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PAPR Reduction Technique Using Advanced Peak Windowing Method of OFDM System

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Abstract*—PAPR reduction techniques, peak windowing found its way into practical implementation without side information while maintaining a good spectral characteristic compared with the clipping method. In a real system, however, when successive peaks emerge less than a half of the window size, windows will unfortunately overlap. As a result, the signal peaks are suppressed much more than the required threshold and degrade the BER performance. we propose an advanced peak windowing method. The proposed method overcomes the drawback of the conventional one while maintaining almost the same spectral mask and providing more efficient BER performance

***Index Terms*—PAPR, BER, OFDM, Windowing Technique**

I. INTRODUCTION

The Orthogonal Frequency Division Multiplexing (OFDM) is a promising communication technique for achieving high data rate in wired and wireless environments. There are numerous benefits associated with OFDM systems. One of them is its high spectral efficiency due to the minimum spectral spacing between the subcarriers, attributed to their orthogonality. Also adaptive modulation schemes can be used on individual subcarriers, according to the transmission conditions on each subcarrier. Further this multicarrier transmission system can be implemented in the digital domain by using computationally efficient IFFT. Despite its multidimensional benefits of OFDM systems suffer however from a number of drawbacks. However, one major drawback is its high peak-to-average power ratio (PAPR) resulting in nonlinear distortion and degradation of bit error rate (BER) at the output of high power amplifier. The most straight forward way of mitigating this problem is to introduce an amplifier back-off, which provides sufficient head-room for the high modulated signal peaks to be amplified in the linear region. Of course, large amount of back-off results in a significant penalty in terms of the power efficiency. Therefore, an attractive solution for a cost effective system is to reduce PAPR of OFDM signals.

II. PROPSED METHOD

A-System Model of Peak windowing

Fig.1 shows an OFDM block diagram under consideration. The binary information bits are mapped to complex-valued MQAM symbols in a 2-dimensional signal constellation.

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The output of the map per is serial-to-parallel converted and processed using an N -point complex inverse fast Fourier transform (IFFT). The N complex-valued time domain signals are then followed by a guard interval (GI), which contains the number of last $L-1$ samples ($N > L$). The GI consists of a partial repetition of an OFDM symbol so it does not affect the PAPR. Therefore, we do not take the GI into consideration here. Passing through a PAPR reduction block such as peak windowing, the signals undergoes a digital-to analog conversion and are transmitted after high power amplifier. At the receiver, the received signals can be demodulated by the reverse process of the transmitter.

If we assume the input complex-valued data symbol of N subcarriers as X_k for $k = 0, L, N-1$, the output signal of the IFFT block is given by

$$x(t)=\sum_{k=0}^{N-1} X_k e^{j2\pi f_k t},\ 0\le t\le NT, \qquad (1)$$

Where f_K is the frequency of the k_{th} subcarrier defined as $f_k = k\Delta f\,(\Delta f = 1/NT)$ and T is the sample interval.

B- Advanced Peak Windowing Technique

The proposed method overcomes the drawback of the conventional method when successive peaks emerge within a half of the window size. The clipping method is the simplest way to reduce PAPR. However, it distorts signals nonlinearly and significantly increases the out-of-band radiation. A different approach is to multiply large signal peaks with a certain window function. In order to maintain the out-of-band radiation within a certain level, it is benefit to increase the window length. On the other hand, the window should not be too long, because a long widow length implies that many signal samples are affected, which degrades the BER performance. Examples of suitable window functions are the Cosine, Kaiser, Hamming, and Hanning window. In general, Kaiser Window is used because it is easy to shape spectrum by changing window length and shape parameter. The Kaiser Window function with window length $M+1$ and shape parameter β is given by

$$w(n)=0.54-0.46\cos\left(2\pi\frac{n}{N}\right), 0\le n\le N \qquad (2)$$

Where the window length is $L = N+1$, α is defined as α $= M/2$, Represents the zero order modified Bessel function of the first kind, and M is a positive even number.

The peak windowing can be expressed as a multiplication of input signals with a scale function at the peak point [7]. It can be accomplished by

$$x(n)=s(n)x(n) \qquad (3)$$

Where $s(n)$ means the scale function that is used to reduce the peak signal level. In addition, the scale function can be expressed as a convolution between weighting coefficient $C(n)$ and window function $w(n)$:

$$s(n) = 1 - \sum_{k=-\infty}^{\infty} c(k)w(n-k) \qquad (4)$$

In order to apply the scale function at the highest value among the oversampled signals exceeding the given threshold level, the peak sample index n_i and its value x (n_i) should be defined as $|x(n_i)| = \max_{n_{i-} \le n \le n_{j+}} |x(n)|, \qquad (5)$

Where n_i is the non-uniformly spaced sample index running over the specific set of samples, which exceed the threshold

C-Proposed Peak Windowing Technique

A detailed description of a new technique for PAPR reduction is now presented. In the following we refer to it as advanced peak windowing (APW) method. The APW is aiming towards detecting the high instantaneous signal peaks and suppressing them to the exact threshold level even in case of consecutive peaks. More specifically, we generate new weighting coefficient $\tilde{c}(n_i)$ instead of c (n_i) in order to avoid excessive suppression.

Proposed Peak Windowing Block

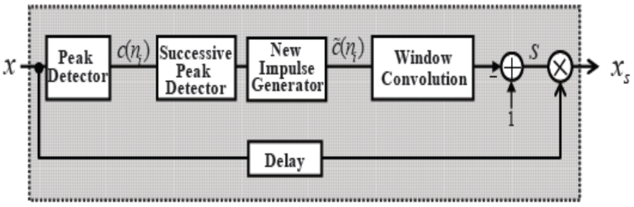

Fig. 1: Block diagram of the proposed peak windowing advanced peak Windowing (APW)

Fig.2 depicts the block diagram of the proposed APW method. Difference between the previous FPW and the proposed APW lies in two blocks, which are successive peak detection and new impulse generation blocks. The successive peak detection block monitors whether or not the distance of the previous peaks is less than a half of the window length, namely *W*/2. The new impulse generation block calculates new weighting coefficients $\tilde{c}(n_i)$ *in* case that series of peaks would appear within a half of the window length.

For a mathematical analysis of new weighting coefficients $\tilde{c}(n_i)$ we define $w_h(n)$ and d_{ij} .First, $w_h(n)$ can be defined as a half of the window function:

$$w_h(n) = w(n)u(n-1), \quad n \ge 1, \qquad (6)$$

Where $w(n)$ is the window function with a length of W and $u(n)$ denotes the unit-step function. Second, d_{ij} denotes the relative distance between successive peak points, n_i *and nj:*

$$d_{ij} = |n_i - n_j|, \quad d_{ij} \ge 1 \qquad (7)$$

Using (7) and (6), we can calculate a general relationship between the conventional weighting coefficient $\{c(n_i)\}$ and the new weighting coefficient $\{\tilde{c}(n_i)\}$, as follows

$$c(n_1) = \tilde{c}(n_1) + w_h(d_{12})\tilde{c}(n_2) + ... + w_h(d_{1M})\tilde{c}(n_M)$$

$$c(n_1) = w_h(d_{12})\tilde{c}(n_1) + \tilde{c}(n_2) + ... + w_h(d_{2M})\tilde{c}(n_M)$$

(4.9)

$$c(n_M) = w_h(d_{M1})\tilde{c}(n_1) + w_h(d_{M2})\tilde{c}(n_2) + \tilde{c}(n_M)$$

III. SIMULATION RESULT

A-Comparison of signal peak between advanced and proposed peak windowing Technique

OFDM system model in fig.1 has been simulated using Matlab coding. The coding is generated using different parameters for the OFDM system is given in table 4.1. In fig4.3 Comparison of signal peak suppression to the given threshold between the advanced Peak windowing method and proposed peak windowing method using the hamming window.

Table 1: The Simulation Parameters for Advanced Peak windowing method

Parameter	Value
Number of subcarriers(N)	1024
number of QAM constellation points(M)	16
Guard Interval	1/4
Bandwidth	22 MHz
Number of OFDM Symbols	100
Windowing Technique	Hamming Window

Fig.3 depicts the amplitude difference between the FPW and the APW. This difference eventually affects the BER performance at the receiver. Nevertheless, we can clearly see that the amplitude of the proposed method is much closer to the given threshold level.

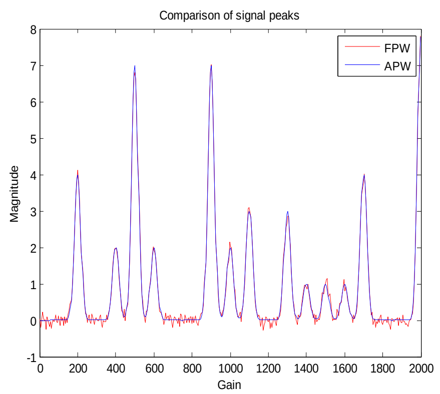

Fig 2- Comparison of peak suppression to the given threshold by previous and proposed method.

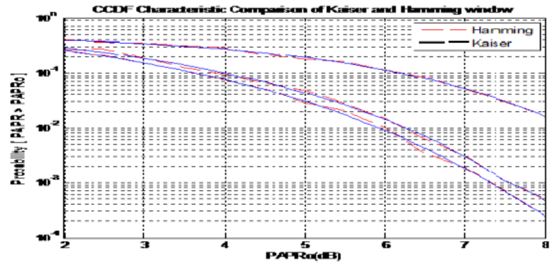

Fig 3- Comparison of CCDF characteristic between Hamming and Kaiser Window technique.

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Table 2: Comparison of hamming and Kaiser Window

Window	Leakage factor (%)	Side Lobe attenuation Factor(db)	Main Lobe Width(-3db)
Hamming	0.05	-41.8	0.078125
Kaiser	1.02	-21.1	0.0097656

IV. CONCULATION

The OFDM symbols are independent identically distributed Gaussian random variables. This correlation characteristic is responsible for the high variability of the OFDM signal, which is the reason for increased PAPR. Considering this analysis, the method proposed by this research uses peak windowing approach, i.e. which is referred to as APW, effectively suppress the peak signals to the desired threshold level in case that successive peaks occur within a half of the window length. By applying the new weighting coefficients, we can tightly limit the successive peaks to the given threshold level.

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