An Implementation a Simulink Based System for PAPR Reduction of OFDM Signals using Modified Partial Transmit Sequences

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***Abstract:** This paper aims to developing a simulation model of Partial Transmit Sequence (PTS) Technique based on modified PTS blocks of Orthogonal Frequency Division Multiplexing (OFDM) systems. As Traditional PTS technique need side information for transmitting, so it increases its complexity. Partial transmit sequences (PTS) is an effective technique to reduce the peak-to-average power ratio (PAPR) of orthogonal frequency division multiplexing signals. However, the modified conventional partial transmit sequence (PTS) technique requires an exhaustive searching over all the combinations of the given phase factors, which results in the computational complexity increases exponentially with the number of the sub-blocks, so it is difficult to achieve in practical system. Most of the research in recent years has been focused on reducing the peak-to-average power ratio (PAPR) of the orthogonal frequency division multiplexing (OFDM) system, which is the most popular technology for multicarrier communication. Among all the proposed schemes, Modified PTS is one of the most effective ways to improve PAPR performance, but it results in high computational complexity.*

***Keywords** – Orthogonal frequency division multiplexing, peak-to-average power ratio (PAPR), partial transmit sequence.*

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has become the most popular multi-carrier modulation technique in wireless communication systems in recent years. The essential of this technique is to convert a high-rate data stream into several low-rate streams [2]. However, the main drawback of OFDM system is the high peak to average power ratio (PAPR). If the PAPR exceeds the nonlinearity limits of high-power amplifier, channel in-band interference and out of band radiation will occur and eventually causes system performance degration [3]. Several schemes have been proposed for reducing the PAPR of the multicarrier system, which can be classified into two classes [4,5]: signal distortion algorithm and signal non-distortion algorithm. Operational amplifiers with large linear scale are expensive and this can increase the cost of the implementation of OFDM. To overcome such effects, many PAPR reduction techniques such as distortion, distortion less or coding have been proposed for OFDM signals [3-10]. Distortion less techniques such partial transmit sequence (PTS) [13] and selective mapping (SLM) [14] can improve the PAPR statistics with only a small data rate loss but has no inherent error control. In the PTS scheme, OFDM subcarriers subblocks are phase shifted separately after the inverse fast Fourier transform (IFFT) computation. It has been demonstrated that if the subblocks are optimally phase shifted, they result in minimum PAPR and consequently reduce the PAPR of the combined signal. In the PTS scheme, the number of subblocks and their partitioning determine the extent of PAPR reduction. Nevertheless, this approach still needs many IFFTs and also the number of optional phase factor sequences is very large. Hence it is very difficult to determine which phase factor sequences are employed in the optimization process [15, 16]. To alleviate the problem of high complexity an approach [17] has been proposed, in which real and imaginary parts are separately multiplied with phase factors, moreover PAPR is conjointly optimized in real and imaginary parts. This scheme has lower complexity with degraded PAPR performance compared to conventional PTS. Coding techniques have been utilized to correct errors as well as to control the PAPR. The combined forward error-correcting code (FECs) with PTS technique [18, 19] for a QPSK modulation has also been proposed. This method divides data bits into PAPR control bits and information bits and then uses these PAPR bits to generate a number of candidates to represent the same OFDM signal [20-21]. We used modified PTS technique for better results of PAPR.

Objective

We The main objective of this work is to modify an existing PAPR reduction technique termed as PTS Technique such that the computational complexity of the technique is reduced. Higher computational complexity demands more time, power and hardware resources thus increasing the cost as well. By reducing the complexity of the technique and yet delivering a performance equal to or better than the existing technique, the power, hardware requirement and cost can be optimized.

II. PROBLEM IDENTIFICATION

In the modern scenarios 3G is not enough as the ever growing demands of multimedia services, online gaming etc. needs higher speed of data. The need for more sophisticated technology is possible with higher and faster data transmission and reception. This can be achieved using 4G wireless technology. MIMO-OFDM is considered as one of the promising solution for increasing high data rates in wireless communication systems. The main limitation of MIMO-OFDM system is its high peak-to average power ratio (PAPR) of the transmitted signals which is required to be reduced [1]. The various PAPR reduction schemes have been proposed for OFDM systems. Among these the dominant type based signal scrambling methods such as the Partial transmit sequence and Selective Level Mapping (SLM) [2] are attractive as they obtain low PAPR. A straightforward way for PAPR reduction in MIMO-OFDM system is to apply existing algorithms separately on each transmit antenna. The mechanism is effective but it requires large amount of side information (SI) [3]. The Modified PTS is investigated to solve this problem, which selects the transmitted sequence to achieve least average PAPR for MIMO-OFDM systems [4]. The Modified PTS reduces the side information at the expense of a slight degradation of the PAPR performance.

III. METHODOLOGY

Orthogonal Frequency Domain Multiplexing

OFDM is multicarrier modulation technique known for its capability to mitigate multipath. In OFDM, a high speed data stream is divided into "N" narrowband data streams and is modulated using subcarriers which are orthogonal to each other and the information is transmitted on each sub carrier. OFDM is well suited for transmission of high data rate applications in fading channels due to its robustness to inter symbol interference. IFFT is per formed at the transmitter and FFT at the receiver, resulting in conversion of wideband signal affected by frequency selective fading, into "N" narrowband flat fading signals. Therefore, simpler equalizer is required at the receiver. OFDM is used for dedicated short-range communications (DSRC) for road side to vehicle communications and as a backbone for fourth generation (4G) mobile wireless systems. In the traditional frequency division multiplexing (FDM) system, signals are transmitted in different channels.

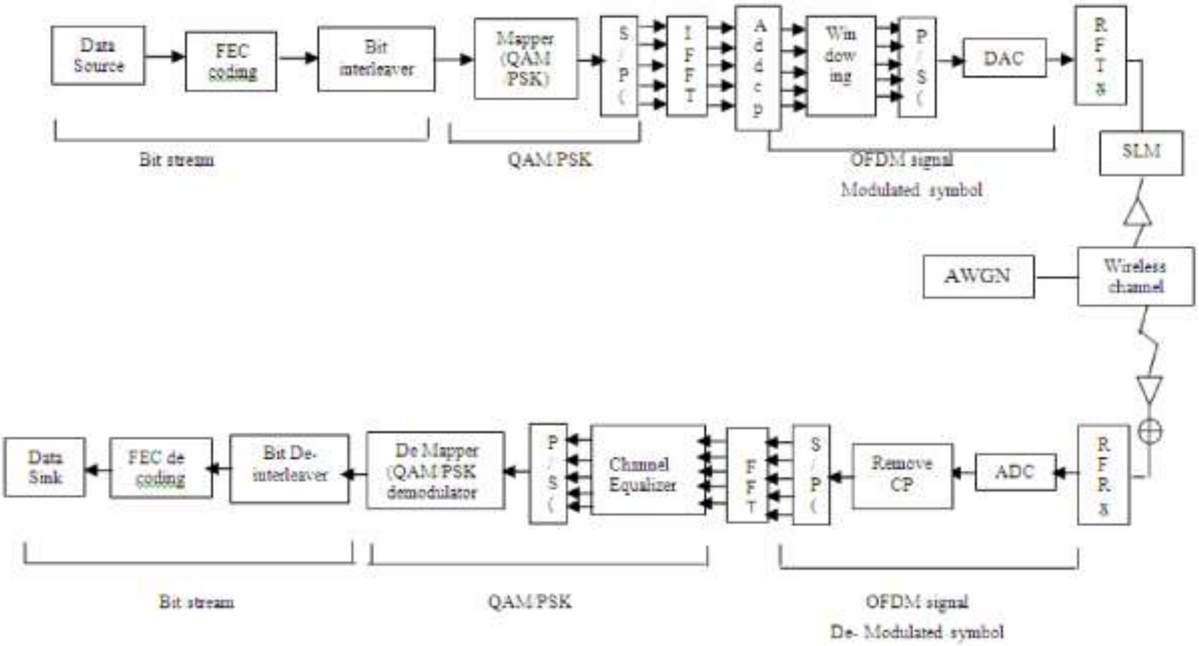

Figure 1: Transceiver of OFDM

Peak to Average Power Ratio (PAPR)

In OFDM system, the peak value of the system can be very elevated as evaluate to the average of the entire system due to occurrence of large number of independently modulated subcarriers. PAPR is defined as the ratio of peak to average power value. OFDM signal may be create by an N point IFFT at the transmitter, and FFT is operational at the receiver. Let us describe a complex input data of N sub-carrier as $X = \{X_0, X_1, \ldots\ldots, XN_{-1}\}^T$ is created and with each sub carrier has orthogonal. T symbolize one of the subcarriers $\{fn, n = 0,1, \ldots \ldots . N-1\}$, where $n\Delta f = 1/NT$ and NT is the duration of OFDM data block X. The discrete OFDM symbol can be written as [2]:

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_n e^{j2\pi\Delta f t}, \qquad 0 \le t \le NT$$

The PAPR of transmitted signal is defined as

$$\text{PAPR} = \frac{\max_{0 \le t < NT} |x(t)|^2}{\frac{1}{NT}\int_0^{NT} |x(t)|^2 dt}$$

Partial Transmit Sequence (PTS)

Partial Transmit Sequence (PTS) method In PTS method, the frequency domain symbol sequence is partitioned into some d is joint sub-blocks which are multiplied by set of phase sequence correspondingly taking the IFFT of sub-blocks (transformed into the time domain partial transmit sequence). The time domain partial sequence sub-blocks is optimally combine by independently multiplying with phase factors to obtain time domain OFDM symbols with lowest PAPR [3]. A block diagram of PTS technique is shown in figure 2. Here, input data block of symbols is separated into disjoint sub-blocks which are represented by the vectors. The input data block can be written in the form of as follows-

$$X = \sum_{v=0}^{V-1} X_v$$

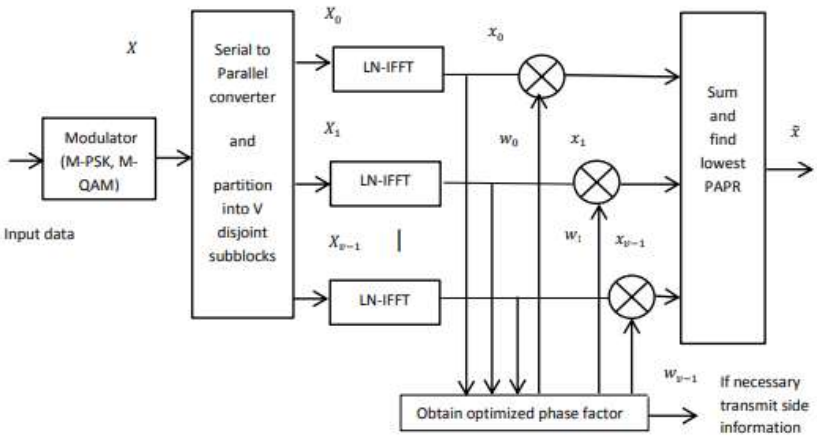

Figure 2: PTS technique for PAPR reduction

Where, $X_v = [X_v^0, X_v^1, X_v^2 \ldots\ldots X_v^{N-1}]^T$ are the sub-blocks of same size. Partition of sub-blocks can be done by three methods: adjacent partition, pseudo-random partition and interleaved partition [3] and each sub-block has equal size.

System design and Modeling

In our project we design a model using Matlab Simulink platform. In the figure below we describe complete model. Each block having the important role in the project.

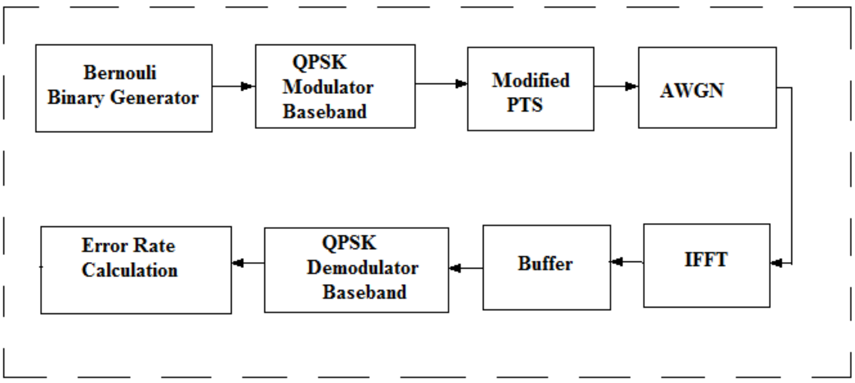

Figure 3: Schematic block diagram of implemented Simulink system

Bernoulli Generator

The Bernoulli Binary Generator block generates random binary numbers using a Bernoulli distribution. The Bernoulli distribution with parameter p produces zero with probability p and one with probability 1-p. The Bernoulli distribution has mean value 1-p and variance p(1-p). The Probability of a zero parameter specifies p, and can be any real number between zero and one.

QPSK Modulator Baseband

The QPSK Modulator Baseband block modulates using the quadrature phase shift keying method. The output is a baseband representation of the modulated signal. If you set the Input type parameter to Integer, then valid input values are 0, 1, 2, and 3. When you set Constellation ordering to Binary for input m the output symbol is exp(jθ + jπm/2). Where θ represents the Phase offset parameter (see the following figure for Gray constellation ordering). In this case, the block accepts a scalar or column vector signal.

A Modified PTS Technique with the Simulation

In the modified PTS technique, analysis of various possible combinations of phase factors has been done. The possible phase factors in weighting optimization can be written as [1, -1, j, -j]. Depending upon the exhaustive search of these various factors, the signal with lesser PAP ratio is selected. The combinations made by these phase factors play a major role in the reduction of peak to average power ratio. It has been analyzed through MATLAB simulations that the factors having a minimum phase shift between contribute to the decreased PAPR rather than those having an increased phase shift. Instead of phase factors having 90 degree angle shifts, those with a lesser degree are supposed to give a high PAPR reduction as compared to conventional PTS technique.

Reduced Computational Complexity PTS:-

The improved PTS algorithm is mainly reflected in the calculation of reducing the amount of multiplication which reduces the hardware complexity. In the PTS algorithm, assuming that the number of sub -blocks is V, the number of phase factor is W, and the number of points in IFFT operation is N. Meanwhile, the computational complexity of traditional calculation PTS noted as O_PTS Modified. it shows that with the increase number of sub -blocks, the computational complexity reduces drastically. When employ sub-blocks defined value of V, the computation can be reduced to about 42%, comparing to the original PTS algorithm.

The subsystem at the Modulator and demodulator for two subcarriers are divides the input data sequence into 2 sub-blocks and the IFFT of each block is calculated and then the obtained sequences is multiplied with efficient phase factors . The phase factors used are [1, -1]. Then the 2 Sequences are added together before transmitting the data through AWGN channel. Similarly for four and eight subcarriers the input data will be divided into four and eight sub-blocks, respectively and the phase vectors used are [1 -j j 1] and [1 -j 1 -1 -1 1 -j 1].

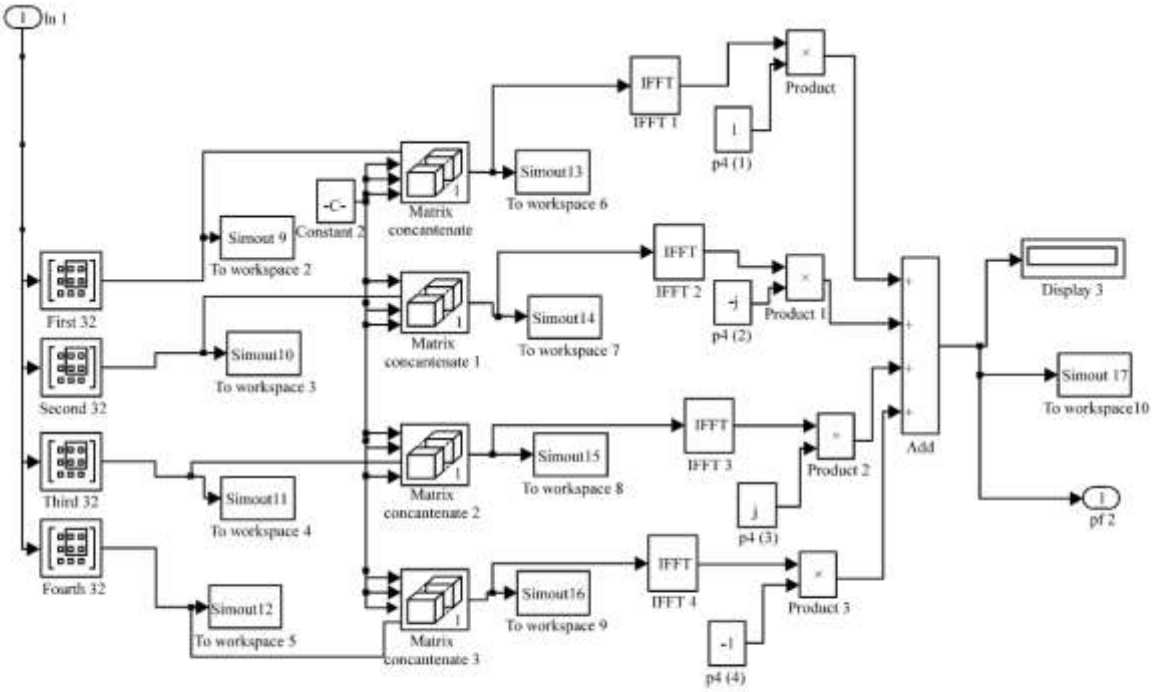

Figure 4: Subsystem at the transmitter with four subcarriers

AWGN Channel

The AWGN Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real, this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal. This block inherits its sample time from the input signal.

IFFT Block

The IFFT block computes the inverse fast Fourier transform (IFFT) across the first dimension of an N-D input array.

When you specify an FFT length not equal to the length of the input vector, (or first dimension of the input array), the block implements zero-padding, truncating, or modulo-M, (FFT length) data wrapping. When the input length, P, is greater than the FFT length, M, you may see magnitude increases in your IFFT output. These magnitude increases occur because the IFFT block uses modulo-M data wrapping to preserve all available input samples.

Buffer Input into Frames

Multichannel signals of frame size 1 can be buffered into multichannel signals of frame size L using the Buffer block. L is greater than 1. The following figure is a graphical representation of a signal with frame size 1 being converted into a signal of frame size L by the Buffer block.

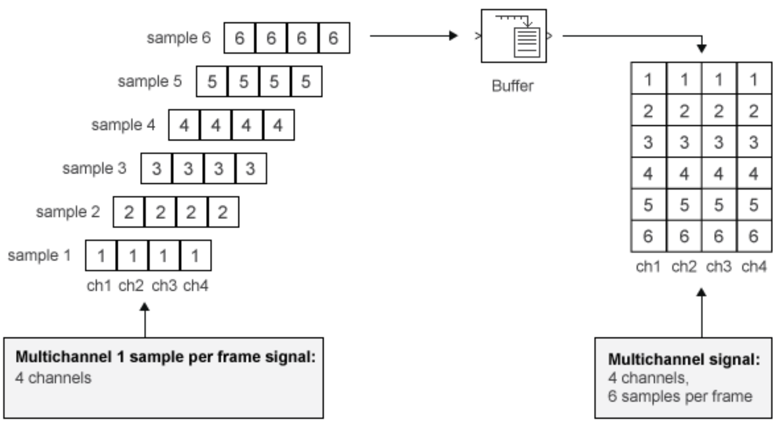

Figure 5: IFFT Sample blocks with Buffer

Complementary Cumulative Density function (CCDF)

The complementary cumulative density function (CCDF) of the PAPR is used to measure the performance. The CCDF of the PAPR is defined as

$$CCDF(PAPR(x[n])) = Pr(PAPR(x[n]) > PAPR_0)$$

Where is a certain threshold value that is usually given in decibels relative to the root mean square (RMS) value.

Simulink Block

The input data block is divided into sub-blocks of 2, 4 or 8 depending on the subcarriers used. Then the sequence is modulated using QPSK modulator whose output will be in the frequency domain as in figure. IFFT block is used for frequency to time domain conversion.

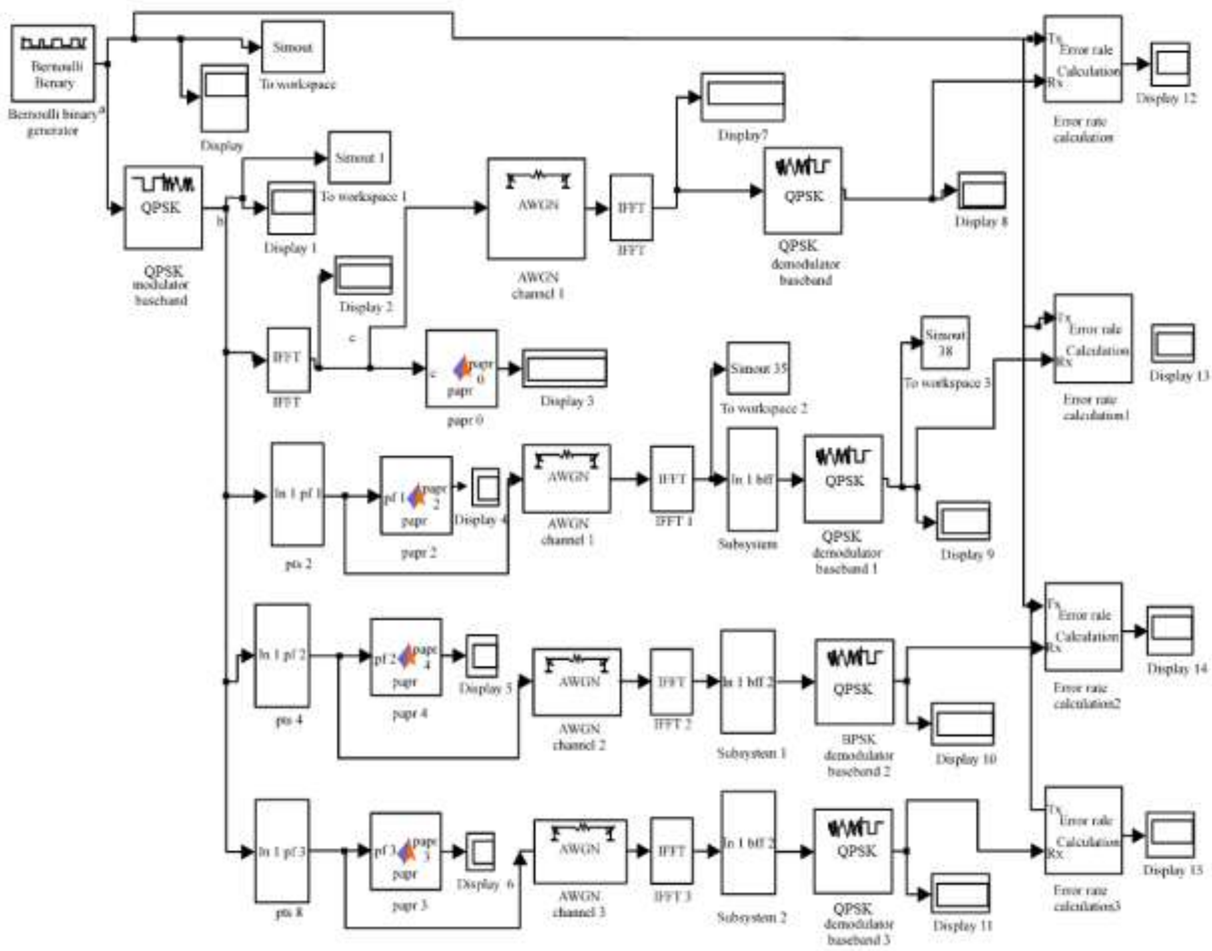

Figure 6: Simulink block of Modified PTS based PAPR reduction of OFDM system with QPSK modulation and demodulation

IV. Result and Discussion

The pseudo random input is given to the implemented Simulink model and demodulated outputs are plotter in figure from the figure it is clear the output data was decoded correctly using QPSK modulation for the subcarrier values 2, 4 and 8 respectively.

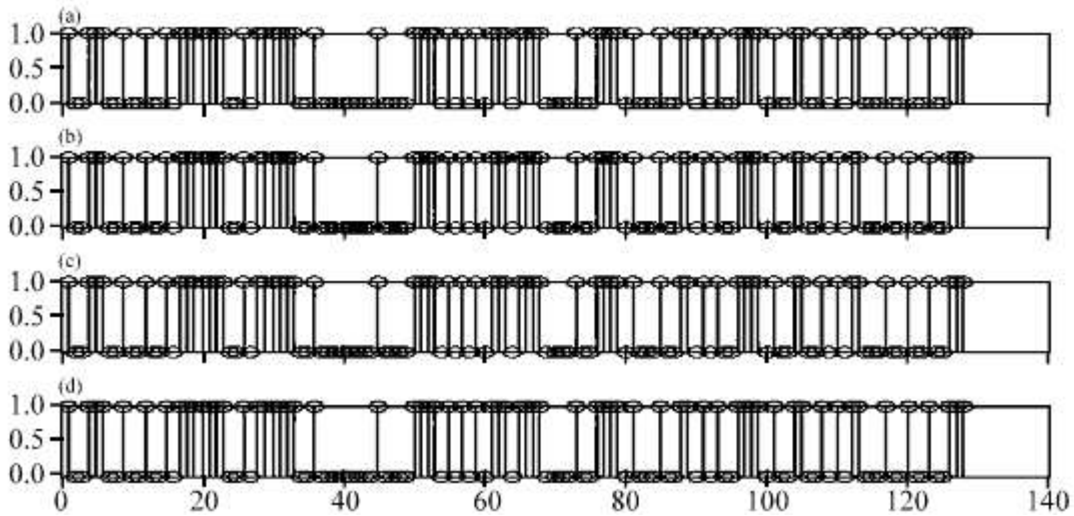

Figure 7: Comparison between input and the corresponding demodulated Output for various values of subcarriers (a) Input (b) PTS i*=2 (c) PTS i* =4 (d) PTS i*=8 using QPSK modulation

In MATLAB to evaluate the ability of the PAPR reduction using M-PTS , in which random OFDM symbols are generated with the number of sub-carriers N=64. For comparisons, we have shown the simulation results of the CCDF curve for Original OFDM, C-PTS and M-PTS scheme in fig 3. For both M-PTS and C-PTS, we divide all the sub-carriers into M= 4 sub-blocks, and phase rotation factors are chosen from the set P = [1, j, -1, -j].

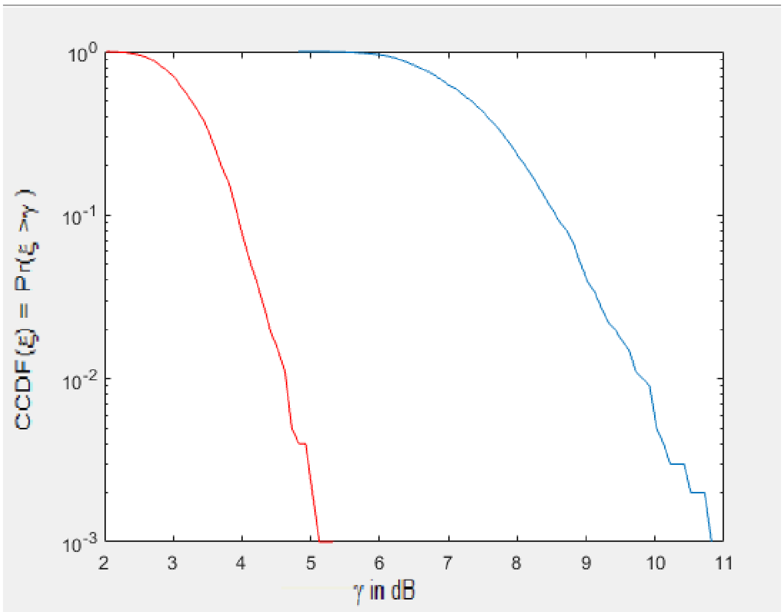

Figure 8: CCDF plot using Modified PTS in OFDM

V. Conclusion

This study analyses Modified Partial Transmit Sequence (PTS) method of PAPR reeducation in OFDM system Simulink model. It provides a comparative study of Modified PTS technique with various values of subcarriers and various modulation schemes like BPSK, QPSK and QAM in terms of complementary Cumulative Distribution Function (CCDF) and Bit Error Rate (BER). It is observed that Modified Partial Transmit Sequence (PTS) method gives improved PAPR reduction when compared with other PAPR techniques like SLM and Clipping. When the number of subcarriers are increased there will a large reduction in PAPR which in turn increases the complexity of the system. From the results the Phase vector values are increased, better reduction in PAPR is achieved this is evident from the graphs obtained.

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