Peak to Average Power Ratio Reduction Techniques of OFDM System

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ABSTRACT—Orthogonal frequency division multiplexing is an attractive technique for the wireless communication systems for transmitting the large number of subcarriers, but PAPR is the major problem for the OFDM system which leads to the system’s inefficiency. In this paper we have discussed about the PAPR Reduction techniques which are distortion-based or distortion-less. We have experimentally analyzed that PAPR reduction technique which gives best performance as compared to the original OFDM.

Index Terms—AM/CF, OFDM, PAPR, PTS, SLM.

I. INTRODUCTION

Orthogonal frequency division multiplexing is the key for the wireless communication but PAPR is the major problem for the OFDM system which degrades the whole system’s efficiency. OFDM is used by many standards such as IEEE 802.11a/b, WI-FI, WI-MAX etc, due to of its several advantages. It overcomes the disadvantage of the frequency division multiplexing of using single channel to single user at a time. It is having many advantage such as less bandwidth uses, cancellation of inter symbol interference and inter carrier interference, data rates etc. but one of the major problem is the peak to average power (PAPR) because it simultaneously transmit many symbol, sum of the sine waves added suddenly and causes high peaks of more power, degrades the power amplifier efficiency. Several techniques are present to reduce the PAPR, from them some are distortion based and some of them are distortion-less such as clipping, companding, partial transmit sequence, selective mapping, coding, tone reservation and tone injection. Distortion based technique are clipping, peak cancellation and peak windowing which clip to the peak up to a certain level. Distortion less techniques are coding, PTS, and SLM which uses any coding technique or use phase factor that helps to reduce the PAPR. IFFT and FFT used at the transmitter and receiver side to convert frequency domain signal in to time domain signal and produces the orthogonality in between the sub-carriers. In this paper we have discussed about the clipping, PTS, SLM and tone reservation. Reduction of PAPR is implemented for PTS and Clipping in this paper.

In wired or wireless communication environment new technology and new application are involved. Upcoming standards for the next generation mobile systems are expected to give high data rates to provide the high performance and with efficient system to fulfill the requirement of upcoming high performance multimedia application technology.

High data rates required by wired or wireless communication network for their application, but due to the multipath delay data rate decreases, however time duration of OFDM symbol increases the data rates and mitigates the effect of fading and inter symbol interference by adding the cyclic prefix. OFDM is also called multicarrier modulation, this divides the whole bandwidth into narrow sub-band channels for transmitting the data over these multichannel simultaneously that’s why OFDM used less bandwidth as compared to other technology [1]. Firstly the multicarrier channel transmission concept has derived in the year 1966 by chang [2], the brief explanation of this concept has given in this paper [3]. In below we have shown a generic block diagram of OFDM system [1]

The rest of the paper is organized as follows: Section II offers the detailed study of an OFDM system and PAPR. The PTS, SLM and other reduction techniques are described in Section III. In Section IV, Simulation results are shown. Finally, the paper is concluded in Section V.

II. SYSTEM MODEL

A. OFDM SYSTEM

Transmitted signal for OFDM system is represented as:

\[
s(t) = \frac{1}{N} \sum_{k=0}^{N-1} S_k e^{j2\pi f_k t}, \quad 0 < n < N-1
\] (1)

Where \( s(t) \) is the transmitted signal from 0 to N-1, \( N \) is the total no of sub-carriers. \( f_k \) is a set of orthogonal subcarrier which is further explained as \( f_k = k\Delta f \).

B. PEAK TO AVERAGE POWER RATIO

PAPR is the big challenge for the OFDM system. It is defined as the maximum power of the OFDM symbol to the average power of the OFDM symbol [4], it can be expressed as below

\[
PAPR = \max_{0 \leq n < N} \frac{\|s(t)\|^2}{E[|s(t)|^2]}
\] (2)
Where \( \max_{0 \leq n < N} [s(t)^2] \) the maximum power of the OFDM symbol and \( E[s(t)^2] \) is the mean power of the OFDM signal.

Complementary cumulative distribution function (CCDF) is used to represent the results of PAPR [4] which is expressed as:

\[
CCDF = P_r\{\text{PAPR} > S\}
\]  
(3)

III. REDUCTION TECHNIQUES

A. CLIPPING

Clipping is a PAPR reduction technique, it is distortion based. This technique employs the method to clip those transmitted signal which is having more power as compared to the average power of the OFDM symbol. It causes the in-band and out-band distortion [5].

\[
S_c(t) = \begin{cases} 
-A & S(t) \leq -A \\
S(t) & |S(t)| < A \\
A & S(t) \geq A 
\end{cases}
\]  
(4)

Where \( S_c(t) \) represent the clipped signal, A is the amplitude level of the signal in this technique amplitude peaks are modified by applying clipping technique. This method creates in band or out band nonlinear distortion with minimal power. it can be used for any number of subcarriers. This technique is less complex as compared to others but produces distortion.

B. PARTIAL TRANSMIT SEQUENCE

Partial transmit sequence is an attractive technique for reducing the PAPR. In this technique the input bits are converted in to the smaller sub-blocks, these sub-blocks data are modulated by any modulation technique by the help of inverse fast fourier transform these frequency domain OFDM symbol converts in to the time-domain with less complexity. These sequences are multiplied with suitable phase factors ‘\( z \)’ to reduce the PAPR. It is expressed as [6]

\[
S = \sum_{m=1}^{M} Z^m \cdot \text{IFFT}(S^K)
\]  
(6)

Where \( m = 1, 2, 3 \ldots M \), \( \phi^m \) is phase factor whose value lie in between the 0 to \( 2\pi \). The main motive to design this technique to reduce the PAPR with the optimal phase factor.

C. SELECTIVE MAPPING:

Block diagram of selective mapping is shown in fig below. This is distortion less based technique, it is slightly differs from partial transmit sequence it is based on following algorithm, we have shown a block diagram of SLM technique below [6].

I. Input serial data converts in parallel form by using serial to parallel converter.

II. Data blocks \( S = S(0), S(1), S(2), \ldots, S(N-1) \) from 0 to N-1 is multiplied with different phase factor which is represented by in the diagram \( M(1) \) to \( M(u) \), which are represented by the function of \( M^u = [M^u_0, M^u_1, M^u_2, \ldots, M^u_{N-1}]^T \).

III. This process produces new blocks of data i.e., \( S^u = [S^u(1), S^u(2), \ldots, S^u(N-1)]^T \)

IV. Take IFFT of ‘\( U \)’ independent block of data, this produces the sequence in this form.

V. From them selects the lowest PAPR for the transmission.

VI. This technique is less complex as compared to the PTS.
IV. RESULTS AND DISCUSSION

This section discusses about the simulation results. In below we have shown the simulation results for the power reduction of OFDM by using PTS and Clipping technique on the given parameters. This simulation is done by using 1024 bits with digital modulation qpsk. PTS technique works on efficient algorithm, we have reduced the PAPR for the 512 OFDM symbols, to avoid the inter symbol interference we added cyclic prefix of small duration.

Table No.1 Parameters which have taken for the simulation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFDM Symbol</td>
<td>256</td>
</tr>
<tr>
<td>Oversampling Factor</td>
<td>1</td>
</tr>
<tr>
<td>Total no. of bits</td>
<td>1024</td>
</tr>
<tr>
<td>Modulation technique</td>
<td>QAM</td>
</tr>
<tr>
<td>Order of modulation</td>
<td>16</td>
</tr>
</tbody>
</table>

Figure no. 5 Simulation result for OFDM & PTS V=4, 8

The fig 5 and 6 showing the comparison for the reduced PAPR by using CCDF plot, we have analyzed that PTS gives the best results as compared to the Clipping on the given parameters (specific). Clipping produces distortion of signals.

Table no.1 Parameter for the simulation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OFDM</td>
<td>11</td>
</tr>
<tr>
<td>Clipping</td>
<td>10.2</td>
</tr>
<tr>
<td>PTS V=4</td>
<td>9.9</td>
</tr>
<tr>
<td>PTS V=8</td>
<td>8.9</td>
</tr>
</tbody>
</table>

V. CONCLUSION

In OFDM, PAPR is major problem which causes system’s inefficiency. In this paper simulation results for reduced PAPR of OFDM system by using PTS and Clipping technique. From the results it has been analyzed that the PTS technique can reduce to the PAPR up to 1 or 2 dB and Clipping can reduce to the PAPR up to 0.8 dB. So it is clear that on the PTS gives the better results as compared to Clipping on the given parameter system with low complexity.

REFERENCES


