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REVIEW PAPER ON PAPR REDUCTION TECHNIQUES IN OFDM SYSTEM

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Abstract: As more and more people started using the communication equipment, the demand for high data rate increased quickly. Orthogonal frequency division multiplexing is one of the latest modulation technique that are used in order to combat the frequency selectivity of the transmission channels which achieves high data rate without inter symbol interference. OFDM system is one of which attracts every researcher because it has many advantages such as no inter symbol interface, high spectral efficiency, power efficiency , tolerance in multipath delay spread high number of orthogonal sub-carriers, frequency selective fading immunity etc. Among all the mentioned advantages it has major flow of peak-to – average-power ration (PAPR) at the transmitter end and Bit error Rate (BER) at the receiving end. In fact PAPR in OFDM system is the most detrimental aspect which decreases power and spectral spreading. In this paper, we review various PAPR reduction techniques which describes that some techniques mitigate PAPR to specific extent but at the cost of BER degradation where as some improve BER but with title amount of PAPR reduction.
Keywords: Orthogonal frequency division multiplexing (OFDM), peak-to-average power ratio (PAPR), partial transmit sequence (PTS), selected mapping (SLM), bit Error Rate (BER).

I. INTRODUCTION

Orthogonal frequency division multiplexing is one of the multicarrier(MC) modulation technique which provides high spectral efficiency, non linear distortion etc. The concept of (MC) transmission was first proposed by Chang [1] in 1996. Due to aforementioned advantages of the OFDM system, it is used in many communication systems. Orthogonal frequency division multiplexing has been adopted for IEEE 802.00, IEEE 802.16, IEEE 802.20, European Telecommunication standard Institute (ETSI), Broadcast Radio access Networks committee (BRAN).The IEEE 802.11a standard for wireless local area network (WLAN) and IEEE 802.16 is also based on OFDM [2]. Orthogonal frequency division multiplexing is bandwidth efficient technique that decomposes the high rate data stream which has bandwidth into n number lower rate data streams and then transmit them over large number of individual subcarriers .These individual subcarriers have bandwidth which is narrower then the coherence bandwidth of channel. Orthogonal frequency division multiplexing is different format .for modulation from the traditional forms of transmission. It uses many carriers together to provide many advantages over simpler modulation and then transmit them over large number of individual subcarriers. These individual subcarriers have bandwidth (w/n) which is narrower than the coherence bandwidth of channel. Orthogonal frequency division multiplexing is different format for modulation from the traditional forms of transmission .It utilizes many carriers together to provide many advantages over simpler modulation formats .But the major problem faces while implementing this system is the high peak to average power ratio of the system. A large PAPR increases the complexity of the analog to digital converter and digital to analog converter and reduces the efficiency of the radio frequency power amplifier. This paper is organized as follows Section II describes PAPR in OFDM system, section III describes PAPR reduction techniques and section IV describes conclusion.

II. PAPR IN OFDM

OFDM system suffers from major disadvantage of large PAPR which arises as a consequence of the coherent addition of multiple sub-carrier Amplitudes & phases from the system. A large PAPR limits the range of linear process of power amplifiers in transmitter. This reduces the efficiency of the system. Let data block of length N is represented by vector $X_k=[X_0,X_1,X_2….X_{N-1}]$ over time interval [0,T]. So OFDM symbol is given by the following mathematical expression

$$x\,(s) = \sum_{k=0}^{N-1} X_k e^{j2\pi k f_0 t} \qquad (3)$$

PAPR of the signal x (s) is given as ration of peak instantaneous power to average power. It is given by the following expression

$$\text{PAPR}\ \{x(s),\tau\} = \frac{\max_{t\xi\tau}[x(s)]^2}{E\{[x(s)]^2\}} \qquad (4)$$

Where x (s) is the original signal, T is the time interval, $\max[x(s)]^2$ is the peak signal power, $E\{[x(s)]\}^2$ is the average signal power ,E[.] is the expectation operator.

III. PAPR REDUCTION TECHNIQUES

Many PAPR reduction techniques are proposed in literature. They are categorized in following two types.

A. Signal scrambling techniques-Block coding techniques, selected mapping (SLM)[3], partial transmit sequence (PTS), golay coding, tone reservation (TR) are signal scrambling techniques.

B. Block Coding Technique- Block Coding is technique to reduce PAPR. The main aspect is to select code words with low peak power after coding from all the possible symbol with N sub-carrier QPSK modulation provides 2N bits and so 22n messages. If K bit data block is encoded by (n,k) block code with generation matrix G at transmitter and a phase rotator vector b is used to produce encoded output. By separating large information sequence into different sub-blocks and encode these sub blocks with system on programmable chips and large PAPR reduction can be achieved.

C. Selected mapping- The main objective of this technique is to generate a set of data blocks at the transmitter end which represent the original information and then to choose the most favorable block among them for transmission. Let us consider an OFDM system with N orthogonal sub-carriers. A date block is a vector x= (Xn)N composed of N complex symbols Xn. X is multiplied element by element with U vector Bu= (bu,n)n composed of N complex numbers bu,n, u{o,1…u-1} defined so that |bu,n||=1.Each resulting vector XU=(XUN)N, ,Xun=bu,m where produces after IDFT, a corresponding orthogonal frequency division multiplexing signal is given by

$$s_u(t) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_{u,n}\, e^{j2\pi n \Delta f t},$$

Among the modified data blocks, the one with the lowest PAPR is selected for transmission. The amount of PAPR reduction in this technique depends upon the number of phase sequences u and the design of the phase sequences. A modified SLM scheme is also proposed in [5] to reduce the complexity of original SLM scheme.

D. Partial Transmit sequence- In PTS method, input data block X is divided in M disjoint sub blocks $X_M = [X_{M0,} X_{M1} \ldots X_{N-1}]^2$, m=1,2,3 and the sub blocks are combine to minimize the PAPR in the time domain. The times oversampled time domain signal of X_m, m=1, 2, 3_ _m is obtained by taking the IDFT of length NL on concatenated with (L-1) N zeros these are called the partial transmit sequences. Complex phase factors are introduced to combine the PTSs .The time domain signal

$$x'(b) = \sum_{m=1}^{M} b_m . x_m$$

Then find the set of face factor that minimizes the PAPR .A suboptimal iterative PTS scheme has been proposed in[6] to reduce the computational complexity of the partial transmit scheme.

E. Golay Coding- Golay Coding is very successful technique to reduce PAPR. Basic fact behind this technique is that if there is an (n;k) code with q element then

$$q^n \geq q^k \sum_{i=0}^{t} (n,i)(q-1)^i$$

Golay Code is a type of linear Block code which uses n bits to generate code word of k bits. The main advantage is that it has the tendency of correction up to three errors in single block.

F. Tone reservation- This is an accurate method for PAPR reduction, as proposed in [7]. Amount of PAPR depends upon the sum factors such as amount of complexity. Location of reserved tones etc. This method show that reserving a small fraction of tones leads to large mitigation of PAPR with simple operation at transmitter and no complexity at receiver end. There is no need for additional operation and no side information to receiver. It is based on summing a data block and time domain signal. A data block is dependent block signal to the original multicarrier signal to minimize high peak. The time domain signal can be calculated at the transmitter and stripped off at receiver. BER is improved to a little extent with tone reservation. Complexity is reduced in this technique.

G. Signal Distortion Techniques – Clipping and filtering ,peak Windowing , Envelope scaling are signal distortion techniques.

H. Clipping and Filtering –The main aim of this technique to clip the some part of signal which is above the selected average region. Less complexity is the main advantage and disadvantage is distortion. Clipping is expressed as

$$C(X) = \begin{cases} x & , \ |x| \leq A \\ A & , \ |x| > A \end{cases}$$

A= positive real number represent clip level It is a non linear process which causes in band noise which degrades performance of BER & out of band noise which reduces the spectral efficiency. Out of band reduction is reduced by Filtering after Clipping but cause peak re-growth which exceed clip level .If clipping and filtering are repeated several times then both the PAPR and out of band radiation will be reduced, as proposed in [8].

I. Peak Windowing –In this technique, it is possible to remove larger peaks at the rate of a little amount of interference where large peaks arise infrequently. It reduces PAPR at cost of increases BER and out of band radiation .It provides better PAPR migration with better spectral properties [9]. Large signal is multiply with a specific window such as Gaussian shaped window, Kaiser, Hamming Window. The window size should be narrow otherwise it affects the number of signal sample which increase bit error rate. PAPR level will decrease to 4dB with peak windowing method.

J. Envelope sealing – The main aim of this techniques is to reduce paper by scaling . Input the envelope for few sub carrier before !FFT operation . According to algorithm input envelop in some sub –carrier is scaled to attain the smallest amount of PAPR at IFFT output. So there is no need of side information at receiver for decoding purpose. PAPR reduces to 4db with this method.

IV. CONCLUSION

In this paper various major PAPR reduction techniques such as partial transmit sequence, selected mapping, envelope scaling, golay coding, clipping and filtering and peak windowing has been studied. We observe that SLM is the most effective techniques to mitigate PAPR to great extent and also improve BER performance of the system. PAPR reduction capacity, increase in power in transmit signal, loss in date rate, complexity of computation are several factors which are taken into account before adopting a PAPR reduction technique of the system.

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