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An ICTF-TPWC Approach To Reduce PAPR of The OFDM System

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ABSTRACT: *One of the important factor to be considered in a communication system is its peak to average power ratio. In this paper an effective technique named Iterative Companding Transform and Filtering –Two piecewise Companding (ICTF-TPWC) is preferred which decreases the Peak to Average Power Ratio (PAPR) as well as Bit Error Rate (BER) in an Orthogonal Frequency Division Multiplexing (OFDM) signal. Here it can be seen that without conducting de-companding at the ICTF receiver it can offer improved BER. In simulations comparisons of traditional ICF technique with proposed ICTF-TPWC technique is done in which ICTF-TPWC reduces the complexity by reducing the number of Iterations when compared to ICF to reach the required PAPR with lesser complications. ICTF-TPWC scheme offers a good BER performance when compared to the traditional techniques.*

KEY WORDS:*OFDM, ICF, ICTF-TPWC, PAPR.*

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I. Introduction

One of the technology considered for 4G wireless communication is OFDM (Orthogonal Frequency Division Multiplexing) a Multicarrier Modulation (MCM) Technique due to its simple implementation. There are many effective features in an OFDM system such as robustness against multipath fading, highly efficient in case of bandwidth, avoids inter symbol interference, etc... but one serious drawback with OFDM is its high Peak to Average Power Ratio (PAPR) [2], which leads to an In Band Distortion (IBD) and Out of Band Distortion (OBD),so in order to overcome these drawbacks multiple techniques such as Selective Mapping (SLM), Clipping and Filtering (CF) ,Partial Transmit Sequence (PTS) have been proposed. Clipping and Filtering (CF) is the simplest technique among the above mentioned techniques [2], but clipping will lead to Out of Band Distortion (OBD) which causes spectral spreading and can be eliminated by performing filtering process after clipping the signal while the In Band Distortion (IBD) will reduce the performance of an OFDM system by degrading the Bit Error Rate (BER). So in order to rectify these drawbacks a better solution is Companding Transform (CT) technique which will compress the signal softly instead of clipping the signal peaks hardly. There are many linear and Non-linear CT methods such as μ – law companding ,Exponential Companding (EC).But in these methods PAPR is reduced at the cost of limited BER degradation and serious Out of Band spectral spreading , so in this paper from above discussion it can be observed that the proposed ICTF-TPWC (Iterative Companding Transform and filtering- Two-Piecewise companding) with reduced number of iterations is better than the existing ICF method which requires more number of iterations with increased complexity to get the desired reduction in PAPR [1].

II. Signal Distortion Techniques

In this the reduction in PAPR is achieved by distorting the transmitted OFDM signal before it passes through the power Amplifier.

2.1 Iterative Clipping and Filtering

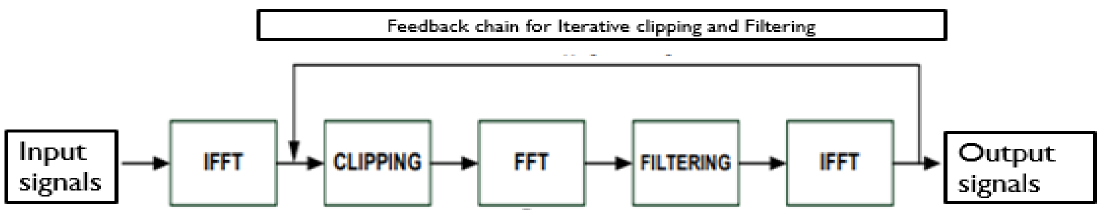

Fig.1 Block Diagram of ICF

The time domain signals is clipped in a clipping block as shown in Fig.1 the input signal is clipped which results in distorted output signal in which the high power peaks in the positive and the negative cycles are clipped, clipping is a very high nonlinear processing and leads to a serious in band and out of band distortions, by performing filtering the clipping the spectral efficiency can be preserved in an OFDM signal by elimination of the out of band interferences and improves BER performance but it can lead to peak power regrowth [3], so in order to overcome these kind of drawbacks with CF technique an Iterative Clipping and Filtering (ICF) technique is preferred to suppress the time domain peak regeneration caused by CF technique. However, to obtain the desired PAPR the process is iterated (repeated), the time domain signal is fed back to clipping as a first iteration process i.e. at i=1 the first OFDM symbol will enter into the Iterative clipping and Filtering process then clipping and filtering process is iteratively performed and in the I^{th} final iteration the output 'x' is produced [4].

2.2 Iterative Companding Transform and Filtering

Consider a QAM input as shown in Fig.2 which is subjected to time domain conversion from frequency domain using IFFT of NJ points, where switch K1 is set to 1 and let k=1, a new symbol enters in to the iterative loop then both K1 and K2 are open that is they are set to 2, where K1 and K2 are switches and x_0^m is companded by Companding Transform function using TPWC approach to generate y^m and now convert time domain signal y^m to frequency domain to generate b^m using FFT of NJ-points then the next step is to perform rectangular filtering in frequency domain on b^m to null the spectral components present out of band we achieve $b^{\sim m}$ which is converted to time domain symbol $x^{\sim m}$ .Now calculate the PAPR of $x^{\sim m}$ denoted by $PAPR^m$, if $PAPR^m \leq PAPR_{des}$ set S2 to 1 to transmit $x^{\sim m}$ and reset m=1, return to step 2 to repeat iteration for current symbol [1].

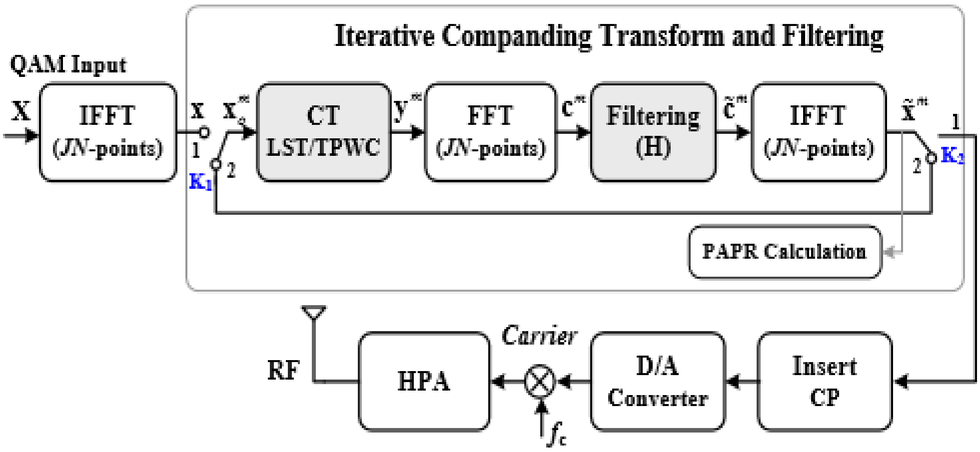

Fig.2 Block Diagram of ICTF

Where LST and TPWC are two linear transforms used in companding technique, LST (Linear symmetrical Transform) treats large and small signals with same scale this is one of the simplest CT profile which considers one parameter k (0<k<1), in order to keep the average signal power constant, k has to be a positive real number smaller than 1. [1]

TPWC compress the large signals while partially enhancing the small ones Two-piecewise Companding is the best in terms of PAPR reduction and BER performance , μ_2 and m are its parameters where m=1.2/1.6/2 is the modulated data, $u_1 > 1$, and $0 < u_2 < 1$ In order to keep the input and output of the TPWC transform at the same average power level these parameters are maintained at these values [1] .

The μ-law companding scheme focuses mainly on enlarging small signals does not change the signal peaks which increases the average power, μ is the parameter of μ-law,μ -Law companding increase the power level, and a big Mu parameter (μ =16) generates a higher power level in comparison with that of using a small Mu parameter (μ =1) and in this the companded signals still exhibit some quasi-Gaussian nature which Causes spectrum side lobe generation [5].

Exponential Companding has d degree as a parameter, in this we are considering d = 1 then the exponential companded signals have more uniform-alike distributions, and therefore can offer much smaller PAPR. (Its degree can be considered as d=2 but the results will be almost similar with slighter difference and the results for the cases d > 2 are found similar to that of d=2.) but the BER degradation is more by using this technique that is the reason we consider ICTF-TPWC technique which produces far less BER degradation than Exponential companding technique [6].

III. PAPR FORMULATION

Let us suppose that $X = [X_0, X_{1,} \dots\dots, X_{N-1}]^T$ denotes the sequence of data that is to be independently transmitted with N sub-carriers in an OFDM symbol. The OFDM symbol in time domain with J times as oversampling $x = [x_0, x_{1,} \dots\dots, x_{JN-1}]^T$ can be given as:

$$x_n = \frac{1}{\sqrt{JN}} \sum_{k=0}^{N-1} X_k . \exp\left(\frac{j2\pi nk}{JN}\right), \quad n = 0,1, \dots, JN-1, \qquad (1)$$

Mathematically the given symbol PAPR is given as:

$$PAPR(dB) = 10\log \frac{\max_{n\in[0,JN-1]}\{|x_n|\}^2}{\frac{1}{JN}\sum_{n=0}^{JN-1} |x_n|^2} (2)$$

Generally, the reduction capability of PAPR is measured by using Complementary Cumulative Distributive Function (CCDF). It is known as the probability of the particular signals PAPR crosses the specific threshold value $\gamma_0 > 0$, i. e.

$$CCDF(\gamma_0) = PROB\{papr > \gamma_0\} \approx 1 - (1 - e^{-\gamma_0})^N, \quad (3)$$

IV. FIGURES AND TABLES

Table.1 Comparison of PAPR

Parameters	ICF	ICTF-TPWC
Original symbol PAPR	10.8dB	10.8dB
Reduced PAPR by	5.6dB	4.8dB
Number of Iterations	8	3
Number of Subcarriers	1024	1024

4.1 Simulation Results

Fig.3 plots the Complementary Cumulative Distributive Functions (CCDF's) of the Peak to Average Power Ratio's (PAPR's) of the existing method Iterative Clipping and Filtering (ICF) and proposed method Iterative Companding Transform and Filtering (ICTF) with Two Piece-Wise Companding (TPWC) approach. These existing and proposed methods are compared with respect to PAPR of Original OFDM symbol that is the processed symbol of different PAPR reduction schemes is compared with the Original OFDM symbol.

In Fig.3 it can be clearly seen that ICTF-TPWC scheme with three (3) iterations can reduce the PAPR significantly when compared to ICF technique. There is a sharp drop in value of CCDF that is equal to 10^{-3}.The PAPR of Original OFDM symbol is 10.8dB where as the PAPR of proposed scheme ICTF-TPWC with three iterations is 6dB that is the PAPR is reduced by 4.8dB. whereas the existing technique ICF scheme with 8 iterations has the PAPR of ICF as 5.2dBreduces the PAPR by 5.6dB.The ICF technique obtains more reduction in PAPR than ICTF-TPWC but the number of iterations required for ICF is more which leads to increase in computational complexity and the Bit Error Rate (BER) degradation is more in ICF with 8 iterations when compared to ICTF-TPWC with three iterations. The Exponential Companding (EC) is one of the non-linear companding profile which obtains maximal reduction in PAPR that is 4.8dB but when it comes to BER degradation the ICTF-TPWC scheme produces less BER degradation when compared to EC. So the proposed ICTF-TPWC is capable to obtain improved BER performance while decreasing the PAPR significantly. In Table.1 the comparison of PAPR can be seen with respect to original PAPR.

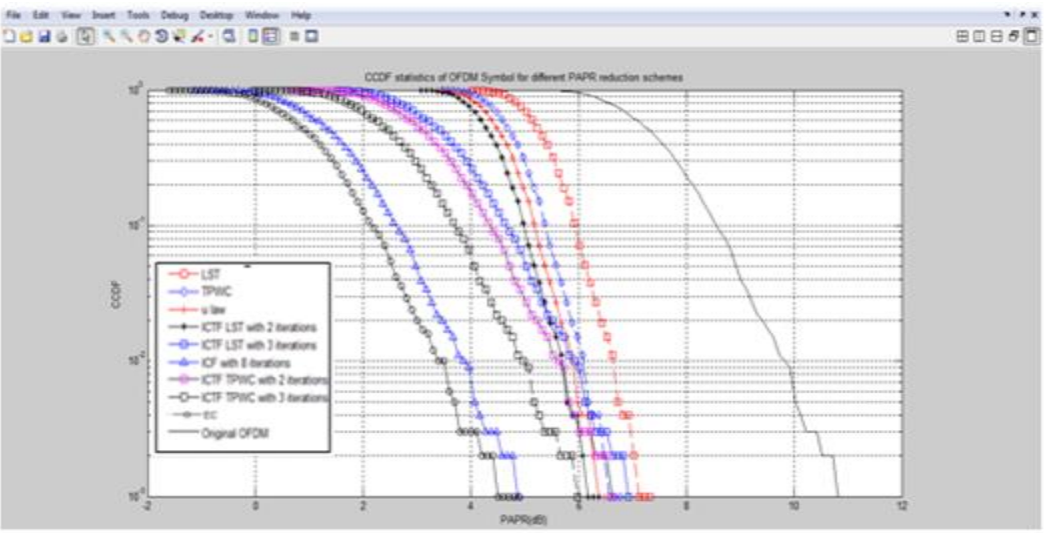

Fig.3 Comparison of PAPR between existing and proposed Techniques.

V. Conclusion And Future Scope

It can be concluded from above simulation results that ICTF-TPWC technique is best in terms of Peak to Average Power Ratio which reduces PAPR by 4.8dB whereas to reduce the similar amount of PAPR the existing method requires more number of iterations which leads to increase in computational complexity and degradation of bit error rate. This paper can be extended in future to find out the Bit Error Rates of these companding techniques and clipping technique using different channels such as AWGN and Rician Fading.

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