REVIEW PAPER ON PAPR REDUCTION TECHNIQUES IN OFDM SYSTEM

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Abstract: Wireless communication is commonly used concept for data transmission and OFDM system is most attractive for (4G) communication. Because it has several advantages such as like high spectral efficiency, robustness to channel fading, immunity to impulse interference, capacity to handle very strong echoes and less non-linear distortion. The only drawback of OFDM system is its high peak-to-average-power ratio (PAPR). In this paper, various PAPR reduction techniques are analyzed and results are compared to which is best for PAPR reduction. From review we find that SLM is best for PAPR reduction when numbers of carriers are large with better BER performance.
Keyword: Orthogonal frequency division multiplexing (OFDM), Peak to-average-power ratio (PAPR), Bit error rate (BER), Selective Mapping (SLM).

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) is most luring technique for high rate of data transmission. In OFDM system large number of parallel channel carry data for transmission which are orthogonal in nature. Due to this orthogonality inter-symbol interference is reduced in successive bits. OFDM is widely used in digital audio broadcasting (DAB), digital video broadcasting-terrestrial (DVB-T), mobile multimedia access communication (MMAC), IEEE802.11a, IEEE802.16 and IEEE802.20 [2].

The basic concept behind OFDM system is bandwidth separation. As bandwidth (*w*) of high rate data stream is divided into *n* number of low data streams which transmit over orthogonal sub-carriers. These carriers have individual bandwidth of (*w/n*). PAPR arises as a result of the coherent addition of multiple sub-carrier amplitude and phases from the OFDM system. This PAPR limit the performance of HPA which further causes the system efficiency. These high peaks amplitude of sub-carriers cannot transmit to the transmitter without mitigating peaks because we use high power amplifier at the transmitter end which is non-linear in nature and can results inter-modulation and out of band radiation. There are number of schemes used for this purpose and these are divided into signal scrambling and signal distortion techniques. This paper is organized as follows. Section II describes, PAPR in OFDM system. Section III describes PAPR reduction techniques. Section IV describes overall analysis of different techniques. Section VI describes conclusion.

II. PAPR IN OFDM SIGNAL

These are high peaks which limit the system performance are necessary to remove. Let data block of length N be represented by vector $X_k = [X_0, X_1, X_2 ... X_{N-1}]$ over time interval [0,T] , OFDM symbol can be written as

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

Mathematically defined as,

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

Where x (s) is the original signal

T is the time interval

$\max_{t\xi\tau} [x(s)]^2$ is the peak signal power

$E\{[x(s)]^2\}$ is the average signal power

Where E [.] is the expectation operator.

III. PAPR REDUCTION TECHNIQUES

Different PAPR reduction schemes are basically described into two forms.

1.1 Signal scrambling scheme

Golay Coding [13], Selected mapping (SLM) [2][5][8], Partial Transmit Sequence (PTS) [5][6], Tone Injection(TI) etc. are Signal Scrambling Techniques.

1.1.1 PTS TECHNIQUE

Partial Transmit Sequence is widely used technique for PAPR reduction. The basic principle behind this scheme is addition of phase rotation to develop candidate signal and select one with low PAPR [6].

Let input data blocks X = { X_K }, where (k = 1, 2…N -1), N is number of sub-carriers. Make N is the frequency domain (FD) data sequences, X^{ξ} (ξ=1, 2…N), by multiplying phase sequences

$$P^{\xi} = \{P_k^{\xi}\} (k = 0,1,2...M-1)$$

With X elements provide following results

$$X^{\xi} = [P_0^{\xi} X_0, P_1^{\xi} X_1 .... P_{N-1}^{\xi} X_{N-1}],$$
$$\xi = (1,2....N) \quad (3)$$

Where $P_k^{\xi} = \exp(j\phi_k^{\xi}), \phi_k^{\xi}$ is uniformly distributed in [0, 2π].

Get N candidates' time domains using IDFT

$$x^{\xi} = IDFT\{X^{\xi}\}, \xi = (1,2....N) \quad (4)$$

One candidate with low PAPR is transmitted from candidate date has same information [6].

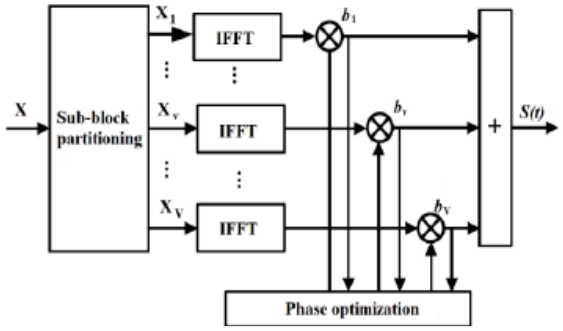

Fig 1: Block diagram of conventional PTS scheme [5].

1.1.2 GOLAY CODING

To reduce PAPR coding techniques play very important role. Golay coding is found to be very effective for this purpose. Basic principle behind this technique is that if there is an (*n; k*) code with an alphabet of *q* elements, and

$$q^n \geq q^k \sum_{i=0}^{t} (n,i)(q-1)^i \qquad (5)$$

Golay code is a type of linear block code which uses *n* bits to generated code word of *k* bits. The main advantage of using golay coding is that it has the tendency of correction up to three errors in single block. The extended version of Goley code *(24, 12)* has the advantage that it has *Hamming* distance of *8*, and code rate exactly equal to *0.5*.

1.1.3 SELECTIVE MAPPING

Selective Mapping is quality technique to mitigate PAPR in OFDM system. Fundamental idea behind scheme is phase rotation. Signal with low PAPR is selected from different independent phase sequences that have same information at transmitter [2].

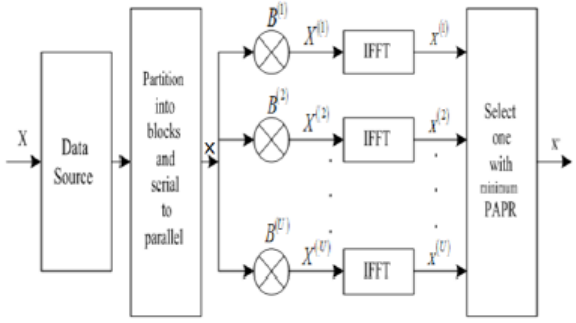

Fig 2: block diagram of SLM technique [2]

Let input data blocks $X = [X_0, X_1, X_2 \ldots X_{N-1}]^T$ (6)

When multiply with independent phase sequence results

$$P^u = [P_0^u, P_1^u \ldots P_{N-1}^u]^T, u = (1,2 \ldots U-1) \quad (7)$$

U= number of phase sequence

Apply IFFT to obtain data block with different PAPR value and phase sequence [8].

$$X^u = [X_0^u + X_1^u + \ldots X_{N-1}^u]^T \qquad (8)$$

Select one with low PAPR and transmit. CCDF of PAPR in SLM will be

$$P(PAPR > PAPR0) = (1-(1-e^{-PAPR0})^{\alpha.N})^U \qquad (9)$$

N= no. of sub-carrier

U=independent phase sequence

PAPR0= threshold value

1.1.4 TONE INJECTION

Tone injection uses a set of equivalent constellation points for an original constellation points to minimize PAPR. It increases original constellation size and map several constellation points to extended constellation from each original constellation points. Since all elements mapped are useful for PAPR reduction. There is no need for additional operation and no side information to receiver is required. It 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. This time domain signal can be calculated simply at the transmitter of system and stripped off at receiver.

1.2 SIGNAL DISTORTION TECHNIQUES

Clipping and Filtering [2][9][10], Peak cancellation, peak power suppression, weighted multicarrier transmission etc. are signal distortion techniques.

1.2.1 CLIPPING AND FILTERING

The technique simply clips the part of signal which is above the selected average region. Advantage of this technique is less complexity and disadvantage is distortion and BER degradation [9]. Clipping is expressed as

$$C(X) = \begin{cases} x & , \ |x| \leq A \\ A & , \ |x| > A \end{cases} \qquad (10)$$

A = Positive real number represent clip level

It is a non-linear process which causes in-band noise, which degrades performance of BER and out of band noise which further reduces the spectral efficiency. Out of band radiation can be reduced by Filtering after clipping but cause peak re-growth which may exceed clip level. This peak re-growth is avoided by iterative clipping and frequency domain filtering.

1.2.2 PEAK REDUCING CARRIER

In this algorithm the amplitude and phase of peak reducing carrier (PRC) to be kept within constellation region pointing the data symbol to be transmitted. For example to use PRC that employ a 16 PSK constellation to carry four regions to represent the four different value of QPSK symbol.

IV. OVERALL ANALYSIS OF VARIOUS TECHNIQUES

Table 1: Comparison of PAPR reduction techniques [12].

NAME OF SCHEME	NAME OF PARAMETERS			
	DISTORTION LESS	POWER INCREASES	DATA RATE LOSS	BER IMPROVED
PTS	YES	NO	YES	YES
GOLAY CODING	YES	NO	YES	YES
SLM	YES	NO	YES	YES
TI	YES	YES	NO	YES
CLIPPING	NO	NO	NO	NO
PRC	NO	YES	NO	NO

V. CONCLUSION

In this paper, various PAPR reduction techniques have been analyzed and also compared these techniques for different parameters. We analyzed that SLM is one technique which has better PAPR reduction capability and efficient if number of sub-carriers are large.

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