Performance Analysis with Linear Block Coding Technique for PAPR reduction in OFDM signal

DISSERTATION – II

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Submitted By

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CANDIDATE DECLARATION

I Ponkhi, student of B.Tech-M.Tech ECE hereby certify that the work, which is being presented in the Dissertation - II Report entitled **“Performance Analysis with Linear Block Coding Technique for PAPR reduction in OFDM Signal”**, in partial fulfillment of the requirement for the award of the Degree of Master of Technology submitted to the institution is an authentic record of my own work carried out during the period 12th January-2015 to 20th April-2015 under the supervision of **Mr. Gopal Krishan**. I also cited the reference about the texts/figures/tables from where they have been taken.

Date: Signature of the Candidate

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

Date: Signature Supervisor

CERTIFICATE

This is to certify that Ponkhi Bhuyan, bearing Registration no.**11006743**, have completed Dissertation-II report titled, **“Performance Analysis with Linear Block Coding Technique for PAPR reduction in OFDM signal”** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation, effort and study. No part of the work has ever been submitted for any other degree at any University. The report is fit for submission and the partial fulfillment of the conditions for the award of B.Tech-M.Tech (Integrated)-ECE.

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Date:

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“If practical knowledge carves and sharps the career of a person, practical experience polishes it and adds luster and brilliance to it.”

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I would like to pay my immense gratitude to **Mr. Gopal Krishan** of Lovely Professional University to undergo this report under his concern. It is my pleasure to express my heartiest gratitude to him for providing us with full knowledge of working of Electronics and Circuits. I am indebted to my guides for energizing my faith towards dignity of work.

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Ponkhi Bhuyan

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ABSTRACT

Linear block codes known as the low density parity check codes are useful in terms of implementation and simplicity and this code can be constructed using bipartite graph. By providing faster flexibility and memory uses, this encoder ensures simplified calculations. These codes enables the noise threshold to set very closely to the theoretical maximum value (i.e. up to Shannon limit) which is for a symmetric memory-less channel because these codes are capacity-approaching codes. Incorporating this technique with PTS (Partial Transmit Sequence), although dealing with high computational complexity it reduces the PAPR of the system significantly, by defining the possible rotation phase combinations. The signal achieved is then further treated with simple linear block coding to yield improvement. The whole process provides a hybrid scheme with relatively better performance of all the techniques included when A-Law companding is introduced.

Analyzing the performance of the OFDM system using LDPC codes using PTS and linear encoding with companding, to reduce PAPR of a given OFDM signal is being performed by proposing a Hybrid scheme.

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List of Abbreviation

OFDM	Orthogonal Frequency Division Multiplexing
FDM	Frequency Division Multiplexing
Wireless LAN	Wireless Local Area Network
LDPC	Low Density Parity Check
PTS	Partial Transmit Sequence
DFT	Discrete Fourier Transform
HDSL	High bit-rate digital subscriber line
ADSL	Asymmetric digital subscriber line
VDSL	Very high speed digital subscriber line
SCM	Single carrier modulation
RECT pulse	Rectangular pulse
FFT	Fast Fourier Transform
QAM	Quadrature division multiplexing
UHF	Ultra high Frequencies
COFDM	Coded OFDM
CDMA	Code division multiple access
TDMA	Time division multiple access
BPSK	Binary phase shift keying
QPSK	Quadrature phase shift keying
IBI	Inter block interference
CP	Cyclic prefix
FEC	Forward error correction
RSC	Recursive convolutional encoder
WWAN	Wireless wide area network
SNR	Signal to noise ratio
BER	Bit error rate

CHAPTER - 1

INTRODUCTION

1.1 Introduction

In this era of fast communication growth, with the increased demand there comes a demanding growing need for transmitting the information wirelessly all over the world with speed and accuracy. There are more demanding consumers, who seek the perfectly consistent and coherent communication in their everyday life including their homes, offices, markets and from cars to public parks. Hence the telecommunication industry is in the middle of an intensified situational explosion in the field of wireless technologies.

With the development of OFDM, there is a great interest among the researchers and research laboratories all over the globe. This technology is a breakthrough which has been accepted worldwide for the new LAN standards IEEE 802.11a and for Mobile Multimedia Access Communication (MMAC) Systems. We can also use it for wireless broadband multimedia purposes.

We can describe the OFDM scheme as a modulation scheme. Interestingly it can also be described as a multiplexing technique. In order to increase the strength and robustness of transmitted signal in multipath fading channels or narrowband interference or frequency selective fading, we employ the use of OFDM. [1]

Even though OFDM is used as a standard all over the world in order to provide users with high data rates followed by advanced intensive applications wirelessly, there are few challenges it faces. The main problems faced are:

(a) ISI due to multipath fading channels.
(b) Due to non-linearity of amplifiers there is a large peak to average ratio (PAPR).
(c) Phase noise from oscillators.
(d) In the receiver there is a need of frequency offset correction

The effects on the transmitted signal when there is a large PAPR can be listed as :

(a) In-band and Out-band interference

(b) Spectral fading

(c) Intermodulation

(d) Changes in the constellation diagram of the signal.

So there is a good need for reducing the large peak to average ration of a signal. [2]

1.2 Fundamental Concept Of OFDM :

Generally, we can state that OFDM is a scheme where the sub-carriers are orthogonal to each other. Any two sub-carriers are orthogonal to each other means their dot product gives value zero. It is a kind of multi-carrier modulation and can also be defined as a parallel transmission scheme. The sub-carriers spacing are chosen such that each carrier is orthogonal to each other. Since it follows a parallel transmission scheme, it operates in a way that it splits the high data rate streams into a number of parallel low data rate streams for reducing inter-channel interferences. Here in this process every data stream is modulated with a different sub-carrier. [1]

1.2.1 What is orthogonality and How it is achieved?

We can call two signals orthogonal if we multiply them and check their integral over a given interval yields a zero. Then those two signals will be orthogonal to each other on that interval of time.

And if we carefully select the carrier spacing and make the carrier spacing be equal to the reciprocal of the desired and useful symbol periods then orthogonality can be achieved. Because the sub-carriers are orthogonally places so the spectrum of each and every sub-carriers has null value at center frequency of each carrier present in the system. This leads to a zero interference situation in between the sub-carriers and this situation allows the sub-carriers to be placed as closely as it is possible theoretically. [1]

In mathematical terms, it can be defined as

$$\int X_i(t)\, X_r^*(t)\, dt = k \quad \text{for } i=r$$
$$= 0 \quad \text{for } i \neq r \qquad \text{(i)}$$

Here, i and r are the ith and rth symbols of a given transmitted signal.

This equation shows that the sub-carriers are orthogonal as the integral of those symbols for a given interval of time is zero. This proves the orthogonality of the sub-carriers. In an OFDM signal, the null point of each carrier coincides with the peak value of the other sub-carrier since they are orthogonal to each other which in return lead to obtain the sub-carrier of our desire in order to transmit it over number of narrowband sub-channel. There could be a large number of narrowband sub-channels. To make the carriers (sub-carriers) perfectly orthogonal to each other, the frequency range is chosen carefully. There is time duration of 1/T between the sub-carriers that is the time interval. Here T denotes the time duration of an OFDM symbol. Here we can show a basic spectrum of an OFDM signal and how it is transmitted :

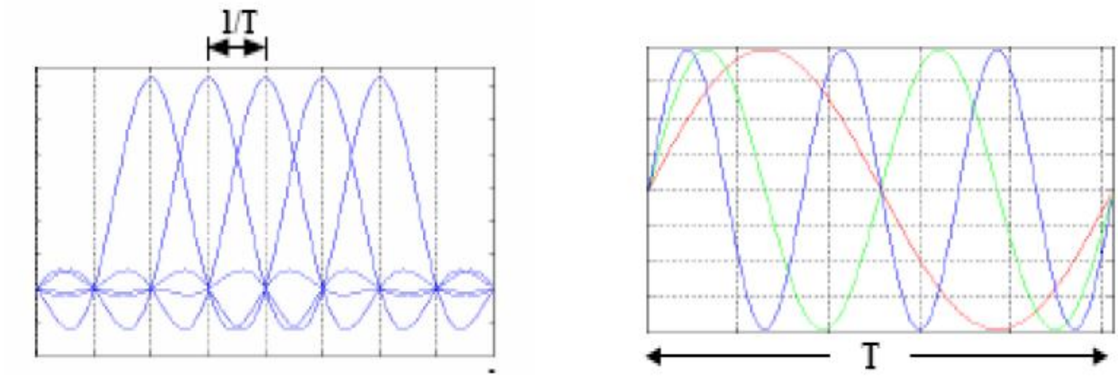


Fig 1.1 OFDM Spectrum [1]

It is clear from the figure that the spectrum of an OFDM signals (frequency spectrum) displays zero-crossing at the center frequency followed by all the other sub-carriers. Hence this helps in the removal of inter-carrier interference i.e. ICI can be eliminated. It does not matter if the spectra of the sub-carriers overlap with each other. But this is not a bigger problem as we can extract the signals (orthogonal signals) by using various techniques like correlation techniques at the receiver side. The receiver usually contains a series of components like demodulators (it can behave as an array or bank of demodulators) which are used to convert the received carrier symbols into the desired message signal or base band signal and the data is being integrated by an integrator over a given period of interval (say a symbol period) so that to recover the sent data.

However, in case of frequency division multiplex it is a necessity to rule out the components like the array/banks of oscillators (subcarriers oscillator) and the coherent demodulator in order to build a perfect and complete implementation digitally around hardware having special purpose like preforming Fast Fourier Transform (FFT). FFT is nothing but a more durable and efficient mechanism over DFT for fast and time saving computations. In case of DFT, there are (N*N) multiplicative computations which is cut down to only NlogN in case of FFT. During the 80's, the concept of OFDM was actually been studied for the purpose of high speed modems and high speed/high density recordings and digital mobile communication. [1]

1.3 Principle Of OFDM Signal :

A practical and traditional system with serial data system, the transmitted sequence are done one by one that is sequentially and with these scheme the frequency spectrum also allow the data symbols to occupy the whole available bandwidth for proper use. A very short symbol duration usually implies a very high bit rate or data rate transmission that concludes a large spectrum for the symbols which are modulated. There are a good chance of introducing ISI that is inter symbol interference if the frequency selective channel response affects the different spectral components in a very distinctive and unusual manner.

In time domain analysis the same situation includes a whole new range of smearing and spreading of the signal symbols. In this case the symbol might interfere with each other and may lose its properties and energy in a way that the signal which is received has a high probability of being interpreted incorrectly.

Hence, in order to lightening the symbol duration on each subcarrier it is necessary that for a given data rate in a channel we must increase the number of subcarriers to reduce the data rate that it might conveys. [3]

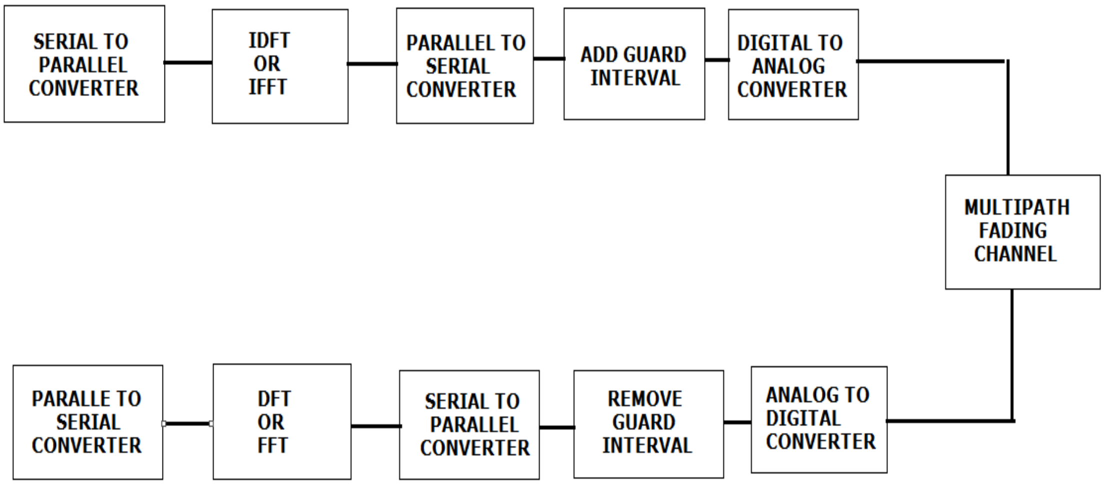


Fig 1.2 OFDM - Block Diagram

1.3.1 Explanation :

A baseband modulated signal is being provided as a input sequence to the OFDM system using an appropriate digital modulation scheme. Modulation methods like BPSK, QPSK, DQPSK and QAM and every range of modulation schemes are compatible and can be employed with their own different signal constellations diagrams. Also distinct channels can be modulated using different modulation schemes which leads to have adequate subcarriers which are more profound and confident like in ADLS systems. So each parallel sub-streams can be modulated that is the symbols which are dependent on adjacent FFT/DFT frames.

Now, the main concept of parallel (multicarrier) transmission can be concluded through the described paragraph. As we know the message signal that is sent, in a radio communication environment have to undergo many different hurdles like multipath and delays. These hurdles are the main reason for the signal to get infused by “channel-induced ISI” which in turn led to distortion in the message signal resulting weak communication. So some kind of filter is needed for the purpose and this is where the multicarrier concept comes in.

In case of frequency selective channels, multipath distortions cause a limitation to the rate of transmission of the signal for which in the receiver side equalizers are needed. Such equalizers are called ‘complex-adaptive equalizer’. So to implement the multicarrier scheme is to convert a single carrier having series transmission into multicarrier having parallel transmission. But in this case the data stream has a slower rate that comes with an advantage of reduced bandwidth of the message symbols.

So that now we have parallel low rate multicarrier data stream for the system we can calculated our desired symbol rate by averaging all the data rates of individual sub-channels. This technique in practical use shows a drastic reduction in distortions caused by ISI. But the drawback includes some major concerns like efficiency of bandwidth usage that generates a little problem. But since OFDM is a technique with all the carriers being orthogonal to each other, the problem seemed to be go better. [2]

1.3.2 Design Of OFDM Signal :

The design of an OFDM signal through an OFDM system can be described through three steps. These steps are listed below:

Step 1: The modulation and demodulation of the data symbols/constellation on the sub-carriers which are orthogonal are done with the help of IDFT and DFT block respectively. The demodulators are being replaced by the signal processing specific algorithms.

Step 2: The modulation and demodulation is followed by second most important step of inserting cyclic prefix in between the subcarriers. These can be written as GI or say Guard Interval which blocks IBI (inter-block interference) from taking place.
Due to this property the effect caused by multipath channel is limited to a point-wise multiplication of transmitted signal due to circular convolution. There is also a problem of losing a little effective transmit power since redundant guard interval are not allowed. The length of GI is equals to the one-tenth to a quarter of a symbol duration/period.

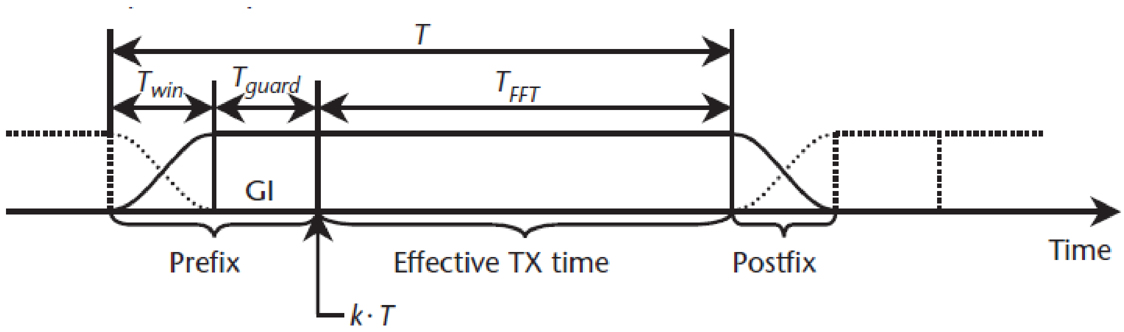


Fig 1.3 Cyclic Prefix [2]

Step 3: The last important step is the involvement of FEC coding that is Forward error Correction Code and Interleaving. These ideas must be employed for security and proper transmission process. It is more important in frequency division selective radio channel as they usually get more severely disgraced by attenuation by attenuating the data symbols which are transmitted on several different subcarriers and hence leads to a large number of bit errors. So this technique is used to eliminate the unnecessary errors. It can be achieved by spreading the symbol coded bits over the transmitted system bandwidth. A good error correcting scheme can be really helpful in correcting any erroneous bit and make full use of the wideband channel's frequency division. This is why OFDM system must exploit the error correction coding techniques in an efficient manner. [4] [5]

1.4 The PAPR Problem

The PAPR problem in OFDM signal can be considered as a big drawback in the high data rate and bit transmission in the signal due to its unstable spikes and behavior. We have a number of independent modulated subcarriers, which when added up coherently can give a very high value of PAPR. It is stand for Peak to Average Power ratio. When all the subcarriers (say N subcarriers) are added up which are having the same phase can produce a peak power that can be N times the total average power. [4]

Mathematically, PAPR can be written as

$$\text{PAPR} = \frac{P_{peak}}{P_{average}} = 10log_{10}\frac{\max[|x_i|^2]}{E[|x_i|^2]} \quad \text{(ii)}$$

where,

P_{peak} = peak output power

$P_{average}$ = average output power

E = the expected value

x_i = transmitted OFDM signal

So the input modulated symbols can be shown as :

$$x_i = \frac{1}{\sqrt{N}}\sum_{K=0}^{N-1} X_r W_N^{nk} \quad \text{(iii)}$$

Since we have N number of subcarriers for a given OFDM system, as we discuss the peak power will be N times the average value (power) when the phase of all the subcarriers are same. The peak to average ratio of a message signal can be said as maximum when it reached the value of 10logN (at dB). [4] [5]

One more parameter which is relatively ad commonly used is called the Crest Factor. The Crest factor (CF) is the ratio of maximum amplitude value of an OFDM signal to the RMS (root mean square) value of the signal. The peak value of an OFDM signal m(t) is equal to the maximum value of its envelop. Mathematically, it can be written as

$$\text{CF(m(t))} = \frac{\max[|m(t)|]}{E[||m(t)|^2|]} = \sqrt{\text{PAPR}} \quad \text{(iv)}$$

1.4.1 Need For Reducing The Value Of PAPR:

Some of the key challenges that OFDM faces are very large peak to average power ration which is caused due to the non-linear behavior of the power amplifier, inter-symbol interferences that are caused by the use of guard interval for multipath propagation, undesired phase noise form the components like local oscillators and the need for frequency offset in order to provide correction to the receiver. Power amplifier is a non-linear component in the OFDM system causes a distortion in the transmitted modulated symbols. The factors that affect the transmitted signal non-linearly can be stated as spectral spreading, interchanging of symbol constellation and inter-modulation. There is also a good probability of causing in-band and out-band interference to the modulated OFDM signal. Hence the non-linear components like the power amplifiers need a certain amount of back off which should be equal to the value of peak to average power ratio in order to provide attenuation free and distortion less transmission. But the whole process may degrade the value of efficiency of the power amplifiers. So reducing the value of PAPR holds a great deal of interest. [4]

1.4.2 Overview Of Some PAPR Reduction Methods :

The techniques for reducing the peak to average power ration is being divided into two broad categories. These categories are :

Signal Scrambling Techniques:

Under these techniques, we followed the following methods for PAPR reduction

- Block Coding Techniques
- Selected Mapping (SLM)
- Partial Transmit Sequence (PTS)
- Tone Reservation (TR)
- Tone Injection (TI) …. Etc.

Signal Distortion Techniques:

- Peak Windowing
- Envelop Scaling
- Peak Reduction Carrier
- Clipping and Filtering

In these review paper , we will discuss more about the coding techniques which are being used to encode the transmitted signal in order to reduce the amount of distortion in them which in turns leads to reduction of peak to average power ratio. Coding techniques find a very prominent and efficient place since this techniques are relatively easier to implement and they have a large scope for adaptability. Coding methods are varied, as there are types of coding including the linear block coding to cyclic coding. [5]

1.5 Techniques Used

Here we will be introducing the techniques which have been used to carry out the entire work for the vary purpose of PAPR reduction. All techniques used are falls in the category of “Signal Scrambling Techniques”. A detail overview of this techniques are provided below :

1.5.1 Low Density Parity Check Codes

LDPC codes are linear codes used for eroor correction, invented by Gallager in 1960s during his Ph.D. dissertation. After being neglected for being impractical codes for many years, now this codes are considered to be most practical one in wireless communication field. These codes are somewhat shares similarity with the Turbo sodes along with the advantage of easy implementation. Used in transmitting the signal over a channel with noise and other attenaution factors, it is practically compatible to the transmitting methods and are constructed using bipartite graph.

This codes are usually depends on the working criteria of parity check codes:

Parity check codes are a type of block codes of fixed length (say n). It is a collection of binary vectors. The LDPC are types of codes which can be represented in the matrix form of (n,r,k). This code generally contains mostly zeros and realtively less one’s. in a matrix of (n,r,k) contains a block lenth of n, r number of parity checks and (n-r)=k number of information digits. The matrix is composed of column of fixed number of 1’s (say j) and each row has a fixed number of 1’s (say i) which does not follow the diagonal property.

This codes are not optmimum in nature but they are better in terms of practical use of minimization of probability of error during decoding of a given code (block length). It has a limit of channel capacity that is the maximum rate up to which the code can operate is the channel capacity (Shannon’s Limit). [7] [8]

1.5.2 PTS and Linear Encoding

PTS is an exhaustive search technique but despite having high computational complexities it can significantly reduces the PAPR by defining all possible rotation phase combinations. As the number of subcarriers increases, the search grow exponentially. This scheme involves the partition of the input symbols to various number of disjoint blocks. This disjoint blocks are then treated with IFFT (Inverse Fast Fourier Transform) and each block will then get multiplied with a rotation phase.

The real and basic idea behind the block coding scheme is out of all the possible message symbols, the symbols which have the lowest value of peak power will be considered as a valid code word for transmission and during the transmission. Let suppose we have N number of total subcarriers and suppose we select a modulation technique say QPSK then there will be 2N number of bits and thus 2^{2N} symbols/modulated messages. If we use the entire message then the information bits will be corresponds to zero bit of redundancy. But if we use only half bits of the message signal there will be only one bit of redundancy. The message that is left unused is then used to divide the space into half and the whole dividing process keeps continuing until we received N bits of redundant symbols. These N bits redundant symbols are actually corresponds to one-half code rate foe N number of subcarriers. [10][11][12]

1.5.3 Use of A-Law Companding

Companding techniques are generally used for organizing the dynamic range of a given sinusoidal signal. The A-law Companding is also used to check the range of the given input signal to it. This law is basically used in 8-bit PCM digital system and are very similar to Mu-Law which is used in North America and Japan. The limiting of range of any signal significantly results in better coding efficiency and the signal distortion level goes down.

CHAPTER - 2
TERMINOLOGY

Description of important terms used in the proposed work are :

1. **OFDM** – Stands for Orthogonal Frequency Division Multiplexing where the sub-carriers are orthogonal to each other. Any two sub-carriers are orthogonal to each other means their dot product gives value zero.
2. **Orthogonality** - We can call two signals orthogonal if we multiply them and check their integral over a given interval yields a zero. Then those two signals will be orthogonal to each other on that interval of time.

3. **LDPC** – Stands for Low Density Parity Check. LDPC codes are linear codes used for error correction. The LDPC are types of codes which can be represented in the matrix form of (n,r,k). This code generally contains mostly zeros and realtively less one's. in a mtrix of (n,r,k) contains a block lenth of n, r number of parity checks and (n-r)=k number of information digits.

4. **PTS** – Stands for Partial Transmit Sequence. PTS is an exhaustive search technique but despite having high computational complexities it can significantly reduces the PAPR by defining all possible rotation phase combinations. As the number of subcarriers increases, the search grow exponentially. This scheme involves the partition of the input symbols to various number of disjoint blocks. This disjoint blocks are then treated with IFFT (Inverse Fast Fourier Transform) and each block will then get multiplied with a rotation phase.

5. **ISI** – Stands for Intersymbol Interference. In this form of interference, the siganl get distorted because of subsequent symbols which get overlapped with each other which results in unreliable communication link. Multipath Propagation are main source for ISI however this problem is negligible in OFDM systems.

6. **BPSK** – Stands for Binary Phase Shift Keying is the simplest form of digital modulation scheme. This modulation technique has two possible phases (0 and 1) i.e logic 0 and logic 1

which are phase separated by 180 degree. It is also called as square wave modulation of continuous waveforms.

7. **Cyclic Prefix (CP)** – It is an important step of inserting cyclic prefix in between subcarriers. These can be written as GI or say Guard Interval which blocks IBI (inter-block interference). Due to this property the effect caused by multipath channel is limited to a point-wise multiplication of transmitted signal due to circular convolution. The length of GI is equals to the one-tenth to a quarter of a symbol duration/period.

8. **IBI** – Stands for Inter Block Interference. This problem arises during travelling of signal from the source to its destination and hence it troubles the accurate flow of the message signal. This problem is generally checked by inserting guard intervals in between sub-carriers.

9. **PAPR** – Stands for Peak to Average Power Ratio. Occurs when all the subcarriers (say N subcarriers) are added up which are having the same phase can produce a peak power that can be N times the total average power. The peak to average ratio of a message signal can be said as maximum when it reached the value of 10logN (at dB).

10. **Crest Factor (CF)** - The Crest factor (CF) is the ratio of maximum amplitude value of an OFDM signal to the RMS (root mean square) value of the signal.

11. **Encoder** – An encoder performs the operation of encoding the received data from the data source and transmits the same data after performing encoding to the desired modulator. In encoder it is to be decided which coding technique is suitable and which is to be used for the data according to the proposed method.

12. **Modulator** – A modulator is used for the purpose of modulating a signal. It converts the original signal to the digital device readable form.

13. **FDM** – Stands for Frequency Division Multiplexing. It is defined as a process in which the total available bandwidth of a communication channel is being divided into small blocks of non-interfering and non-overlapping frequency sub-bands. Each sub-bands are entitled to carry different signals. This increases the bandwidth efficiency and link re-usability.

14. **Wireless LAN** – Stands for Wireless Local Area Network. This distribution uses wireless computers to create a wireless link between two or more such devices. It is having span over local areas such as school, college, building or any enterprise.

CHAPTER -3
LITERATURE SURVEY

M.R.Dey and M.S.Islam in '**Performance Analysis of PAPR reduction for OFDM-BPSK,-QPSK,-QAM using Forward Error Correcting Code'** in 2012 7th International Conference on Electrical and Computer Engineering shows the importance of using OFDM modulation technique for digital data. It is known that the most common problem in an OFDM signal transmission is its large peak to average power ratio. This problem usually leads to non-linearity since larger PAP ratio makes the OFDM signal to be clipped by high power amplifiers. They provide a unused method in order to overcome the shortcomings of having large PAP ratio in OFDM signal using forward error correcting code in the input sequence. The type of block coding they use iteratively in each phase to bring down the level of PAPR from a previously determined threshold value. Further the paper presents a comparison of OFDM signal using different modulation methods like BPSK, QPSK and QAM and encoding the input sequence using block coding. In final results, by using the Hamming code – a type of block code brings improvement in the modulated output by changing the signal phase which shows a great performance in terms of PAPR reduction. The results, the paper provides can demonstrate the significant improvement in the performance in bit error rate and in PAPR reduction. [3]

H. Liang in **'Combining block-coded modulation codes and improved constellation extended schemes to reduce peak-to-average power ratio in orthogonal frequency-division multiplexing systems'** published in IET Communications 2012, doi: 10.1049/iet-com.2011.0886 stated that for wireless transmission all over the globe, OFDM is highly recommended and the provides a highly correlated method to reduce the high peak to average power ratio by initially calculating the number of candidate signals which is a constellation extended scheme (CES). This method is helpful as candidate signals increases the value of large PAPR reduces significantly. This method is achieved by using linear block coding method (BCM) along with the constellation extended scheme (CES) since employing a system with large number of candidate signal needs proper attention. The combination of both the methods leads to the self-error correction capabilities and high data rates and computational ability of CES. Moreover, the study of CES also employs a way of dividing the candidate signal points into two categories of symmetric and asymmetric form. They employ the whole process through a well-defined block diagram. So the results of using BCM with CES scheme provides a significant improved result in terms reduction of PAPR. This methods lad to the evolvement of good extended constellation set and the scheme also includes the error correction capability in the modulation methods used. Also it is shown that the side information are not required to be sent by the transmitted signal. A reduced computational complexity and error correction capability are being showed. [4]

S. Al Muaini, Al-Dweik, and M. Al-Qutayri in **'BER Performance of LDPC-Coded Nonlinear OFDM Systems' 2012** analyses the problem relevant in orthogonal frequency division multiplexing systems. The problems such as low data rate, non-efficient performance of OFDM systems due the unwanted large PAP ratio is being disguised by exploiting the way of un-coded bit error rate. The non-linearity caused by the non-linear components like power amplifiers could cause misleading due to over-estimation. This results in high interference level. There comes the need of a perfect coding technique to check the parity problem and hence it introduces a low density parity check (LDPC) code in the OFDM system for its betterment. Various low density parity check codes with various lengths and data rates are incorporated with Extensive Monte Simulations to display the fact that performance of BER reduces gradually due to non-linearity of power amplifiers. Hence the coding methods are employed but there is a reduction in its gain by 4dB and for some cases it is less than 1dB. Hence the LDPC codes are employed to a number of 128 carriers for better results. As in conclusion the results confirmed that using LDPC codes in transmitter side can considerably save the degraded BER performance.[5]

Kavita Bani, Rajesh Bansode and B.K. Mishra in **'Novel Technique for PAPR Reduction in OFDM System using π/4-Shifted-DQPSK Modulation & Turbo Code' 2010** shows the calculation of PAPR of an OFDM transmitted signal and through comparison those transmitted signals are sent who possessed least value of PAPR. A forward error correcting methods like Turbo code is used in accordance with OFDM signal. The method of incorporating the Turbo codes in OFDM signal along with the idea of DQPSK (Differential Quadrature Phase Shift Keying) modulated transmitted signal which is π/4-shifted in order to have good spectral efficiency and high capacity. In order to achieve a low computational complexity at the receiver side the method of differential detection is employed. So to reduce the value of PAPR in associated manner, selective mapping technique with turbo coding is used in OFDM systems with the components like the inter-leavers for encoding and decoding presents in the system. The whole described scheme is being used in the presence of radio multipath fading channels where the transmitted symbols are get distorted by the Additive White Gaussian Noise (AWGN). So it is shown that there is a reduction in the PAPR value of the transmitted signal by combining both SLM with DQPSK modulation of OFDM signal with a significant reduction in the computational complexity at the receiver side. For the purpose of comparison, the PAPR for the system is calculated first without employing the SLM technique and then after employing the SLM technique which directly gives the result of reduction in the value of PAPR by 3dB. In order to model the characteristics and behavior of encoder and decoder, the Simulink characteristics are also displayed. The paper fulfills its term by presenting the evaluation of BER calculation for very high speed data which goes approximately up to in between 1/100 to 1/1000000 suitable for appropriate applications.[6]

V. Vijayarangan and R. Sukanesh in **'An Overview Of Techniques For Reducing Peak To Average Power Ratio and its Selection Criteria for Orthogonal Frequency Division Multiplexing Radio System'** in Journal of Theoretical and Applied Information Technology 2009 shows a sufficient measure for the employability of standard systems in form OFDM systems. If we have to transmit a large amount of digital data over a radio channel, then OFDM seems to be as an ideal method for the purpose. But due to several consecutive sinusoidal waves there is problem prevails which is called as peak-to-average power ratio i.e. PAPR. Its disrupt the signal in time domain aspect. In this review paper a numerous amount of techniques and criteria's for reduction of PAPR is being proposed, compare and investigated. The selection of the best criteria out of the proposed one is being emphasized and discussed thoroughly. The whole concept primarily gives a brief and important idea and overview of different techniques that can be used for the purpose of reducing the PAPR of OFDM signal. [7]

Harleen Kaur and Amandeep Singh Sappal in **'Construction of 16-QAM OFDM Codes with Reduced Peak to Average Power Ratio using Golay Complementary Sequences'** in International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 6, 2013 shows OFDM technique as a strong multicarrier transmission technique that can be used extensively and exhaustively for high data rates and various other wireless applications and also highlighted the disastrous peak to average power ratio challenges. Using a new method that concludes the exploitation of construction methods like construction of M-ary techniques (16-QAM) with other sources. Using 16-QAM with linear coding like Golay sequences have been considered. Apparently the combination of two QPSK constellation gives the 16-QAM constellation but the paper shows the use of Golay complementary sequences to achieve the same by exploiting the error correction capabilities which also results in the reduction of prevailing PAPR problem.

The results conclude the reduction of PAPR of the system and threshold the value at 5.56dB. It demonstrate the possibility of increasing the data rate by using Goaly sequences in QPSK scheme as compare to 4-PSk scheme. Hence improved versions of constellation may provide the same effect and improve the results by significant amount too. [9]

Md. Mahmudul Hasan in **'A New PAPR Reduction Technique in OFDM Systems Using Linear Predictive Coding'** in Springer Science + Business Media, 2013 shows the problem of PAPR in OFDM systems that cause non-linearity to the whole system which is highly undesirable. So the paper investigates a new approach using Linear Predictive Coding (LPC).

The method proposed works basically on the signal by its signal whitening property during the processing / primary steps in the OFDM system. In order to reduce the predictable amount of auto-correlation present in the signal some proposed error filtering methods can be used. This leads to the evolvement of new significant reductions in the value of PAPR. It also keep some signal properties intact like the spectral behavior, computational requirement and error performance. There is no need for any modulation schemes as it does not require any in support. And this makes it's possible to apply it in a number of sub-carriers irrespective of presence of Additive White Gaussian Noise (AWGN) channel or Rayleigh Fading channel. [11]

P. Mukunthan and P. Dananjayan in **'Modified PTS combined with Interleaving Technique for PAPR reduction in OFDM System with Different Sub-blocks and Sub-carriers'** in IAENG International Journal of Computer Science, 39:4, IJCS_39_4_02 shows combination of OFDM signal with technique of space time coding which leads to effective communication with spectral wideband. To combat the problem of PAPR, modified PTS scheme has been applied. Modified PTS scheme involves the joint optimization of real and imaginary part of the signal using IFFT so that calculation of optimum rotation phase factors get simplified and hence reducing the computational complexities. From this we can conclude sub-block partition scheme has been used effectively for optimum results. The whole scheme is brought by applying QPSK modulation of the OFDM signal. The selection of the best criteria out of the proposed one is being emphasized and discussed thoroughly. The whole concept primarily gives a brief and important idea and overview of different techniques that can be used for the purpose of reducing the PAPR of OFDM signal. [12]

V. Sudha and D. Sriram Kumar in **'Peak-to-Average Power Ratio Reduction of OFDM Signals by Applying Low Complexity SLM and Clipping Hybrid Scheme'**, 2012 in International Journal of Electrical Engineering and Informatics – Volume-6, No. – 2 states the analysis of OFDM system by analyzing the PAPR problem prevails in the system by using some techniques including Clipping , PTS (Partial Transmit Sequence) and SLM (Selective Mapping). Each results have been showed by plotting appropriate CCDF plot of every selected scheme and a fine observation has been provided. A comparison of original OFDM signal is also being provided. Hybrid techniques used to provide a better analysis by reducing the number of computational complexities. Further the paper presents a comparison of OFDM signal using different modulation methods like BPSK, QPSK and QAM and encoding the input sequence using block coding. In final results, by using the Hamming code – a type of block code brings improvement in the modulated output by changing the signal phase which shows a great performance in terms of PAPR reduction. The results, the paper provides can demonstrate the significant improvement in the performance in bit error rate and in PAPR reduction. [13]

Diaming Qu, Li Li and Tao Jiang in **'Invertible Subset LDPC Code for PAPR Reduction in OFDM Systems with Low Complexity'**, 2014 in IEEE Transaction on Wireless Communication, Vol. 13, No. – 4, introduces a new approach of LDPC codes known as Invertible Subsets which checks the complexity and reduces PAPR significantly. It uses the concept of disjoint invertible subsets to produce codewords using LDPC. This also helps in checking the error and provides a good error – correcting performance. [14]

CHAPTER -4

RATIONAL AND SCOPE OF STUDY

Generally, we can state that OFDM is a scheme where the sub-carriers are orthogonal to each other. Any two sub-carriers are orthogonal to each other means their dot product gives value zero. It is a kind of multi-carrier modulation and can also be defined as a parallel transmission scheme. The sub-carriers spacing are chosen such that each carrier is orthogonal to each other. Since it follows a parallel transmission scheme, it operates in a way that it splits the high data rate streams into a number of parallel low data rate streams for reducing inter-channel interferences. Here in this process every data stream is modulated with a different sub-carrier. [16]

Even though OFDM is used as a standard all over the world in order to provide users with high data rates followed by advanced intensive applications wirelessly, there are few challenges it faces. The main problems faced are:

(e) ISI due to multipath fading channels.
(f) Due to non-linearity of amplifiers there is a large peak to average ratio (PAPR).
(g) Phase noise from oscillators.
(h) In the receiver there is a need of frequency offset correction

The effects on the transmitted signal when there is a large PAPR can be listed as :

(e) In-band and Out-band interference
(f) Spectral fading
(g) Intermodulation
(h) Changes in the constellation diagram of the signal.

So there is a good need for reducing the large peak to average ration of a signal.

Hence it is clear that there are many challenges arise due to non-linear distortion. It causes both the undesired in-band and out-band interferences to the transmitted signals. In order to limit these factors we use non-linear components like Power Amplifies (Pas) which need a back off which approximately equals the value of PAPR in a transmission which is distortion less. This also reduces the efficiency factor for the amplifiers. Hence reduction of PAPR is of practical interest.[16][17]

There are many proposed methods to reduce the problem of large PAP ratio of a transmitted signal. Some of these techniques are coding selective mapping with tone reservation and implicit or explicit side messages or information based on redundancy test. One unusual effect because of redundancy test on OFDM signal is the reduction in the transmission rate. There are some more coherent methods like exploitation of signal constellation (extended), for example tone injection which has to be compensated with increase in the power and complexity of the implementations etc.

One more way to view the study by incorporating the PTS and Linear Coding concept :

1) PTS is an exhaustive search technique but despite having high computational complexities it can significantly reduces the PAPR by defining all possible rotation phase combinations. As the number of subcarriers increases, the search grow exponentially.
2) The real and basic idea behind the block coding scheme is out of all the possible message symbols, the symbols which have the lowest value of peak power will be considered as a valid code word for transmission and during the transmission.

The most important advantages are:

(a) Efficiency of message transfer

(b) Link Reliability

(c) Improve data rate

(e) Increase in transmit power

(f) No additional power or bandwidth requirement

OBJECTIVES OF THE STUDY (In General) :

The main objectives of this work is to

- To evolve an approach on Electronic and Communication in view the basic goal of development of world class electronic infrastructure for supporting accelerated growth of communication field and other sectors of the economy.
- To make recommendations on development of an appropriate system of electronics and tele-communication approach in OFDM signal transmission, this should be affordable and efficient.
- To make recommendations on the further restructuring/ reforms required in the electronics and communication in order to make transmission modes more secure and fulfilling.
- To help better measures to be adopted for promoting private sector investment in the light of the experience gained so far and the requirement of funds for future growth.
- To enhance this technology for future use.
- To create more ideas for bringing reliable and easy going fast service access everywhere.
- To make the electronics and tele-communication models more popular to be adopted efficiently and easily all over the world.
- To give us an insight for the upcoming future projects will be undertaken and to fulfill the basic needs and previous base knowledge of the whole process.

To evolve with more brighter ideas to be implemented and augmented in the topic undertaken.

OBJECTIVES OF THE STUDY (In Proposed Work) :

The objectives of the whole work is being summarized below :

- To study and gain knowledge and sufficient formulation techniques of various techniques regarding OFDM systems in order to reduce the PAPR of the signal.
- To deduce the necessary technique used to reduce the PAPR in OFDM and its enhance performance characteristics using LDPC codes.
- Implementing the PTS and Linear Block Coding in a system by employing the technique stated i.e. the LDPC coding.
- Implementation of the proposed technique and improving the results by implementing A-Law Companding to show the result in terms of reduced the PAPR value by proposing a Hybrid Technique.
- Simulations in MATLAB for all the proposed objectives.

CHAPTER - 5

MATERIALS AND RESEARCH METHODOLOGY

5.1 Problem Formulation :

Linear block codes known as the low density parity check codes are useful in terms of implementation and simplicity and these code can be constructed using bipartite graph. By providing faster flexibility and memory uses, this encoder ensures simplified calculations. These codes enable the noise threshold to set very closely to the theoretical maximum value (i.e. up to Shannon limit) which is for a symmetric memory-less channel because these codes are capacity-approaching codes. . The threshold values set an upper limit to the channel noise, up to which the probability of the information which is lost can be made as small as desired.

Incorporating this technique with PTS (Partial Transmit Sequence), although dealing with high computational complexity it reduces the PAPR of the system significantly, by defining the possible rotation phase combinations. The signal achieved is then further treated with simple linear block coding to yield improvement. The whole process provides a hybrid scheme with relatively better performance of all the techniques included when A-Law companding is introduced.

Analyzing the performance of the OFDM system using LDPC codes using PTS and linear encoding with companding, to reduce PAPR of a given OFDM signal is being performed by proposing a Hybrid scheme.

5.2 Research Methodology :

This section provides an analyzed view of the principles and procedures of inquiry in the proposed method of the paper. It is the methods that followed. It gives us a basic overview of the work and way of how the work is going to be proceeded further using the proposed methods and techniques.

Here I will provide an idea of the methods and ways that are to be followed and implemented in a manner with the descriptions and its purposes. It also provides an idea of which diagram block is specifically going to follow which technique or methods and how it can be simplified.

Here is a simple block diagram of the proposed work at the transmitter side:

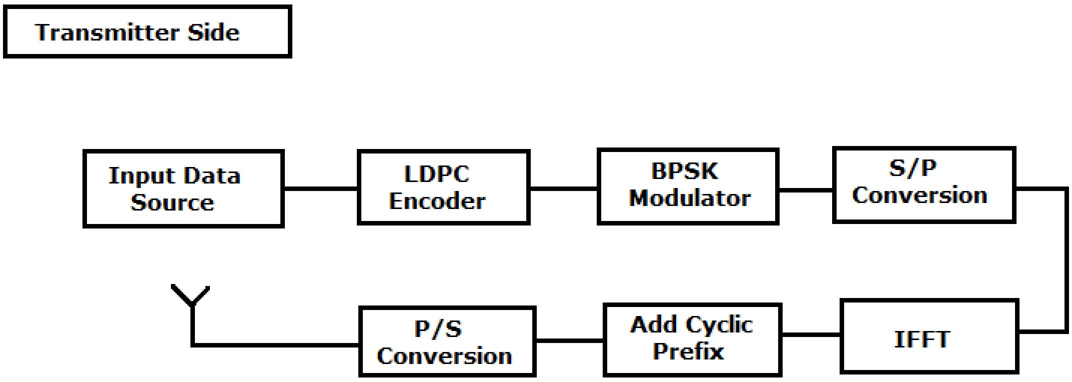


Fig 5.1: Block Diagram for Transmitter Side Wireless Model

<u>Data Source :</u> It is the way through which the input signal is provided for various modifications in the further steps. It is the source for the whole process. Here we provide the digital data for its further decided procedures.

<u>Channel Encoder :</u>

A channel encoder performs the operation of encoding the received data from the data source and transmit the same data after performing encoding to the desired modulator. In encoder it is to be decided which coding technique is suitable and which is to be used for the data according to the proposed method.

For example, if we consider a block of data bits which could be a sound signal and transmit the same for say five times over the channel, the receiver at the receiving side will definitely observe the pattern of repetition of data bits five times and it will take a majority vote depending on the most familiar data bits block. The process is carried out five times to spread the data. This way the codes are repeated with less vulnerability. Moreover various codes are present with more effective way of repaeting the codes and detecting the errors using 'burst' methods. [18]

Using LDPC in Channel Encoder :

LDPC codes are linear codes used for eroor correction, invented by Gallager in 1960s during his Ph.D. dissertation. After being neglected for being impractical codes for many years, now this codes are considered to be most practical one in wireless communication field. These codes are somewhat shares similarity with the Turbo sodes along with the advantage of easy implementation.

LDPC codes given by Gallager, known for having sparse parity check matrix are consider a special type of linear block codes. The parity matrix that generated comprises of a small number of ones (non-zero element) in comparison to other elements present. They are specially used in noisy communication for error correction bearing the capability of reaching the channel capacity significantly. A parity check matrix can be represented by **H** and notation for LDPC codes is (n, k). Here n is size of codeword and k is information bits and **H** can be shown as (n-k, k) in matrix form. A sparsely distributed matrix means either distribution of 1's randomly in each column or distribution of 1's randomly in each row. 1's can be distributed randomly in both column and row simultaneously. In a matrix of (a x b), for number of 1's present in column, let the weight be **Wc** and similarly for each row the weight will be **Wr.** Sparsely distributed LDPC code offer us the advantage of regular code i.e. if weight **Wc** is constant for every column, the weight **Wr** will be constant for every row too. A LDPC code is known to be irregular if it is not regular i.e. no sparsely distributed matrix. [18][19][20]

$$Wr = Wc\frac{a}{b} \qquad \text{(v)}$$

This codes are usually depends on the working criteria of parity check codes:

Parity check codes are a type of block codes of fixed length (say n). It is a collection of binary vectors. The LDPC are types of codes which can be represented in the matrix form of (n,r,k). This code generally contains mostly zeros and realtively less one's. in a mtrix of (n,r,k) contains a block lenth of n, r number of parity checks and (n-r)=k number of information digits. The matrix is composed of column of fixed number of 1's (say j) and each row has a fixed number of 1's (say i) which doesnot follow the diagonal property.

An example for hoe LDPC works :

A LDPC code has relatively less percentage of 1's in the parity check matrix. Some properties of regular LDCP codes are:

- The number of equations will contain every code digit.
- Equations will also contain the equal number of code symbols.
  (No properties are required in irregular LDPC).

Let the equation for a simple LDPC code with n=12

C3 * C6 * C7 * C8 = 0

C1 * C2 * C5 * C12 = 0

C4 * C9 * C10 * C11 = 0

C2 * C6 * C7 * C10 = 0

C1 * C3 * C8 * C11 = 0

C4 * C5 * C9 * C12 = 0

C1 * C4 * C5 * C7 = 0

C6 * C8 * C11 * C12 = 0

C2 * C3 * C9 * C10 = 0

Because of 7 independent equations, we have 7 parity digits.

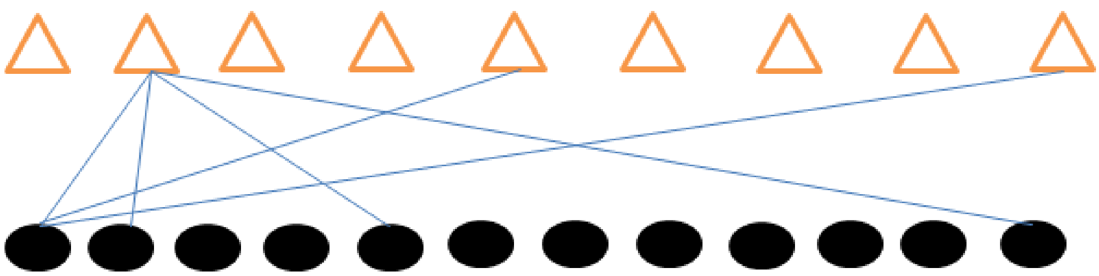
So the parity check matrix for this equations are :

0 0 1 0 0 1 1 1 0 0 0 0
1 1 0 0 1 0 0 0 0 0 0 1
0 0 0 1 0 0 0 0 1 1 1 0
0 1 0 0 0 1 1 0 0 1 0 0
1 0 1 0 0 0 0 1 0 0 1 0
0 0 0 1 1 0 0 0 1 0 0 1
1 0 0 1 1 0 1 0 0 0 0 0
0 0 0 0 0 1 0 1 0 0 1 1
0 1 1 0 0 0 0 0 1 1 0 0

Note : Every three equations contains code symbol of same kind and every equation is made of foru symbols. This is how codes are encoded in the system.

This codes are decoded very simply by the use of bipartite graphs. It becomes easily understandable. The graph representation contains two kinds of nodes. One is called the parity node and other is called as the bit node.Parity nodes used to representing the equations and bit nodes are for representing code symbol.

For the second iteration, that is second row and second column the graph will be :



Where triangles are parity equations and ovals are code symbols.

By passing the messages along the lines of the graph (transmission lines), decoding can be accomplished.[19][20]

BPSK Modulator :

BPSK is the simplest form of digital modulation scheme available. This modulation technique has two possible phases (0 and 1) i.e. logic 0 and logic 1 which are phase separated by 180 degree. It is also called as square wave modulation of continuous waveforms. The advantage of using this modulation scheme is its robustness out of all other PSK techniques available.

Partial Transmit Sequence :

After modulating the received data, serial to parallel conversion on modulated data is performed; this is then followed by IFFT block which is where the concept of PTS appeared.

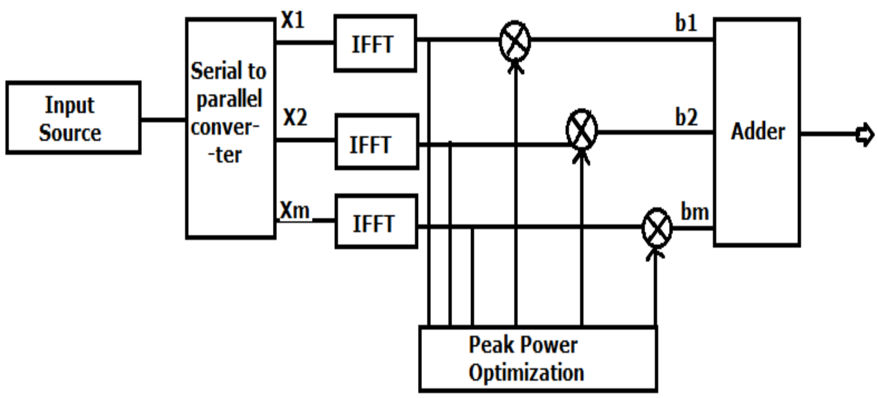


Fig 5.2 Block Diagram for PTS [12]

Despite of showing some computational complexities, PTS technique is known for its high redundancy utilization and system performance. This technique requires the division of high rate data from original OFDM signal into a number of sub data and then transmits it through different sub-blocks.

After applying IFFT, these sub-data streams are multiplied by different rotating vector and are then summed together. PAPR is computed for each resulting sequence simultaneously and by comparing the sequence with minimum PAPR value is transmitted further. Basic or simple modulation techniques can be used to check the high computational complexities without compensating in redundancy check [21].

The main objective of using PTS block after IFFT block and divided the stream into sub-data blocks to multiplied with different defined phase rotating phases is to perform combination of all

sub-data blocks in an unique optimum way in order to achieve a significant reduction in PAPR value of the given signal.
Such techniques are also defined as sub-optimal solutions or techniques.

The entire input data in its sub-stream form with an assumption of having equal gap between them is represented as:

$$X=\sum_{m=1}^{M} X_m b_m \qquad \text{(vi)}$$

Here, b_m is the weighing factor for rotating vector and can be represented as

$$b_m = e^{-jw_m} (w_m\ [0,2\pi]) \qquad \text{(vii)}$$

where, m = 1, 2, 3……X_m

So for representing this equation in time domain, it requires to apply IFFT to each sub-stream such as :

$$x = \text{IFFT}(X) = \sum_{m=1}^{M} X_m b_m \qquad \text{(viii)}$$

Linear Encoding :

This signal is then transmitted further to analyzed upon the linear block codes as follow:

The real and basic idea behind the block coding scheme is out of all the possible message symbols, the symbols which have the lowest value of peak power will be considered as a valid code word for transmission and during the transmission. Let suppose we have N number of total subcarriers and suppose we select a modulation technique say QPSK then there will be 2N number of bits and thus 2^{2N} symbols/modulated messages. If we use the entire message then the information bits will be corresponds to zero bit of redundancy. But if we use only half bits of the message signal there will be only one bit of redundancy. The message that is left unused is then used to divide the space into half and the whole dividing process keeps continuing until we received N bits of redundant symbols. These N bits redundant symbols are actually corresponds to one-half code rate for N number of subcarriers. [14]

In a block code **C**, our message is encoded by dividing the message into blocks of equal bits say **k** bits. Now each block is mapped onto codeword **c** of **n** bits. Condition is **n>k.** In order to add redundancy, we can append **n-k** additional bits called parity bits. The rate of this code can be calculated by **k/n.** Every message bit will be with only one codeword and the message will contain a total of $\mathbf{2^k}$ codewords. A linear block code is fundamentally determined by a Generator Matrix. For a given code, the Generator matrix can be represented as **"k x (n-k)"** in matrix form. It comprises of an identity matrix I^k of dimension **k x k** and a parity matrix P [15].

<u>Overview of System Model :</u>

OFDM signal is :

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kft}, \quad 0 \le t \le T \qquad \text{(ix)}$$

where, T = symbol interval and f=1/T

The PAPR problem in OFDM signal can be considered as a big drawback in the high data rate and bit transmission in the signal due to its unstable spikes and behavior. When all the subcarriers (say N subcarriers) are added up which are having the same phase can produce a peak power that can be N times the total average power [1].

Mathematically, PAPR can be written as

$$\text{PAPR} = \frac{P_{peak}}{P_{average}} \qquad \text{(x)}$$

$$\text{PAPR} = 10log_{10} \frac{\max[|x(t)|^2]}{E[|x(t)|^2]} \qquad \text{(xi)}$$

E[ ] = expectation operator

CCDF is stand for Commentary Cumulative Distribution Function is a probability occurs when *PAPR* exceeds its threshold level say $PAPR_0$.

i.e. $$CCDF(PAPR(x(a)))= P_r(PAPR(x(a)))> PAPR_0 \qquad \text{(xii)}$$

x(a)= discrete time version of OFDM signal

For N number of independent symbols (symbols are uncorrelated), PAPR is represented as

$$P = P_r(PAPR(x(a)) > PAPR_0 \qquad \text{(xiii)}$$

Every sub-stream is being treated with PTS algorithm after IFFT operation and then followed by adding cyclic prefix as:

$$X=\sum_{m=1}^{M} X_m b_m \qquad \text{(xiv)}$$

Here, b_m is the weighing factor for rotating vector and can be represented as

$$b_m= e^{-jw_m}(w_m\ [0,2\pi]) \qquad \text{(xv)}$$

where, m = 1, 2, 3……X_m

So for representing this equation in time domain, it requires to apply IFFT to each sub-stream such as :

$$x = \text{IFFT}(X) = \sum_{m=1}^{M} X_m b_m \qquad \text{(xvi)}$$

The importance of using PTS block is to combine the different phase shifted sub-carriers to generate a signal of different phase factor among which the phase factor with low PAPR is selected. These phase factors maintains orthogonality and enhance reduction of redundancy. [6]

Implementing A-Law Companding :

Implementation of A-Law promises a huge variation in terms of improved results in coding efficiency. Hence in order to improve the efficiency of linear coded message, the linearly coded message is being companded to yield desired results.

Companding techniques are generally used for organizing the dynamic range of a given sinusoidal signal. The A-law Companding is also used to check the range of the given input signal to it. This law is basically used in 8-bit PCM digital system and are very similar to Mu-Law which is used in North America and Japan. The limiting of range of any signal significantly results in better coding efficiency and the signal distortion level goes down.

$$F(x)= \text{sgn}(x)\frac{A|x|}{1+\ln(A)} \quad \text{when } |x|<1/A \qquad \text{(xvii)}$$

$$F(x)= \text{sgn}(x)\frac{1+\ln(A|x|)}{1+\ln(A)} \quad \text{when } 1/A\leq |x| \leq 1 \qquad \text{(xviii)}$$

where, A = 87.56

After implementing all the above techniques stated the desired results are obtained which are being explained in detail in Chapter -6 i.e. Results and Discussions.

5.3 Thesis Objectives

To carry out the work related to the literature gain through Dissertation-I is to completely understand the aspects of OFDM signal, the related knowledge regarding the transmitter and the receiver side of the system is also considered necessary.

The objectives of a study can provide a rational way to judge the current work by its originality, authenticity, scope, future uses along with the advantages and disadvantages. Working against the technological hindrance of recent requires fast results and adaption and hence my objectives for future study tries to bring out the valuable points with a proper technique in order to present a more durable results in the field of wireless communication.

One of the main goals is to thoroughly understand the behavior of Low Density Parity Check (LDPC) codes for a given system since the behavior of the system in accordance with the coding scheme is to be formulated, especially in case of surveying the performance of BPSK (Binary Phase Shift Keying) systems for wireless communication. It's a relational study to give an idea of performance of linear block coding in the field of wireless communication.

Our second aim is to theoretically and mathematically calculate the PAPR (Peak to Average Power Ratio), with the help of a tool called MATLAB (matrix laboratory) using PTS and Linear Blok codes with A-Law Companding. MATLAB tool is used to present the statistical and theoretical aspect of a given matter in terms of comparison. It is a software tool to implement all kind of systems with desired parameters without actually employing the system physically and hence it provides a great platform to check or double check our implementations or results before employing them for humankind.

Our main objective is to bring down the value of PAPR of an OFDM signal which results in non-linearity in the system by analyzing the performance of the cascade combining using the codes called LDPC technique. Reducing the value of PAPR leads to a healthy way of maintaining strong wireless communication through high speed (data rate) with efficiency.

The objectives of the whole work is being summarized below :

- To study and gain knowledge and sufficient formulation techniques of various techniques regarding OFDM systems in order to reduce the PAPR of the signal.
- To deduce the necessary technique used to reduce the PAPR in OFDM and its enhance performance characteristics using LDPC codes.

- Implementing the PTS and Linear Block Coding in a system by employing the technique stated i.e. the LDPC coding.
- Implementation of the proposed technique and improving the results by implementing A-Law Companding to show the result in terms of reduced the PAPR value by proposing a Hybrid Technique.
- Simulations in MATLAB for all the proposed objectives.

5.4 MATLAB Tool :

For the purpose of bringing out the practical results, we use the tool called MATLAB stands for Matrix Laboratory. As described in objectives of this review work we're going to provide the simulations of the discussed methods and their comparisons and all the work will be carried out through the tool MATLAB. It is basically easy to employ this tool as this comes handy in operations like modifying data, transporting data, and setting parameters, draw up a whole system with desired specification and a lot more. MATLAB is used to implement and demonstrate the transmitted and the final received OFDM signal. We can observe the behavior of the parameters and bring changes to it since it shows the power through its flexibility.

MATLAB comes very handy as they also deals with the elements of lambda calculus. This software provide function handles also known as function references which can be used in nested form.

CHAPTER - 6
RESULTS AND DISCUSSIONS

6.1 Experimental Work

The PAPR value of the OFDM signal is to be brought down by incorporating the Low Density Parity Check (LDPC) code in the channel encoder of an OFDM system. Linear block codes known as the low density parity check codes are useful in terms of implementation and simplicity and this code can be constructed using bipartite graph. By providing faster flexibility and memory uses, this encoder ensures simplified calculations. These codes enable the noise threshold to set very closely to the theoretical maximum value (i.e. up to Shannon limit) which is for a symmetric memory-less channel because these codes are capacity-approaching codes. . The threshold values set an upper limit to the channel noise, up to which the probability of the information which is lost can be made as small as desired.

Incorporating this technique with PTS (Partial Transmit Sequence), although dealing with high computational complexity it reduces the PAPR of the system significantly, by defining the possible rotation phase combinations. The signal achieved is then further treated with simple linear block coding to yield improvement. The whole process provides a hybrid scheme with relatively better performance of all the techniques included when A-Law companding is introduced.

The whole experimental work is being carried out according to the above stated procedure. The procedure is done step wise according to the system model given below with supported formulas :

OFDM signal is :

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kft}, \quad 0 \le t \le T \qquad \text{(xix)}$$

where, T = symbol interval and f=1/T

Mathematically, PAPR can be written as

$$\text{PAPR} = \frac{P_{peak}}{P_{average}} \qquad \text{(xx)}$$

$$\text{PAPR} = 10log_{10} \frac{\max[|x(t)|^2]}{E[|x(t)|^2]} \qquad \text{(xxi)}$$

E[ ] = expectation operator

CCDF is stand for Commentary Cumulative Distribution Function is a probability occurs when $PAPR$ exceeds its threshold level say $PAPR_0$.

i.e. $$CCDF(PAPR(x(a)))= P_r(PAPR(x(a)))> PAPR_0 \quad \text{(xxii)}$$

x(a)= discrete time version of OFDM signal

For N number of independent symbols (symbols are uncorrelated), PAPR is represented as

$$P = P_r(PAPR(x(a))> PAPR_0 \quad \text{(xxiii)}$$

Every sub-stream is being treated with PTS algorithm after IFFT operation and then followed by adding cyclic prefix as:

$$X=\sum_{m=1}^{M} X_m b_m \quad \text{(xxiv)}$$

Here, b_m is the weighing factor for rotating vector and can be represented as

$$b_m= e^{-jw_m}(w_m\ [0,2\pi]) \quad \text{(xxv)}$$

where, m = 1, 2, 3……X_m

So for representing this equation in time domain, it requires to apply IFFT to each sub-stream such as :

$$\text{X} = \text{IFFT(X)} = \sum_{m=1}^{M} X_m b_m \quad \text{(xxvi)}$$

The importance of using PTS block is to combine the different phase shifted sub-carriers to generate a signal of different phase factor among which the phase factor with low PAPR is selected. These phase factors maintains orthogonality and enhance reduction of redundancy [6].

In a block code **C**, our message is encoded by dividing the message into blocks of equal bits say **k** bits. Now each block is mapped onto codeword **c** of **n** bits. Condition is **n>k.** In order to add redundancy, we can append **n-k** additional bits called parity bits. The rate of this code can be calculated by **k/n.** Every message bit will be with only one codeword and the message will contain a total of $\mathbf{2^k}$ codewords. A linear block code is fundamentally determined by a Generator Matrix. For a given code, the Generator matrix can be represented as **"k x (n-k)"** in matrix form. It comprises of an identity matrix I^k of dimension **k x k** and a parity matrix *P*.

Companding techniques are generally used for organizing the dynamic range of a given sinusoidal signal. The A-law Companding is also used to check the range of the given input signal to it. The limiting of range of any signal significantly results in better coding efficiency and the signal distortion level goes down.

The improved results are shown in the simulations attached below.

6.2 Performance Evaluation

The OFDM system is being implemented by passing it through various necessary phases in order to show the detail characteristics obtained in transmitter side. The characteristics obtained are :

(a) Characteristics of the OFDM signal

(b) Simulations results without introducing A-Law Companding

(c) Simulation results after introducing A-Law Companding

BPSK Modulated Data is :

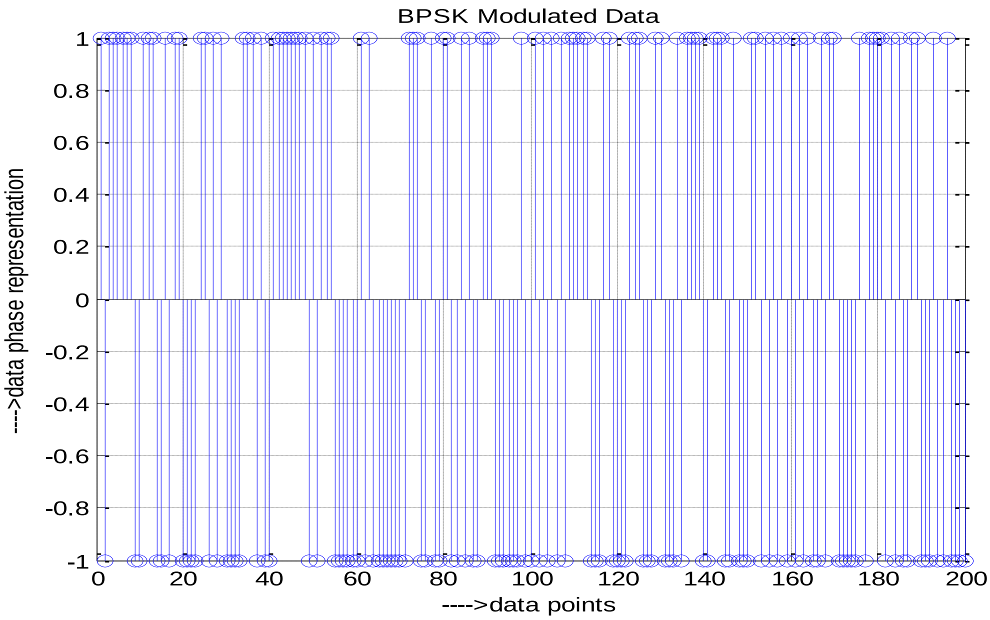


Fig 6.1 BPSK Modulated Data

The transmitted OFDM Signal is :

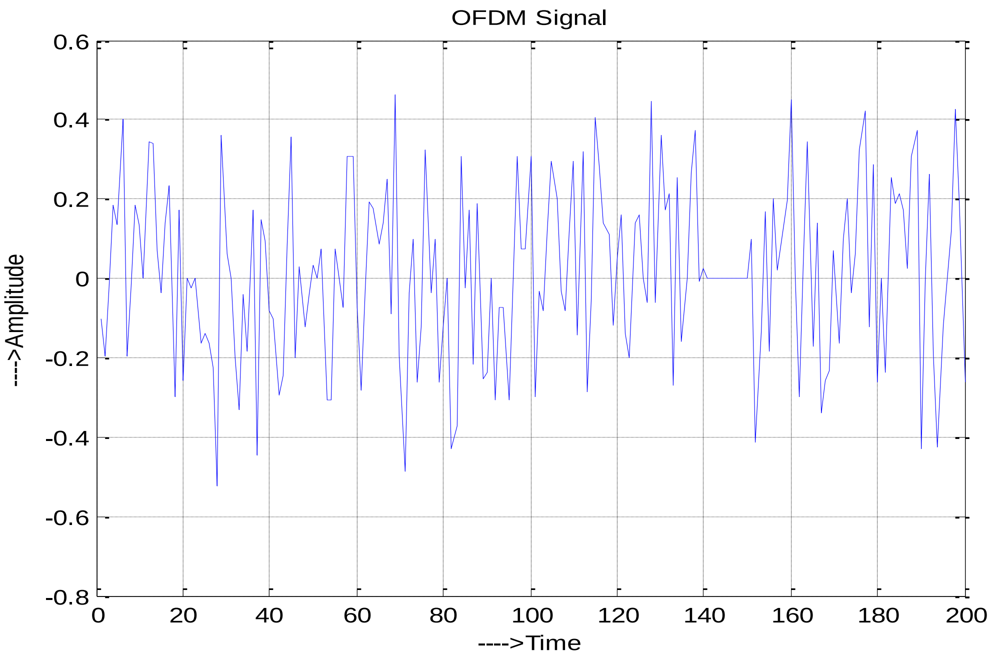


Fig 6.2 Transmitted OFDM Signal

Simulation results for LDPC Encoded OFDM signal without A-Law Companding :

Here, the graph attached shows the PAPR values for the original OFDM signal and then the PAPR values for OFDM signal with applied PTS technique in the real part of the signal. After that the signal is being treated with linear block coding to see any changes in the PAPR value obtained earlier. The results are shown below :

Table 1 : PAPR values for LDPC Encoded OFDM Signal Without A-Law Companding

Techniques Used	PAPR Value (in dB)
1) LDPC + PTS	9.3
2) LDPC + PTS + Linear Coding	8.1

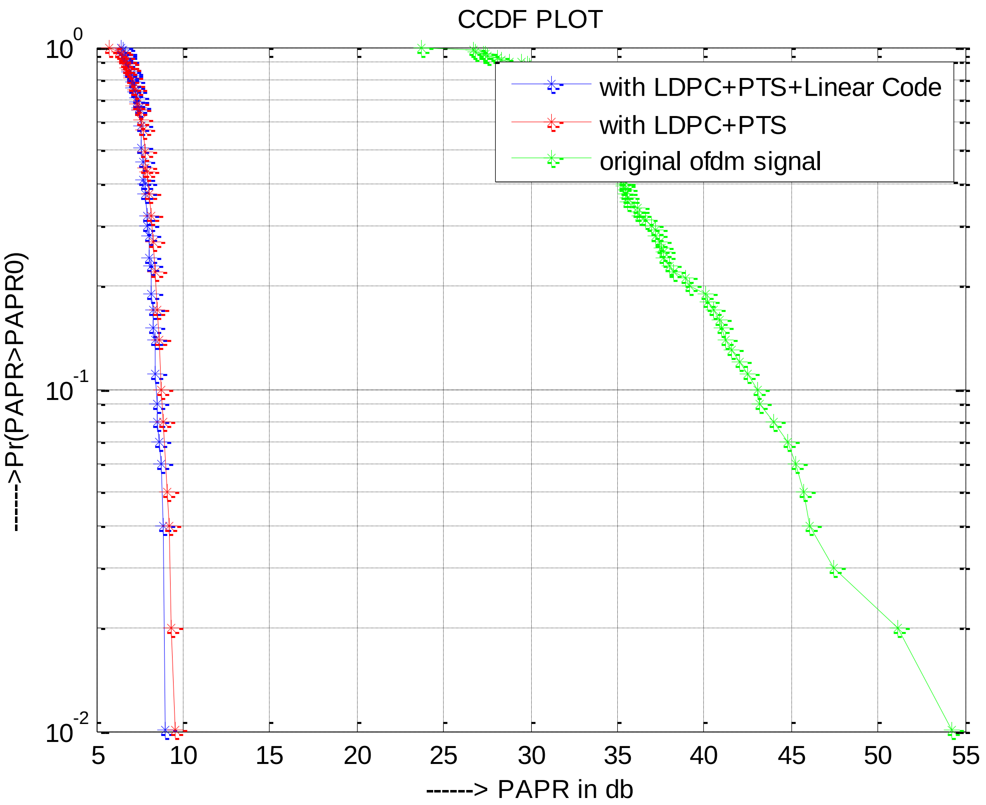


Fig 6.3 PAPR values of LDPC Encoded OFDM signal without Companding

Simulation results for LDPC Encoded OFDM signal with A-Law Companding :

The result from above does not seem to provide much satisfaction and hence for a better analysis, the techniques used above have been treated with companding of the message signal to obtain more satisfying result. It also shows a considerable reduction in the value of PAPR with A-Law Companding.

Table 2 : PAPR Values for LDPC Encoded Signal with/without Companding

Techniques Used	PAPR Value (in dB)
1) OFDM without Companding	57.3
2) OFDM with Companding	26.1

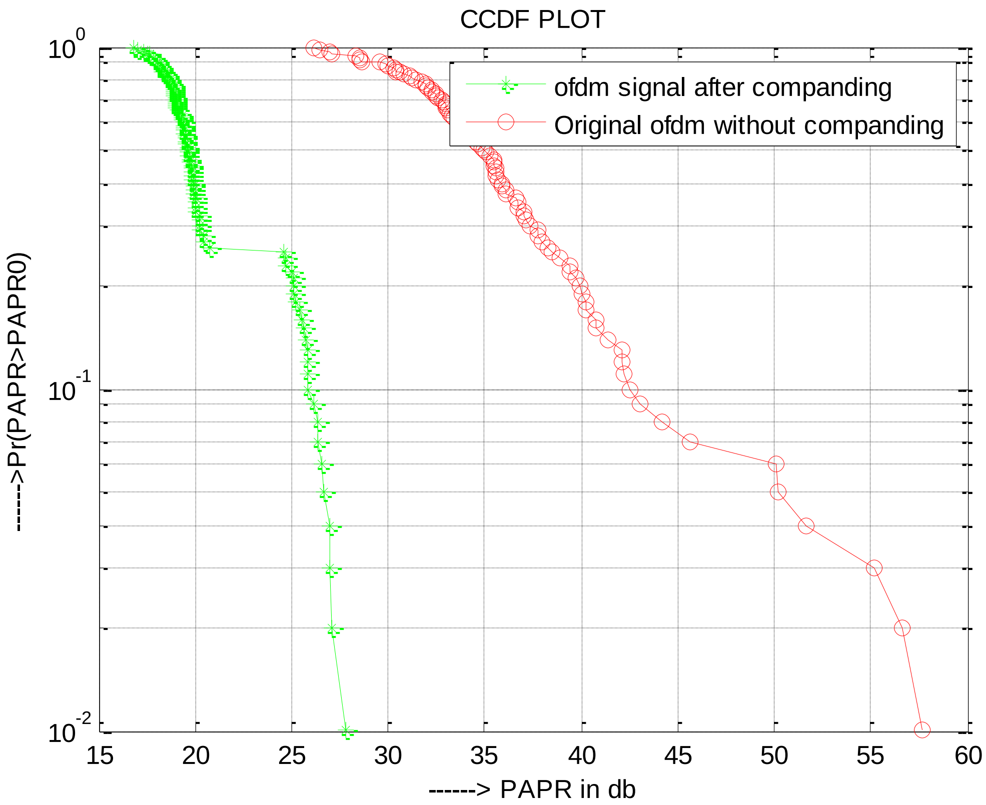


Fig 6.4 PAPR values of LDPC Encoded OFDM signal with/without Companding

Table 3 : PAPR Values for LDPC Encoded Signal + Linear Coding

Techniques Used	PAPR Value (in dB)
1) OFDM without Companding	57.3
2) OFDM with Companding	26.1
3) Companded OFDM + Linear Code	16.7

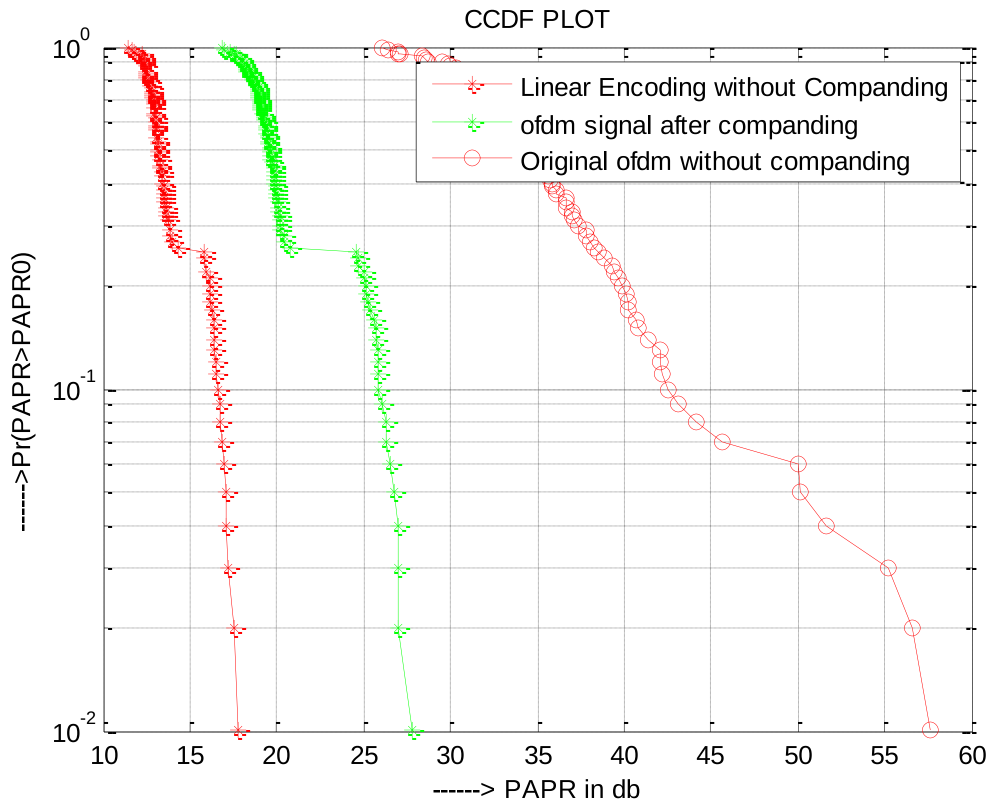


Fig 6.5 PAPR values of LDPC Encoded OFDM signal + Linear Encoding

This graph shows the variation of three techniques used to analyze the reduction in PAPR i.e. the PAPR values corresponds to the original OFDM signal without companding, values corresponds to OFDM signal after companding and the values of PAPR corresponds to companded OFDM signal with Linear Encoding.

Table 4 : Final PAPR Values for LDPC Encoded Signal

Techniques Used	PAPR Value (in dB)
1) OFDM without Companding	57.3
2) OFDM with Companding	26.1
3) Companded OFDM + Linear Code	16.7
4) Companded Linearly Coded Signal	5.7

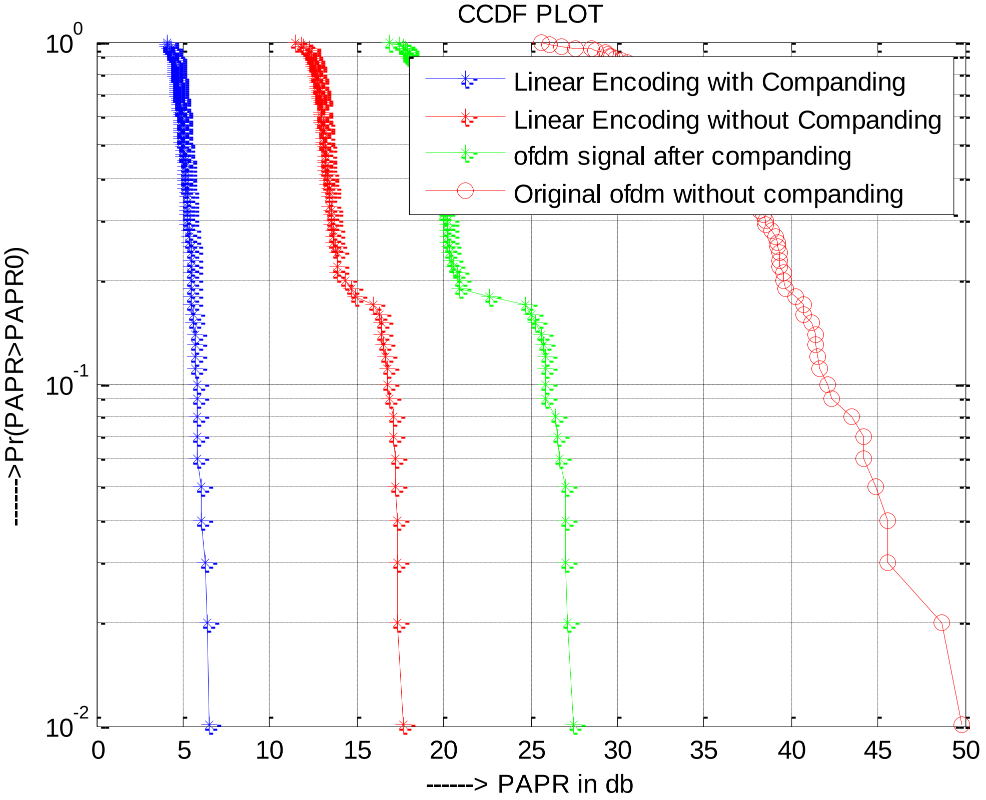


Fig 6.6 Final Results for PAPR values of LDPC Encoded OFDM Signal

CHAPTER - 7
CONCLUSION AND FUTURE SCOPE

Conclusion :

We describe and summarize several aspects of OFDM signal and the problem related to it like PAPR and the ways of reduction methods. Out of which, linearly coded the channel is seems to be a solution for PAPR Reduction**.** As the selected technique provides us with a good range in performance to reduce PAPR problem. It is adaptable with the system and the channel and relatively easily implementable.

It is particularly suitable with the OFDM system because of its high compatibility and demand in the recent eruption technological revolution.

My research has concluded the following points:

Firstly, PAPR reduction concepts will be expanded for distortion less transmission and implementing the proposed methods in terms of performance increase.

Secondly, PAPR reduction technique will be develop for low data rate loss and efficient communication. A study of the complexity issues of the PAPR reduction technique is required, especially looking at ways of further reducing the complexity of the OFDM systems is being done.

The incorporation of techniques like PTS and Linear Coding is analyzed over A-Law Companding to yield a Hybrid Process which in turn reduces the PAPR value with much efficiency and without any tough implementation.

Future Scope :

- To help better measures to be adopted for promoting private sector investment in the light of the experience gained so far and the requirement of funds for future growth.
- To enhance this technology for future use.
- To create more ideas for bringing reliable and easy going fast service access everywhere.
- To make the electronics and tele-communication models more popular to be adopted efficiently and easily all over the world.
- To make recommendations on the further restructuring/ reforms required in the electronics and communication in order to make transmission modes more secure and fulfilling.
- To evolve with brighter ideas to be implemented and augmented in the topic undertaken.

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