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Analysis of BER and Out-Of-Band Interference Enhanced Using ICTF Approach for PAPR Reduction

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***Abstract*— PAPR reduction in OFDM modulation scheme attains attention because of its high application ability. Tremendous work carried out in literature to solve the issue of PAPR but none can meet the desired result. Iterative companding transform and filtering is implemented in this work which achieves reliable trade-off between PAPR reduction and BER performance. Low OUT-OF-BAND interference is another significant approach of proposed work. Simulation results show good performance and reliable efficiency over traditional state of methods.**

Keywords— ICTF, PAPR, BER, OUT-OF-BAND interference.

I. INTRODUCTION

OFDM is known as multiplexing/modulation scheme and it acts on the “orthogonality principle”. OFDM offers high data and supports advance applications. Although OFDM have advantages over traditional communication models frequently suffer from timing jitter, relative fading, distortion and PAPR. The presence of PAPR results in Gaussian distributed output samples in OFDM. Inter-modulation among sub-carriers and undesired Out-of-Band Interference (OBI) are the resultant of PAPR.

PAPR presence has been area of concern in OFDM and vast amount of research has been carried out using different techniques like Clipping and Filtering (CF), Tone Reservation (TR), Companding Transform (CT), etc. But none of the above techniques succeed in achieving the desired result. Clipping and filtering technique architecture remains easy to tackle the issue of PAPR but presence of significant OBI, in-band distortion and nonlinear processing makes this technique unused in real time. Compare to in-band distortion, OBI is more critical because it severely interferes with the radio communications in adjacent channels.

In the paper, enlightened by the iterative filtering approach in ICF method, an Iterative CT and Filtering (ICTF) technique is proposed for reducing the PAPR of OFDM signal. By using an iterative procedure, ICTF can obtain a significant PAPR reduction as well as an improved BER performance simultaneously Moreover, to tackle with the OBI issue, a frequency-domain filtering is adopted for minimizing the out-of-band spectral regrowth. In addition, when compared to classic ICF method, ICTF dramatically decreases the number of required iterations to obtain a desired PAPR with lower computation complexity. Specifically, it is shown that the ICTF without de-companding operation at the receiver offers a good BER performance.

2. PROPOSED METHOD

Communication domain comprises of three important parts namely (i) Transmitter, (ii) Receiver and (iii) Channel. In proposed method both AWGN channel and SUI channel for reliability and efficiency.

(A) Channels

AWGN- the short form of Additive White Gaussian Noise, mainly applies to semi-flex or coaxial cable between transmit and receive path or applicable to space communication. It takes care of thermal noise available in the channel or generated in electronic devices at transmitter and receiver.

SUI channel model- Designed for fixed WiMAX system implementation as per IEEE 802.16-2004 OFDM specifications. In order to investigate the performances of OFDM based BWA an accurate channel model needs to be considered. Usually all the wireless channels are characterized by path loss (including shadowing), multipath delay spread, fading characteristics, Doppler spread, and co-channel and adjacent channel interference. Ricean distribution can be used for characterization of narrow band received signal fading. In this distribution the key parameter is the K-factor, which is defined as the ratio of the “fixed” component power and the “scatter” component power.

(B) Description of the Proposed Method

International telecom union for radio frequencies (ITU-RF) has approved the bit error rate (BER) as performance evaluation parameter to get desired statistics of the signal. In OFDM, BER is gradually declined due to companding distortion and the sudden declination in BER performance is due to signal attenuation factor which compresses the original symbols. Minimization of OBI is another prominent factor to be considered and to successfully handle the problem of OBI a frequency-domain filtering is utilized in the latter stage. Finally the compression of peak signals came into control by performing the companding and filtering approaches for multiple times respectively till to achieve the desired result.

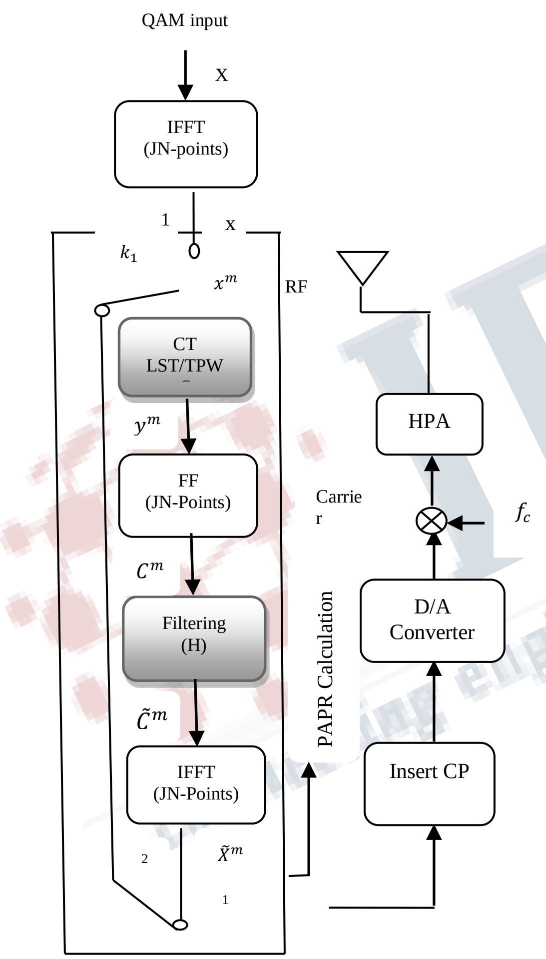

Figure 6: Proposed block diagram

OFDM offers high data rate at one end and on other end its performance is badly impacted by PAPR. The above block diagram design intended to mitigate the peak values in accurate way. Here OFDM system model is comprises of transmitter and receiver, while ICTF technique is deployed at transmitter end for PAPR reduction. Over-sampled Inverse IFFT operation is used to convert the complex vector $X \in C^N$ in accurate manner. Here two constants K1 and K2 are used to switch the single and multiple operations in respective iteration level. If K1 value is set to 1, then OFDM symbol $X \in C^{JN}$ is given as input to ICTF at the iteration, M=1 and these iterations are processed based on symbol-by-symbol process. In case, if both K1 and K2 are set to 2, then in that stage both companding and ICTF are used for the same ODFM symbol. In last iteration both constants values are set to 1 again to get the output as $\tilde{X}^m \in C^{JN}$ respectively. Assume $c^m \in c^{JN}$ and $\tilde{c}^m \in C^{JN}$ represented the frequency-domain OFDM symbol at mth iterative level (before and after filtering process).

(C) Quantify the Level of Companding Distortion

Although companding transform approach has achieved good results in PAPR reduction but usage of companding transform technique results in companding distortion which has significant impact on OFDM system performance. A natural question arises, how to quantify companding distortion because companding operation is extra operation added to OFDM system model and quantifying the companding distortion remains as concerned area. In proposed method signal attenuation factor (SAF) is used as equipped factor to quantify the level of companding distortion in effective way and SAF factor time-invariant for the non-stationary Gaussian signal.

$$\mathrm{SAF} = \frac{1}{\sigma^2}\int_0^{\infty} x \cdot f(x) \cdot p(x)dx, \quad (1)$$

- When SAF value is small then it corresponds to larger companding distortion (i.e. reduced BER)
- In companding function, both desired PAPR and SAF threshold value preset to select the parameters
- PAPR calculation of each current symbol is calculated in each iteration

(D) The proposed ICFT process is follow up as follows

Step 1: Initialization settings. Set $PAPR_{des}$, SAF_{thod} and the maximum iteration number M. Select companding parameters.

Step 2: Convert the frequency-domain symbol $\boldsymbol{X}$ to oversampled time-domain OFDM symbol $\boldsymbol{X}$ using NJ - points IFFT. Set K1 to 1 and let $= 1$, a new symbol

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enters the iterative loop. Then, both K1 and K2 are set to 2.
Step 3: if m=1, Let $X_0^1 = X$: otherwise let $X_0^m = \tilde{X}^{m-1}$
Step 4: $X_0^m$is companded by CT capacity to create y^m
Step 5: convert y^m to frequency domain to create c^m using NJ points FFT.
Step 6: Perform the frequency domain filtering on c^m using H_{rect} to null the out of band spectral components.
Step 7: Convert $\tilde{c}^m$ to time domain symbol $\tilde{x}^m$ using NJ points IFFT calculate the PAPR of $\tilde{x}^m$ denoted by $PAPR^m$.
Step 8: If $PAPR^m \leq PAPR_{des}$ or m>M set k2 to 1 transmit $\tilde{x}^m$ and reset m=1, return to step 2 to process the next original symbol otherwise let m=m+1,return to step 3 to repeat the iteration for the current symbol.

(E) Companding Distortion Analysis

The BER performance in ICTF procedure is investigated. Based on Bussgang theorem for real and complex Gaussian Signal, the companded signal can be approximately decomposed into two parts: the attenuated signal component and companding noise,ρ_n, i.e. $y_n = SAF \times x_n + \rho_n$. Thus, the transmitted symbol with 'm' iterations using ICTF can be approximately decomposed as$x_n^m = SAF^m \times x_n + \rho_n$

3. RESULTS

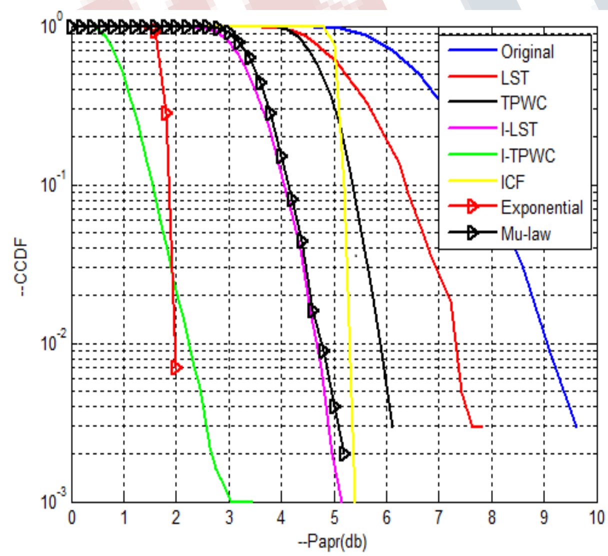

Figure 2: CCDF statistics of OFDM symbol for different PAPR-reduction schemes (N=1024, QPSK, and the over-sampling ratio J=4)

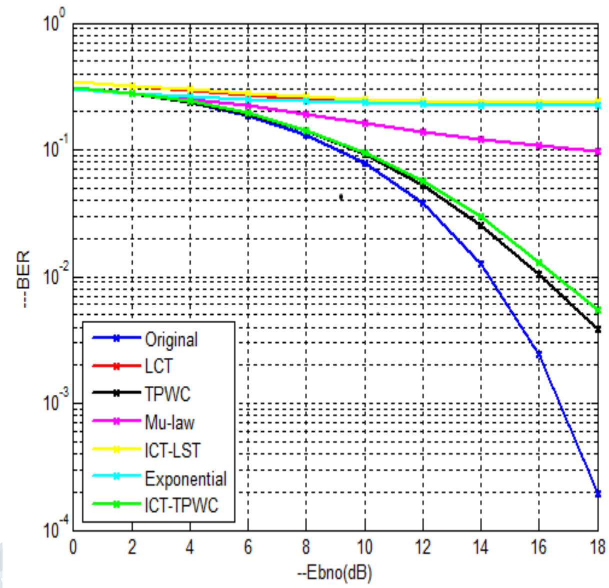

Figure 3: BER comparison for different PAPR-reduction schemes through AWGN channel for OFDM system (N=1024, QPSK)

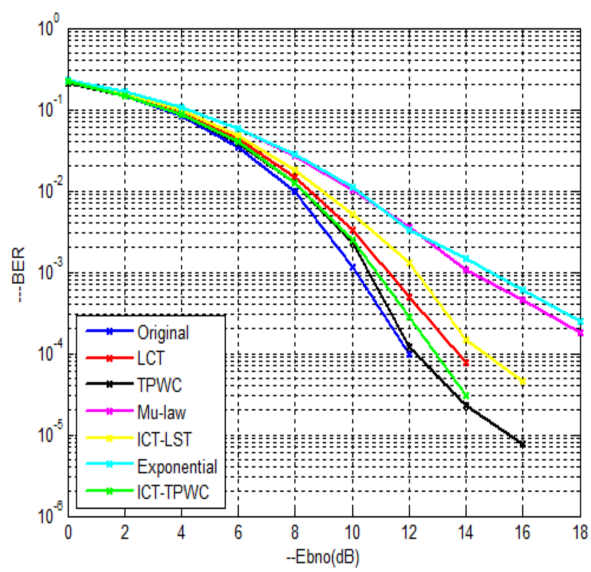

Figure 4: BER comparison for different PAPR-reduction schemes through AWGN channel for OFDM system (N=1024, 16-QAM)

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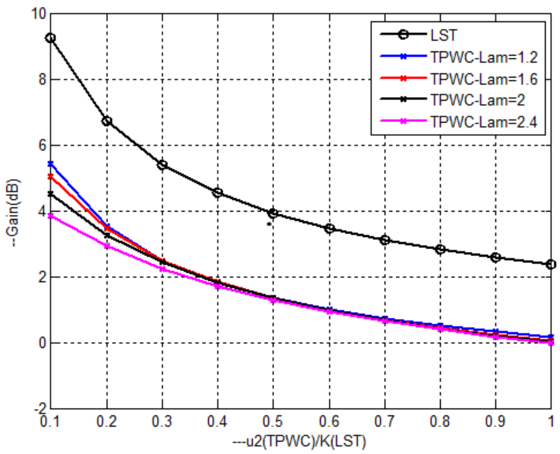

Figure 5: Theoretical transform Gain in PAPR

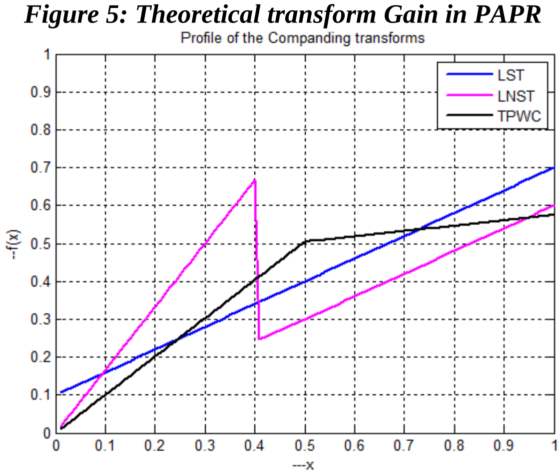

Figure 6: Transform profiles of LST, classic LNST, and TPWC

4. CONCLUSION

ICTF is an equipped approach has ability to reduce PAPR and improved BER performance. Both AWGN channel and SUI channel for reliability and efficiency. ICTF achieves good results over conventional techniques. the proposed ICTF technique not only obtains significant PAPR reduction with improved BER and OBI performance, but also dramatically decreases the iterations number. In addition, ICTF procedure can also be extended to other well known linear and nonlinear companding profiles.

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