Exploration of PTS Technique for PAPR Reduction in OFDM

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Abstract- *OFDM is an attractive modulation technique for transmitting large amounts of digital data over radio waves. One major disadvantage of OFDM is that the time domain OFDM signal which is a sum of several sinusoids leads to high peak to average power ratio (PAPR). Number of techniques have been proposed for reducing the PAPR in OFDM systems. In this paper the PTS techniques proposed for reducing the PAPR and the selection criteria for choosing these techniques have been discussed.*

Keywords- *Orthogonal frequency division multiplexing(OFDM), peak to average power ratio(PAPR), partial transmits sequences (PTS), Long term-evolution (LTE),*

I . INTRODUCTION

The demand of high data rate services has been increasing very rapidly. The data transmission includes both wired and wireless medium. Often, these services require very reliable data transmission over very harsh environment. Long Term Evolution (LTE) is standardized by the 3rd Generation Partnership Project (3GPP) as an evolution of the 3G systems to meet the requirements of increasing the data rates, high mobility and low latency over a bandwidth of up to 20 MH [1]. To provide such a high spectral efficiency, an efficient modulation scheme is to be employed. A promising modulation technique that is increasingly being considered for adoption by 4G community is Orthogonal Frequency Division Multiplexing (OFDM) [2] Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier modulation technique, in which a single high rate data-stream is divided into multiple low rate data streams and is modulated using sub-carriers which are orthogonal to each other [3].

Major advantages of OFDM are its multi-path delay spread tolerance and efficient spectral usage by allowing overlapping in the frequency domain. Also another significant advantage is that the modulation and demodulation can be done using IFFT and FFT operations, which are computationally efficient. Unfortunately the major drawback of OFDM transmission is its large envelope fluctuation which is quantified as Peak to Average Power Ratio (PAPR).The PAPR is the relation between the maximum powers of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol [3]. PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other. At each instant they are different with respect to each other at different phase values. When all the points achieve the maximum value simultaneously; this will cause the output envelope to suddenly shoot up which causes a 'peak' in the output envelope. Due to presence of large number of independently modulated subcarriers in an OFDM system, the peak value of the system can be very high as compared to the average of the whole system.

To reduce the PAPR, many techniques have been proposed. If we consider Tone Reservation (TR) technique it also allows the data rate loss with more probable of increasing power. Tone Injection (TI) and the Active Constellation Extension (ACE) having criteria of increasing power will be undesirable in case of power constraint environment[3].Clipping and Filtering is one of the basic technique in which some part of transmitted signal undergoes into distortion. Clipping causes in-band signal distortion, resulting in Bit Error Rate performance degradation Also the Coding scheme reduces the data rate which is undesirable[4]. Among these techniques, PTS scheme has been found to an efficient and attractive method that has several advantages over others. In PTS, an input data sequence is divided into a number of disjoint sub blocks, which are then weighted by a set of phase factors to create a set of candidate signals. Finally, the candidate with the lowest PAPR is chosen for transmission.

II OFDM SYSTEM MODEL-

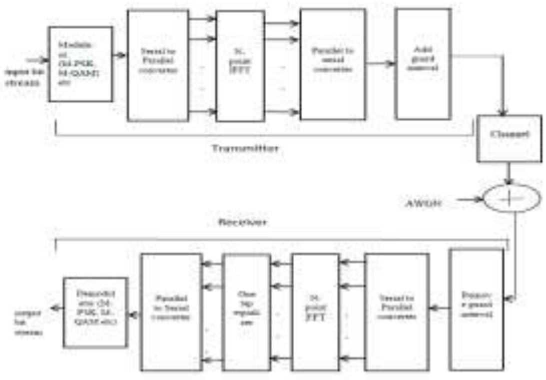

Figure-2.1: Block diagram of OFDM system

OFDM System Model

The discrete time baseband OFDM system with N subcarriers is shown in figure 2.1. It consists of transmitter, channel and receiver blocks.

A) Transmitter

In this model, a block of input bits (symbols) are modulated by M-ary data modulators and then,N such symbols are transferred by the serial to parallel converter. Different types of data modulator can be used depending upon system requirement (e.g. M-PSK, M-QAM etc.). The complex parallel data symbols (Xk) obtained by using modulation techniques are given toN point IFFT block as shown in figure 2.1.

The complex envelope of the baseband transmitted OFDM signal can be written as-

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

where, is the N total number of subcarriers X_k, k=(0,1,2...N-1) block of input bits (symbols),f_k =*k f*, where *f=1/ (NT), T*=original symbol period. Generally, the complex data are uncorrelated as shown in below-

$$E[X_k X_l^*] = \begin{cases} 1, & k = l \\ 0 & k \neq l \end{cases}$$

where ,X_l*represents the complex conjugate of X_l

The discrete form of OFDM signal X(n) is given by,

$$x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k\, e^{\frac{j2\pi kn}{N}}, \qquad for\; n = 0,1,2,3 \ldots N-1$$

Equation shows that transmitted signal X(n) is obtained by taking the inverse discrete fourier transform (IDFT) of modulated input data symbols X_k . As shown in figure 2.1, practically IDFT can be comfortably and thoroughly obtained by using inverse fast fourier transform (IFFT).

B) Addition of Guard band

Guard interval in OFDM system is used to remove ISI which is generally introduced between consecutive OFDM symbols. The delay spread of multipath channel caused ISI in OFDM symbols. To remove ISI entirely a guard band interval with no signal transmission can be used but it can produce ICI because of higher spectral components which occurred due to quickly change of waveform.

C)Channel Model

The phenomenon of noise and multipath environment can be predicted by using channel model. Generation of noise can be done by adding few random data to the OFDM symbol and multipath environment can be generated by adding attenuated and delayed copies of the OFDM signal.

D) Receiver

At the receiver, inverse of the transmitter is done. Here, first the guard interval of OFDM symbol is removed. Then, these unguarded OFDM symbol is converted from serial to parallel which are passed through FFT block. The FFT converts these parallel OFDM data streams into frequency domain. The output of FFT operation can be expressed as-

$$X(k) = F(k)x(k) + w(k), for\ 0 \le k \le N-1$$

where, w(k) is the AWGN component in frequency domain and f(k) denotes the FFT (frequency response of the multipath fading channel at the k sub channel) which is expressed as-

$$F(k) = \frac{1}{\sqrt{N}} \sum_{l=0}^{L-1} h_l e^{\frac{j2\pi kn}{N}}, k = 0,1,\ldots\ldots,N-1$$

The complex data received symbol X(k) can be recovered by single tap frequency domain equalizer and expressed as-

$$G(K) = \frac{1}{F(k)}$$

Finally, the recovered data symbol are converted back into serial stream and demodulated by using scheme like (M-PSK, M-QAM) to baseband.[5][6].

III Partial transmit sequence technique-

PTS is one of the most important methods that is used to reduce PAPR in the OFDM system. And it can be presented in two main steps.

First, by dividing the original OFDM signal into a number of sub-blocks. Secondly, adding the phase rotated sub-blocks to develop a number of candidate signals to pick the one with smallest PAPR for transmission. There is another way that can also be used to express PTS method by multiplying the original OFDM signal with a number of phase sequences PTS technique partitions and input data block of N symbols into V disjoint sub-blocks as follows:[7]

$$X = [X^0 X^1 X^2, \ldots \ldots, X^{V-1}]^T$$

Where X i the subblocks that are consecutively located and are also of equal size, scrambling is applied to each subblocks which rotating its phase independently in the PTS technique as in Fig. Then each partitioned subblocks is multiplied by a corresponding complex phase factor $b^v = e^{j\emptyset v}$ where v = 1,2,…….,V, subsequently taking its IFFT to yield:

$$X = IFFT\{\sum_{v=1}^{V} b^v X^v\} = \sum_{v=1}^{V} b^v . IFFT\{X^v\} = \sum_{v=1}^{V} b^v x^v$$

Where X ψis referred to as PTS .The phase vector is chosen so that the PAPR can be minimized [8], which is shown as:

$$[b^{-1},..,b^v] = \underset{[b^1 \ldots b^v]}{arg\,min} \left(max \left| \sum_{v=1}^{V} b^v x^v(n) \right| \right)$$

Figure shows that the number of computations in this suboptimal combination algorithm is V, which is much fewer than that required by the original PTS technique which make (V << WV).Then the corresponding time-domain signal with the lowest PAPR vector can be expressed as:

$$\tilde{x} = \sum_{v=1}^{V} \overline{b^{v} x^{v}}$$

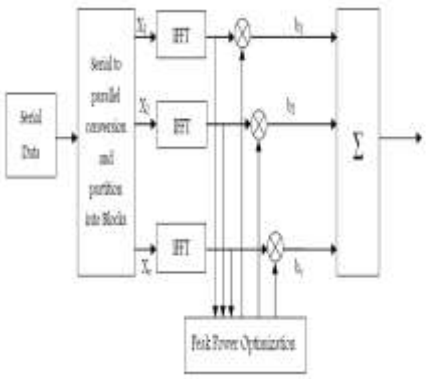

fig 3-block diagram of pts method

IV simulation result

In PTS method, we set the different number of sub-carriers as 64,32,16 and apply pseudo-random partition scheme for each carrier, adopting QPSK constellation mapping and weighting factor (rotation factor ε={±1,±j}. Oversampling factor is 4 and 1000 ofdm symbol generated. we are going to compare the output of different number of subcarrier.

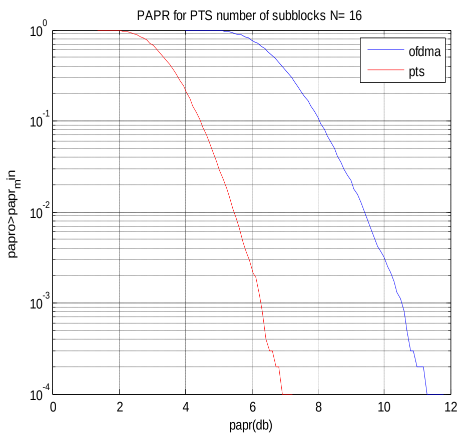

Fig-PAPR for PTS with number of sub-blocks is 16

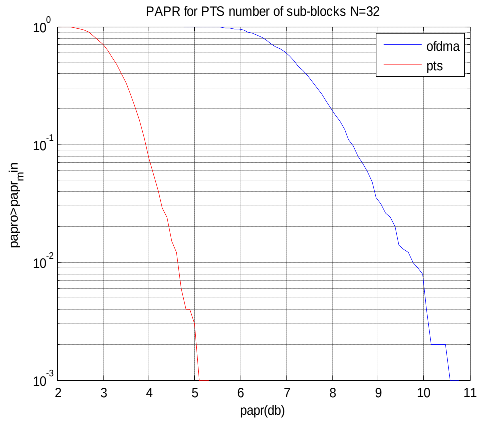

Fig-PAPR for PTS with number of sub-blocks is 32

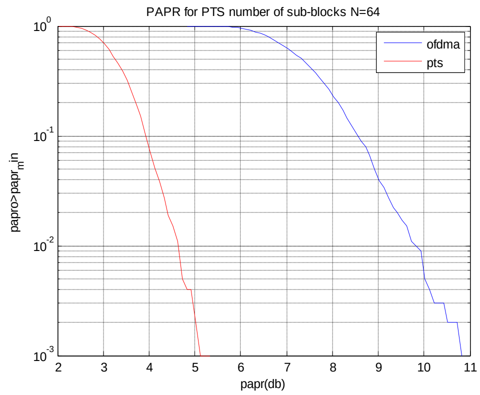

Fig-PAPR for PTS with number of sub-blocks is 64

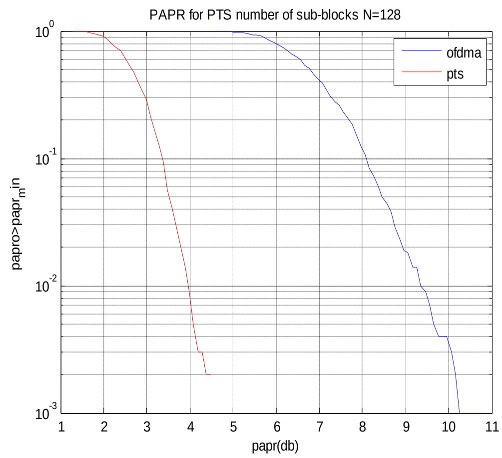

Fig-PAPR for PTS with number of sub-blocks is 128

V. Conclusion-

In this paper, the concept of PAPR in OFDM signals is discussed. The PAPR reduction technique Partial Transmit sequence(PTS) has been investigatated. We are going to compare the different number of subcarriers the above graph shows the output of all the simulations. The Simulation results show that In PTS technique as the number of sub blocks increases, the PAPR decreases. As the PAPR reduces with these techniques, they can be used in OFDM transmitter effectively.

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