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A Study on PAPR Reduction in OFDM System using Hybrid Continuous Modulus Algorithm

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ABSTRACT

PAPR is a generic problem in OFDM system. Loss of data at transmitter and receiver end is an inherit part of communication system. Different techniques have been proposed to solve this PAPR problem based on artificial intelligence. A PAPR reduction way for OFDM system is proposed, inspired by constant modulus property known as weight pattern hybrid continuous modulus algorithm. This coupled with the idea of weight pattern to change the scale of convergence with alter step size for optimal solution. Proposed method is tested on OFDM system for PAPR value and comparison is made with different techniques in literature. Test results shows the efficacy of projected method.

Keywords: PAPR, OFDM.

1. INTRODUCTION

OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Each sub-carrier is modulated with a conventional modulation scheme (such as quadrature amplitude modulation or phase-shift keying) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. OFDM is a method of encoding digital data on multiple carrier frequencies. OFDM has developed into a popular scheme for wideband digital communication, whether wireless or over copper wires, used in applications such as digital television and audio broadcasting, DSL Internet access, wireless networks, power line networks, and 4G mobile communications [1]. OFDM has been used for the purpose of video broadcasting, digital audio and for Asymmetric Digital Subscriber Line (ADSL) wired links which provides high data rates. OFDM has also been standardized for various wireless systems such as digital TV systems, digital radio systems, mobile TV, wireless personal area network (PAN), wireless networking standard HIPERLAN2 and as the IEEE standards such as 802.11a,802.11g 802.11n, 802.11ac and others in the US, capable of providing data rates between 6 and 54Mbps. It has also been implemented for different broadcast systems as well as including Digital Radio which communicates in the long medium and short wave bands. Orthogonal Frequency Division Multiplexing is a digital transmission Scheme introduced to meet the growing petition for the faster speed of the systems and the communication systems which can be applicable in both wired and wireless surroundings, providing high data rates [1].

ADVANTAGES OF OFDM

i) High spectral efficiency as compared to other double sideband modulation schemes, spread spectrum, etc.
ii) Can easily adapt to severe channel conditions without complex time-domain equalization.
iii) Robust against narrow-band co-channel interference, Robust against intersymbol interference (ISI) and fading caused by multipath propagation.
iv) Efficient implementation using Fast Fourier Transform (FFT).
v) Low sensitivity to time synchronization errors.

DIS-ADVANTAGES OF OFDM

i) Sensitive to Doppler shift.
ii) Sensitive to frequency synchronization problems.
iii) High peak-to-average-power ratio (PAPR), requiring linear transmitter circuitry, which suffers from poor power efficiency.
iv) Loss of efficiency caused by cyclic prefix/guard interval.

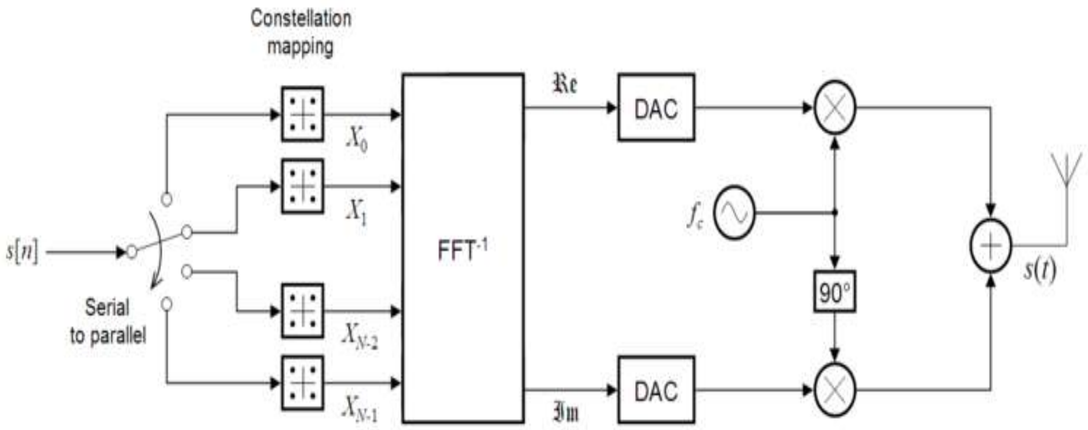

Fig1: Block diagram of OFDM transmitter

An OFDM carrier signal is the sum of a number of orthogonal sub-carriers, with baseband data on each sub-carrier being independently modulated commonly using some type of quadrature amplitude modulation (QAM) or phase-shift keying (PSK). This composite baseband signal is typically used to modulate a main RF carrier. $s[n]$ is a serial stream of binary digits. By inverse multiplexing, these are first de-multiplexed into N parallel streams, and each one mapped to a symbol stream using some modulation constellation (QAM, PSK, etc.). Note that the constellations may be different, so some streams may carry a higher bit-rate than others. [2]

An inverse FFT is computed on each set of symbols, giving a set of complex time-domain samples. These samples are then quadrature-mixed to pass band in the standard way. The real and imaginary components are first converted to the analogue domain using digital-to-analogue converters , the analogue signals are then used to modulate cosine and sine waves at the carrier frequency, f_c, respectively. These signals are then summed to give the transmission signal, $s(t)$.

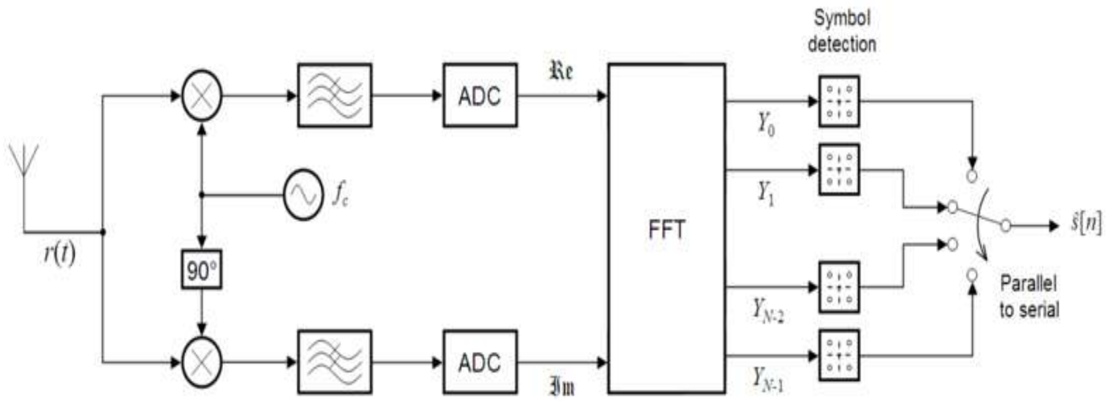

Fig 2: Block diagram of OFDM Receiver

The receiver picks up the signal $r(t)$, which is then quadrature-mixed down to baseband using cosine and sine waves at the carrier frequency. This also creates signals centred on $2f_c$, so low-pass filters are used to reject these. The baseband signals are then sampled and digitised using analog-to-digital converters (ADCs), and a forward FFT is used to convert back to the frequency domain. This returns N parallel streams, each of which is converted to a binary stream using an appropriate symbol detector. These streams are then re-combined into a serial stream , $\hat{s}[n]$, which is an estimate of the original binary stream at the transmitter.

Sequential Quadratic Programming

SQP is one of the most popular and robust algorithms for non-linear constraint optimization. Here, it is modified and simplified for the phase optimization problem of PAPR reduction, but the basic configuration is as same as general SQP. The algorithm proceeds based on solving a set of subproblems created to minimize a quadratic model of the objective, subject to a linearization of the constraints. The SQP method has been used successfully to many practical problems, see [12-14] for an overview. An efficient implementation with good performance in many sample problems is described in [15].

Quadratic Programming

In a quadratic programming (QP) problem, a multi-variable quadratic function is maximized or minimized, subject to a set of linear constraints on these variables. Basically, the quadratic programming problem can be formulated as: minimizing f(x) = 1/2 xT C x+ cT x with respect to x, with linear constraints Ax ≤ a ,which shows that every element of the vector Ax is ≤ to the corresponding element of the vector a .

2. LITERATURE SURVEY

Y.-C.Wang et.all develop an optimized ICF(Iterative clipping and filtering) method which determines an optimal frequency response filter for each ICF iteration using convex optimization techniques. The design of optimal filter is to minimize signal distortion such that the OFDM symbol's PAPR is below a specified value. Simulation results show that our proposed method can achieve a sharp drop of CCDF curve and reduce PAPR to an acceptable level after only 1 or 2 iterations, whereas the classical ICF method would require 8 to 16 iterations to achieve a similar PAPR reduction. Moreover, the clipped OFDM symbols obtained by our optimized ICF method have less distortion and lower out-of-band radiation than the existing method. [4]

LOU Xiaocui et.all proposed a precoding scheme using a new encoding method of zerolization .The obtained results show that this pre-coding method is not only reducing the PAPR with low complexity, also has well performance in Bit Error Rate(BER) since it has no effect on the magnitude. The novel method proposed here is based on zerolization which is used in the signal pre-coding block, and all the signals would be transformed into the ones with low PAR. It improves the performance of the PAPR in the OFDM, without cutting the data. [5]

V.Vijayarangan et.all prposed 'Low Crest Mapping (LCM)' technique for Reduction of PAPR in OFDM Systems. This new technique is a simple and novel one without any increase in Bandwidth and no in-band and out-of-band distortions apart from its simplicity. Simulation results show a considerable reduction in the PAPR when the Low Crest Mapping (LCM) is applied to a sample of Four/Eight Sub carriers with BPSK Modulation. The performance of this Low Crest Mapping Scheme has been investigated with the specific example of four carrier signal and eight carrier signals. The simulation results show a PAPR reduction of 2.57 db is achieved for four eight carrier signals. This reduction in PAPR is achieved without any increase in bandwidth and increase of transmit power. This Low Crest Mapping (LCM) technique has the potential to remove the obstacle in the way of wide spread adoption of Multicarrier transmission systems for the future generation mobile wireless air interface standards. [6]

Hem Dutt Joshi et.all proposed a combination of pre-coding and clipping technique to reduce PAPR. This dual operation of precoding and clipping provides better PAPR than both conventional pre-coding and clipping method. With this technique, the PAPR can be reduced without increasing roll-off factor. The bit error rate (BER) has also been taken as performance evaluation parameter.it reduces the overhead in comparison to conventional pre-coding method. Increasing the roll-off factor degrades the BER .The clipping after pre-coding reduces PAPR but degrades BER. However this degradation in not significant in comparison to degradation obtained by increasing roll off factor. [7]

Lin Yanget et.all presented Selective mapping (SLM) one of the most promising techniques which has been shown to offer PAPR reductions of several dBs. The SLM technique requires invoking the IFFT process several times per transmitted OFDM-block increases the system complexity and hence results in long latencies and high power consumption. A novel post-IFFT PAPR reduction technique combined with a strategy for generating a unique time-domain sequence per OFDM block that can minimize the PAPR .When compared with the ordinary SLM technique the PIAT technique is shown to be able to achieve huge complexity reductions while at the same time has a better overall PAPR reduction ability than the SLM technique[8].

Hongxian Chen et.all presented to reduce the peak-to-average power ratio (PAPR) of the orthogonal frequency-division multiplexing (OFDM) signal, a novel null subcarrier shifting scheme is proposed in an intensity-modulated direct detection OFDM system. At the receiver, a constant subcarrier is used as the location information to implement demodulation accurately; computational complexity is reduced by adopting the proposed method. The experimental results show that the PAPR reduction of the OFDM signal can reach about 2 dB. [9]

Matthias Gayy et.all presents a scheme combines two well-known techniques, selected mapping (SLM) and clipping in an adaptive way. Allowing an affordable PAPR, which might be exceeded with very small probability, the proposed method aims at minimizing the instantaneous number of clipped peaks per OFDM frame to limit the resulting transmit signal distortion. Using Compressed Sensing based algorithms which account for the potential variation of the number of clips per frame; this clipping strategy directly translates into an improved receiver-side peak reconstruction compared to choosing a fixed number of clipped peaks. [10]

Anusha Chacko et.all proposed a technique in which to provide solution for the problem when High PAPR force the High Power Amplifier (HPA) to operate in its linear region with wide dynamic range, where the power efficiency is very poor. The poor power efficiency makes the reduction of PAPR more important in OFDM systems. Selected Mapping (SLM) is a promising technique to reduce the PAPR. The proposed technique is a modification of the conventional SLM. SLM technique the data sequence is multiplied with each phase sequences generated. And thus sequences which carry same information are formed. From these signals the signal with minimum PAPR is selected for transmission. [11].

3. PROPOSED METHOD

3.1 Research Gap in the Previous Researches

1) Complex Mathematical Formulation

2) Local Minima Trap

3) Memory Consumption

4) Compromised Accuracy

5) Slow Computation

3.2 Advantages of Proposed Method

1) Computation efficient

2) Fast

3) Reliable

4) Global Solution

5) Less Memory consumption

3.3 Objectives

1) Development of Weight Pattern Hybrid Continuous Modulus Algorithm

2) Evalution of Weight Pattern Hybrid Continuous Modulus Algorithm on OFDM system

3) Comparison of Weight Pattern Hybrid Continuous Modulus Algorithm with other techniques in literature

3.4 MIMO-OFDM

A basic point to point MIMO communication system consists of *Mt* transmit antennas and *Mr* receive antennas. Space-time block codes (STBC) are designed to form the transmission blocks which exploit both diversity and multiplexing gain in MIMO. In MIMOOFDM, the transmit sequences of multiple antennas are mapped to parallel symbols and then modulated by the IFFT operation to form the OFDM transmit blocks. Accordingly, the concept of time in the MIMO STBC is analogous to frequency in a MIMO-OFDM system and it is referred to as space frequency block codes (SFBC) . As the transmit symbols are divided over different time slots in STBCs, in MIMO-OFDM the whole OFDM band is divided into several sub-bands and each sub-band is called a cluster. WiMAX and LTE standards specify two main modes of transmitting pilots: common pilots and dedicated pilots. Here, dedicated pilots allow per-cluster beamforming since channel estimation is performed per cluster [2]. Note that the whole band is divided into *C* clusters while each cluster spans a portion of time and frequency 2. The number of subcarriers in each cluster denoted by *Nc* and we assume *Mt* OFDM blocks are sent over *Mt* number of antennas in one time slot.

4. SIMULATION RESULTS

4.1 Layout

In this, we have investigated SLM and WPHCMA technique to reduce PAPR in OFDM system. Different studies have been carried out. Results are compared with literature.

4.2 Simulation Investigation

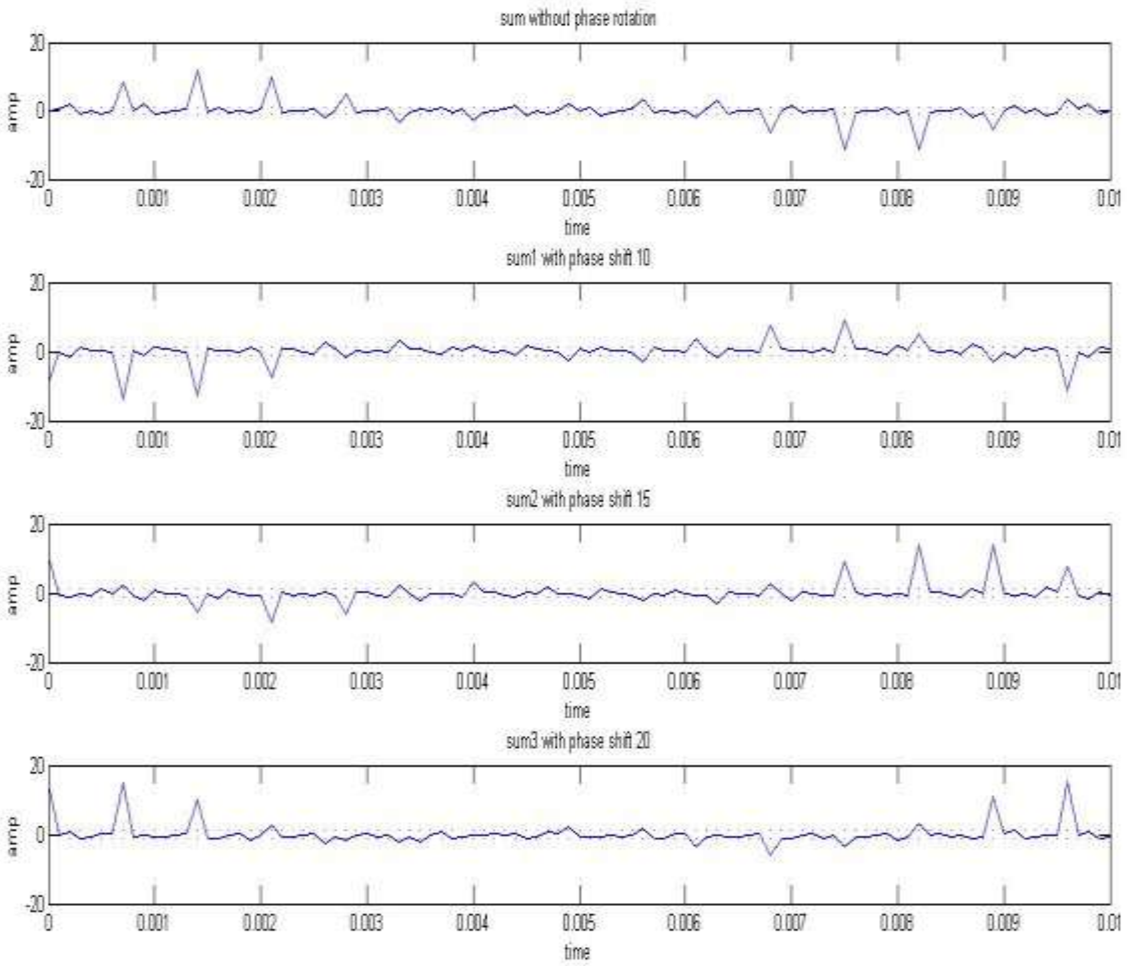

Fig 4.1: Varition of amplitude of sub transmission carriers at different phases

In fig 4.1, variation of amplitude of different sub carriers at different phases with difference of 10 degree have been reflected.

Table 4.1. PAPR Values with SLM

Phase Rotation (Radian)	PAPR Value (db)	CCDF
0	29	4.0696e-12
10	22	4.4631e-09
15	31	5.5067e-13
20	32	2.0250e-13

As PAPR is varied according to phase, it is observed that PAPR is minimum at phase of 10 in OFDM system. Lower PAPR means uniform distribution of signal.

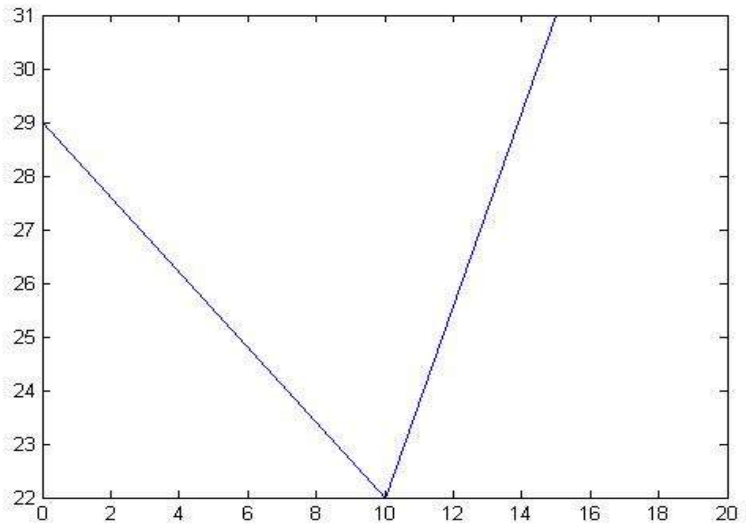

Fig 4.2: PAPR vs. Phase Rotation

CONCLUSION

In this research, WPAHMA is proposed to solve PAPR reduction problem in OFDM system. Weight pattern functionality is incorporated to enhance the solution search capability of proposed method. Proposed method is tested on OFDM case study. Test results show the reduced PAPR value as compared to other methods like PSO, SQP, ASQP, PTS, CP-PTS etc in literature. Hence, WPAHMA is effective in solving the problem of PAPR in OFDM system.

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