A Comparative Study Between the BER Plot and PAPR Reduction Plot using The PTS Method and Concatenated Operation of Convolution Encoding, DCT and PTS Method in the OFDM System

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Abstract: PAPR (Peak Average Power Ratio) is one of the important components to be considered in any communication system. Continuous efforts have been applied in the direction to reduce PAPR. Here propose a system for Orthogonal Frequency Division Modulation (OFDM) to reduce the PAPR for and improve the Bit Error Rate (BER) for the developed system. In the proposed system an encoding technique followed by Discrete Cosine Transform (DCT) and PTS algorithm is incorporated to achieve the desired results. The generated output has been further given to OFDM. The Design has been implemented on MATLAB. The output obtained from the design has been compared with present design for obtained PAPR and also for the BER plot. It has also been observed that the design performance has been improved by 32 percent as compared to the design implemented in the recent past.

Keywords: Orthogonal Frequency Division Modulation (OFDM), Peak Average Power Ratio (PAPR), Discrete Cosine Transform (DCT), Partial Transmit Sequence (PTS).

Introduction

Multicarrier communication system is becoming popular due their advantages such as high data rate better security and low bit error rate. OFDM is one among the multicarrier techniques that is used in communication industry and has earned popularity. The technique is designed in a manner that there is a unique symbol provide to each of the carrier such that the security is improved also each carrier is allotted with binary data. The data occupied is further transferred to modulation technique namely QAM/PSK etc. The overall performance of the system is good implementation is better as compared to other modulation technique. Due to above advantages mentioned above the technique has found its application in various fields such as Digital Video Broadcasting (DVB), Wireless Metropolitan Area Network (WMAN) and Wireless Local Area Network (WLAN). One of the biggest challenges faced by the OFDM system is due to its own advantage multiple carriers. If signal is considered in time domain all the subcarriers of the system will be added together to compute the peak power. After observation it has been noticed that this peak power is much higher than the average power and hence it is necessary to minimize the ratio known as Peak to Average Power Ratio (PAPR). High PAPR results in various disadvantages such as complex design at transmitter. The transmitter for the signal with huge PAPR basically requires high gain amplifier of amplification factor which ultimately results in high power consumption and an inefficient system. Other disadvantages of the high PAPR is complex design and implementation for receiver section in terms of A/D convertors and D/A convertor. This complex design at the receiver also results in reduction of power amplifiers efficiency.

PAPR has got a standard value of 12 for the OFDM based signal. In any condition if the value increases more than 12 there is a need to use high power amplifiers which will result in more power consumption. Hence, there is a huge necessity to reduce power consumption. Various technique has introduced in order achieve the minimum PAPR of the OFDM signal. The well known techniques are Selected Mapping (SLM), Clipping and PTS. Simplest method of all the technique is clipping architecture. In this method the OFDM signal with some amplitude above the given threshold value is clipped off in order to maintain the average power. This is quiet simple but give rise to loss of data for the system. Other technique used for the reduction is SLM in the process of execution a series of sequences are generated using Linear Feedback Shift Register (LFSR).

The generated data is inserted in the main data sequence before the signal is mapped in modulation technique. The generated sequences are compared for the PAPR and the sequence with reduced PAPR is selected by the system for the transmission. The process is bit complicated and lengthy due to which throughput of the system is affected. One very important technique is PTS in this method the data sequence from the OFDM signal is grouped in to set of disjoint set. Each set further is appended with zeros so that they get to the original size. Once the data is of equal length they are multiplied with the phase value for different combinations. These products are further used for computational of PAPR values. The stream with the minimum value of PAPR is shortlisted from the set and is transmited.

Previous System

Lot of efforts has been put from different researchers and developers in order to optimize the design and reduce the PAPR. OFDM signal includes a lot of individual modulated subcarriers, which creates a problem of PAPR. It is not possible to transmit the high peak amplitude signal to the transmitter without minimizing peak amplitude. Hence to minimize the peak before transmission. To slove with the PAPR problem more numbers of methods have been implemented and presented in the literature. These techniques include amplitude clipping and filtering [3-4], tone reservation (TR) and tone injection (TI) [5], Active Constellation Extension (ACE) [6], and multiple signal representation techniques such as selective mapping (SLM) [7], partial transmit sequence (PTS) [8], Iterative flipping algorithm [9]. These techniques achieve PAPR minimization at the cost of increase in transmit signal power and bit error rate (BER). The data rate loss and computational complexity also increases [2].

Proposed Method

One of the techniques used to reduce PAPR in OFDM system is Partial Transmit Sequence (PTS), which is implemented in this paper. The basic idea of this method is to split the original OFDM symbol data into sub carriers which is transmitted through the sub-blocks which are then expanded by the weighing value which are divergent by the phase rotation factor. The phase rotation factor is choosen such a way that the optimum value which has low PAPR.

In OFDM the powerful probabilistic based PAPR minimization technique is Partial Transmit Sequence (PTS). In this scheme the original data X is sub divided into N non-overlapping sub data blocks. In each sub data block the sub carriers are weighted by a phase rotation factor. The selection of phase rotation factors makes sure that the PAPR is redueced.

The divided input data X is denoted as

$$X^{(m)} = \left[X_0^{(m)}, X_1^{(m)}, X_2^{(m)}, \dots \dots \dots, X_{N-1}^{(m)}\right] \quad \text{(Eq. 1)}$$

$$m = 1,2, \dots, M$$

The sum of all the sub blocks is the original signal, which is given by

$$X = \sum_{m=1}^{M} \mathrm{X}^{(\mathrm{m})} \quad \text{(Eq.2)}$$

The proposed algorithm is shown in Figure 1.

In the proposed method, the input data is converted into binary stream. The binary stream is encoded by using the Convolutional Encoding technique as shown Figure 2.

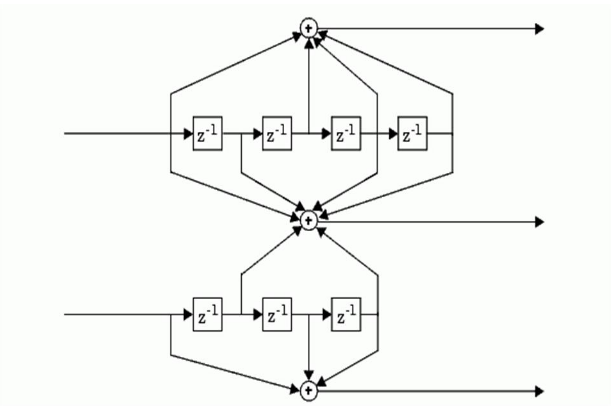

Figure.2. Convolutional Encoder

This example uses the rate 2/3 feed forward convolutional encoder depicted in the figure (2). Then the encoded binary stream is subjected to the QAM – M modulation where M is the M array value. The modulated signal is subjected to the Discrete Cosine transformation (DCT).The 2D - DCT equation is shown below

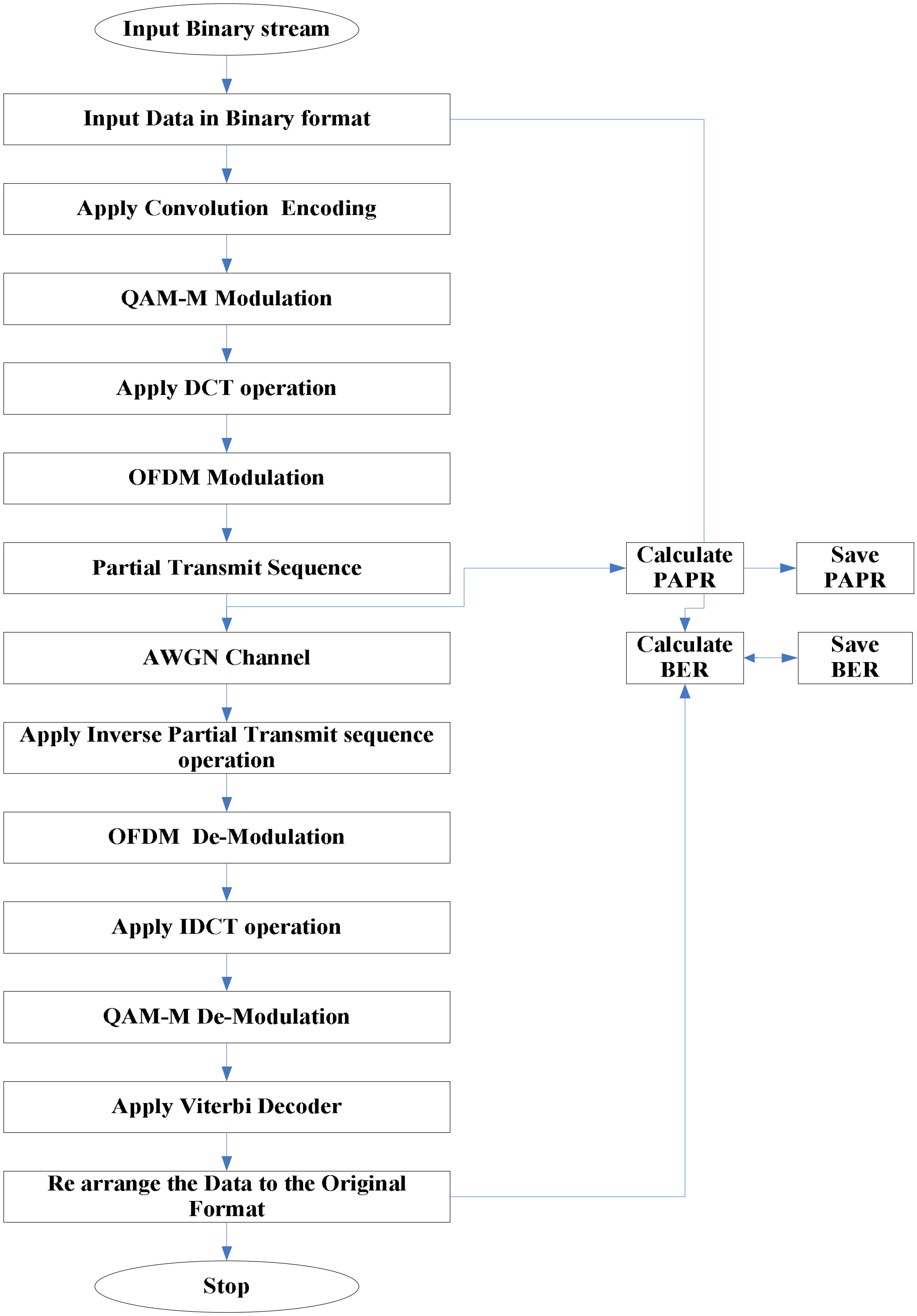

Figure.1. Proposed Algorithm

$$DCT(i,j) = \frac{1}{\sqrt{2N}} C(i)\, C(j) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} pixel(x,y) \cos\left[\frac{(2x+1)i\pi}{2N}\right] \cos\left[\frac{(2y+1)j\pi}{2N}\right]$$

$$C(x) = \frac{1}{\sqrt{2}} \text{ if } x \text{ is } 0, \text{ else } 1 \text{ if } x > 0$$

--------------- (Eq. 3)

For DCT data, OFDM modulation is applied by using the IFFT operation.

$$X_p = \sum_{n=0}^{N-1} x_n\, e^{-j\frac{2\pi}{N}np}, \quad p \in \{0, 1, ..., N-1\}$$

---------------- (Eq. 4)

Here Xp is the OFDM signal, for this signal, Partial Transmit Sequence (PTS) is applied. The PTS algorithm operation is shown Figure 3.

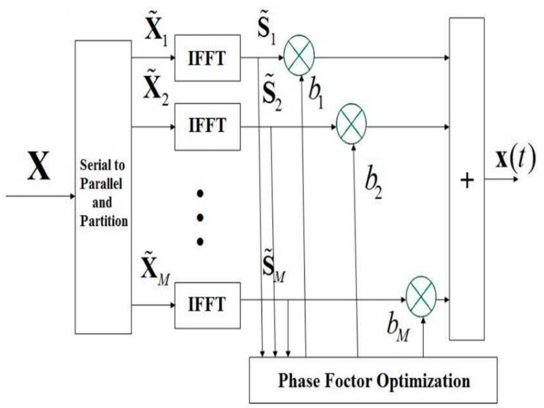

Figure.3. PTS algorithm

The OFDM specifications are shown in Table 1

Table.1.The OFDM specifications

Parameter	Value
N_{sd}: Number of total data subcarriers	48
N_{sp}: Number of total pilot subcarriers	4
N_s: Number of total subcarriers	52 (N_{sd}+ N_{sp})
Δf: frequency spacing in subcarrier	0.3125MHz (=20MHz/64)
T_{fft}: IFFT/FFT period	3.2μs (1/Δf)
$T_{preamble}$:PLCP preamble duration	16μs (T_{short}+ T_{long})
$T_{preamble}$: Duration of signal symbol of BPSK-OFDM	4μs (T_{gi} + T_{fft})
T_{gi} : Guard band interval duration	0.8μs (T_{fft} /4)
T_{sym}: Symbol interval	4μs (T_{gi} + T_{fft})
T_{short} : Short training sequence duration	8μs (10*T_{fft} /4)
T_{long} : long training sequence duration	8μs

Then the PTS modified signal is passed through the AWGN channel ranging from-30 dB to +30dB. At the receiver end, Inverse partial transmit sequence is applied. Then the OFDM demodulation is applied. Then IDCT operation is applied. Then QAM-M demodulation is applied. Then the Viterbi decoder is applied. The received data is rearranged to get back the original format. The received data is compared with input data with respect to the bit error rate. The computer simulations are shown using the Matlab Programming language. Here binary random data is given as the input data. The PAPR plot for the PTS algorithm and proposed algorithms are shown below. Along with the PAPR plot, BER plots are shown in figures (4) and (5).

Results

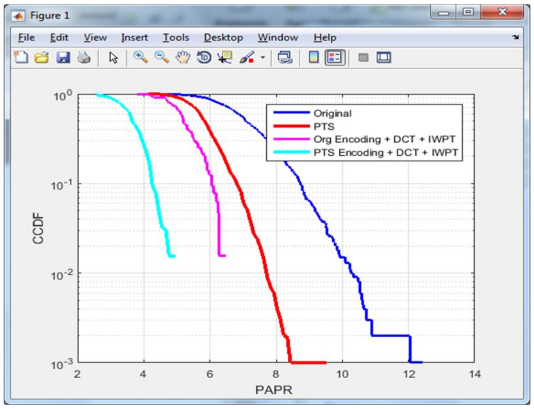

Figure.4. PAPR plot results of the PTS algorithm and the proposed algorithm

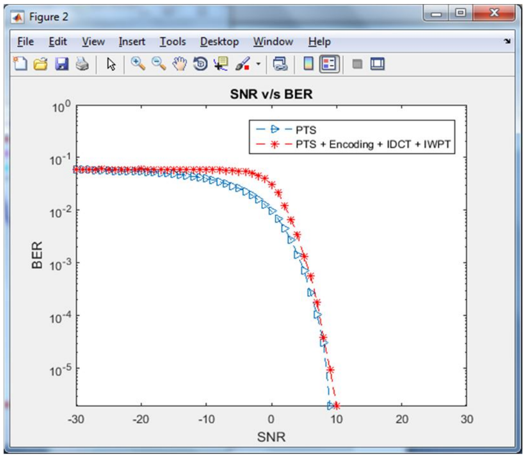

Figure.5. The BER plot obtained by comparing the input data with received data recovered by using the reverse PTS operation and reverse concatenation operation of Encoding, DCT and IWPT

Figure.4 shows the plot between PAPR and CCDF for different coding techniques. One can observe that there is significant amount of PAPR reduction in proposed method. When compared with other conventional methods. Figure.5 shows the BER plot for the proposed method. It shows that the proposed method performs better in minimising PAPR without compromising the BER.

Conclusions

A OFDM System that composed of a transmitter and receiver has been designed in the proposed work. One of the major contributions during the development of the proposed work is the concatenation of DCT and PTS. It can be observed that by combining DCT and PTS, able to achieve the reduction in the PAPR as compared to other implementation The system has also been tested for the BER parameter and it can be concluded that the presented system with novel architecture has better BER with almost minimal data loss. This has been achieved due to the use of encoding and decoding scheme at the transmitter and receiver section before main OFDM section. The overall performance of the system is improved and can conclude the presented system is efficient and better in terms for reduction of PAPR and improvement in BER.

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