PERFORMANCE ANALYSIS AND COMPARISON OF VARIOUS PAPR REDUCTION TECHNIQUES IN OFDM SYSTEM

DISSERTATION-II

Submitted

By

PRABAL GUPTA

Department of ECE

In partial fulfillment of the Requirement for the

Award of the Degree of

Master of Technology

In

ECE

Under the guidance of

Mr. B. Arun Kumar

Lovely Professional University

DECLARATION

I hereby declare that the dissertation proposal entitled, **PERFORMANCE ANALYSIS AND COMPARISON OF VARIOUS PAPR REDUCTION TECHNIQUES IN OFDM SYSTEM** submitted for the M.Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

PRABAL GUPTA
REG NO. -11006653

CERTIFICATE

This is certify that the thesis "**PERFORMANCE ANALYSIS AND COMPARISON OF VARIOUS PAPR REDUCTION TECHNIQUES IN OFDM SYSTEM**" being submitted by Prabal Gupta for the fulfillment of requirement for the award of MASTER OF TECHNOLOGY DEGREE, is done in my guidance. The material used in this thesis is not taken from any other source.

Mr. B. Arun Kumar
Guide
Lovely Professional University

ACKNOWLEDGEMENT

It is my pleasure to have such an opportunity to show my gratitude and regards to Mr. B. Arun Kumar, Mr. Sandeep Kumar Jain, Mr. Balpreet Singh, Mr. Nikesh Bajaj (COD), Dr. R.K Singh Department of Electronics and Communication Engineering, Lovely Professional University, Punjab for their valuable guidance during the preparation of this work. Whenever I came across any problem then their advices always work as wonder for me. This is the remarkable experience for me to work under their supervision.

Finally last but not the least, I would like to express my love, gratitude and heartily respect to my parents, divine mother, my sister and Mr. Shivguru, who have always supported and guided me in each phase of life.

PRABAL GUPTA
REG NO. - 11006653

ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier technique used for high data rate and robust against ISI, frequency selective fading. OFDM is used by DAB, DVB, Wi-max, LTE, and OFDMA etc. But besides all these advantage OFDM has problem of high PAPR (peak to average power ratio) which degrade system performance. Due to high PAPR, amplifier starts operating in non linear region finally leads to distortion in our data therefore cause inter carrier interference (ICI). There are so many techniques proposed in literature like distortion less technique i.e. SLM (selective mapping) and PTS (partial transmitted sequence), these are also called as scrambling sequence techniques. Clipping and filtering is also there, although this technique reduces PAPR but it generally creates in-band and out-band distortion as well. Coding technique is also among all these technique which uses some sort of scrambling codes which added to existing data and finally help in reducing PAPR. Among all these various techniques we have selected most important techniques known as PTS and SLM. PTS technique was given by Muller and Huber and after that continuously work is going on the same technique. This technique was chosen because it is distortion less and also a scrambling technique. In context of complexity this scheme suffers sometimes. This is the main reason why this technique is chosen among many techniques. In this technique data block is partitioned into many small sub-blocks and each sub-block are scrambled by different phase and finally the sequence which generated minimum PAPR is selected from many sequence. Another technique which is also chosen in this report is SLM (selective mapping). This technique is also called as distortion less and scrambles technique. In SLM all sub carriers are multiplied by same length vector known as phase vector. Then transform by IFFT block, generally this transformation, we called as time domain transformation. So after the sequence which generate minimum PAPR is selected for transmission. This dissertation report present two techniques mainly SLM and PTS. In this dissertation we will study existing technique SLM and PTS and analyze it using MATLAB software. We try to learn the behavior of both scheme and try to derive knowledge from it. Then in future work we will improve the work.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF ABBREVIATIONS

OFDM	Orthogonal frequency division multiplexing
PTS	Partial transmitted Sequence
SLM	Selective Mapping
CCDF	Complementary cumulative distribution function
PAPR	peak to average power ratio
SB	Sub block
FDM	Frequency Division Multiplexing
TDM	Time Division Multiplexing
MPTS	Modified Partial transmitted Sequence
IFFT	Inverse Fast Fourier Transform
HPA	High power Amplifier
BCH	Bose Chaudhuri Hocquenghem Cod

CHAPTER-1
INTRODUCTION

1.1 History

Now, a days we are switching from wired to wireless communication system. In wired communication system is always complex and limited while in wireless communication system complexity has been reduced therefore, it has been opted by all. Wireless communication systems are easy to install, very easy to maintain. But in case if wired if in any case cable becomes damaged then we have to replace it therefore cost will automatically be increased and also cost and maintenance of wired is tough to do. Wireless communication stand for sending of information from one point to another when they are not connected by any conductor. The most common technologies which we are using i.e. radio. With the help of radio distance found to be very less like some meters for the television and millions of kilometer for space communication. Some examples of radio wireless technology keyboards, headsets, garage door opener, satellite television. Multiplexing is the technique by which we generally combined multiple signal they can be analog or digital in nature to form one signal over the sharing mediums. In 1870 this technique came into picture in telegraphy and now a day's deployed in communication. This multiplex signal sends over channel like cable etc. Device which we generally use for this is known as multiplexers or we called as MUX, on the other hand for recovering back our signal we use reverse of it which we called as demultiplexer or DEMUX. Types of Multiplexing we are available such as FDM, TDM etc. Frequency division multiplexing combines several signals into single medium only where different signal have different frequency ranges. Application of this technique is old radio, television broadcasting, cable television etc. Justification for FDM can be clearly understood after understanding this example; a service provider always send multiple signal through same cable but those subscriber has access to see all then they can see all but those who have paid for only two or three they can see only two or three. Time Division Multiplexing is a technology by which we can transmit and receive signals over common path with the help of switches such that every signal which is present on line only in some fraction of time in some pattern. Another multiplexing which we generally called as OFDM was proposed by R.W Chang in 1966, which is the basis for upcoming wireless technologies like WiMax, LTE etc. R.W Chang received patent of OFDM in 1970.

1.2 Single Carrier System

A single carrier system consisting of symbols of T period seconds having data rate which is the reciprocal of T, is passed through filter for pulse shaping at transmitter side then through channel where generally additive white Gaussian noise (AWGN) is added then at the receiver side we have filter, equalizer along with detector for the recovery of information signal back. Equalizer is there in order the settle the effect of channel or awgn noise. So after performing analysis we have found that inter-symbol interference is dominating in case of single carrier system. The effect of this ISI is that it generally, diminishes the performance of system.

Problem associated with single carrier system

When considering for higher data rate it simply means we send symbols, where symbols are the combination of bits hence, for higher data rate where a symbol contain 4 bits, 5 bits, 6 bits, 7bits so we are increasing bandwidth also therefore required bandwidth is found greater then coherence bandwidth. This leads to generation of ISI, distort our data and simultaneously creating problem in recovering our data back.

Solution for this problem

Generally we use adaptive equalizer in order to compensate for ISI. So when data rate are increasing then complexity of equalizer are also increasing i.e. number of taps which are required in equalizer will also increase. Therefore we can conclude that for high data rate single carrier system is not feasible at all. So in the next upcoming section we will study about multi- carrier system. How multi-carrier use different carriers and face flat fading because of bandwidth which it require is less then coherence bandwidth. How it is suitable for higher data rate and further modification leads for the generation of orthogonal frequency division multiplexing (OFDM) system.

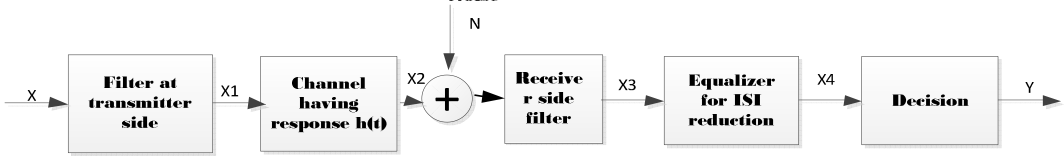


Figure 1.1 Block diagram of single carrier system

1.3 Multi-Carrier System

In order to surmount the frequency selectiveness of wide channel faced by single-carrier (SC), multi-carriers are considered for the high data rate. In multi-carrier system (MCS) wideband signal is divided into several narrow band signals with the help of many narrow band filters at the transmitter side and using multiple filters at the receiver to cover-back our information signal. Since band-width of each sub-carrier is found to be less than coherence bandwidth, therefore ISI is found to be less hence, this technique is found to be more reliable than the previous single carrier technique. Due to small bandwidth possess by each sub carrier this drastically reduce complexity of equalizer. Since sub-carriers are orthogonal to each other in this multi- carrier technique so this orthogonality is also retain in this case.

Problems Associated with technique

This multi-carrier technique is complex as compared to single carrier system. Although we are getting advantages like reduction in inter symbol interference (ISI), distortion less transmission of information signal, diminish inter carrier interference (ICI). Complexity with depend on encoders which we are using at the transmitter side, oscillators which we are using.

Complexity depend on

Complexity of this system will depend on oscillators, encoders and decoders at the transmitter and receiver side respectively.

Solution to this Problem

The solution was proposed by EBERT AND WEINSTEIN researchers. They told above complexity will be reduced by just by using IDFT and DFT at the receiver side respectively.

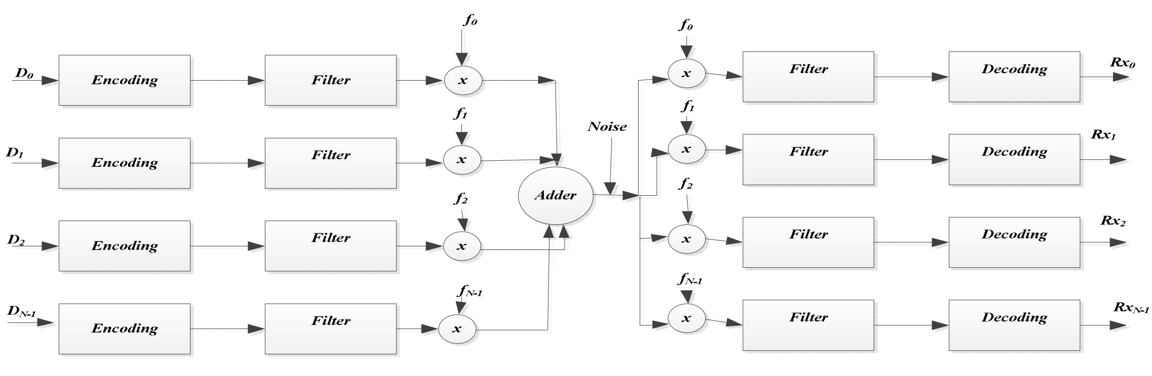


Figure 1.2 Block diagram of multi-carrier system

1.4 Orthogonal Frequency Division Multiplexing

Orthogonal Frequency Division Multiplexing (OFDM) is also called as multi-carrier transmission scheme because it uses multiple sub-carriers for the transmission of data from transmitter side to receiver. It do not require encoder, decoder and oscillator both at the transmitter and receiver side rather it uses IDFT and DFT. In more precise way we can say that it uses IFFT (Inverse fast Fourier transform) and FFT (fast Fourier transform). If we observe it's spectra then it look as if they are overlapping but actually they are orthogonal to each other therefore, it leads to saving in bandwidth hence we called it highly spectrally efficient technique. This technique came into picture after implementation of multi-carrier technique where we were using many encoders, decoders and oscillators on transmitter and receiver side because we want to get rid of ISI. In order to reduce complexity of multi-carrier system EBERT and WEINSTEIN did their job in this field. They told that from now we will use IDFT and DFT on transmitter and receiver side respectively. Orthogonal frequency division multiplexing (OFDM) is the technique which uses data on different sub-carriers frequencies. OFDM is used in digital communication it can be wired or wireless. It is the basis for LTE, 4G technology. It is also called as multi-carrier modulation. All sub-carriers carry data on it. Every sub-carrier is digitally modulated in nature such as PSK (phase shift keying) and QAM (Quadrature Amplitude Modulation). Main task which we achieve after doing this, to reduce ISI. Finally reduce the complexity of equalizer. Actually here in this modulation technique we divide large bandwidth into several small frequency band. Finally small bandwidth found to be less then coherence bandwidth therefore reduce ISI. Cyclic Prefix is also used to remove inter symbol interference (ISI). Guard band which we called as Virtual carriers are used to reduce out of band radiation. In OFDM we follow these steps.

1. Generate random binary data.
2. Modulated the above generated data with the help of modulator. Here we generally used technique like M-PSK or M-QAM.
3. Now convert data from serial to parallel. After serial to parallel conversion, transformation of data from frequency domain to time domain through IDFT at transmitter.
4. Then we add cyclic prefix for the removal of ISI.

Mathematically we can represent all the sub-carriers which are orthogonal to each other by IDFT.

$$x[\mathrm{n}] = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X[\mathrm{k}].\mathrm{e}^{\frac{j2\pi kn}{N}} \qquad 0 \leq n \leq N-1$$

where

$X[\mathrm{k}]$ = modulated *data*

$x[\mathrm{n}]$ = time domain signal

k = frequency index

n = time index

1.4.1 Advantages of OFDM system

1. Orthogonality among Sub-carriers- Orthogonal Frequency Division multiplexing is highly spectrally efficient in nature. Due to this orthogonality guard band has been removed therefore leads in saving of bandwidth. It's spectrum shows as if sub-carriers are overlapping but actually they are orthogonal to each other. Hence in this way we can show that how it is spectrally efficient technique.

2. Robust against ISI- In single carrier system when we increase data rate at that time we found that bandwidth is more than that of coherence bandwidth hence leads to ISI. But in case of OFDM system we use several sub-carriers of narrow bandwidth therefore, sub-carriers bandwidth found to be less as compared to coherence bandwidth hence ISI reduced.

3. Channel Estimation Easier: In case of Single carrier system this is quite complex to do this. But in OFDM since orthogonality is present among sub-carriers hence process for doing the above calculation is easy.

4. Complexity of equalizer reduced: Since in the case of Multi-carrier system we use many oscillators in transmitter and receiver side therefore, we have to increase number of tabs in equalizer so complexity increase. But here to IDFT and DFT operation this problem has been reduced.

5. IFFT and FFT used: In order to reduce number of multiplication and addition on both side i.e. transmitter and receiver side we require IFFT and FFT respectively. These are very fast algorithms, therefore, reduced complexity drastically.

1.4.2 Disadvantages of OFDM system

Peak to Average Power ratio problem- Papr is defined as the ratio of max power to the average of power which is generally represented by E operator; here E is called as expectation operator. Due to high papr in transmitter side amplifier start working in non-linear region, therefore, leads to distortion in our information symbols so it necessary to control this problem. In this Report we are working to reduce to this problem using different algorithms like PTS, SLM etc. Above mentioned technique are also known as distortion less as scrambling techniques.

$$PAPR[\mathrm{x[n]}] = \frac{\max(|\mathrm{x[n]}|^2)}{E[|\mathrm{x[n]}|^2]}$$

x[n] – discrete time domain signal; E – Expectation operator means mean value of signal

Inter carrier interference- When even loss in orthogonality take place then this inter carrier interference take place. Due to this problem our data become distorted which finally leads to failure in recovery of information.

Phase offset- Whenever there is problem in tuning of frequency at the receiver side then during recovery of our data there exist a problem of phase as well as frequency offset.

OFDM Transmitter

Before orthogonal division multiplexing we were continuously following single carrier system but due to the existence of ISI problem in single carrier system, researcher try there level best in designing something new which new which they called as Multi-carrier System. In Multi-carrier system we were using encoders, several oscillators of different frequencies after that we send our data through channel. Since we were dividing complete channel into many small frequency channels

So this mechanism somehow reduces the problem of ISI. But simultaneously increase the complexity of system. So in order to get rid of this problem we used IFFT and FFT on transmitter and receiver side respectively. In OFDM we generally have sub-carriers in power of 2 for example; 64, 128, 256, 512, 1024, 2048 etc. If we want to increase the data rate then we have to use more number of sub-carriers. More and more sub-carriers lead to enhancement in speed.

1.4.3 Applications of OFDM system

For wideband communication now days, we are using this multicarrier modulation technique it is the basis for wireless communication systems. It's main application are as follows digital TV, Digital Audio Broadcasting. OFDM is also opted by wireless LAN along with protocol 802.11a, 802.11g and also used by 802.11n.

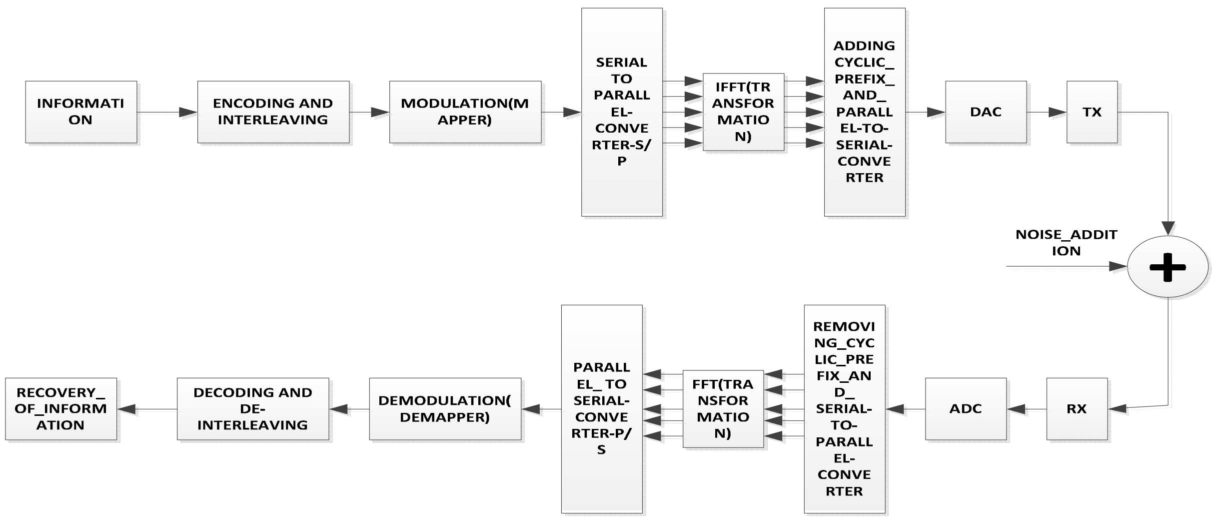


Figure 1.3 Block diagram of OFDM SYSTEM

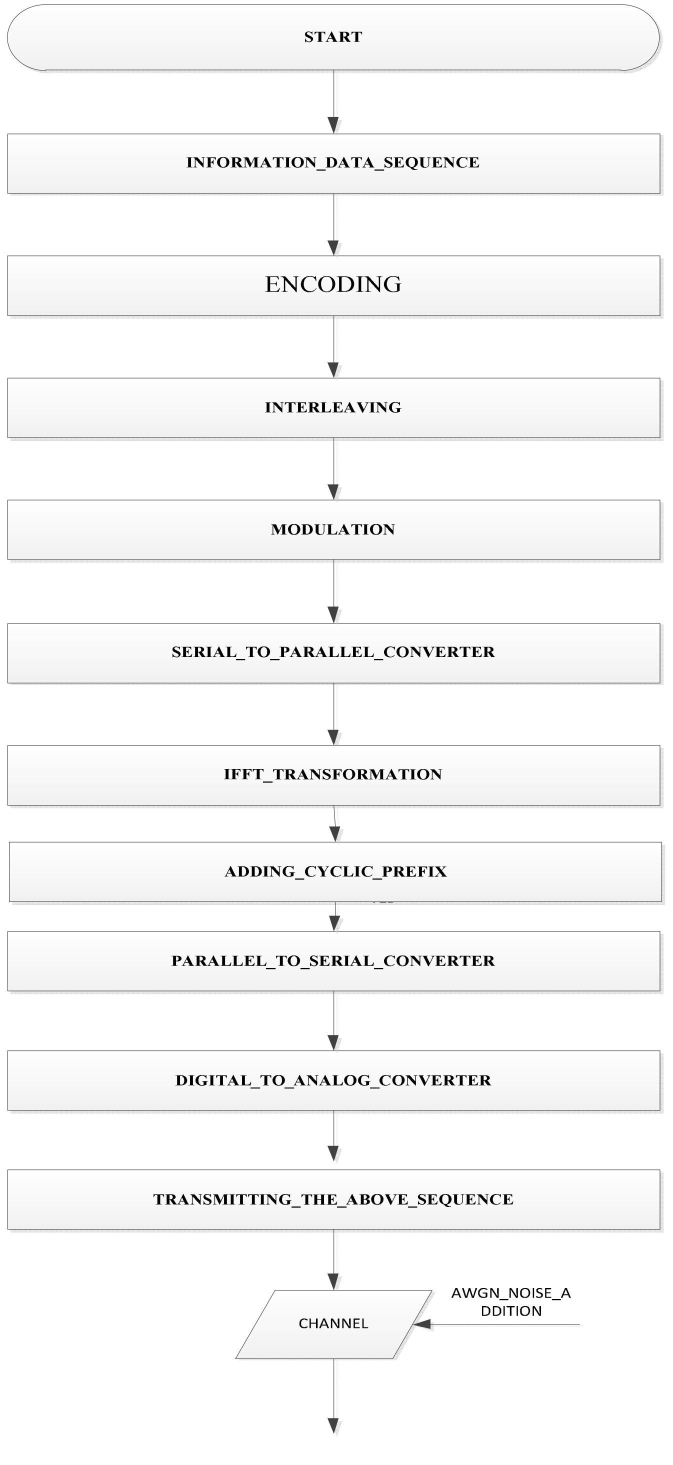


Figure 1.4 Flow Chart of Ofdm System transmitter

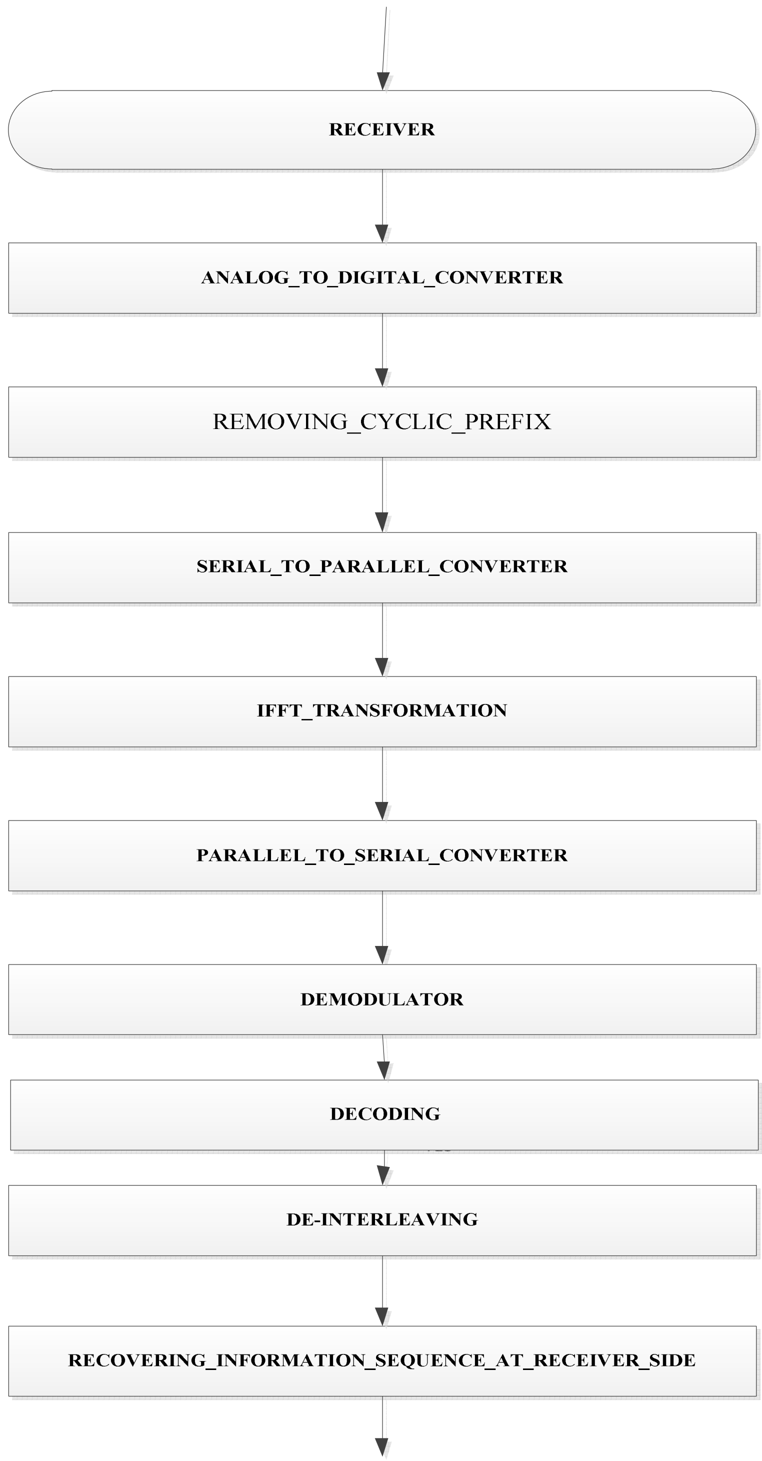


Figure 1.5 Flow Chart of Ofdm System Receiver

1.4.4 Objective of Study

Our main task behind all this study is to do some mandatory changes in the conventional PTS and SLM scheme. This PTS and SLM scheme is very effective in reduction PAPR problem of OFDM system. But due to the use of higher order partitioned in PTS and higher number of phases in SLM algorithm leads to the increment in complexity of PTS and SLM scheme. Due to this complexity execution time, power utilized by resource has been increased and also hardware resource wills also going to be increased. So our task is to minimize this complexity and simultaneously increase the performance of this technique. We will study the existing PTS technique and try to understand its behavior completely. Here we will understand actually how this algorithm work and also computation complexity. After understanding we will try to reduce the existing complexity and try to improve the performance of this technique. Finally we will understand the behavior of newly proposed technique with the help of CCDF curve. In this thesis we proposed two novel method one uses BCH codes for the reduction PAPR and another method is based on exploration of PTS algorithm so we called as upper order partitioned PAPR reduction method.

CHAPTER-2
LITERATURE REVIEW

[3] Dhungana, H. et.al there paper tell us that, day by day there is increasing in demands for higher speed in data. It is found that contamination is found to be more in wired then wireless systems. That's why there is problem in retaining quality of service (QOS). A promising technique is proposed which is known as multi carrier modulation technique which we called as orthogonal frequency division multiplexing (OFDM). Although it help us in achieving high data rates but there exit a problem which we called as peak to average power ratio (PAPR). So many techniques have been proposed by researchers to get rid of problem. In order to understand this problem we have to use a curve known as complementary cumulative distribution function (CCDF). So this paper proposed symbol scramble technique i.e. selected mapping (SLM) and partial transmitted sequence (PTS). Therefore, performance analysis has been done for two different technique mentioned above. Due to continuous advancement in wireless technology from last decades, it is found that it is the technique for future products. Tremendous new challenges are being faced by researchers for achievement of spectrum resources. From many existing technique, it is found that OFDM gaining attention from so many researchers. OFDM transform frequency selective channel into several frequency flat channels. It uses the concept of sub carriers actually these are used to carry our data. Spacing between sub carriers must be in such that so that orthogonality must be maintained. Spectrum due to this orthogonality looks as if it is overlapping but it is orthogonal in nature. That's why this technique is highly spectrally efficient. Due to addition of several sub carriers in time domain after IFFT operation high PAPR is found. Due to this problem complexity in A/D and D/A along with RF amplifier have been increased.There are two techniques which are proposed i.e. SLM and PTS.

a) In selective mapping method we select that sequence which generates minimum papr among many signals. SLM technique is very easy technique which does not put any restriction in data whenever modulation is applied. This technique states that initially we will have data, which will be multiplied by phase vector sequence, and then it will be transformed by IFFT block. Since we had several phase vectors for incoming data that's why we will have many papr. Out of many papr we will chose that sequence which generate minimum papr. We will store that phase which generates minimum papr because we have to recover that sequence at the receiver side. Partial

Transmit Sequence scheme firstly partitioned incoming modulated data sequence into sub sequences, then transformation from frequency domain to time domain takes place with the help of IFFT. After transformation through IFFT in time domain we multiply with different phases sequences. This is done by algorithm which we called as phase optimization algorithm. Finally, we select that sequence which generates minimum papr among several sequences. The author of this paper state that as we are increasing partitioned through this scheme search complexity increases with number of sub sequence or sub blocks. After studying the paper some remarkable conclusion can be drown. For getting improvement in PAPR reduction by increasing signals of OFDM, phase complexity also increases. SLM is found to be good technique for PAPR reduction. In PTS improvement is found to be around 3 dB. As we are increasing number of sub blocks performance have been increasing. Finally, PTS method provides better papr reduction as compared to SLM technique and conventional OFDM system.

[4] Pyla, S. et.al, Every day number of users are increasing demand for services are also increasing. In order to full fill the requirement high speed is desirable. So in order to meet the demand OFDM came into existence. For high data rate this is the best technique. But besides, all these it has a problem of high papr. This PAPR problem leads to in band distortion due to clipping and out band distortion due to spectrum broadening. Number of technique is there to reduce this problem of PAPR but each one has some kind of draw back associated with it. Significantly reduction is there by distortion less technique like PTS. Improvement in PAPR is observed after applying different modulation technique. Here in this paper author uses PTS algorithm to reduce PAPR and try to find out which modulation actually suits or meet the requirement. Orthogonal Frequency Division Multiplexing generally considered for high data rate in radio condition. This technique is also called as multi carrier technique. In this technique big data stream divided into small data streams. This technique use many sub carriers, these sub carriers are orthogonal to each other. Bandwidth efficiency comes from this orthogonality principle. This multiplexing technique is used in order to reduce ISI effect. IFFT block is used in this technique to provide orthogonality among sub carriers. Due to this IFFT block implementation is very easy. Application areas of this technique are as follows Digital audio broadcasting (DAB), terrestrial video broadcasting, IEEE 802.16 etc. Besides all these application areas which proves its requirement or advantages it has some draw backs like Inter-carrier interference. There is also a problem of high PAPR. Due to this amplifier produces in band as well as out band distortion. As we will increase the size of IFFT, inter carrier interference will also increase. Hence from here author conclude that size of inverse fast Fourier should be selected very carefully. ISI in OFDM system uses a concept of CP called as cyclic prefix. This CP is added in time domain and should of maximum Delay Spread. Due to the usage of CP in this multiplexing technique reduction in complexity of receiver is achieved. In this paper author used PTS technique along with LDPC code. Important component in communication system now a days are forward error correction codes. Since there is a presence of noisy channel through which digital data we pass so that's why there is a very high probability that our data become corrupted or in more precise way it become distorted. Author showed through his paper that partial transmitted technique reduces PAPR very effectively as compared to other technique. Author showed that peak to average power improvement increases with the order of PSK and QAM. In term of error probability QAM is much better than PSK. More and more number of candidates can be used with the help of this technique. Finally, we can say that proposed algorithm.

[5] Kyeongcheol Yang; et.al, This paper shows a technique to decrease the PAPR of orthogonal frequency division multiplexing using linear block Codes. This technique can considered as an enhanced version of traditional papr reduction technique which we called as selective mapping or SLM. This method is basically scrambling technique to decrease PAPR by choosing a signal of minimum peak to average power ratio. The sequences which generate minimum PAPR among several sequence is transmitted. Advantage proved by author is that, no side information will be transmitted so saving in power is there. On the other hand, at receiver side we will use syndrome decoding. Author's simulation results are found to be better than traditional technique. This multiplexing technique is very efficient technique for fast data sending in communication system. Many advantages associated with these techniques are as follows, spectrum efficiency, strong against fading, immune against interference. But if we see another part we will find that there is a problem of high PAPR due to which amplifier moves out Author shows that several techniques are there to diminish the effect of PAPR like Clipping, Clipping and filtering, SLM which we called as selective mapping technique. Clipping leads to inserting distortion in our data therefore leads to decrease in performance of system. Several coding techniques are there like golay complementary sequence, linear block codes. Author depict that around 3 dB gain have been achieved but transmission rate is slow for many sub carriers. Two important scrambling techniques like SLM, PTS. Among these two PTS method is found to be much better. In these two techniques different combination of phase factors are being used. So from many phase factors many sequence generated. Out of several sequence, the sequence which generate minimum papr is selected for transmission purpose. Authors showed that there proposed reduction method using Standard Arrays of Linear Block Codes can be very easily used and applied. During the usage of this algorithm no side information is supposed to be send from transmitted side to receiver side. Very little improvement in results can be observed but from side information point of view this technique is quite appropriate.

[6] Xin-chun Wu ; et.al, This OFDM is a very pleasing technique for wireless communication systems. But it generally has the problem of High papr for transmitted signal that's why it comes under its disadvantages. Author of this paper presents a new technique for the reduction of this problem papr. Author said that, PTS is able to accomplish the task of reducing papr. Complexity and cost is drastically reduced by some percentages as shown in paper. Author depict in his paper that 75.6% memories cost reduced, 44% multiplier cost has been reduced etc. Running time of FFT and IFFT has been reduced up to 75%. Candidates have been reduced to 16 from 64 with the help of phase factors. OFDM technique is a very effective technique in term of spectrum efficiency. This technique is also called as Multi carrier modulation technique. Due to saving in bandwidth this technique has been opted in many wireless standard or application. Time domain occurrence of papr leads to creation of papr which is most dominating problem of OFDM system. Reduction of this problem is very necessary otherwise it will generate problem like signal distortion. Due to this distortion performance of OFDM varies. There are some which we categorized as distortion based technique like direct clipping, clipping and filtering and also companding method. Very easy method for reducing papr just by compressing the information signal in which when power is found to be more than some specified threshold. But there is problem with this like out of band energy is noticed. Some important technique which we termed as redundancy technique like PTS, SLM. Another name for such type of technique like

Scrambling techniques, distortion less. In the proposed method author considered number of sub-carriers as 128, number of sub blocks are found to be 4, phases used are +1,-1,+j,-j. Different module have been proposed related to different block of PTS block diagram. There is optimization block in algorithm so author used optimization module for that. Shift register module has been proposed in two formats left shift register and another one is right register. Max module is also there which has comparator in order to find out maximum value. There is table which comes out as result. This table has four parameter like memory size, Complex multiplier, Adders and rom. So with the help of table it can be clearly understood that complexity has been reduced drastically.

[7] Chackochan et.al- For high speed data transmission multi carrier modulation technique is favorable. This multi carrier technique we generally called as OFDM. It has many advantages like high spectral efficiency or spectrum efficiency. But besides all these advantages this OFDM system has a problem of papr which effect the linearity of amplifier therefore leads to distortion in data. This paper propose SLM technique under several modulation technique and several sub carriers. Simulation results are there using MATLAB software. For Analysis CCDF curve has been considered. This curve always tell us that what the probability that papr is found to be greater than certain threshold. The orthogonal frequency division multiplexing is used for high data rates under variable radio condition. This multi carrier technique provides us many advantages due which it become the part of mobile communication system. Advantages like high spectrum efficiency, ISI reduction. Application areas like IEEE 802.11 a etc. Due to the addition after IFFT operation, a large papr generated. This large papr increase the complexity of A/D and D/A converter along with power amplifier. Due to all these it has become necessary that papr must be reduced. For the reduction of papr several technique have been proposed like distortion technique i.e. clipping or clipping and filtering. Proceeding further there are some coding technique such as forward error correction coding technique. Last but not the least Scrambling technique like SLM, PTS. In both of these technique we have to consider different phase sequence which we have to multiply, with the help of phase optimization algorithm we have to select that sequence which show minimum papr out of several sequence. Block diagram of SLM technique have been proposed which have random sequence, for modulation purpose we are considering QPSK digital modulation technique. After performing this we have convert the data from serial to parallel. After this we have to multiply with different phase vectors. Then we pass through IFFT block, this block will then convert data from frequency to time domain. Finally, we select that sequence which generate minimum papr out of several sequence and that sequence will be transmitted. In this paper papr for different sub carriers have been plotted. That figure depict that as soon as we are increasing number of sub carriers from 64 to 1024 or more this problem will also increase. Another comparison graph is also there which compare four variable namely clipped signals, Original OFDM system papr, Riemann Matrix.

[8] Mathew, B. et.al- this paper uses two different transform techniques like IFFT with FFT and IDCT and DCT at transmitter and receiver respectively. Based on these two techniques BER which we called as bit error rate. It states that error bit divided by total number of bits. Channel used by author are Rayleigh and awgn. Ultimately the purpose of this paper is to reduce BER and simultaneously increasing the efficiency of system. Two modulation techniques have been proposed which are as follows BPSK, QPSK. Author finally concludes that the DCT based OFDM system found to be good as compared to FFT based OFDM system. – Radio communication is now a day's found to be dependent on this multi carrier technique which we are calling here as OFDM technique. Author show that it is a combination multiplexing and modulation both. This technique is famous due to high data rate and spectrum efficiency. Main principle of this technique is orthogonality on which it is based on. It comprises of many sub carriers. Its block diagram consists of first time DCT and another time FFT and vice-versa on receiver and transmitter side respectively. Author steps are as follows, first incoming random data sequence passed through modulator and it become parallel from serial after that transformation takes place by IDCT or IFFT one at a time. All these are performed on transmitter side and just opposite operation is performed on receiver side. Two modulation techniques have been proposed which are as follows BPSK, QPSK. Author finally concludes that the DCT based OFDM system found to be good as compared to FFT based OFDM system. In author's proposal have constellation diagram of both BPSK and QPSK respectively. Number of sub carriers considered are 52, Number of OFDM symbols used are 1000, IFFT points are 64, Channel used Awgn, Rayleigh.Author has shown that for a particular 4 dB of SNR the bit error rate of IFFT and IDCT based OFDM system are found to be .013 and .012 respectively. Another modulation technique like QPSK shows .084 and .083 respectively. So conclusion which can be drawn is that DCT based OFDM is better than FFT based OFDM system.

[9] Prashant Pandey et.al -this paper says that how the performance of ofdm system can be increased. For this we have to use some techniques which are used in this paper. This paper also tell us that once we find the condition by which we can decrease PAPR and then we can easily enhance the performance of ofdm system and also improve the performance of system in which this ofdm is generally used. Techniques used in this paper are as follows, Clipping and Filtering This technique clips the signal which is found outside its range. If signal amplitude if less then predefined value then author takes same signal otherwise it considers the predefined level. In partial transmitted sequence In this technique incoming sequence of data is firstly become parallel from serial then divided in different sub blocks e.g., 2,4,8….. .Here all the sub blocks of data is multiplied with different phases. For one phase we calculate PAPR then for other phase we calculate PAPR so if PAPR found to be less then we consider that PAPR value. This is how we find PAPR less. Complementary Cumulative distributive function is used by author for the simulation purpose. With the help of Complementary CDF be try to find the Probability that given PAPR is found to be greater than given threshold. OFDM is the technique which is used in multi carrier transmission. It help us in providing high data rates. But besides all these advantage it has one serious problem i.e., high PAPR. So this paper proposed some techniques so that we can reduce this effect.

[10] Jen-Ming Wu et.al- this Paper says that 3 bit to 4 bit coding technique has been proposed to solve the problem of papr means to reduce the effect of papr up to some extent. Here author tell us that they will do encoding of data in time domain only because according to them this problem occur in time domain so why not correct this thing in time domain only. The author tells us that they will use CCDF to show simulation result. There is only one technique which used in the paper. The author called this technique as 3bit to 4bit encoding technique. Actually author in this paper is using a code word for each incoming message bit. Here they are replacing 3 most significant bits with 4 bit hence they called this as 3B to 4B encoding technique. According to writer of this paper this technique reduces PAPR so much. There is no problem when we are going to number of sub carriers. Due to this technique BER is also going to be decreased so much. In this paper author is using encoder after IFFT block since after IFFT block signal will be in time domain only. For e.g., 000 be replaced by 0001 which means adding redundancy to our information. According to writer since there is noise present in the channel so due to this our data become corrupted. Therefore writer is using code word so that in receiver correct information will be obtained easily. With the help of this paper PAPR is reduced. Correction of data is also done. Detection of Error of data is also there.

[**11] Emad Alsusas et.al-** In this paper multiple users are there for sending their own data form transmitter side to receiver side. So in this paper suppose data coming from user1 one then it generally converted into parallel then it will get multiplied with specific code then pass with IFFT block to be converted form single carrier to multiple carrier. The results which are shown are based on 256 subcarriers,16 Qam modulation scheme, and separate code for each user. Walsh Hadamard matrix has been used to convert each incoming message from user1,user2,upto user n into unique code. At the receiver side in order to get back our own information it is necessary that we must have the same spreading code so that we can easily recover our data. The author tell us that $\log_2(k)$ of side information required. Receiver must know how many operations have been performed. Different user in this way can send their data easily from transmitter side to receiver side it is important to know that there is no correlation between any of the data which has been encoded. Because separate spreading code is there for each user.

[12] D.Meenakshi et.al- There are so many multiplexing techniques which are available but among all of them we focusing on OFDM which in which all different sub-carriers are orthogonal to each other. Saving in bandwidth is obtained. There is a problem of ISI in this system which can be reduced by guard band. Main problem in this High peak to Avg. Power ratio. This paper mainly put comparison among there techniques like SLM , PTS, Amplitude clipping. Input sequence-Incoming stream of data then Converting that data from serial to parallel Then Applying digital modulation schemes on that data Then Modulation scheme like QPSK,BPSK,QAM,PSK etc After that Taking IIFT operation on that mapped data Again converting parallel data into serial then Inserting guard interval then passing through channel then channel may be AWGN and vis-versa blocks in receiver. In amplitude clipping and filtering A predefined level is already defined in this case so if value of amplitude crosses that mark then automatically clip or cut that portion of amplitude. In this way it reduce papr but in band and out band radiation is also there. Selected mapping technique In this technique incoming data is being multiplied by different phases then pass with IFFT block where it get converted into time domain signal here actually we calculate PAPR for the data. Select the data which give minimum papr and also find phase associated with so that this information will be transmitted into receiver side with the help of this we can recover our data back. In Partial Transmitted Sequence we convert data form serial to parallel then convert it into different sub-blocks. here each sub-blocks is multiplied by different phases they can be plus and minus 1 by which we generally multiply our data .Multiplication by different phases is only after taking IIFT operation means in time domain we are doing this operation.

[13] Dr. Himanshu Soni et.al - This paper tell us that PARP defined as ratio of max power to Avg. power and discuss about SLM technique . Author tells us that in SLM transmitter produces same data in such a way that each will be shifted by some phase in comparison to original data. All blocks of data multiplied by different phases and new blocks will be generated. Finally we calculate papr of the data. We will choose minimum papr among all. FFT/IFFT size-64, Sampling Frequency-20 Mhz, Subcarrier spacing -312.5 Khz, Cyclic Prefix duration- .8us, Data symbol- 3.2us, Total symbol duration- 4us, Modulation -4-QAM. In CCDF graph we generally has two axis one is for probability and another for PAPR this graph tell us that it is the probability (papr>threshold papr)

[14] Chahavi Sharma et.al- This paper focus on clipping method i.e., amplitude clipping. In this paper author tell us how he will fix a threshold for amplitude if in any circumstances value increases from that level then it will cut that part or clip that part. Clipping Ratio-20*log10 (A/P) db. Where A=clipping ratio; P=root mean square(r ms) power level of ofdm signal. The author has shown us a block diagram which has s/p converter along with IFFT block followed by P/S converter. Input sequence, QAM mapping has been used, IIFT operation, Clipping, FFT, Out of band removal , PAPR<A, IFFT , O/P. Shows better result as compared to previously used techniques.

[15] Slimane Ben Slima et.al - This paper tell us that higher speed in data sending can easily be achieved with the help this modulation technique i.e, OFDM , But there is a problem in ofdm which of papr. input stream of data, Baseband modulator, Precoder, S/P (serial to parallel), Different oscillators then summation for all the above steps finally CCDF curve has been used it tell us that the 10^-3is the probability precoding has 4db and 1db respectively.

3.1 Partial Transmitted Sequence

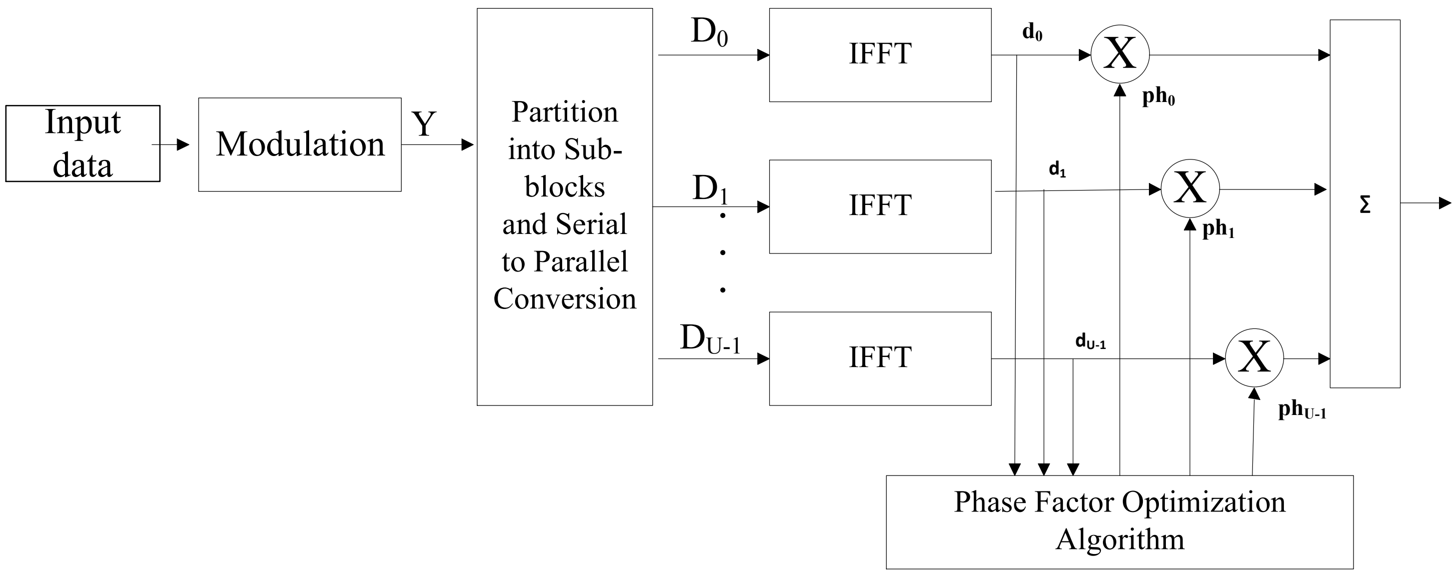


Figure 3.1 Block Diagram PTS Algorithm

3.1.1 PTS Scheme Consist Of Following Steps As,

a) First modulated incoming data sequence is partitioned into U number of sub-blocks, which can be written as;

$$Y = \sum_{q=0}^{U-1} D_q$$

b) In order to generate OFDM signal, by applying IFFT transformation on each sub-blocks, multiplied with different phase factors and finally add them together as described in below expression,

$$y = IFFT[\sum_{u=0}^{U-1} ph_u . \mathrm{D}_u]$$

$$y = \sum_{b=0}^{U-1} ph_u .IFFT[\mathrm{D}_u] = \sum_{b=0}^{U-1} ph_u . \mathrm{d}_u$$

Phase factor ph_u used in above expression can be written as:

$$ph_u = e^{j\phi_u} \ where\ u = 0,1,2,3.......\mathrm{U}-1; \phi_u \in [0, 2\pi]$$

c) Finally to achieve minimum PAPR from generated signal, we find set of optimized phase factor, which is given as;

$$[ph_0^{\wedge}, ph_1^{\wedge}, ...ph_{u-1}^{\wedge}] = \arg\min(\max_{n=0..N-1} | \sum_{u=0}^{U-1} ph_u . \mathrm{d}_u |)$$

d) At last, a sequence which has minimum value of PAPR is selected and represented as given in below expression

$$y^{\wedge} = \sum_{u=0}^{U-1} ph_u^{\wedge} . \mathrm{d}_u$$

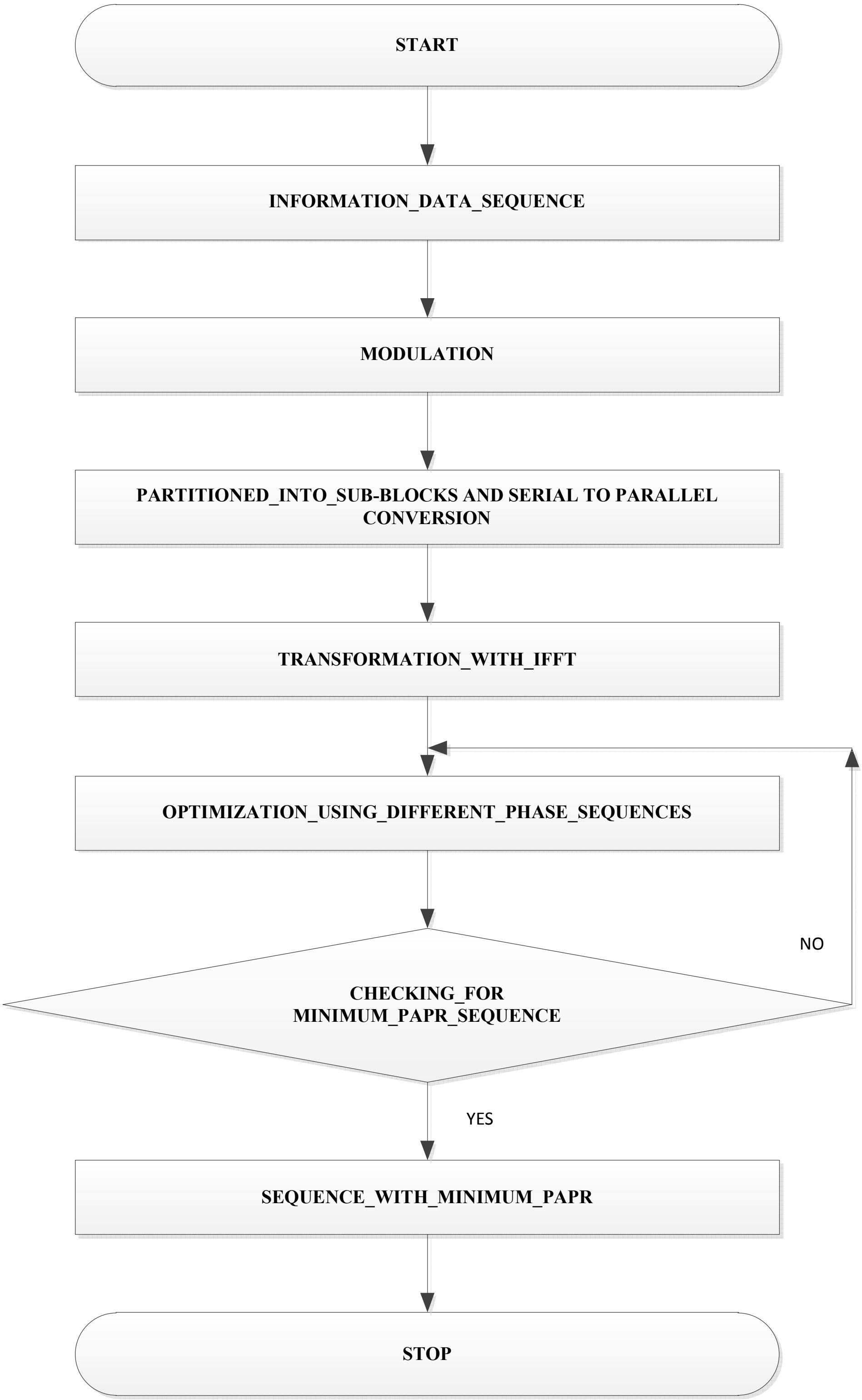


Figure 3.2 Flow Chart of PTS Algorithm

3.2 Selective Mapping Technique

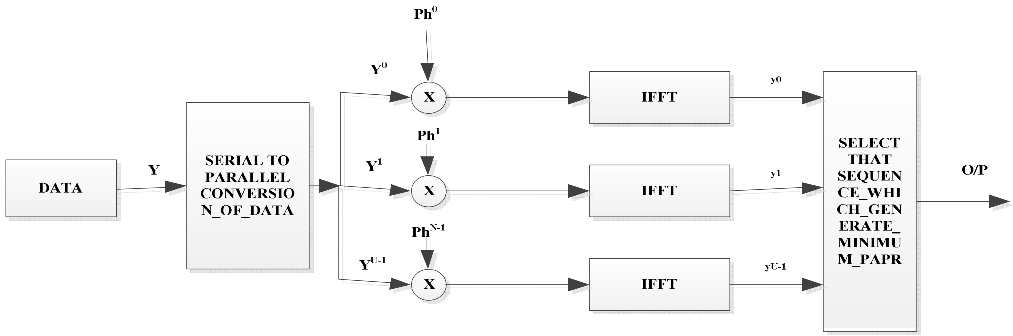


Figure 3.3 Block Diagram SLM Algorithm

Mathematically we can represent this technique as

$$Y = [Y0, Y1, \ldots. YN-1]T$$

$$Ph^{m} = [Ph^{m}0, Ph^{m}1, \ldots\ldots Ph^{m}N-1,]T \quad 0 \le m \le U-1$$

$$Sm = [Y0. Ph^{m}0, Y1. Ph^{m}1, \ldots\ldots YN-1. Ph^{m}N-1]T$$

$$y_d = \underset{0 \le m \le U-1}{\arg\min} \left(PAPR(y^{m})\right)$$

Selective Mapping (SLM) in this algorithm initially we have binary random data sequence, this random sequence in then modulated using different modulation scheme, after performing this serial to parallel conversion of data take place. Here Ph^{z} etc are defined as phased factors which will be multiplied by this data sequence. Frequency to time domain transformation take place using IFFT after that the sequence which generate minimum PAPR is selected for transmission along with the corresponding phase factors. Here N is number of sub carriers used by this algorithm. So vector Y is representing serial to parallel conversion of data sequence. Here we will have number of phase which is equal to length of data sequence. Sm is defined as multiplication of phase and data sequence both. Now argmin represent sequence which generate minimum PAPR out of several sequence.

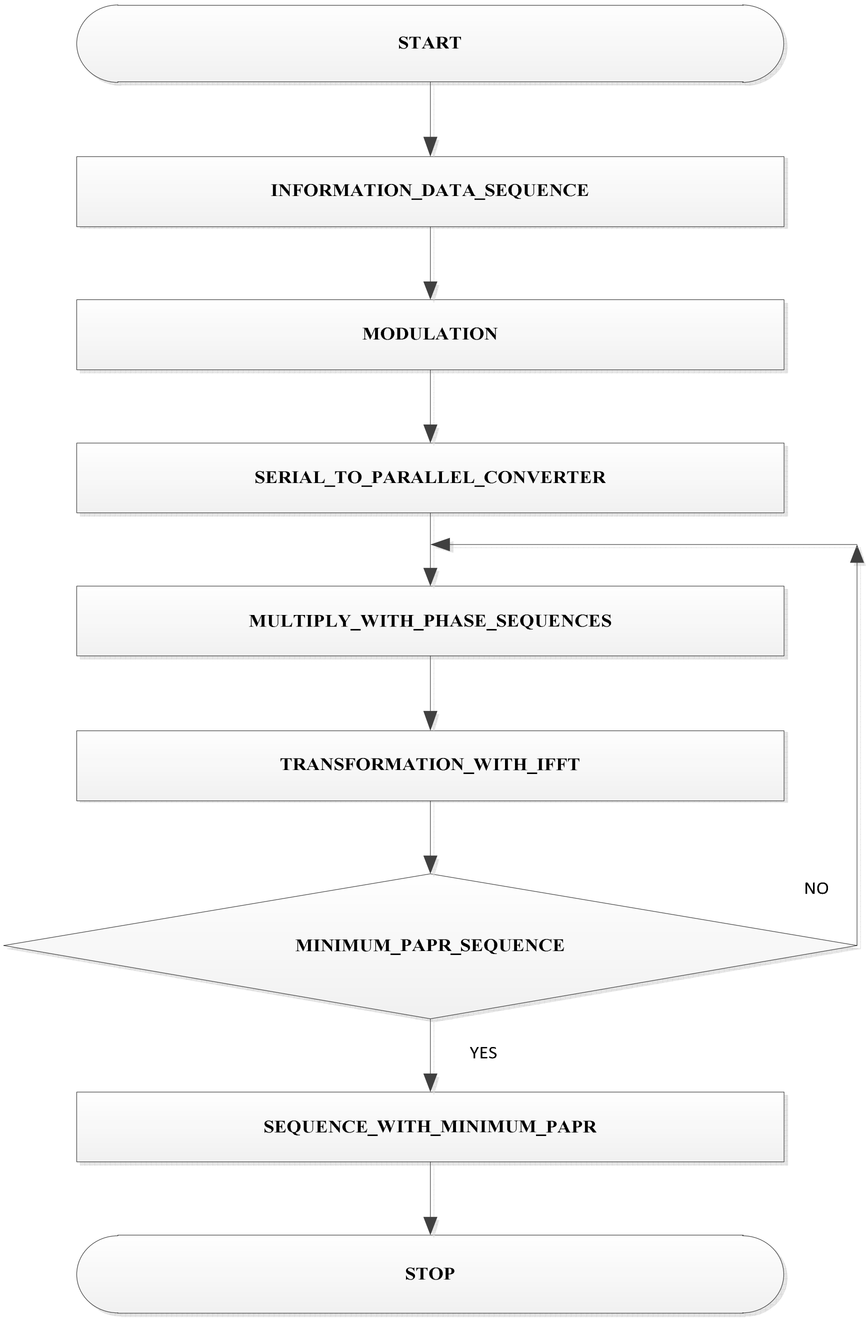


FIGURE 3.4 FLOW CHART OF SLM ALGORITHM

Chapter-4
PROPOSED WORK METHODOLOGY

4.1 Peak to Average Power Ratio Reduction in OFDM Using Higher Order Partitioned PTS Sequence and Bose Chaudhuri Hocquenghem Codes

4.1.1 About Algorithm

Orthogonal frequency division multiplexing (OFDM), also known as multi-carrier modulation scheme, is an attractive technology for upcoming communication system, to enhance data rate, higher spectral efficiency and better quality of service (QOS). In OFDM, first higher data stream has been divided into lower data streams and after modulation these data streams are together transmitted by orthogonal subcarriers. Due to orthogonal nature of sub-carriers proper utilization of bandwidth is achieved along with reduced cost of OFDM communication system. A major challenge in OFDM system is its higher Peak to Average Power ratio (PAPR), which degrades system efficiency. Due to larger PAPR, High power amplifier (HPA) starts to operate in non linear region hence distortion introduced in transmitted data. In this work, combination of higher order partitioned partial transmitted sequence (PTS) along with Bose Chaudhuri Hocquenghem Code (BCH), have been proposed to diminish the PAPR significantly. This proposed scheme is used to minimize PAPR by choosing the signal which is having less PAPR among many signals. At transmitter side, scrambling process uses Coset leader of Bose Chaudhuri Hocquenghem Codes (BCH) and syndrome decoding method to recover the transmitted sequence are being used at receiver side. This particular section of Bose Chaudhuri Hocquenghem Codes is powerful class of linear block codes (LBC). Generally, for much error correction we opt for such types of codes. These Codes provides us very ease in designing encoder which generally perform encoding operation as well as decoder which perform decoding operation. Till now, we generally construct codes after that we find minimum distance so that we can estimate error correction capability. Our desire to correct the errors leads to generation of these Bose Codes. Here, we start to make generator polynomial for these codes. As specified above, these BCH codes come in the category of Cyclic Codes. So decoding method which we were using in cyclic codes remains same here as well. That's why we can conclude that, BCH codes can be easily decoded. We start with sufficient mathematical analysis in the upcoming section. We shall see then at the method for creating generator polynomial, encoding process and decoding strategy.

4.1.2 Why this Algorithm

Orthogonal frequency division multiplexing is the desirable technique to achieve higher speed in data rates and better spectrum efficiency. In OFDM first higher data stream has been divided into lower streams of data and after modulation these data streams are together transmitted by orthogonal subcarriers. One of the major challenges in OFDM system is high Peak to average power Ratio (*PAPR*), which produced non linear distortion and degrades system performance. As a consequence of increased value of *PAPR*, *HPA* starts operating in non linear region, hence transmitted data became distorted. To overcome the issue of high *PAPR* and improve the system performance, number of techniques has been proposed in various literatures. One of the simple approaches is clipping technique, in which *PAPR* has been diminished by clipping the higher peaks of the signal. This technique sometimes encounters with in-band and out- band interference. Some of the other techniques, which also use same kind of mechanism, are clipping and filtering, peak windowing, peak cancellation etc. In another approach i.e. coding techniques, where selection of the appropriate codeword to reduce *PAPR* significantly, has been proposed . There are two other probabilistic schemes also known as scramble techniques as follows; partial transmitted sequence (*PTS*) and selective mapping (*SLM*) .In *SLM*, input data with specified length is multiplied by phase vector of same length. After that these generated data sequence have been passed through IFFT blocks. At the end, we select signal which is having minimum *PAPR* among different transmitted signals. On the other hand, In *PTS*, modulated incoming data is partitioned into different *SB* then these *SB* are passed individually through IFFT blocks. Finally, phase optimized sequence which generates minimum *PAPR* will be selected among various signals.

4.1.3 Mathematical Analysis for the BCH Codes

We will make use of GF(q) where q is 8 using polynomial $p(x)=x^3+x+1$. Suppose primitive element is found to be α. So here we can show all different elements of GF(q) by different powers of a modulus p(x) .

Tabular form representation of all elements of GF (8)

Power of α	*Elements in GF* (8)	function
α^1	z	$f_1(x)$
α^2	z^2	$f_2(x)$
α^3	$z^3=z+1$	$f_3(x)$
α^4	$z^4=z^2+1$	$f_4(x)$
α^5	z^2+z+1	$f_5(x)$
α^6	z^2+1	$f_6(x)$
α^7	1	$f_7(x)$

$$x^7-1=(x-1)(x^3+x+1)(x^3+x^2+1)$$

Defining generator matrix

$g(x)=x^3+x+1$

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

Generator of systematic form

$$G_{sys}=\begin{bmatrix}1&0&0&0&1&1&0\\0&1&0&0&0&1&1\\0&0&1&0&1&1&1\\0&0&0&1&1&0&1\end{bmatrix}$$

G_{sys} is the combination of Identity matrix and P matrix.

P Matrix defined by the below matrix

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

$$P^T=\begin{bmatrix}1&0&1&1\\1&1&1&0\\0&1&1&1\end{bmatrix}$$

Parity Check matrix

$H = [-P^T : I]$

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

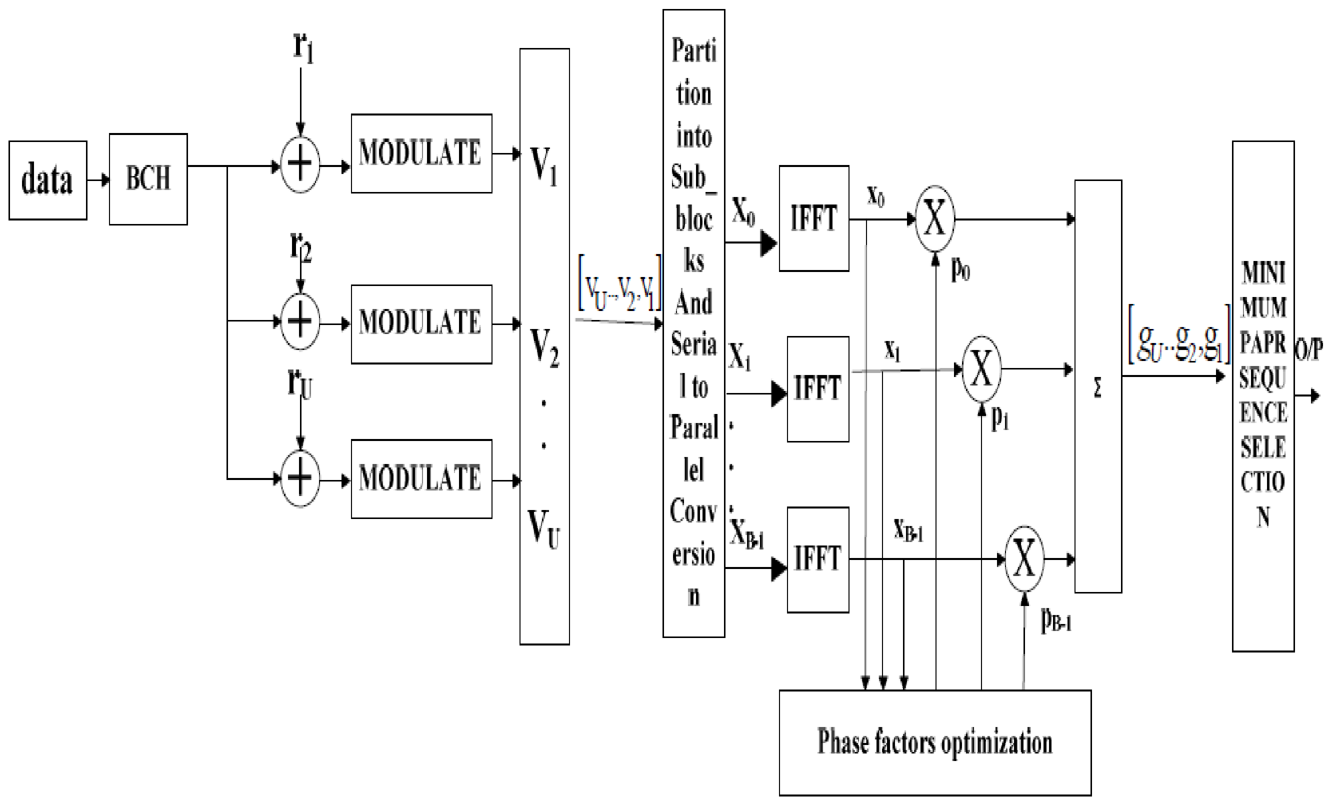


Fig4.1 Block Diagram of Proposed Algorithm

4.2.1.1 Steps of Proposed Scheme are as follows:

1) First incoming data sequence is segregated into groups of *k* length information bits and encoded into a valid codeword c through *BCH* encoder.

2) *U=2(n-k)* different vectors of *r* are generated as,

$$C_i = r_i + C \quad 1 \le i \le U$$

Where, r1,r2,..rU are chosen as coset leaders of specified code in term of *PAPR* and also known as scrambling vectors .

3) Generated sequences in step *2* have been passed through BPSK modulator, which gives vectors *V1 to VU*. Then send *V1 to VU* vectors sequentially.

4) Now *V*1 is partitioned into *B* no. of SB, as follows

$$V_i = [X_0, X_1, X_2, X_3, \ldots\ldots X_{B-1}]^T \quad 1 \le i \le U$$

As we know that sum of all SB comprise original signal which can be shown as,

$$V_i = \sum_{z=0}^{B-1} X_z \quad 1 \le i \le U$$

5) Partitioned data sequence is transformed into OFDM signal by *IFFT* as,

$$v_i = IFFT[\sum_{b=0}^{B-1} p_b . X_b] \quad 1 \le i \le U$$

Where, symbol *p* represents phase sequence. Now apply linear property of IFFT to get partitioned data sequence in time domain as follows,

$$v_i = \sum_{b=0}^{B-1} p_b .IFFT[X_b] \Rightarrow v_i = \sum_{b=0}^{B-1} p_b .x_b$$

7) Select the sequence having minimum PAPR, represented by *g1*. (As shown in our proposed block diagram as given in Fig.1)

8) Similar process, given in step no. *4* to *7* have to be repeated in remaining *V*. i.e. *V2 to VU* and results of minimum *PAPR* will be stored in *g2* to *gU* respectively.

9) Finally, select the signal with lowest PAPR (among *g1* to *gU*) as transmitted signal.

10) At receiver end, received signal translated into received vector *dr* by FFT and demodulator. Then syndrome is calculated from *dr* to get the same coset leader *r* as selected at transmitter side. At the end, the valid codeword can be obtained as *c=r+dr*.

4.3 Parameters Considered For Simulation Results

In our proposed technique, we consider results as *CCDF* of *PAPR* in *OFDM* signals. During scrambling process, we consider *BCH* as *[n,k]*, where *n* and *k* are representing block length and message length having values are *7* and *4* respectively. The coset leaders for standard array are randomly chosen for *U=2(n-k)* under the condition as they have different syndrome.

TABLE I. SIMULATION PARAMETERS USED IN PERFORMANCE ANALYSIS AND COMPARISONS

Sr. No.	Name of the parameters	Value
1	Number of Sub Carriers (N)	64,128, 256
2	Number of SB	2
3	Over sampling Factor (L)	4
4	Modulation	BPSK
5	Size Of IFFT	L*N
6	Phase factors	[+1; -1; +1j ;-1j]

TABLE II. PERFORMANCE ANALYSIS AND COMPARISON OF *PAPR* IN CONVENTIONAL *OFDM*, EXISTING *PTS* AND MODIFIED *PTS* TECHNIQUES AT GIVEN *CCDF =0.1%*

Sr. No.	Name of technique	N=64	N=128	N=256
1	Conventional OFDM	10.55	10.58	10.82
2	PTS 2-SB	8.61	8.7	9.02
3	Modified PTS 2-SB	6.95	7.13	7.72

As given in Table II, performance of proposed modified *PTS* technique with *2-SB* are significantly improving as sub carriers are increasing. For example in case of *N=64* at CCDF of *0.1% PAPR (dB)* of conventional *OFDM*, *PTS 2-SB* and modified *PTS 2- SB* techniques are *10.55, 8.61 and 6.95Db* respectively. Now it is clearly observed that proposed scheme achieve more *PAPR* reduction.

TABLE III. GAIN ACHIEVED BY MODIFIED *PTS* USING *2*-SUB BLOCKS

Sr. No.	Name of technique	Achieved gain in dB for various no. of sub carriers		
		N=64	N=128	N=256
1	Conventional OFDM	3.60	3.45	3.10
2	PTS 2-SB	1.66	1.65	1.30

Table III shows that, remarkable gain achieved by our proposed modified *PTS* technique. For example in case of *N=64* at same *CCDF*; the *PAPR* gain *(dB)* obtained, when we compare with conventional *OFDM* and *PTS 2-SB* are *3.60 and 1.66dB* respectively.

4.4 FLOW CHART REPRESENTATION OF FIG 4.1

4.5 An Improved and Efficient PAPR Reduction Method in OFDM System using Modified Partial Transmitted Sequence

4.5.1 About Algorithm

Orthogonal frequency division multiplexing (OFDM), also known as multicarrier modulation method, is preferred for high speed data transmission. OFDM system has a unique property that all the sub-carriers are orthogonal to each other. Due to uncorrelated subcarriers, saving of bandwidth and cost is obtained, but on the other hand problem of PAPR (Peak to Average Power Ratio) also occurs. As a consequence of PAPR, transmitting amplifier starts working in non-linear region; hence distortion takes place in our data. In this paper, we propose an improved and efficient PAPR reduction method in OFDM system using modified partial transmitted sequence (MPTS). To achieve the same, we consider higher order data split-up scheme of PTS using different sub carriers. This chapter presents theoretical as well as mathematical analysis along with simulation results given in result and discussion chapter using MATLAB (Matrix Laboratory) software. In our simulation results, existence of PAPR problem and its solution have been focused. Orthogonal frequency division multiplexing is a modulation scheme which is currently used in communication system such as Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB), and WiMax etc. OFDM transform frequency selective channel into many parallel frequency flat channel which are commonly known as sub-carriers. These sub-carriers are orthogonal to each other. Hence, this technique is highly spectral efficient. The main benefit of OFDM is high spectrum efficiency, lustiness against inter symbol interference (ISI) and it also breaks a radio channel into many narrow band sub-carriers, hence many symbols can be transferred in parallel, but it has a serious problem of high peak to average power ratio (PAPR). Due to high PAPR power amplifier starts operating in non-linear region therefore, introduce distortion in data at the same time it creates problem to A/D (analog to digital converter) and D/A (digital to analog converter).The PAPR of continuous time signal of OFDM system can't be explained by the use of N samples every signal period. In order to remove this problem, we have to do oversampling (L) i.e. L=4 is enough to estimate PAPR of continuous time OFDM signal. In this paper, An Improved and Efficient PAPR Reduction Method in OFDM System using Modified Partial Transmitted Sequence, the problem PAPR studied and technique has been proposed to diminish the PAPR. Various techniques are there in literature like SLM and

PTS which are also distortion-less technique to mitigate the effect of high PAPR. In SLM input data is multiplied by phase vector of same length, then these new data sequence transformed through IFFT block. Finally, signal which possesses minimum PAPR will be selected for the transmission while in PTS technique modulated data divided into sub-blocks transformed through IFFT block, multiplied by many phase. At the end, sequence which generates minimum PAPR will be selected for transmission.

4.5.1 Mathematical Analysis For PAPR In Ofdm System

A time domain sequence x(n) is obtained by performing IFFT on frequency domain sequence X(k)

$$x(\text{n}) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(\text{k}).\exp^{\frac{j2\pi nk}{N}} \qquad 0 \leq n \leq N-1$$

Where, n and k are time and frequency index respectively.

PAPR can be defined as the ratio of maximum peak power to average power, denoted by E as,

$$PAPR(\text{x(n)}) = \frac{\max(|\text{x(n)}|^2)}{E[|\text{x(n)}|^2]}$$

Complementary cumulative distribution function (CCDF) can be defined as the probability that the PAPR of time domain sequence x(n) is found to be greater than certain threshold and can be expressed as,

$$CCDF(PAPR(x(n))) = \Pr(PAPR(x(n) > P_{th})$$

Where, $P_{th}=PAPR_0$

4.5.2 Steps For Modified Pts Scheme

Our MPTS scheme consist of following steps as,

a) As shown in fig.1, first modulated incoming data sequence is partitioned into *U* number of sub-blocks, which can be written as;

$$Y = \sum_{q=0}^{U-1} D_q$$

b) In order to generate OFDM signal, by applying IFFT transformation on each sub-blocks (D_u), multiplied with different phase factors (ph_u) and finally add them together as described in the following expression,

$$y = IFFT[\sum_{u=0}^{U-1} ph_u . D_u]$$

$$y = \sum_{b=0}^{U-1} ph_u . IFFT[D_u] = \sum_{b=0}^{U-1} ph_u . d_u$$

Phase factor ph_u used in above expression can be written as:

$$ph_u = e^{j\phi_u} \text{ where } u = 0,1,2,3.......U-1; \phi_u \in [0, 2\pi]$$

c) Finally to achieve minimum PAPR from generated signal, we find set of optimized phase factor, which is given as;

$$[\hat{p}h_0, \hat{p}h_1, ... \hat{p}h_{(u-1)}] = \arg\min(\max_{n=0...N-1} | \sum_{u=0}^{U-1} ph_u . d_u |)$$

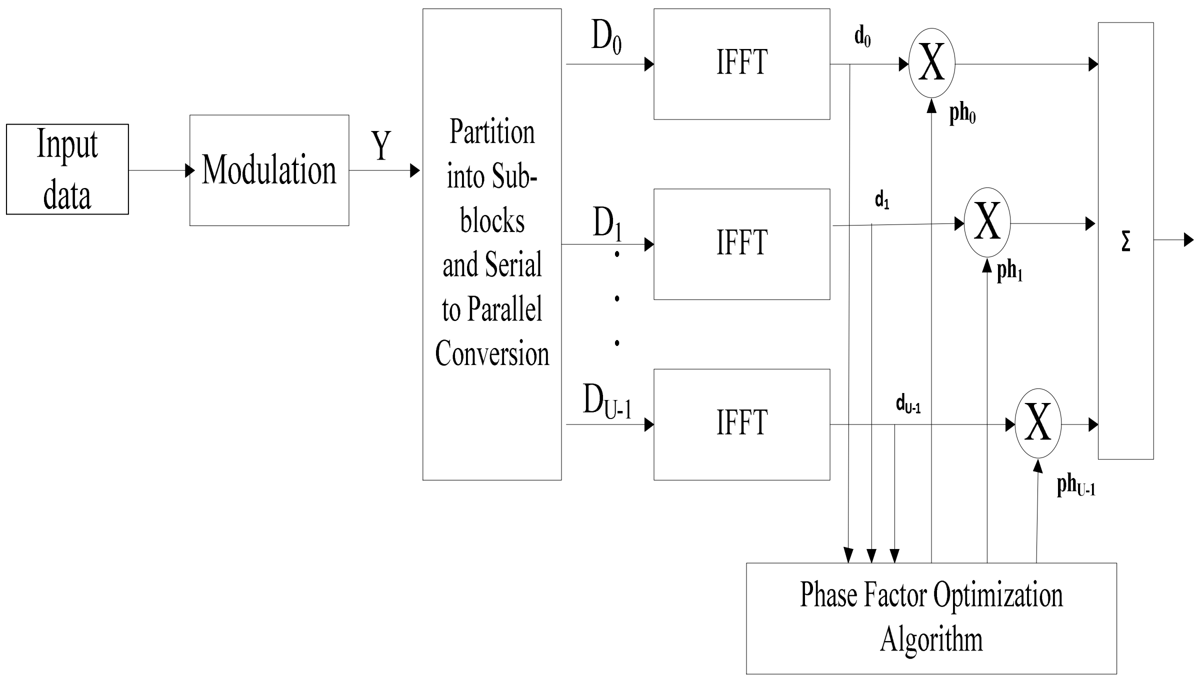


Fig.4.2 Block diagram of modified PTS scheme

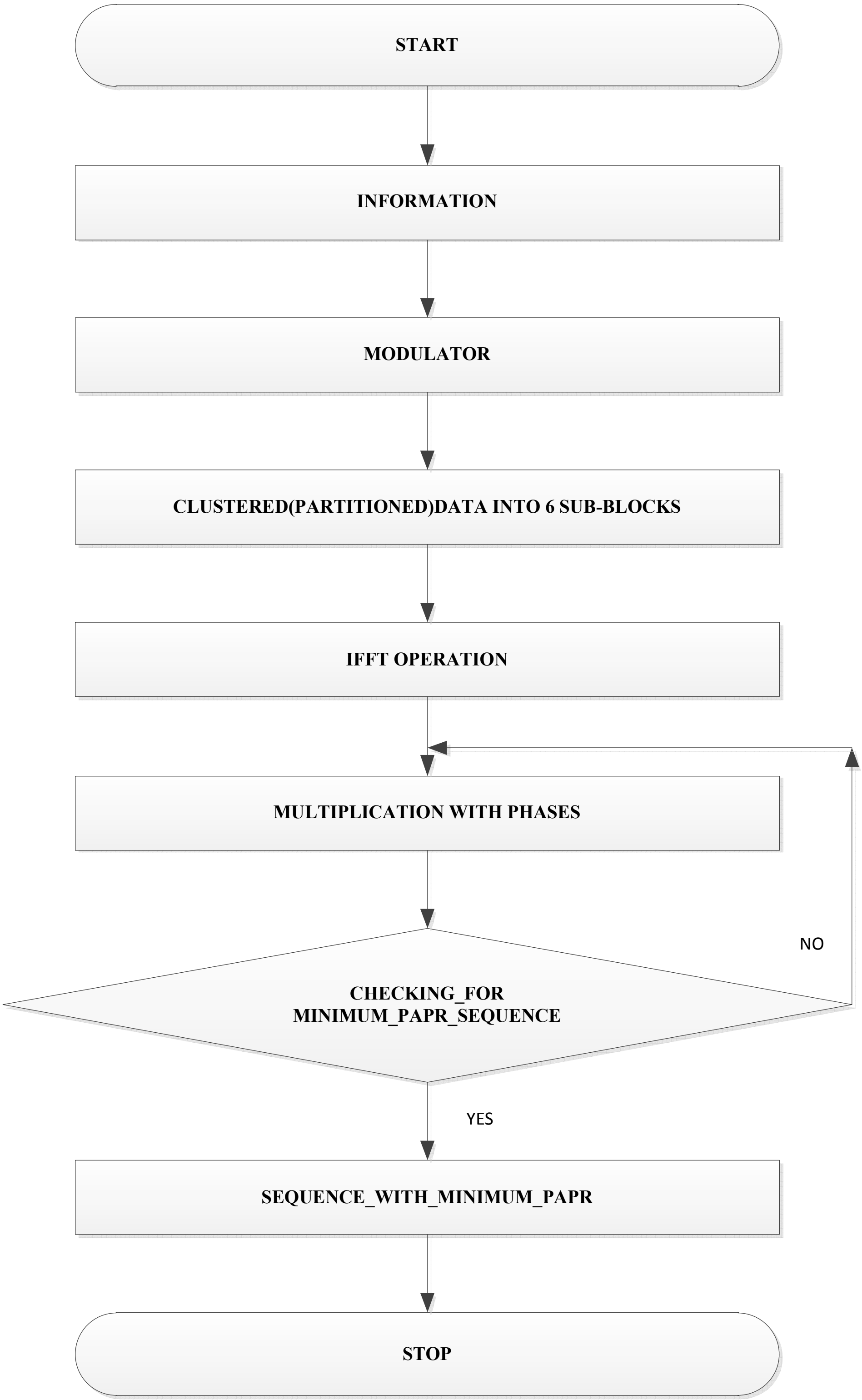
At last, a sequence which has minimum value of PAPR is selected and represented as given in below expression,

$$\hat{y} = \sum_{u=0}^{U-1} \hat{p}h_u \, . \, \mathrm{d}_\mathrm{u}$$

4.5.3 ANALYSIS FOR CONSIDERING PARAMETERS

This section presents the simulation parameter considered for the modified PTS scheme which offer significant reduction in PAPR given in Simulation and Result Chapter. PAPR is reduced to 5.2, 6, 6.55, 7.2 dB as compared with traditional OFDM system where PAPR is found to be 9.1, 9.85, 9.92, and 10.22 respectively presented in Chapter of Simulation. Our simulation results have been carried out in MATLAB. We consider the situation where number of subcarrier N=64, 128, 256 and 512, number of sub blocks U=6, oversampling factor L=4, modulation techniques used as QPSK and phase factor is selected as [+1 -1 +j -j].We obtained the results for comparison of PAPR in traditional OFDM system and modified PTS scheme while considering number of sub block U=6.

4.6 FLOW CHART OF BLOCK DIAGRAM



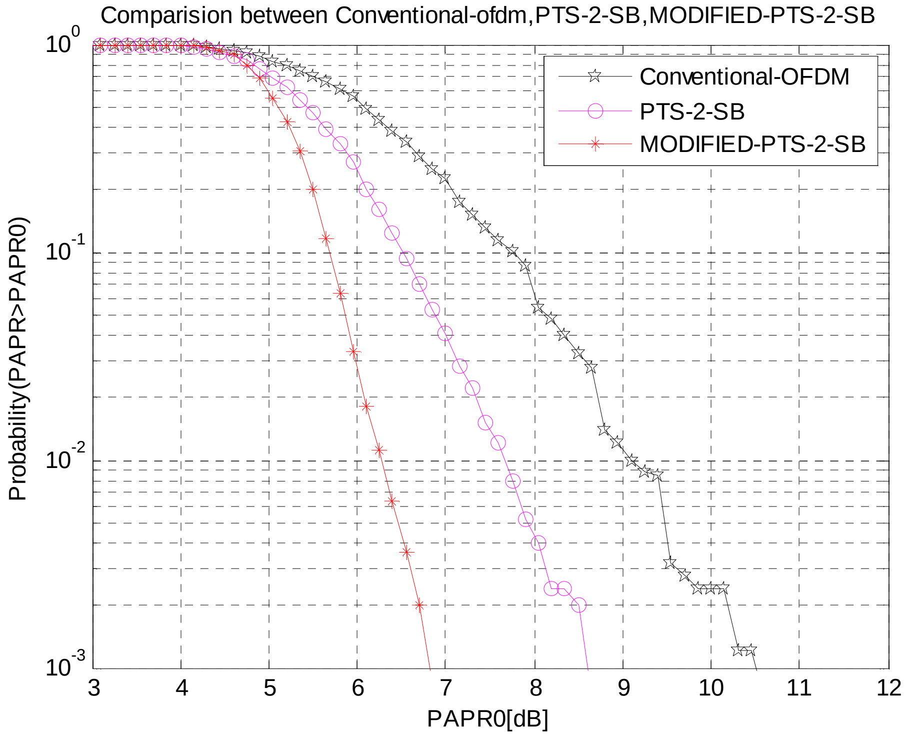


Fig.5.1 ***CCDF*** **of** ***PAPR*** **in conventional** ***OFDM*****,** ***PTS*** **with two sub-blocks (*****PTS- 2-SB*****) and modified** ***PTS*** **with two sub-blocks (*****PTS- 2-SB*****). [*****N=64 sub carriers, oversampling factor of L=4, modulation= BPSK*****]**

Analysis: Above graph state the comparison between Conventional OFDM system, Conventional PTS(Partial transmitted Sequence) and modified PTS(modified Partial Transmitted Sequence). Here we can easily see that only .1% probability that papr is found to be 6.95 dB where at the same .1% probability papr for Conventional PTS is 8.61 dB and for the Conventional OFDM system it is found to be 10.55 dB. Here we have considered phase factors which is the combination of [±1, ±1j]. Number of sub carriers which we have considered are 64 represented by N=64. In order to estimate for the continuous time papr we have used the consideration of up sampling factor L=4. We are modulating our data by the modulation technique we called as Binary Phase Shift Key (BPSK). Conventional as well as modified PTS scheme both have same number of partitioned i.e, SB=2. Due to Oversampling for the estimation of papr of continuous domain from discrete domain we using the size of FFT defined by the product of oversampling factor and Number of sub carriers L*N.

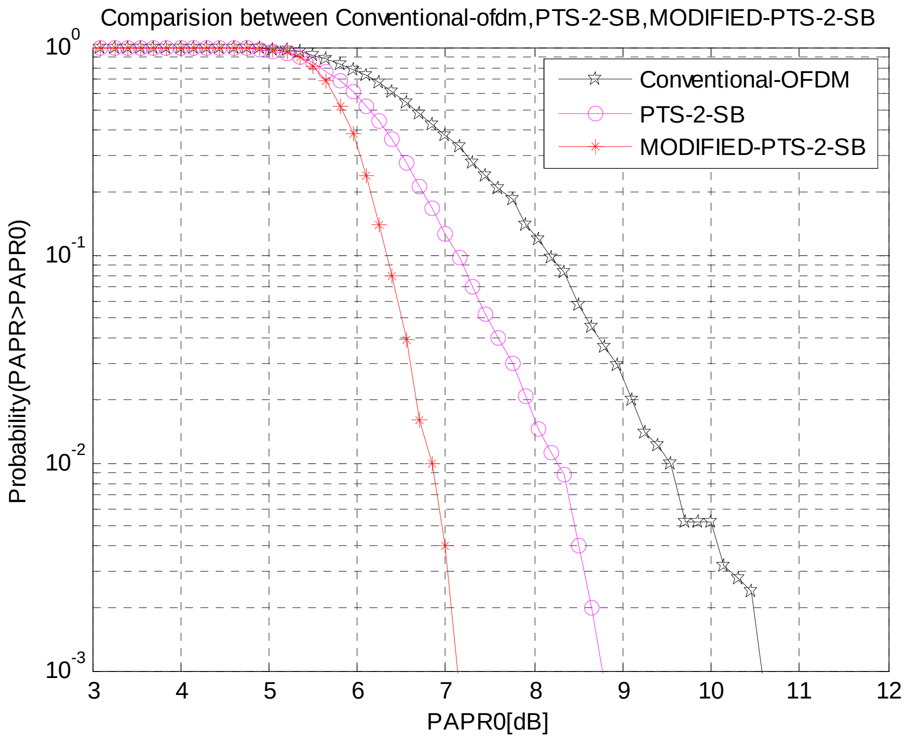


Fig.5.2 ***CCDF*** **of** ***PAPR*** **in conventional** ***OFDM, PTS*** **with two-sub blocks (*****PTS- 2-SB*****) and modified** ***PTS*** **with two-sub blocks (*****PTS- 2-SB*****). [*****N=128 sub carriers, oversampling factor L= 4, modulation scheme= BPSK*****]**

Analysis: Here we are using all algorithms in case when number of sub carriers is more. Here number of sub carriers are 128 which are defined by N. Above graph state the comparison between Conventional OFDM system, Conventional PTS (Partial transmitted Sequence) and modified PTS(modified Partial Transmitted Sequence). Here we can easily see that only .1% probability that papr is found to be 7.13 dB where at the same .1% probability papr for Conventional PTS is 8.7 dB and for the Conventional OFDM system it is found to be 10.58 dB.

We can easily notify that as soon the number of sub carriers are going on increasing, this problem of PAPR is also increasing but one thing which is important that; our newly modified approach is working very efficiently in this scenario as well. This show that the proposed is good because it suits very well in different environment. we have considered phase factors which is the combination of same which are defined above. Number of sub carriers which we have considered are 64 represented by N=128.

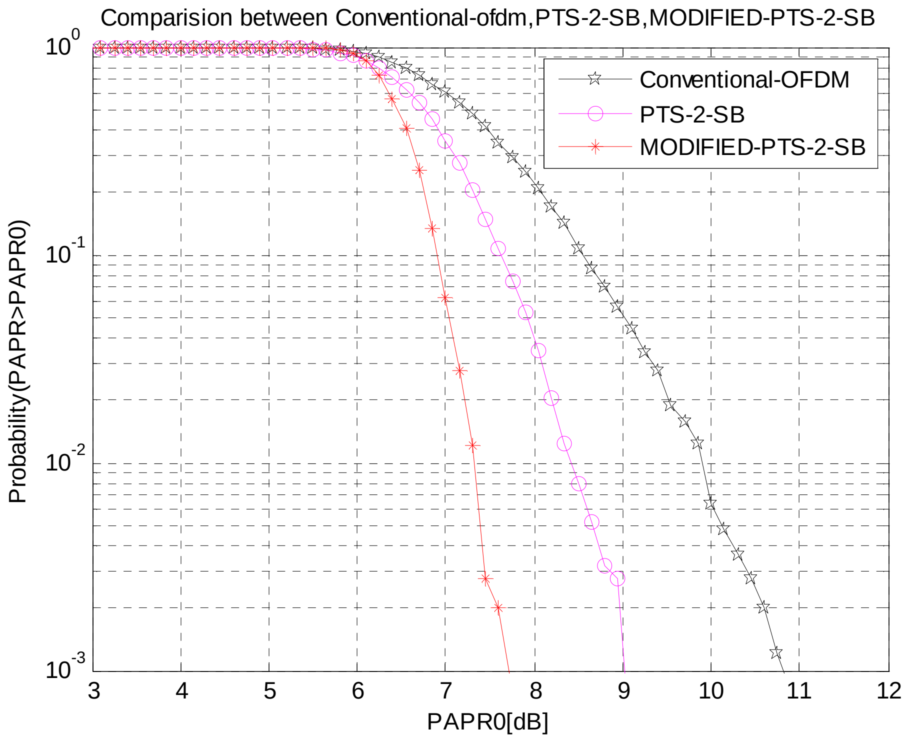


Fig 5.3 ***CCDF*** **of** ***PAPR*** **in conventional** ***OFDM***, ***PTS*** **with two sub-blocks (*PTS- 2-SB*) and modified** ***PTS*** **with two sub-blocks (*PTS- 2-SB*). [*N=256 sub carriers, oversampling factor of L=4, modulation= BPSK*]**

Analysis: Considering modified PTS, Conventional PTS and Conventional OFDM system again in different platform that is increased number of sub carriers. We are increasing number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as 256. Here we can easily see that only .1% probability that papr is found to be 7.72 dB where at the same .1% probability papr for Conventional PTS is 9.02 dB and for the Conventional OFDM system it is found to be 10.82 dB.

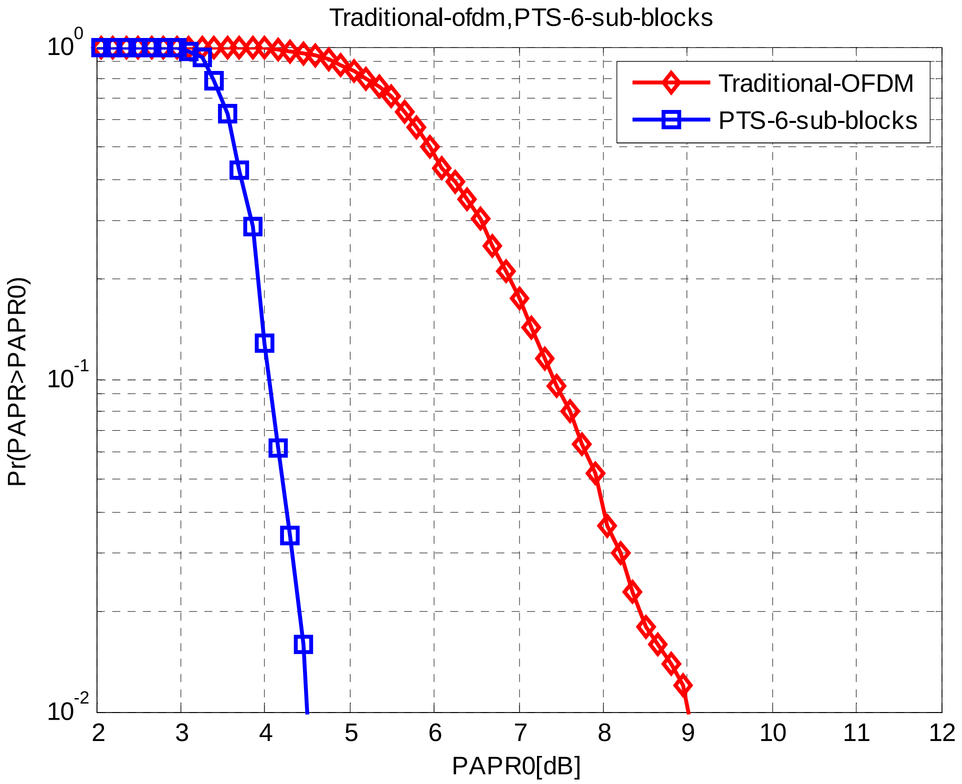


Fig 5.4, Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=64; QPSK modulation)

Analysis: By considering modified PTS and Conventional OFDM system number of sub carriers are 32. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 4.5 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 9.0 dB. Here we can see the gain achieved by our proposed algorithm is 4.5 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

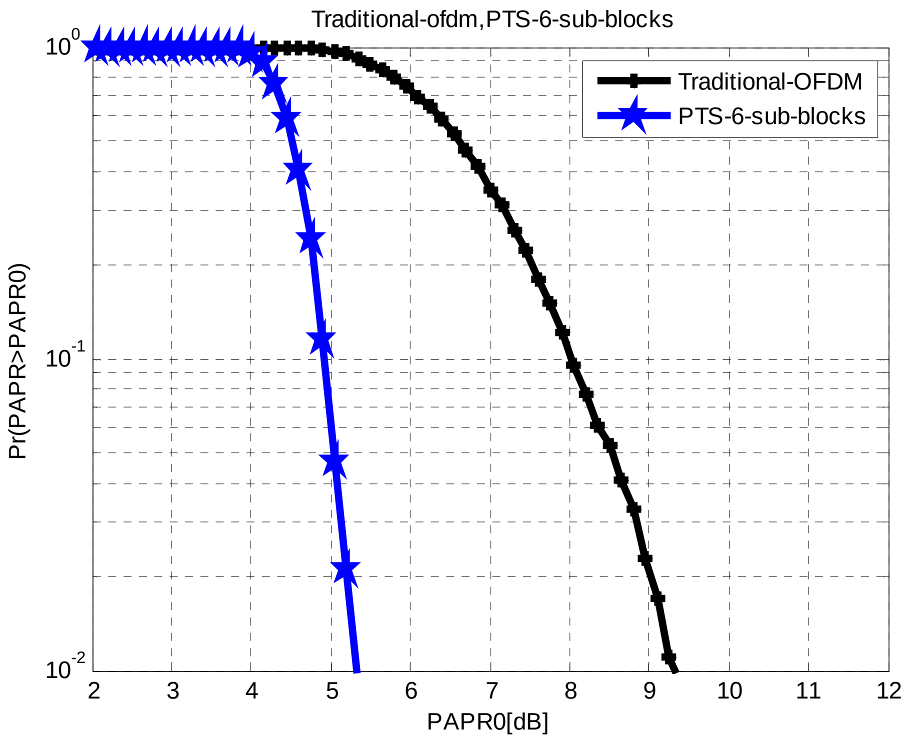


Fig 5.5, Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=64; QPSK modulation)

<u>Analysis:</u> By considering modified PTS and Conventional OFDM system number of sub carriers are 64. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 5.2 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 9.1 dB. Here we can see the gain achieved by our proposed algorithm is 3.9 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

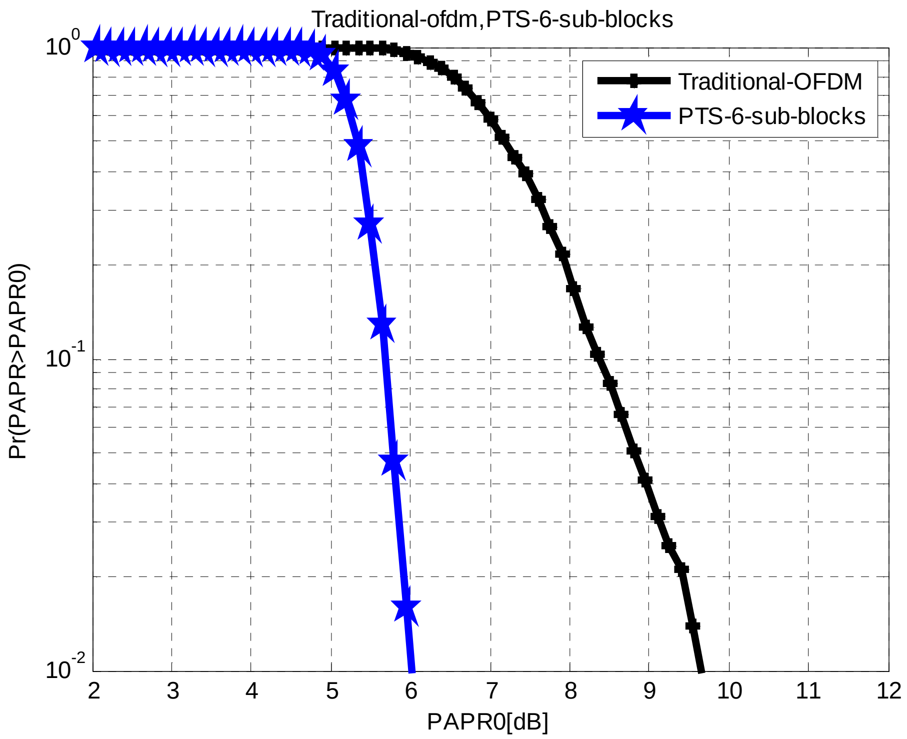


Fig 5.6 Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=128; QPSK modulation)

<u>Analysis:</u> By considering modified PTS and Conventional OFDM system number of sub carriers are 128. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 6.00 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 9.85 dB. Here we can see the gain achieved by our proposed algorithm is 3.85 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

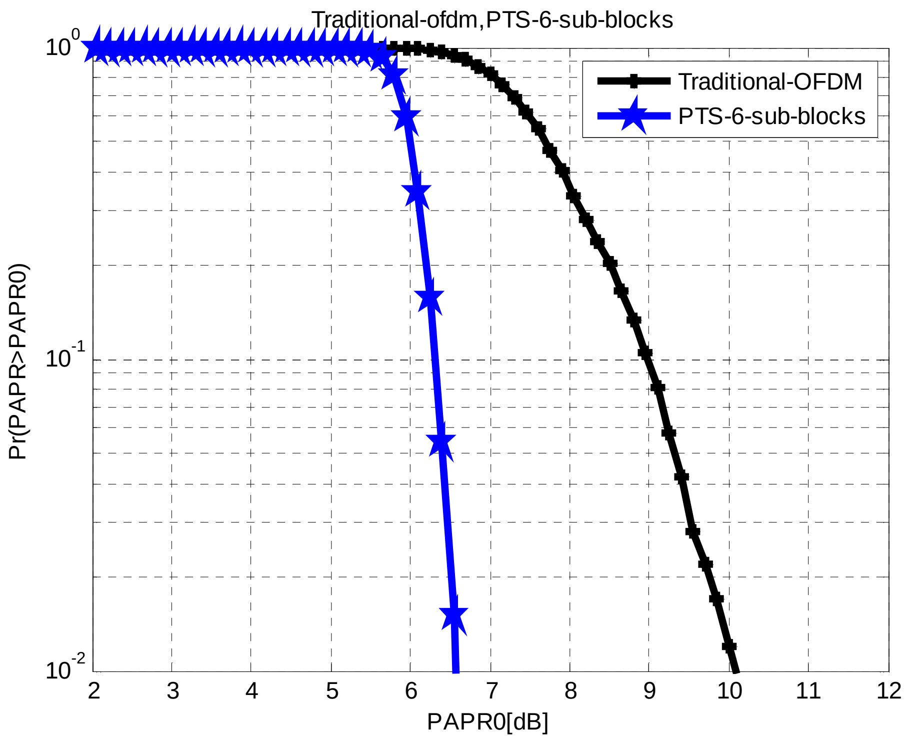


Fig 5.7 Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=256; QPSK modulation)

Analysis: By considering modified PTS and Conventional OFDM system number of sub carriers are 256. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 6.55 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 9.92 dB. Here we can see the gain achieved by our proposed algorithm is 3.37 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

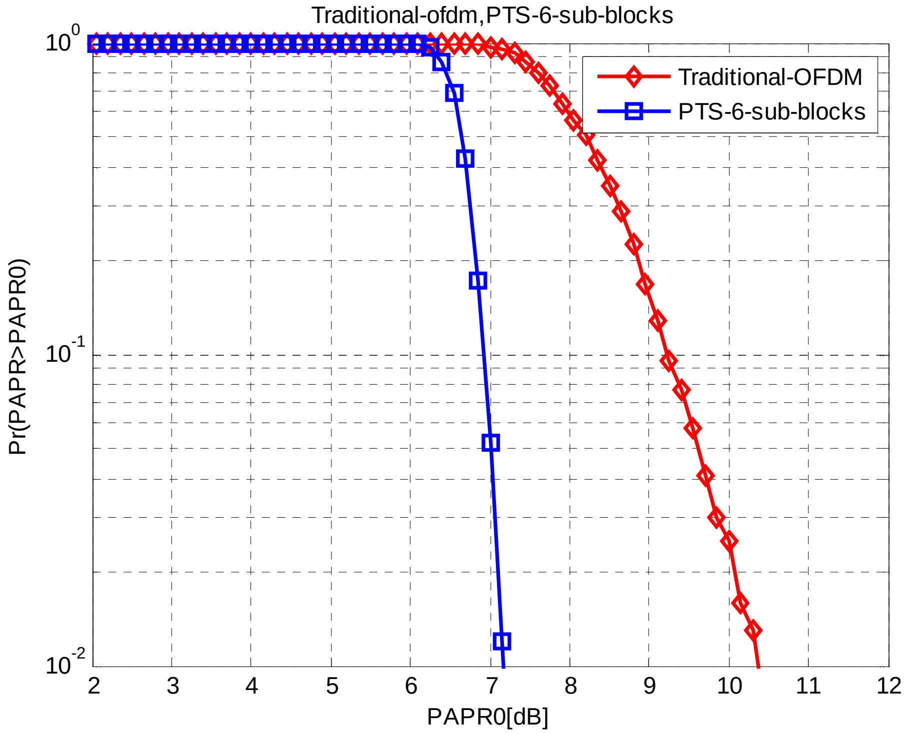


Fig.5.8 Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=512)

Analysis: By considering modified PTS and Conventional OFDM system number of sub carriers are 512. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 7.2 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 10.22 dB. Here we can see the gain achieved by our proposed algorithm is 3.02 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

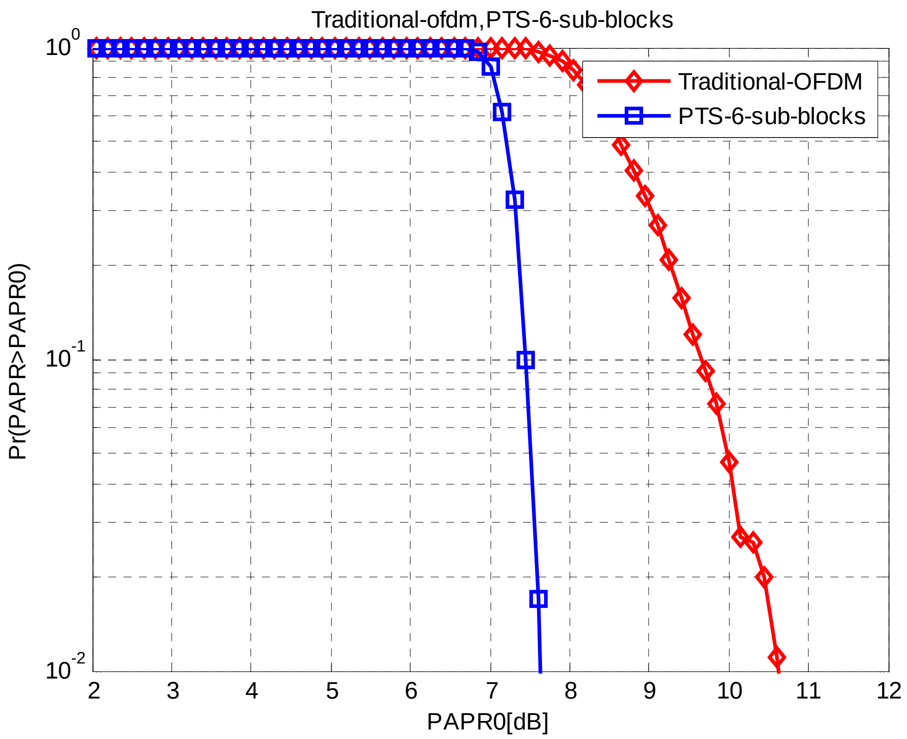


Fig.5.9 Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=1024)

Analysis: By considering modified PTS and Conventional OFDM system number of sub carriers are 1024. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 7.70 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 10.60 dB. Here we can see the gain achieved by our proposed algorithm is 2.90 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

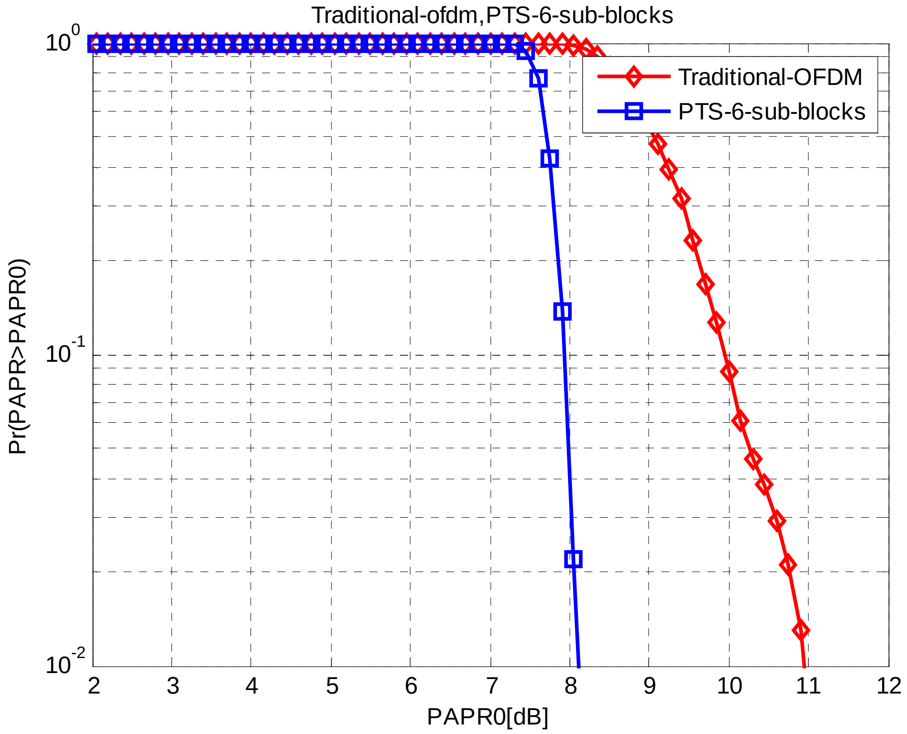


Fig.5.10 Comparisons of PAPR in traditional OFDM system and modified PTS scheme using 6 sub block (No. of subcarriers N=2048)

Analysis: By considering modified PTS and Conventional OFDM system number of sub carriers are 2048. We will increase number of sub carriers in order to check the efficiency of algorithm. Here we are considering number of sub carriers as sixty four and modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 8.1 dB for modified PTS where at the same 1% probability papr for the Conventional OFDM system it is found to be 10.90dB. Here we can see the gain achieved by our proposed algorithm is 2.8 dB. This gives the justification that our algorithm is best in these circumstances. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Partitioning which is used here is of U=6.

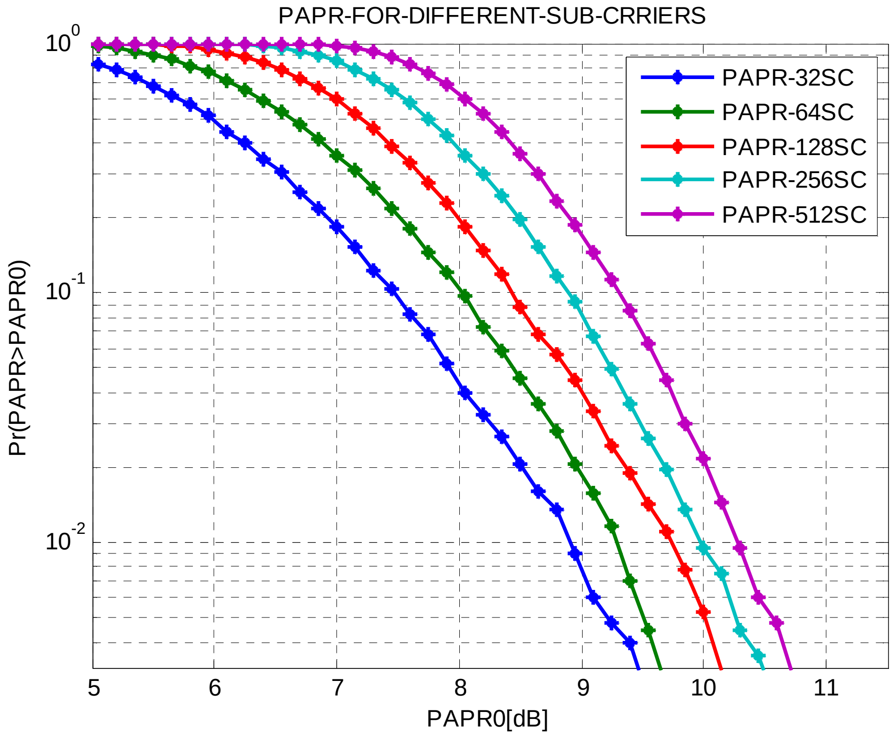


Fig.5.11 Comparisons of PAPR of Different Sub-Carriers (32,64,128,256,512)

Analysis: By considering Conventional OFDM system number of sub carriers from 32 to 512. We will increase number of sub carriers in order to check the behavior of OFDM system. modulation scheme is found to be QPSK where we will take symbols i.e. 1 symbol consist of 2 bits. Here we can easily see that only 1% probability that papr is found to be 9.5 dB for sub-carriers 32 where at the same 1% probability papr for 64 sub-carriers it is found to be 9.6dB, at the same 1% probability papr for 128 sub-carriers it is found to be 10.1 dB also at the same 1% probability papr for 256 sub-carriers it is found to be 10.5 dB and for 512 it is 10.7dB.

This gives the behavior analysis of OFDM system PAPR. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4.

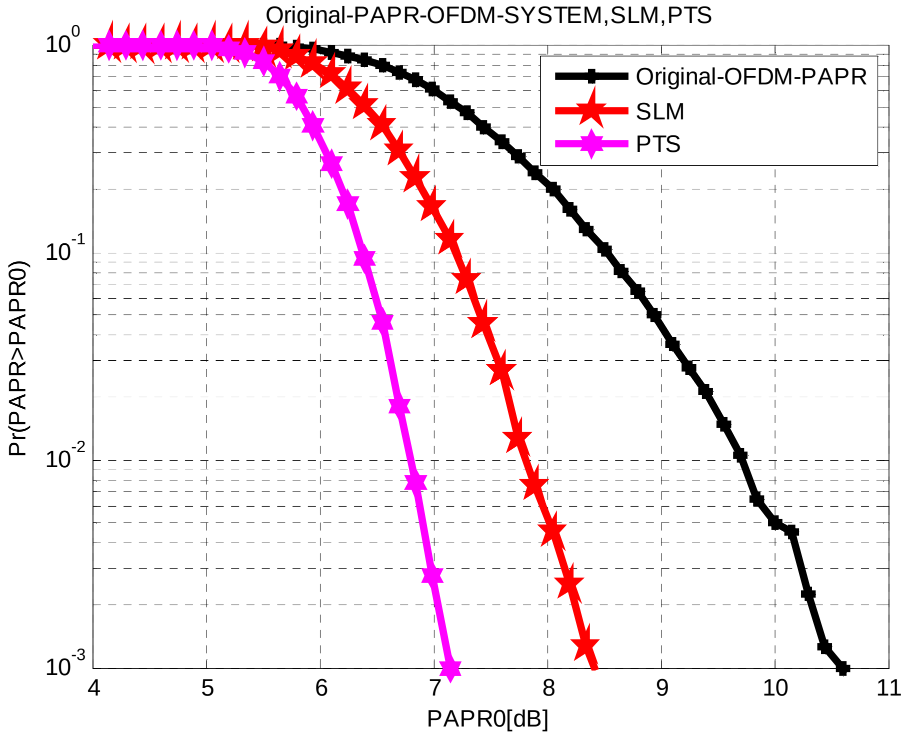


Fig 5.12 Comparison between Original OFDM System with SLM and PTS. It is found that Performance of PTS is best among all.

Analysis: By considering Conventional PTS, Traditional SLM and Conventional OFDM system. Here we can easily see that only 1% probability that papr is found to be 7.1 dB for PTS where at the same .1% probability papr for the Conventional SLM system it is found to be 8.45 dB and for conventional OFDM system it is 10.5 dB. Here we can see the gain achieved by our PTS algorithm is 3.4 dB while comparing SLM with OFDM it is found to be 2.05 dB. This gives the justification that PTS algorithm is best in these circumstances as compare with SLM. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j.

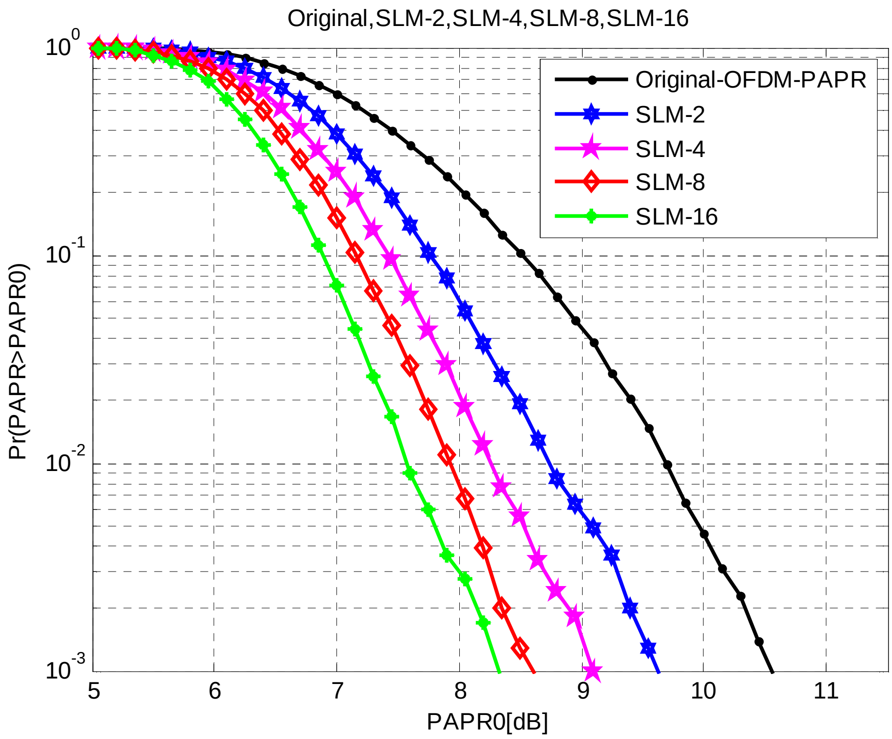


Fig 5.13 considered different number of phases of SLM from 2 to 16. It can be seen that as number of phase are increasing then performance is increasing.

Analysis: By considering SLM and Conventional OFDM system. Here we can easily see that at .1% probability that papr is found to be 9.5 dB for SLM-2 where at the same .1% probability papr for the SLM-4 system it is found to be 9.1 dB , for the SLM-8 system it is found to be 8.65 dB, for SLM-16 system it is found to be 8.3 dB for conventional OFDM system it is 10.5 dB. Here we can see the gain achieved by our SLM-2 algorithm is 1 dB while comparing SLM-4 with OFDM it is found to be 1.4 dB, with SLM-8 it is 1.85 dB and for SLM-16 it achieves remarkable gain of 2.2 dB. This gives the justification that SLM algorithm is best in these circumstances as compare with OFDM system as soon as we are going to increase number of phases. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Important thing to note down here that length of SLM phase vector is same as length of data so elementary multiplication is required here and also desirable through out.

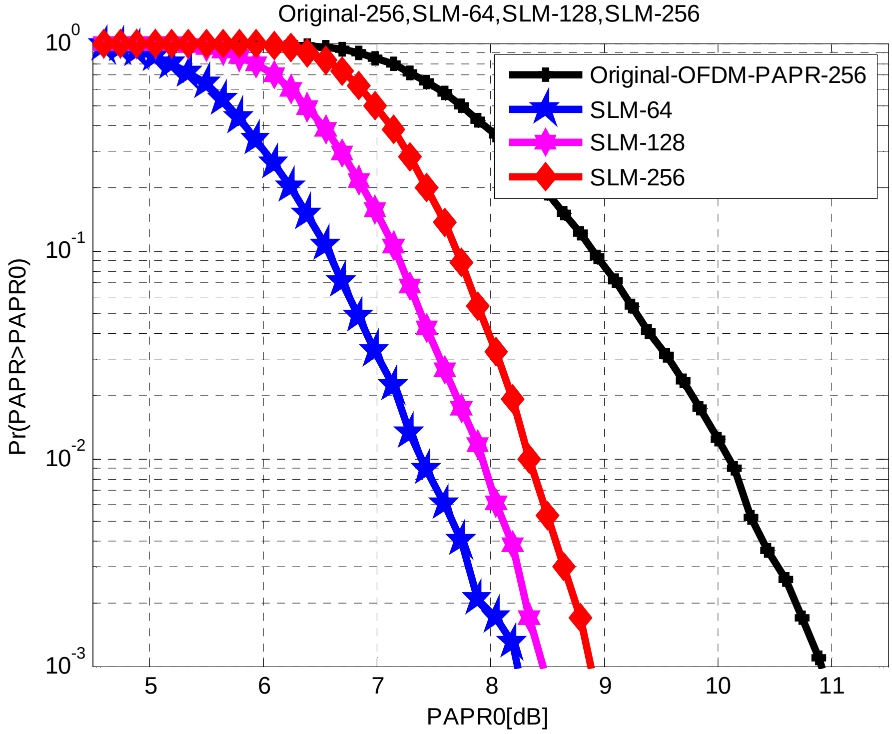


Fig 5.14 this graph shows that as we are increasing number of sub carriers in SLM with total phase =8; performance of PAPR is decreasing.

Analysis: By considering SLM and Conventional OFDM system. Here we can easily see that at .1% probability that papr is found to be 8.2 dB for SLM-64 where at the same .1% probability papr for the SLM-128 system it is found to be 8.4 dB , for the SLM-256 system it is found to be 8.8 dB and for conventional OFDM system it is 10.8 dB. Here we can see the gain achieved by our SLM-64 algorithm is 2.6 dB while comparing SLM-128 with OFDM it is found to be 2.4 dB, with SLM-256 it is 2.00 dB and This gives the justification that SLM algorithm is best in these circumstances as compare with OFDM system but as we are increasing number of sub carriers problem of papr is also increasing. Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Important thing to note down here that length of SLM phase vector is same as length of data so elementary multiplication is required here and also desirable throughout.

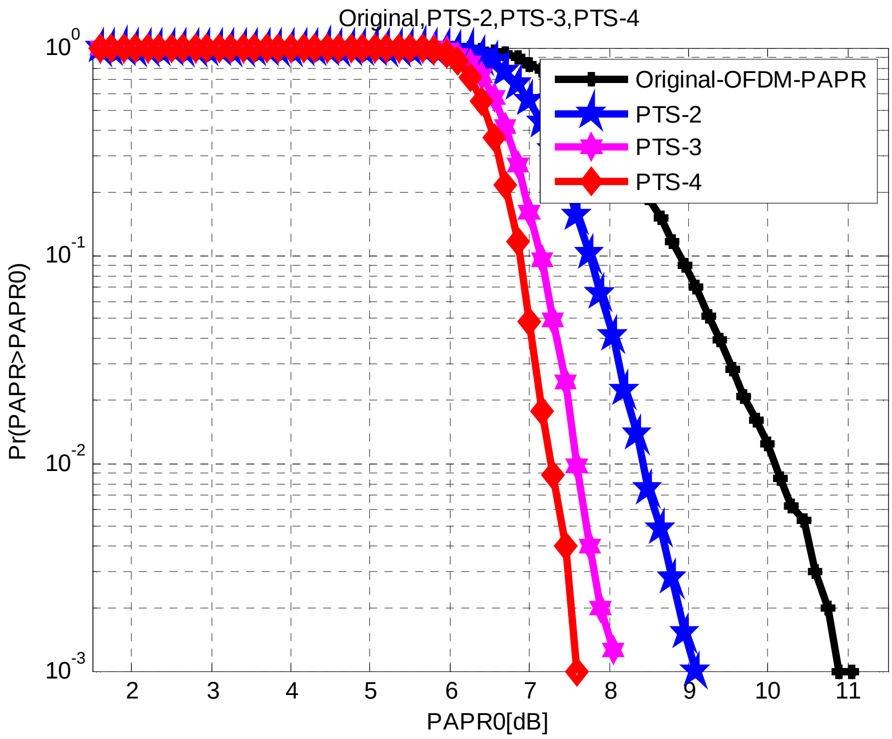


Fig 5.15, considered different number of partitioned of PTS i.e. 2, 3, 4. It can be seen that as number of partitioned are increasing then performance is also increasing.

Analysis: By considering PTS with different length of phases which we generally categorized as a partitioned PTS algorithm and Conventional OFDM system. Here we can easily see that at .1% probability that papr is found to be 9.00 dB for PTS-2 where at the same .1% probability papr for the PTS-3 system it is found to be 8 dB , for the PTS-4 system it is found to be 7.6 dB and for conventional OFDM system it is 10.8 dB. Here we can see the gain achieved by our PTS-2 algorithm is 1.8 dB while comparing PTS-3 with OFDM it is found to be 2.80 dB, with PTS-4 it is 3.2 dB and This gives the justification that PTS algorithm is best in these circumstances as compare with OFDM system with increasing number of phases Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j. Important thing to note down here that length of PTS phase vector length depend upon partitioning of data. Here Partitioning is compared which is totally depend upon length of phases vector.

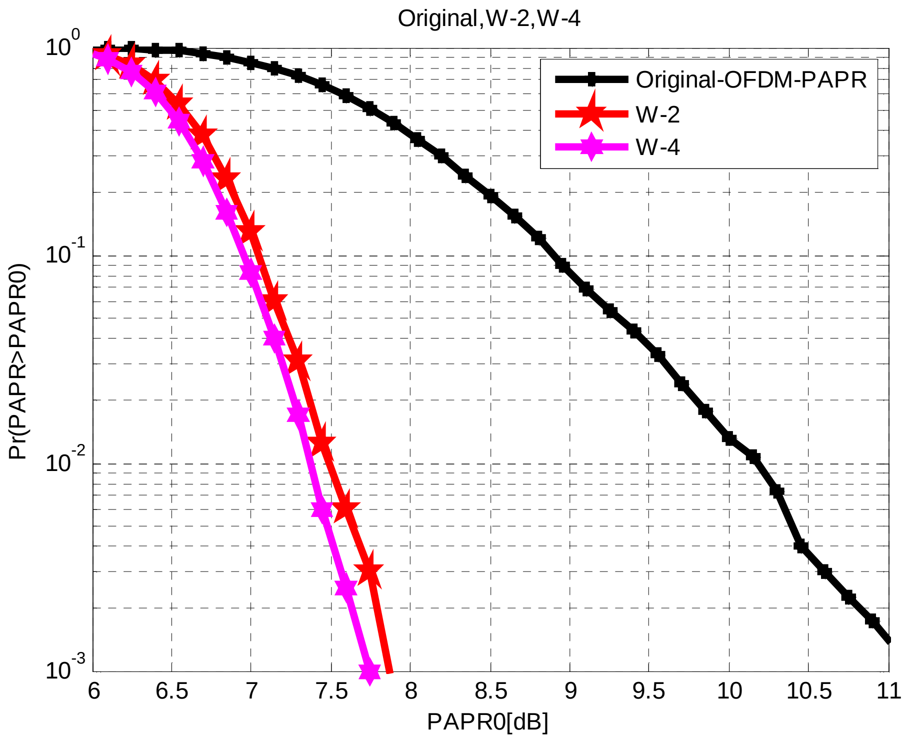


Fig 5.16, considered different number of phases of PTS from 2 to 4 It can be seen that as number of phase are increasing then performance is increasing.

<u>Analysis:</u> By considering PTS with different number of phases and these are 2 and 4 along with Conventional OFDM system. Here we can easily see that at .1% probability that papr is found to be 7.9 dB for W-2 PTS where at the same .1% probability papr for the W-4 PTS system it is found to be 7.75 dB and for conventional OFDM system it is 11.2 dB. Here we can see the gain achieved by our W-2 PTS algorithm is 3.3 dB while comparing W-3 PTS with OFDM it is found to be 3.45 dB and This gives the justification that PTS algorithm is best in these circumstances as compare with OFDM system with increasing number of phases Here in order to estimate the problem papr for OFDM system in continuous domain we will have to over sample it by a factor of 4. Phases which we have considered here are +1,-1,+1j,-1j.

CONCLUSION

This thesis proposed two novel methods for the reduction of PAPR in OFDM system. First method has title, "Peak to Average Power Ratio Reduction in OFDM Using Higher Order Partitioned PTS Sequence and Bose Chaudhuri Hocquenghem Codes"**.** This modified PTS scheme has been proposed to overcome the issue of higher PAPR in the OFDM system. To get the better outcome from our proposed scheme, we consider standard array of BCH code along with PTS algorithm. Simulation results show that, although reduction in PAPR is there with the existing techniques but significant reduction achieved through our proposed scheme. Futuristic goal may be in the field of complexity reduction as well as BPSK modulation scheme can also be carried into M-PSK, M-QAM with OFDM system. Second novel method has title "An Improved and Efficient PAPR Reduction Method in OFDM System Using Modified Partial Transmitted Sequence", This is also a modified PTS scheme for the reduction of PAPR significantly as compared to traditional OFDM system. Simulations result inferred that performance of our MPTS scheme remain efficient in all the cases; even if the numbers of sub-carriers are increasing. Although the MPTS scheme gives better PAPR reduction but future research can be carried on to reduce its complexity In the beginning of the thesis, theory along with the main principle of OFDM system has been explained with detailed description. Later we identified the factors responsible for high PAPR i.e. high peaks are due to IFFT operation. Simulation results clearly depict that how this high PAPR is not good for the OFDM system and how these high peaks are controlled by two novel techniques. Study of Literature is also done which come under literature review chapter which generally include coding technique, Partial transmitted Sequence, Selective mapping etc. Coding technique which we generally used for the reduction of high PAPR introduce redundancy and become very complex at very high number of sub carrier i.e. 1024, 2048 etc. On the basis of graphical analysis some decision can be drawn i.e. to get a very little improvement in SLM, this algorithm have to undergo very high complexity. On the other hand performance of PTS is remarkably well as compared with SLM technique. In PTS at .01 probability of error with four number of sub block along with some specified phases, significant gain have been achieved. Therefore, it can be concluded that as we are increasing number of phases then performance of this algorithm is also increasing. Finally, we can conclude that PTS technique is found to be very effective as compared with SLM technique.

FUTURE SCOPE OF THE STUDY

In this work we generally focused on the most predominant problem of OFDM system which we describe as PAPR problem in which due to appearance of high peak leads to non-linearity in amplifier. Since it is crystal clear that this every research work never stops on one point rather it goes on increasing. A new start always in a waiting list. So this work can utilize in described direction as follows:

[1] Various modulation schemes can be applied in the work which is proposed in this thesis in order to read out the complete behavior and also to find which modulation scheme work really very well in tem of performance.

[2]Complexity Analysis study can be done on the proposed work so that only required or even less than require information can be transmitted.

[3]The proposed work can also be done for Multiple input and multiple output system.

REFERENCES

[1]**<u>Prabal Gupta</u>**; B. Arun Kumar ;Sandeep Kumar Jain, " Peak to average power ratio reduction in OFDM using higher order partitioned PTS sequence and Bose Chaudhuri Hocquenghem Codes " ***<u>IEEE International Conference</u>*** on Signal Processing And Communication Engineering Systems (SPACES), 2015

[2] **<u>Prabal Gupta</u>**, B. Arun Kumar, Sandeep Kumar Jain and Balpreet Singh ," An Improved and Efficient PAPR Reduction Method in OFDM System using Modified Partial Transmitted Sequence" ***<u>EBAS International Conference(Published in Elsevier Proceeding Book)</u>*** Nov-2014

[3] Dhungana, H. ; Sah, S.K. ; Shakya, S. "Performance evaluation of PAPR reduction in multicarrier system by PTS and SLM methods ",Internet (AH-ICI), 2012 Third Asian Himalayas International Conference on, on page(s) :1-5,23-25 Nov.2012

[4] Pyla, S.; Raju, K.P; Balasubrahmanyam, N." PAPR reduction in OFDM systems using PTS and various modulation schemes "on page(s):1-6, 21-22 Sept.2013

[5] Kyeongcheol Yang; Chang,S.-I." Peak-to-average power control in OFDM using standard arrays of linear block codes ", Communications Letters, IEEE, on page(s):174-176, April 2003

[6] Xin-chun Wu ; Jin-xiang Wang ; Zhi-gang Mao "A novel PTS architecture for PAPR reduction of OFDM signals", Communication Systems, 2008. ICCS 2008. 11th IEEE Singapore International Conference on, on page(s):1055-1060, 19-21 Nov.2008

[7] Chackochan, R.; Soni, H." Peak to Average Power Ratio (PAPR) reduction in OFDM for a WLAN network using SLM technique ", on page(s):57-59,8-10 April,2011

[8] Mathew, B. ; George, P. ; Nathan, R.V. ; Shukkor, S. ; Lakshmi, A.N. ," BER comparison of DCT and FFT based OFDM systems in AWGN and RAYLEIGH fading channels with different modulation schemes", Emerging Research Areas and 2013 International Conference on Microelectronics, Communications and Renewable Energy (AICERA/ICMiCR), 2013 Annual International Conference on DOI: 10.1109/AICERA-ICMiCR.2013.6576021, 2013

[9]Prashant Pandey and Rajeev Tripathi,” Performance Analysis of Peak to Average Power Ratio (PAPR) Reduction Techniques in an OFDM system.”IEEE Trans, pp. 245-249, 2012

[10] Jen-Ming Wu and Zhiwei Xiong ,’’Novel Time Domain 3B/4B Precoding for efficient papr reduction in ofdm communication systems”,IEEE transac.

[11] Emad Alsusas and Linn Yangs ,” MC CDMA specified papr reducing techniques utilize spreading codes redistribution IEEE

[12] D.Meenakshi , S.Prabha , N.R Improved performances in OFDM system by papr techniques of reduction

[13] Dr. Himanshu Soni,Reena chackocan ,” Peak to Avg. Power Ratio(PAPR) reduction in ofdm for WLAN network using SLM technique”

[14] Chahavi Sharma, pankaj kumar Sharma, s.k tomar, a.k gupta,” A modified iterative Amplitude clipping and filtering technique for papr reduction in ofdm systems”

[15] Slimane Ben Slimane,”Reducing the peak to avg. power ratio of ofdm signal through precoding”

[16] Tao Jiang ; Yiyan Wu" An Overview: Peak-to-Average Power Ratio Reduction Techniques for OFDM Signals",Broadcasting, IEEE Transactions on ,on page(s) 257-268, Volume: 54 , Issue: 2 , June 2008.

[17] Singh, K. ; Bharti, M.R. ; Jamwal, S. " A modified PAPR reduction scheme based on SLM and PTS techniques ", Signal Processing, Computing and Control (ISPCC), 2012 IEEE International Conference on ,on page(s):1-6, 15-17 March 2012.

[18] Xinchun Wu ; Zhigang Mao ; Jinxiang Wang ; Bin Zhou " A Novel PTS Technique with Combinative Optimization in Real Part and Imaginary Part for PAPR Reduction in OFDM Systems ", on page(s):215-218,15-18Sept.2009.

[19] Zid, S. ; Bouallegue, R. " Low-complexity PAPR reduction schemes using SLM and PTS approaches for interleaved OFDMA ", Ultra Modern Telecommunications & Workshops, 2009. ICUMT '09. International Conference on ,on page(s):1-5, 12-14 Oct