PAPR Reduction techniques for OFDM systems

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Abstract— **OFDM is very popular technique for huge data transmission but the major limitation is PAPR (Peak to average power ratio). Peak-to-Average Power Ratio (PAPR) is an important variable for the evaluation of orthogonal frequency division multiplexing (OFDM) signals in wireless network. OFDM is used in parallel transmission which split the overall bandwidth into subcarriers. This paper presented an overview of PAPR reduction techniques which are different from each other.**

Keywords— OFDM (Orthogonal frequency division multiplexing), PAPR (Peak-to-Average Power Ratio), Signal Scrambling Techniques, Signal Distortion Techniques..

I. INTRODUCTION

OFDM is most important part for data transmission over long distances. in the present scenario, the high rate transmission techniques are much demanded. in wireless and wired networks OFDM is most widely used technique in many applications digital audio broadcasting(DAB),digital video broad casting(DVB), high definition television(HDTV), wireless local area network(WLAN), mobile worldwide interoperability microwave access (mobile Wimax)etc.

II. OFDM

OFDM is a modulating/multiplexing technique to transmit the data in wireless communication .In OFDM, the total channel is divided into equal and multiple sub channels to carry the data. In digital communications, information is expressed in the form of bits. The term symbol refers to a collection, in various sizes, of bits [2]. OFDM data are generated by taking symbols in the spectral space using M-PSK, QAM, etc, and convert the spectra to time domain by taking the Inverse Discrete Fourier Transform (IDFT). Since Inverse Fast Fourier Transform (IFFT) is more cost effective to implement, it is usually used instead [1].

The main aspect in OFDM is maintaining orthogonality of the carriers. If the integral of the product of two signals is zero over a time period, then these two signals are said to be orthogonal to each other. Two sinusoids with frequencies that are integer multiples of a common frequency can satisfy this criterion. Therefore, orthogonality is defined by

$$\int_0^T \cos(2\pi n f_0 t)\cos(2\pi m f_0 t)\, dt = 0 \ (n \neq m)$$

Where n and m are two unequal integers; f_o is the fundamental frequency; T is the period over which the integration is taken. For OFDM, T is one symbol period and f_o set to 1/T for optimal effectiveness [3and 4].

A. Description of basic block diagram

1)Data generator: This is the first block of the OFDM system which is generate the random data in binary (0 and 1) form for transmission.

2)S/P Convertor: Serial to parallel convertor is converting the binary sequence format into parallel in the form of pairs.

3)Modulation: The data to be transmitted on each carrier is then differential encoded with previous symbols, then mapped into a Phase Shift Keying (PSK) format.

4)Guard Insertion: In this section the guard period is added to the modulated data before transition of the signal.

5)*AWGN Channel:* A channel model is then applied to the transmitted signal. The model allows for the signal to noise ratio, multipath, and peak power clipping to be controlled. The signal to noise ratio is set by adding a known amount of white noise to the transmitted signal.

6)*Guard Removal:* In this section the guard period is removed from the received signal and sends to the demodulation block.

7)*Demodulation:* The demodulation basically does the reverse operation to the modulation. The data is decoded and converted into bits.

8)*P/S Convertor:* The parallel data are than combined back to the serial data sequence as the original data.

9)*Error Calculation:* This is the final block of the system which is counting the number of bit errors PAPR and repeating for multiple values of SNR.

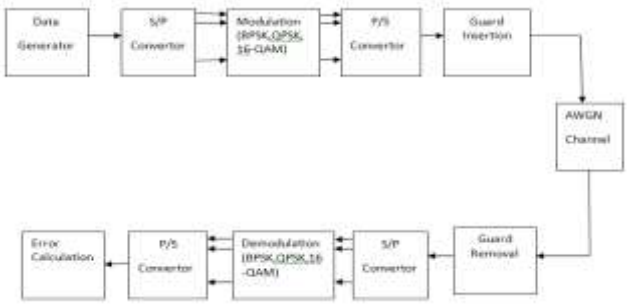

Fig. 1 Figure: Basic OFDM transceiver

B. PAPR REDUCTION TECHNIQUE

PAPR reduction techniques are divided into two parts first is signal scrambling techniques and second part is signal distortion techniques.

(i)*Signal Scrambling Techniques*

1. Block Coding Techniques: This method is used to reduce the peak to mean envelope power ratio of multicarrier communication system [7]. In this scheme firstly collect the sets of codeword for carriers to accomplishment of the encoding/decoding process than errors are detected and corrected. This method not only minimizes the PAPR but also can have the error correction capability.

2. *Sub block coding techniques:* The paper, by Zhang, et.al, [12] proposes the sub-block coding scheme to reduce PAPR more than 3db sub block coding technique is widely used. But this can be achieved at ¾ code rate. This techniques based on ¾ code rate systematically with added last odd parity checking bit to develop lowest peak envelope power. This coding scheme is termed as systematic odd parity checking coding (SOPC). Large reduction in PAPR can be obtained by the divided large frame into sub block encoded with SOPC.

3. *Selected Mapping (SLM):* This scheme is adapted to a theory of probability which is a simple technique based on phase rotation and it has no distortion but side information must be transmitted through the signal. It is very complex method.

4. *Partial Transmit Sequence (PTS):* The paper, by Muller and Hubber, [11] proposes an effective and flexible peak power reduction scheme for OFDM system by combining Partial Transmit Sequences (PTS) in 1997. The main idea behind the scheme is that, the data block is partitioned into non-overlapping sub blocks and each sub block is rotated with a statistically independent rotation factor. The rotation factor, which generates the time domain data with the lowest peak amplitude, is also transmitted to the receiver as side information. The actual OFDM signal is split into various sub-sequences and each sub-sequence has multiplied along different masses until an appropriate value is select. It is distortion less method and the modification technique of SLM which gives more desirable result compare to SLM.

5. *Tone Reservation(TR):* This technique is adding a data block which is depend on time domain signal can be calculated simply in the transition section. Not necessary any side information and addition performance in the receiver section. The main drawback is losing of spectral efficiency causes by tone reservation.

6. *Tone Injection (TI):* This scheme is based on additive algorithm to obtain small amount of data rate loss. The main idea behind this method is to increase the constellation size. Then, each point in the original basic constellation can be mapped into several equivalent points in the extended constellation, since all information elements can be mapped into several equivalent constellation points. These additional amounts of freedom can be utilized for PAPR reduction [11]. It has needs to transmit the side information at the receiver section.

7. *Interleaving:* In this technique highly correlated data frame .in this adaptive technique also reduces the complexity. Adaptive interleaving is to establish an early terminating threshold. So the searching process is terminated when the value of PAPR reaches below the threshold value. So, these low threshold force the AIL to search for all interleaving sequence. This technique is less complex than PTS.

(ii) Signal Distortion Techniques

1. *Clipping& Filtering:* Here clipping is the nonlinear processes which increase the band noise distortion, also increase in the bit error rate also decrease the spectral efficiency. Here using with filtering this techniques will give better performance. Filtering after clipping will reduce out of band radiation. [8]. if the OFDM signal is over sampled then the scheme of correction is suitable with the clipping so that each subcarrier generated with the interference. So for proposed this scheme each signal must be oversampled by factor of four. This scheme is more compatible with the PSK modulation scheme.

2. *Envelope Scaling:* The key idea of this scheme is that the input envelope in some sub carrier is scaled to achieve the smallest amount of PAPR at the output of the IFFT. In this technique 256 subcarrier is used so all subcarrier will remains equal. Thus, the receiver of the system doesn't need any side information for decoding the receiver sequence [10].this technique is better for PSK modulation not for QAM modulation because high humiliation is occurred in the BER.

3. *Peak windowing:* In this method a large signal peak is multiplied with a certain window, such as Gaussian shaped window, cosine, Kaiser and Hamming window. Since the OFDM signal is multiplied with several of these windows, the resulting spectrum is a convolution of the original OFDM spectrum with the spectrum of the applied window. Ideally the window should be as narrow band as possible, on the other hand the window should not be too long in the time domain because that implies that many signal samples are affected increasing the BER. With windowing method, PAPR can be reduced down to about 4dB, independent of the number of sub carriers. The loss of SNR caused by the signal distortion is limited to about 0.3dB. A back off relative to maximum output power of about 5.5dB is required in order to keep undesired spectra distortion at least 30dB below the in-band spectral density. This technique gives excellent spectral efficiency with suitable PAPR values.[9] This is signal distortion technique causes by the loss of signal to noise ratio.

C. PAPR

PAPR is the ratio of maximum instantaneous power to average power of OFDM signal. [5]

$$\text{PAPR}[x(t)] = \frac{P_{PEAK}}{P_{AVERAGE}} = 10log_{10}\frac{\max[|X(n)|^2]}{E[|x_n|^2]}$$

Where P_{PEAK} represents peak output power of the OFDM system, $P_{AVERAGE}$ means average output power of the OFDM system. E[.] denotes the expected value, X_n represents the transmitted OFDM signals which are obtained by taking IFFT operation on modulated input symbols .X_n is expressed as[6]

$$x_n = \frac{1}{\sqrt{N}}\sum_{K=0}^{N-1} X_K W_N^{nK}$$

Where X_k represents k^{th} input symbol. CCDF is an important parameter for the analysis of PAPR in OFDM system. CCDF is basically described the relationship between power levels and probability.

(i).Problem with PAPR

There has randomly sinusoidal cycles lead which creates high peak levels in IFFT process of the transmitter section. These peaks affected ADC, DAC, and HPA to operate in the saturation region. The saturation region generates in-band distortion and out-of-band distortion which causes BER and ACI increasing respectively.

(ii). Performance factor for PAPR reduction:

1. Average Power: A technique must decrease PAPR as well as the average power of the signal from an acceptable region.
2. Minimum Bandwidth Require: some method needs side information which increases the bandwidth usage. A technique must not increase the bandwidth to value which causes degradation in the through put.
3. Less Complexity: A technique must reduce the complexity of the overall system.
4. Low Extra Power Require: The technique should no need of additional power for PAPR reduction, otherwise the power efficiency of the system will decrease.

III. Conclusions

In this paper, different PAPR reduction techniques have been discussed. To reduce the PAPR any techniques can be used. Impact of each technique is different from each other for PAPR. This is concluded that signal scrambling techniques are better than signal distortion techniques but it needs side information in receiver section to recover original data.

5. Better performance of BER: BER must be better performance including PAPR of the system.

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