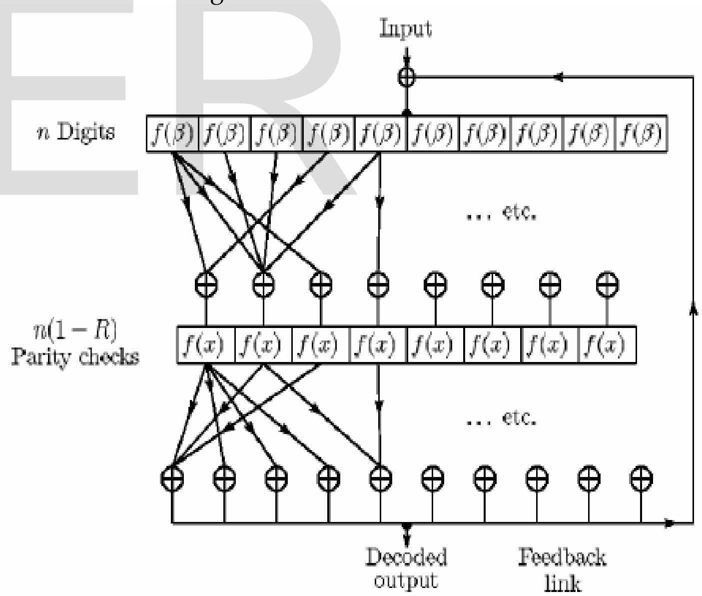

Fig 3: Decoding Implementation

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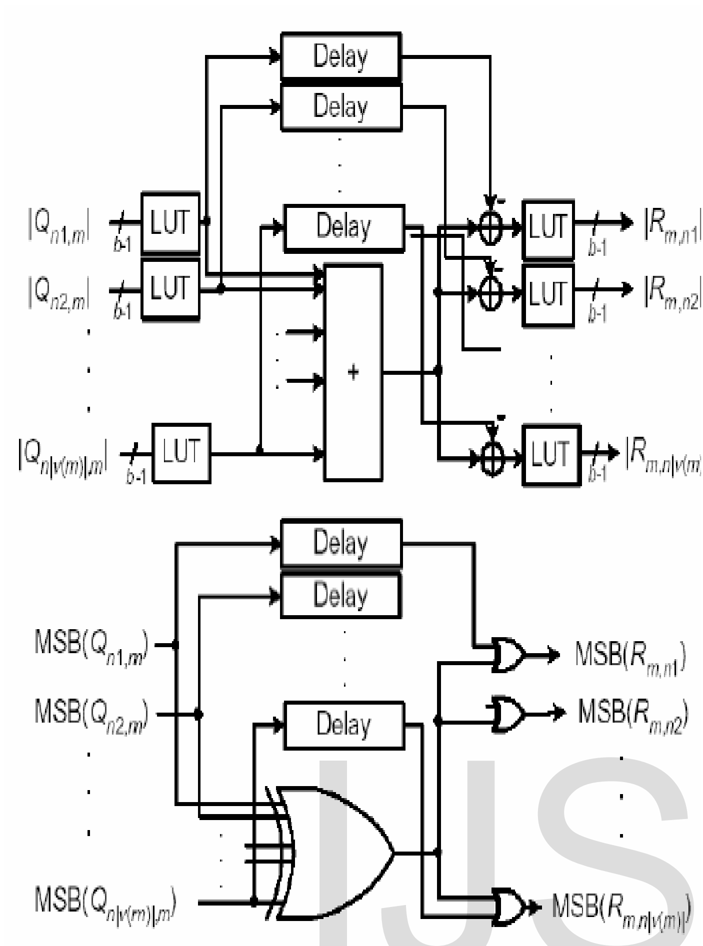

Fig 4: check node processor elements

The message passing algorithm is inherently parallel because there is no dependency between computation of either Qi_j, for i = 1, 2. . . N or Rj_i for j = 1, 2. . . N.

Parallel decoder architectures directly map the nodes of a bipartite graph onto message computation units known as processing elements, and the edges of the graph onto a network of interconnect. Thus, such decoders benefit from a small switching activity, resulting in low power dissipation. Very little control logic is needed for the parallel architecture, because the LDPC code graph is directly instantiated by the interconnection of processing elements. Higher throughput with parallel decoder can be achieved by implementing a code with a large block size and maintaining the same clock frequency. The major drawbacks with parallel decoder architecture are the relatively large area and the inability to support multiple block size and code rates on the same core. However, for application that requires high throughput and low power dissipation and can tolerate a fixed code format and large area, the parallel architecture is very suitable.

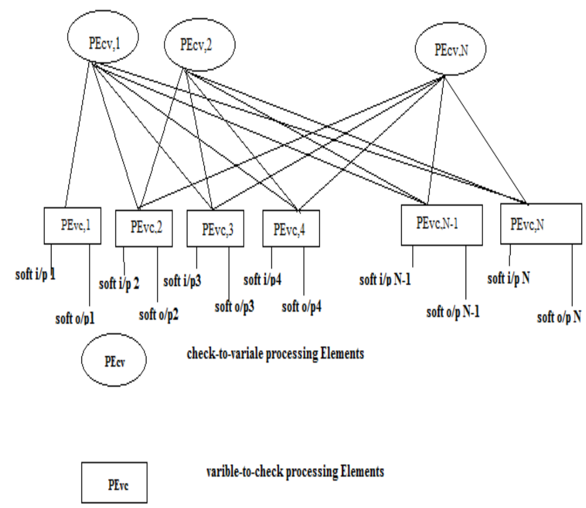

Fig 5: Parallel decoder Architecture

3. COMMUNICATION SYSTEM USING THE LDPC CODE

Till now turbo codes were considered as these are the best code but message passing algorithm and the iterative algorithms change the trends that by using these techniques LDPC codes are having the better results as compare to other code or turbo codes for the communication system.
Now different modulation schemes are used to designed LDPC codes based communication system for noisy channel conditions for varying data rate applications. The performance of wireless system can be improved using the diversity techniques. High data rate wireless applications uses MIMO_OFDM technique but problem arise for high PAPR.
High PAPR may distorts the signal if transmitter having the some nonlinear components like power amplifiers due to that reason some deficiencies may occur like inter modulation changing in constellation or spectral spreading [25].
So that we try to make the average signal power as low in order to prevent the transmitter amplifier and other circuitry limiting. Minimizing the PAPR allows a higher average power to be transmitted for a fixed peak power, improving the overall signal to noise ratio at the receiver.

- **PAPR Reduction**

The technique which is shown in the Figure 6 is used to PAPR in the MIMO-OFDM system. PAPAR is reducing by spreading the symbol number of times as the number of antennas. By reducing the Pavg we can reduce the PAPR or increasing the OFDM symbols duration by multiplying the LDPC codes with IIFT symbols.

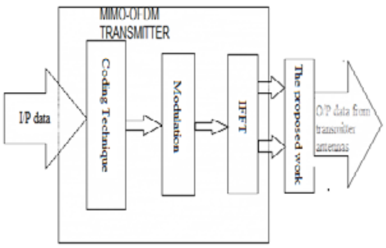

Fig 6: MIMO-OFDM based LDPC Coding Technique based Transmitter for PAPR Reduction

4. RESULTS

The performance communication system for any coding schemes is measured in terms of Bit Error Rate and Frame Error Rate. Now the performance of LDPC Code based communication systems is measured by calculating the BER/FER. The performance is calculated for AWGN and various fading channels using different modulation schemes for varying data rate applications in wired / wireless communication.

enerate the Parity Check Matrix, Load H, Define SNR Range, Set Maximum number of iterations, and Set Maximum number of codeword-errors for which to run simulation and select the MATLAB as decoder.

The Performance communication systems based on LDPC codes are shown in Fig. 7. , Fig. 8. , Fig.9 for parameters: LDPC Matrix Size: M=1000, N=2000 & Code rate = ½, Varying SNR. Column Weight = 3 Iterations = 10 (5*2) per frame with 10 frames (N bits per frame) and OFDM symbol spreading rate = I = 2.

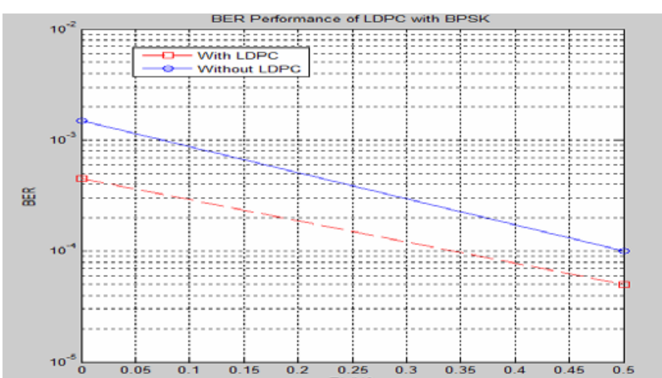

Fig 7: BER Performance of LDPC System with BPSK Modulation Scheme

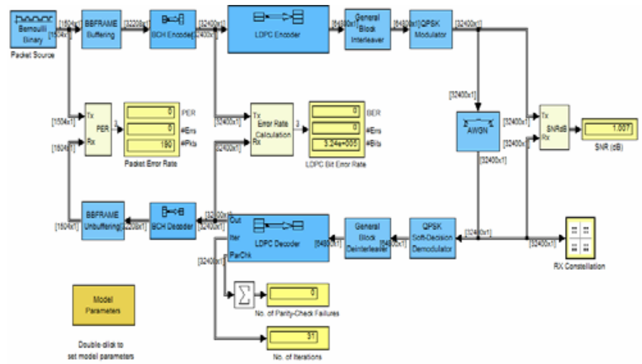

Fig 8: Simulink Model for LDPC Code base Communication System with QPSK Modulation after simulation

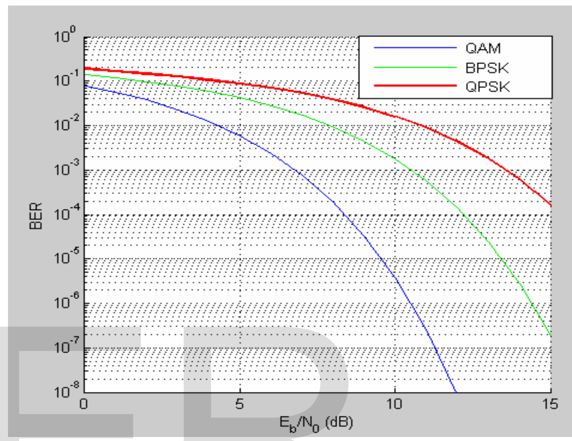

Figure 9: Combined BER performance for LDPC code based communication systems over AWGN channel using various modulation schemes

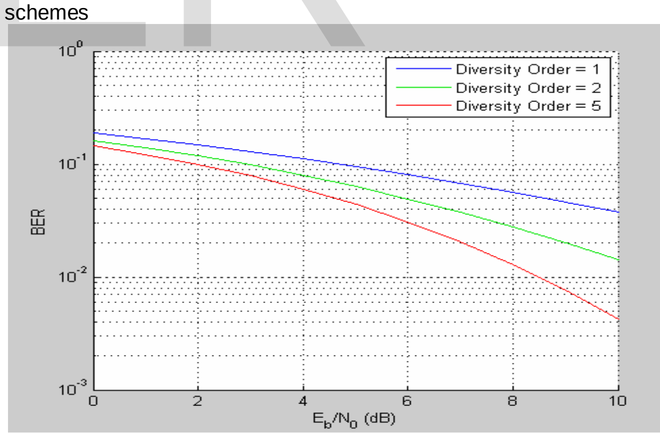

Figure 10: Performance Improvement using Diversity for Rayleigh Channel with QAM Modulation

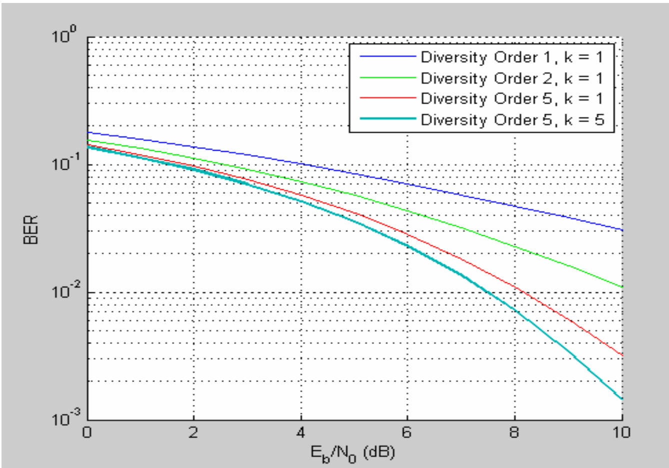

Figure 11: Performance Improvement using Diversity for Rician Channel with QAM Modulation

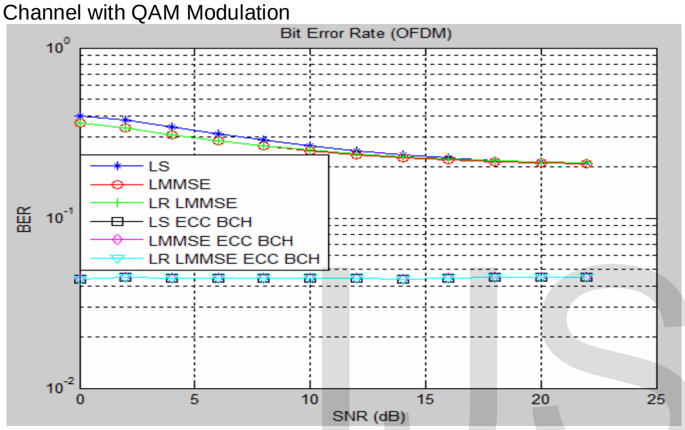

Figure 12: BER Performance of OFDM based wireless communication system

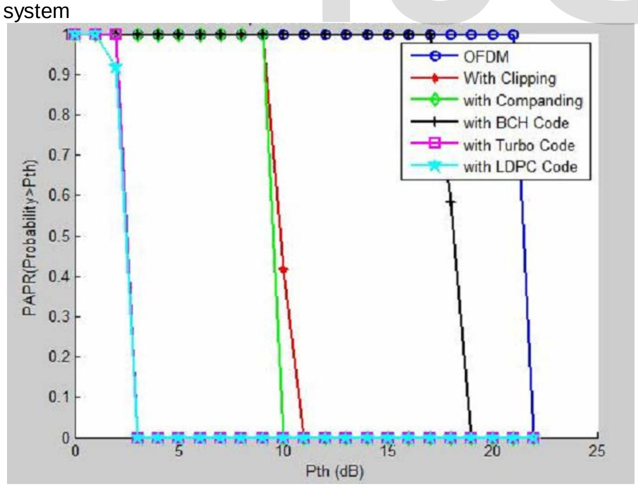

Figure 13: Comparison of the PAPR reduction performance (CCDF of PAPR) of 16QAM Modulation based

Above results are showing that the BER performance of LDPC code based systems is improved with increasing the SNR for the specific bit error. With the different-2 modulations schemes results are shown in the figures. For QSK and QAM result is shown in fig 8 and fig 9, improvement with the diversity concept is shown in the figure 10 and fig 11. And the fig 13 is showing the result for high PAPR problem in high data rate wireless OFDM-MIMO using the LDPC code.

5. CONCLUSION

In this paper, advance communication system is proposed by using the LDPC code with reduced PAPR.

Results are showing that LDPC code based communication system with the different modulation schemes are much better or provides the much better error performance for different data rate as per the user requirement under the noisy channel conditions along with the diversity concept for fading channels. PAPR reduction technique with LDPC encoder for wireless communication system for high speed data rate with OFDM-MIMO is better than the older PAPR reduction technique. LDPC code base communication system is having the excellent performance for different data rate applications under the noisy channel. PAPR reduction technique using the LDPC encoder is best for OFDM-MIMO for data rate communication when compared to other technique.

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