Different Techniques to Reduce the PAPR and Their Comparative Study in OFDM System

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Abstract - **Orthogonal Frequency division multiplexing (OFDM) is a well known technique to combat the multipath fading effect for Radio waves. However, OFDM faces the Peak to Average Power Ratio (PAPR) problem that is a main disadvantage in OFDM, which reduces the efficiency of the transmit signal in RF section of the transmitter.**
This paper present Reduction of PAPR using all proposed techniques. These techniques give better results for PAPR Reduction. Any technique can be used according to the need of parameter performance.

Keywords: **Orthogonal Frequency Division Multiplexing (OFDM), Peak-to-Average Power Ratio (PAPR)**

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is a efficient technology for multipath transmission.

It is the attractive multiplexing technique for fourth generation (4G) wireless system. It offers the solution of multipath fading channel and improvement in bandwidth efficiency but it would lead to inefficient amplification (i.e. large input power required). One of the problems in OFDM is PAPR (Peak to average power ratio). For efficient signal transmission this PAPR should be reduce [1].Different PAPR reduction technique can be use in OFDM system. In this paper describe different PAPR reduction techniques in OFDM system All the reducing techniques has the advantage in terms of their own parameter performance. This paper contain an overview of all PAPR reduction techniques in OFDM system this paper organized as follow: First we describe the OFDM and their application, in section II. And then we calculate or investigate the PAPR in OFDM system in section III. Then after we describe the proposed PAPR reduction techniques in section IV, and finally we present some conclusion in section V.

II. OFDM

OFDM is multicarrier transmission technique used for many wireless communication standards Such as Digital Television Broad casting (DTB), Mobile world-wide interoperability for microwave access (Mobile Wimax), Digital audio broadcasting (DAB) and 3GPP long term evolution(LTE) [2].International standards used for OFDM In high speed wireless communication are already established by IEEE 802.11, IEEE 802.20, and broadcast radio Access network committees.

The Basic principle of OFDM is to split a high data rate steam into a number of lower rate steams which are transmitted simultaneously over subcarrier. It eliminates the need for equalizers; the efficient technique can be realized by Fast Fourier transform (FFT) technique. The OFDM uses the spectrum more efficiently by making the entire sub carrier orthogonal to one another, preventing interference between the sub carriers.

III. PAPR PROBLEM & REDUCTION

In OFDM information is carried on several orthogonal subcarriers. Each subcarrier being mapped by a complex constellation like QAM or PSK. If we consider N bit $Xk = (X0, X1, \ldots, XN-1)$, over a time [0,T], the OFDM signal can be express as

$$x(t) = \sum_{K=0}^{N-1} X_K \; e^{j 2\pi k f_o t} \qquad (1)$$

Where: $\mathbf{f}_o = 1/T$ By putting $t = nT_b$, where $T_b = T/N$, we arrive at the discrete time domain given by

$$x_n = \sum_{K=0}^{N-1} X_K e^{j 2\pi k n / N} \qquad (2)$$

The PAPR of the signal x(t) is the ratio of the peak instantaneous power to the average power, can be express as

$$PAPR = \frac{\max_{0 \le t < NT} |x(t)|^2}{\frac{1}{NT}\int_0^{NT} |x(t)|^2 dt}$$

Where $\frac{1}{NT}\int_0^{NT} |x(t)|^2 \, dt$ is the average value of x(t).

If N is large enough the x(t) has real and imaginary part follow Gaussian distribution and its envelope will follow a Rayleigh distribution. Due to central limit theorem this large value of N results large PAPR.

Most radio system uses high power amplifier(HPA) at the transmitters to obtain enough transmission power for achieving maximum output power efficiency, the amplifier is usually operated at saturation region at which the input-output characteristic is non linear.

This nonlinearity causes the HPA very sensitive to the variation in the amplitude of signal. The nonlinearity of HPA causes the reduction in spectral efficiency of OFDM based transmitter. Due to the variation of the instantaneous power in OFDM signal their PAPR value is very high. This PAPR value must be low for the efficient transmission.

IV. PAPR REDUCTION TECHNIQUES

Various PAPR reduction techniques have been proposed past decade. These techniques are divided into two part first is the signal scrambling techniques and another is signal distortion techniques.

A. SIGNAL SCRAMBLING TECHNIQUES

Block coding technique [1], Selected mapping (SLM)[3],Partial transmit sequence(PTS)[4][5], Interleaving [6], Tone reservation (TR), Tone injection (TI)[8]etc. Are signal scrambling techniques.

1. BLOCK CODING TECHNIQUES

The main objective of this technique is to PAPR using block coding & set of code words. The block coding is widely used for reducing peak to average power ratio. While selection of the codeword many things should be considered like m-ray PSK scheme, coding rate, suitability of encoding-decoding & the main thing is that error correction/ decoding. Large PAPR reduction can be achieved by separating the long information sequence into different sub blocks, and all sub blocks encoded on a programmable chip (SOPC).

2. BLOCK CODING SCHEME WITH ERROR CORRECTION

The method not only minimizes the PAPR but also can have the error correction capability. A n bit data block is encoded by (n,k) block code by using the Generator matrix 'G' at the transmitter of the system. The phase rotator vector b to produce the output of encoder x= a.g+ b(mod2). After the generator matrix 'G' and the phase rotator produced vector 'b'; the encoded data symbol are used modulation. The converse function of the transmitter are perform at the receiver side the parity check matrix 'H' achieve from the generator matrix 'G' the exception is that the phase rotator vector 'b' is removed before syndromes calculation.

3. SLECTED MAPPING (SLM)

In selected mapping technique the signal contain the same signal but from it most favourable signal is to be hosen. The side information must be added the transmitter with the chosen signal. This technique based on the probability [7]. The probability of PAPR the generated signal larger than a threshold Z can be written as $P(PAPR>Z)=1-(1-exp-Z)^N$. Assuming m OFDM signal contain the same information and independent each other in this case the probability of PAPR greater than Z can be written as the product of each independent probability.

This can be expressed as $P\{papr_{low}>Z\}=(P\{PAPR>Z\})^m=((1-exp(-z))^N)^m$ Firstly m statistically sequences are generated and next the resulting m statistically independent data blocks $S_m = [S_{m,0},S_{m,1}.....S_{m,n-1}]^T$,m=1,2,.....M
Are than given to the IFFT operation simultaneously. Eventually, the sequences with the smallest PAPR will be selected for final serial transmission. This scheme is very reliable but the drawback is that, side information must be transmitted along with the chosen signal.

4. PARTIAL TRANSMITS SEQUENCE (PTS)

Partial transmit sequence is the modified technique of SLM technique. It is also based on the probabilistic Theory. The idea of this technique is data block divide into non-overlapping sub blocks, each block having independent rotation factor. This rotation factors generates time domain data having lowest amplitude. This Technique gives better performance than SLM techniques. Because we use differential modulation no need to transmit the side information.

5. INTERLEAVING

In this technique K interleaver are used at the transmitter. The output of the interleavers is the K permuted frames of the input data sequence. This permutation can be generate either before or after the mapping. The frame having minimum PAPR among all the K frames is selected for transmission, identity of the corresponding interleaver has to be sent to the receiver as the side information [6].
The computer simulation can be seen with N=256,512and 1024 subcarriers using 16 QAM, 64 QAM. By using this technique highly co-related data structures having large PAPR can be reduced. The main advantages of this technique are that, it is less complex than the PTS scheme but can be obtain comparable result. Although this technique is less complex than PTS, but this method does not give the assurance result for PAPR reduction.

6. TONE RESERVATION

The principle of this method is to keep a small set of tone for PAPR reduction. This method is based on adding a time domain signal with the data block. A data block is dependent time domain signal to generate multicarrier signal to minimize the high peak. This time domain signal can be calculate simply at the transmitter of system and removed at the receiver. The PAPR reduction depends on some factor such as number of reserved tones, location of the reserved tones, and the complexity. It shows that reserving a small fraction of tone leads to large minimization in PAPR using with simple algorithm at the transmitter side of the system without any additional complexity at the receiver end. The advantage of these tone reservation is very positive that no process needed at receiver end and the method is also less complex. There is

no need of additional information required at the transmitter to be sent.

7. TONE INJECTION (TI)

Tone injection method has been recommended by Muller, S.H. and Huber ,J.B.[8].this method is generally used addition method for PAPR reduction. This method results data rate loss is very less. Tone injection uses a set of equivalent constellation points for an original constellation point for reducing PAPR. The basic things behind this method are to increase the constellation size. Then, each point in the original basic constellation mapped into several equivalent point in the extended constellation since all information elements mapped into several equivalent constellation point. This freedom can be utilized for PAPR reduction. The main demerits are that the transmission of side information is necessary at the receiver side, and cause extra IFFT operation which is more complex.

B. SIGNAL DISTORTION TECHNIQUES

Signal distortion is clipping and filtering [9], Peak windowing [9], Envelope scaling.

1. CILLIPING AND FILTERING

Clipping and Filtering is the mostly effective technique to reduce the high PAPR in OFDM system. However clipping yield distortion power, this called clipping noise, and expands the transmitted signal spectrum, which cause interfering. Here clipping is the nonlinear process which cause increases the band noise distortion, also increase the bit error rate which also decrease the spectral efficiency [9].

Filtering technique will give better performance. Filtering after clipping will reduce out of band radiation. Filtering after clipping can reduce the out- of- band expansion. So for proposed this technique each signal must be over sampled by factor of four. This scheme is more suitable with the m-ray PSK modulation scheme.

2. PEAK WINDOWING

Peak windowing technique is similar to the clipping technique it gives better performance with adding some self interference and increasing in the bit error rate (BER). Peak windowing reduces PAPRs at the cost of increasing the BER and out-band radiation. In peak windowing method we multiply large signal peak with a specific windowing, for example: Kaiser, cosine, Hamming windowing and Gaussian shaped window [9]. OFDM signal is multiplied with several of these windows, the output of the window is a convolution of the original OFDM spectrum with the spectrum of the applied window. The window should be narrow as possible as. This technique gives PAPR reduction up to 4db of each subcarrier. SNR is limited to 3 db due to signal distortion

This technique is use scaling means before OFDM signal sent to the IFFT all subcarrier is scaled the input envelope. They used 256 subcarriers with QPSK modulation technique, so that all the subcarriers envelopes are equal.

Main idea of this technique is that the input envelope in some subcarrier is scaled to get the smallest amount of PAPR at the output of the IFFT. Here, there are no needs to transmit any side information for decoding at the receiver. This scheme is suitable for the m-ray PSK modulation. The envelopes of all subcarriers are equal. Results show that PAPR can be reduced significantly at around 4 db. When this scheme uses QAM high degradation is occurred in the BER.

V. CONCLUSION

Basically all technique described above to reduced the PAPR in ORDM system are different in their way. Using each technique PAPR can be reduced at some level. To reduce the PAPR any technique can be used.

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