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A Novel Blend Of Pre-Coding With RCF For PAPR Reduction In OFDM Systems

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Abstract: The desire to achieve maximum spectral efficiency in order for attaining high bit rate mobile communication open the doors for a new modulation technique called as orthogonal frequency division multiplexing (OFDM). High peak to average power ratio (PAPR) is considered to be one of vital drawbacks of OFDM system which makes the system complex and signal to suffer from spectral spreading and in-band distortion. In this paper a blend of pre-coding and repeated clipping and filtering (RCF) technique is used to diminish the high values of PAPR. The combined operation yields a fine recommended deduction in PAPR when compared with regular traditional pre-coding technique and RCF done separately. This paper emphasizes the execution and advantages of the postulated technique. The simulated results attached with the paper exhibits that the suggested method perceives a better PAPR and BER.

Keywords: OFDM, PAPR, Pre-coding, Repeated clipping and filtering (RCF)

1. INTRODUCTION

Today's wireless communication systems have open out to bear elevating number of subscribers and furnish extended data rate services in the restricted frequency resources. Orthogonal frequency division multiplexing (OFDM) is a special modulation technique of multiple carries. Here the bandwidth is divided into number of carries with each carrier modulated by a data stream of lower rates. The spectrum utilization of OFDM is very productive by dividing same bandwidth into multiple channels and orthogonally spacing between these channels halts closely spaced carrier interference. The use of orthogonal frequency division multiplexing conserves 50% of bandwidth and also abandons the requirement of high complex equalizers which are generally used in single carrier transmission techniques [1].

However OFDM have many advantages like effective bandwidth utilization, minimization of inter-symbol interference, easy implementation of modulation and demodulation using IFFT and FFT, easy equalization ,robustness to burst error and frequency selective fading it has a major drawback of having high values of peak to average power ratio (PAPR) [2]. This high PAPR occurs mainly when number of independent modulated subcarriers having same phase in an OFDM signal superimposed upon each other.

There are mainly two major problems arises due to the occurrence of high PAPR. One is because of the high dynamic range of the OFDM signal there is a need for the requirement of high complex analog to digital (A/D) and digital to analog (D/A) converters having capability of large number of bit convergence .As a result complexity and cost of the circuitry increases. Secondly due to this high PAPR the signal which is transmitted undergo remarkable spectral spreading in-band distortion which intern responsible for inter-modulation effect caused by nonlinear nature of power amplifier, mainly due to high dynamic range of input [3]. To curb this problem large power amplifiers having high power back off permitting power amplifier to run in the linear region is needed. But this results increase in the cost of transmitter equipment and lowers the life of battery at the user terminal. Thus there is a predominate requisite of well-organized schemes that can diminish the occurrence of large signal peaks.

There are various techniques proposed in the literature to decelerate the high values of PAPR. These techniques constitute coding methods, filtering and clipping methods, various companding techniques like tan-companding, μ-companding, root companding etc., probabilistic methods such as SLM and PTS. Out of all these techniques mentioned pre-coding is considered to be one of the best method because of its capability to improve PAPR with less complexity and without violating orthogonality phenomena between the channels [4]. The BER (bit error rate) performance is also elevated in pre-coding in analogy to traditional OFDM systems due to its gain diversity procured by data symbol spreading on various sub carriers. In addition to all these advantages the normal pre-coding technique has a disadvantage of reducing roll off factor to reduce the PAPR which results in the deceleration of BER performance. Therefore in paper an attempt of blending pre-coding and RCF (repeated clipping and filtering) was made to deliver an improved PAPR without any increment in roll of factor. Clipping is one of the easiest method of reducing PAPR .Clipping restricts the peak value of OFDM signal to a pre-determined level. Usually clipping is enabled at the transmitter end. Clipping method has a drawback of in-band distortion, so it is followed by filtering to eliminate this disadvantage [5], [6]. This novel hybrid method yields a better result by the virtue of initial pre-coding to make an almost constant envelope and there after repeated clipping and filtering diminishes the peak value.

2. SYSTEM MODEL

The discrete time integration of pre-coding and RCF having N-subcarriers is illustrated in Fig.1

In the illustrated system, initially a QPSK data encoder transforms the information input bits in to complex data symbols. Here we can use any type of encoder like BPSK, M-ary data encoder etc. The encoder is followed by a serial to parallel converter which mainly converts serial complex data into parallel bits. Next to serial to parallel converter we have pre-coding block. In pre-coding block we have pre-coding matrix. The pre-coding matrix can be Walsh-Hadamard Transform (WHT), Discrete Cosine Transform (DCT), Discrete Sine Transform (DST) and Discrete Hartley Transform (DHT). In this pre-coding block the pre-coding matrix is multiplied in prior with each data block.

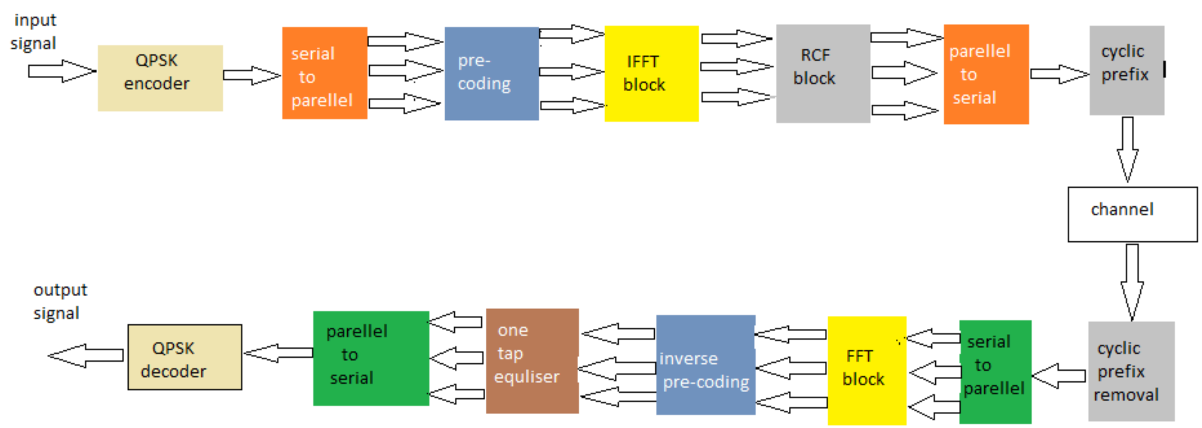

Fig.1 OFDM system model with the blend of Pre-coding and Repeated clipping and filtering

The DHT Pre-coded matrix is defined by $H_k = \sum_l^{L-1} z_l[\cos\left(\frac{2\,pi\,lk}{l}\right) + \sin\left(\frac{2\,pi\,lk}{l}\right)]$ .Here we use DHT as pre-coding matrix and IDHT (Inverse discrete Hartley Transform) as inverse pre-coding block. The resultant of pre-coding is fed to OFDM modulator. Here IFFT (Inverse Fast Fourier Transform) block acts as OFDM modulator and FFT (Fast Fourier Transform) as OFDM demodulator. After OFDM modulation the signal is iteratively clipped and filtered in RCF block.

In the RCF block the signal is clipped first. Here we go with time domain clipping after IFFT block. The clipping done here defined by equation bellow

$$Cp = \begin{cases} \sqrt{c_R * |\bar{x}|^2} * sig(x) & |x|^2 > c_{\bar{x}} \\ x & |x|^2 \leq c_{\bar{x}} \end{cases}$$

Where Cp represents clipped response of the time domain signal. $c_{\bar{x}}$ is threshold clipping level and c_R is the clipping ratio which is obtained by dividing clipping level with mean power of original signal.
The clipping is followed by the filtering. The filtering performed here is FFT filtering. After RCF block we will add cyclic prefix and send the signal through the channel.

3. SIMULATION RESULTS

The following Table represents the parameters used for simulation.

Table 1: LTE Simulation Parameters

Number of frames (FFT size)	128
Size of OFDM symbol	128
Clipping ratio c_R	1.5
Modulation type	QPSK
Pre-coding technique	DHT
Cyclic prefix length	13

PAPR is defined as the ratio of peak power to the mean power. The simulated results gives the information about PAPR of the original OFDM system without any reduction technique is 20.20dB, with only pre-coding we have 8.9 dB, with only RCF we have 12.22 dB and with the blend of pre-coding and RCF we have an improved PAPR of 5.30 dB. Generally OFDM signal power is expressed in chi-square distribution, while PAPR distribution is expressed in terms of Complementary Cumulative Distribution Function (CCDF). Fig.2 illustrates CCDF of PAPR for OFDM systems with integration of Pre-coding and RCF. From the simulated Fig it is observed that as the number of iterations of clipping and filtering the improvement in PAPR increase further.

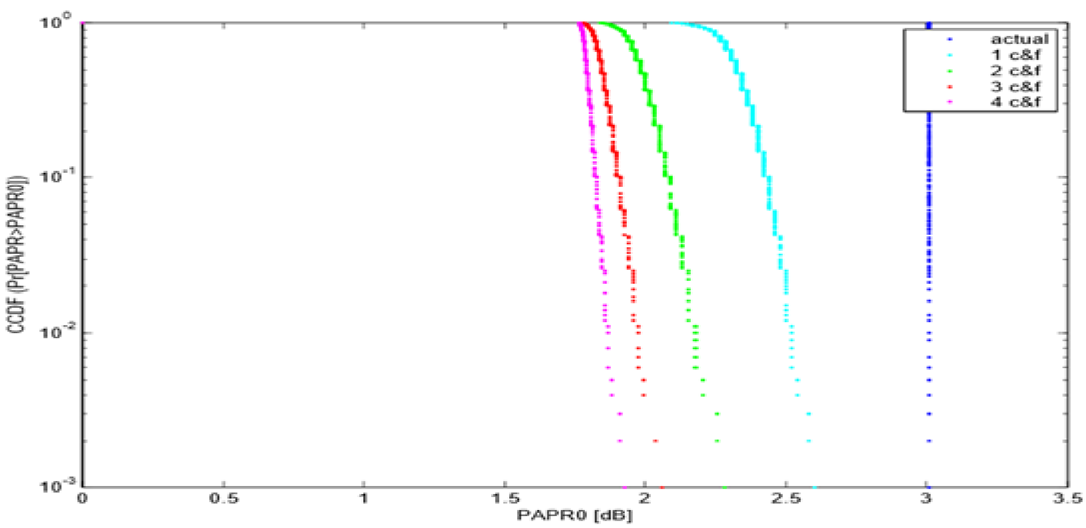

Fig 2 CCDF of PAPR for OFDM system with Pre-coding and RCF

Fig 3 illustrates the bit error rate (BER) of OFDM System with Pre-coding and RCF. From simulations it is observed that BER of 10^{-4} is obtained at SNR ≤13.

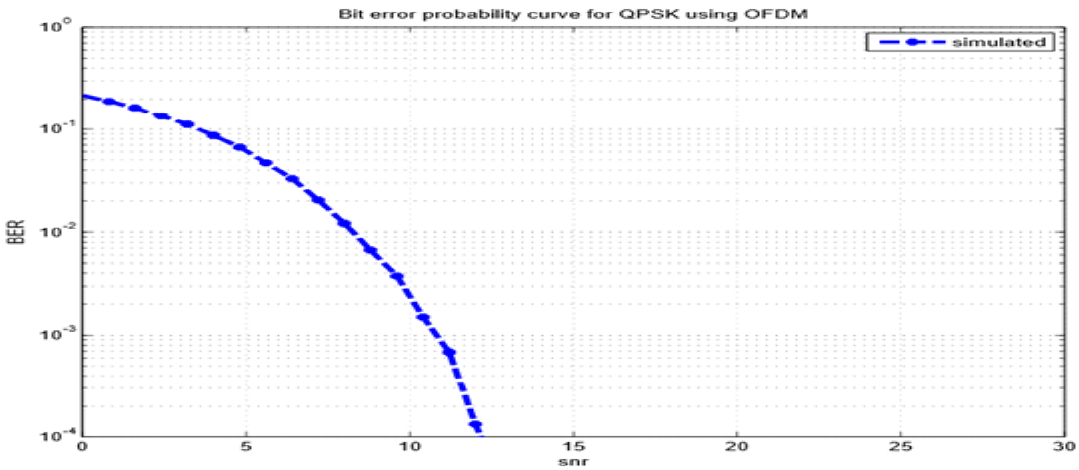

Fig.3 BER for OFDM system with Pre-coding and RCF

4. CONCLUSION

In this paper we have presented and scrutinized the execution of the blend of Pre-coding and RCF. We have found that improved PAPR is obtained with the use of the hybrid combination of Pre-coding and RCF technique in comparison with each technique used individually. The resulted BER with this technique also have a better performance.

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