Reduction of an PAPR in OFDM by Partial Transmit Sequences Technique

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ABSTRACT

Orthogonal frequency division multiplexing (OFDM) is an appealing technique approach for achieving high bit rate data transmission in wireless transmission. It uses available channel more efficiently by placing the subcarriers close enough provided subcarriers are orthogonal to each other. OFDM reduces the inter-symbol interference caused by multipath propagation. OFDM also reduces bit error rate. Its high peak to average power ratio (PAPR) is a major drawback which limited its applications. Recently various promising techniques for reducing the PAPR have been proposed. In this paper we present the reduction of the PAPR using the Partial Transmit sequence.

Keywords—Frequency selective channel, Flat fading channel, inter symbol interference, orthogonal frequency division multiplexing (OFDM), Partial transmit sequence (PTS) Peak to average power ratio (PAPR).

I. INTRODUCTION

OFDM is the technique which divides available spectrum in number of carriers and each carrier is modulated by low data rate stream. OFDM uses the spectrum more efficiently by spacing the channels closely. This can be done by making the carriers orthogonal to each other which prevents interference and leads to the optimal use of the available band width. This technique is the base of 4G and Wimax (Worldwide Interoperability for microwave access) technologies. It also removes the ISI by using the Cyclic prefix method.

The major drawback of OFDM system is the high peak to average power ratio. This arises due to the IFFT operation at the transmitter end. It leads the non linear HPA (High power amplifier) to work in the saturation mode and properties of the OFDM cease to hold. This can be resolved by clipping the signal but it leads to the loss of data and increase in BER. Other methods are, to use linear power amplifier or to shift the operating point but both the approaches result in the significant loss of power.

II. METHODOLOGY

In OFDM systems to reduce PAPR we employ PTS technique. Smaller M sub blocks of the input sequence are generated with equal number of sub-carriers. Then using IFFT the sub blocks are transformed in to partial time sequences and rotated by phase factors. Out of the sequences generated one with the lowest PAPR is selected and transmitted over the channel. Number of sub blocks and allowed phase factors influence the output of the PAPR technique.

III. PRIOR APPROACH

In SLM technique set of signals represent the same information out of which most favorable signal is chosen having the least PAPR. The side information must be transmitted with the selected signal. This technique is probability based, which will not remove the peaks but prevent their frequent generation. This scheme is reliable but the drawback is the need to transmit the side information along with chosen signal which needs complex algorithm and adds to system complexity.

Let us consider information symbol X (0), X (1), X (2) ……X (N-1) each having amplitude ±a. These information symbols are loaded on the subcarriers

\[
\begin{align*}
X (0) & \quad \rightarrow \quad x (0) \\
X (1) \quad \rightarrow \quad x (1) \\
\vdots & \quad \rightarrow \quad \vdots \\
X (N-1) & \quad \rightarrow \quad x (N-1)
\end{align*}
\]

Figure 1: Block diagram of IFFT of the input data

After IFFT operation the transmitted samples are x (0), x (1), x (2) …… X (N-1). The IFFT operation results in the high PAPR because the data symbols adds up to produce high peak value signal. It has been observed that peak to average power ratio of an OFDM signal is directly related
to the number of subcarriers. As the value of the number of subcarriers increases peak to average power ratio of the OFDM system increases. Mathematically peak to average power ratio is defined as

\[ \text{PAPR} = \max_x |x(k)|^2 / E[|x(k)|^2] \]

Where \( \max_x |x(k)|^2 \) shows the peak value of the system and \( E[|x(k)|^2] \) average value of the OFDM signal.

There are various techniques to reduce the PAPR value. Some employs scrambling and other uses coding methodology. Partial transmit sequence put in to use the scrambling method to effectively reduce the PAPR in the OFDM.

**IV. PARTIAL TRANSMIT SEQUENCE**

There are many promising technique which alleviate the PAPR problem in the OFDM and multiple signal representation is one such technique which includes partial transmit sequence (PTS) and Selective mapping (SLM). Here input data is divided into number of sub blocks and each block undergoes through the process of IFFT at the transmitter end. Afterwards each block is multiplied with the rotation factor and this factor lies between \((0, 2\pi)\). The blocks are then added to form the signal for transmission.

PTS technique divide the input data or information symbol into the number of the non-overlapping sub blocks, let us consider the divided number of sub blocks are \(M\), therefore \(X_m (0 \leq m \leq M-1)\) and the number of subcarriers are same as that of the sub blocks, therefore Now the number of sub blocks undergo the IFFT (inverse Fast Fourier Transform), such that

\[ x = \text{IFFT} \left\{ \sum_{m=0}^{M-1} X_m \right\} = \sum_{m=0}^{M-1} x_m \]

Now the resultant after the IFFT operation is multiplied by the rotation factor \( \Omega = (\Omega_1, \Omega_2, \Omega_3, \ldots, \Omega_M) \).

This multiplies of the rotation factor or the Phase factor with the IFFT sub blocks leads to the reduction of the PAPR up to some extent.

\[ X' (\Omega) = \sum_{m=0}^{M-1} x_m e^{i\Omega_m} \]

By multiplying the best phase factor that yield the reduction of the PAPR of the transmit OFDM signal.

CCDF (complementary cumulative distribution function) function used to represent the PAPR value because PAPR is the random variable and 1-CDF that is complementary cumulative distribution function is used to represent PAPR.

**V. RESULT AND DISCUSSION**

The change in the PAPR value can be observed with help of mat lab. Let us consider the value of \(M=8\) and apply PTS scheme. The obtained graph shows the PAPR0 attains the value of 8.5. Searching the optimal phase factors has been a very difficult problem.. In order to reduce the search complexity, the selection of the phase factors is limited to a set of finite number of elements. According to this concept of OFDM transmission we should make a data block considering \(N\) number of symbols from the constellation plot. Where \(N\) is the number of sub carriers to be used. In PTS, the input data sequences have been multiplied by each of the phase factors to generate alternative input symbol sequences. Each of the alternative input data sequences is made the IFFT operation, and then the one with the lowest PAPR is selected for transmission. Therefore, the ability of PAPR reduction in PTS depends on the number of rotation factors and the design of the phase factors \(\Omega\).

**Figure 2: Partial Transmit Approach**

Consider the \(N\) number of subcarriers in OFDM system. The composite transmit OFDM signal is given by

\[ X(u) = \frac{1}{N} \sum_{i=0}^{N-1} x(i) e^{j2\pi u i / N} \]

Where \(X(i)\) is the information symbol, \(x(u)\) describing the discrete time index, \(U\) stands for the samples of the OFDM signal.

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VI. CONCLUSION

High bit-rate transmission is possible using OFDM system. However the potential of the system is marred by the presence of high PAPR. PTS technique is examined here to reduce the PAPR. OFDM system efficiency increases due to the increase in the HPA performance. The outcome of the simulation in the Mat lab shows reduction in PAPR after the employment of PTS. From graph we can conclude that the PAPR has been efficiently reduced in the OFDM signal.

REFERENCES