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A Hybrid Technique for BER and Paper Analysis of OFDM Systems

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Abstract

Background/Objectives: The paper is classified to analyze different Peak to Average Power Ratio techniques and centered on that the PTS method is used for finding the PAPR and BER value for different partition groups. **Methods/Statistical Analysis:** The PAPR reduction is done using MATLAB for different blocks in PTS technique based on different partition groups. **Findings:** The proposed PTS method reduces PAPR for higher partition groups by doing phase optimization to each sub blocks up to 2-3 dB at the cost of good BER performance. The results are shown by plotting CCDF and error rate performance of the system that are generated from the system using MATLAB. **Applications/Improvements:** The proposed method used for finding PAPR and BER, uses less iterations and for each sub block the phase optimization is done. Also, by increasing the number of subcarriers the PAPR performance will get better as compared to other techniques.

Keywords: OFDM, PAPR Reduction, PTS Scheme and Signal Distortion and Signal Scrambling Techniques

1. Introduction

For the transmission of data through wireless radio channels, we need to have high bit rate at megabits per second. But if the bit rate is increased to several megabits per second, the delay between the delayed signals will increase. To mitigate this multipath fading problem, an overview of Orthogonal Frequency Division Multiplexing (OFDM) scheme for efficient transmission of data[1].

OFDM is multicarrier modulation system that provides high spectral efficiency, non-linear distortion, capacity to handle very strong echo's etc. OFDM divides high rate data stream into a set of low rate sub-streams thus becoming a bandwidth efficient technique. These sub streams are transmitted over individual subcarriers that have narrow bandwidth then the coherence bandwidth of the channel[2]. OFDM is used broadly used in mobile multimedia access communication, digital video broadcasting terrestrial, digital audio broadcasting, IEEE 802.11a, IEEE 802.16 etc. OFDM provides the transmission of data efficiently and it is very useful in growing technology like 4G and 5G. OFDM is the multicarrier modulation. In OFDM system model, first the input signals are modulated using different techniques like QAM (Quadrature Amplitude Modulation), PSK (Phase Shift Keying) etc. and at the end of the transmitter we perform the IFFT operation[3]. The OFDM has a large PAPR which is main disadvantage and it affects the efficiency of the systems. So, it's necessary to mitigate the problem of PAPR as it decreases the performance of OFDM systems. This paper has been prepared as follows: Introduction in Section I, Effect of PAPR in OFDM System in Section II, Different PAPR Reduction Techniques in Section III, Section IV presents the investigation of QPSK and 16QAM modulations using PTS technique and Conclusion has been presented as Section V.

2. PAPR Problem in OFDM

The N-point IFFT is used to generate the OFDM signals at the transmitter and at the receiver FFT is used to regain the signals. Considering N block symbols $X_N = \{X_k, k = 0,1,....,N-1\}$, which are formed by each individual symbol correspondingly modulating the equivalent sub-carrier, where X_k represents symbol on k_{th} subcarrier. Thus the OFDM signal can be mathematically represented as,

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$$x(n) = \frac{1}{N}\sum_{k=0}^{N-1} X_k e^{j\frac{2\pi}{N}kn}, 0 \le n \le N-1. \quad (1)$$

N represents the no. of individually modulated subcarriers which are the main cause of large PAPR. In OFDM systems, PAPR is the ratio of peak power to average power of the composite signal and can be given by,

$$PAPR = \left[\frac{\max[x(n)]^2}{E\{[x(n)]^2\}}\right] \quad (2)$$

Where $x(n)$ denotes original signal, the peak signal power is represented by $\max[x(n)]^2$ and $E\{[x(n)^2]\}$ denotes the average signal power. If we reduce the maximum/peak signal power of the composite signal, this will lead to the reduction of PAPR as it is directly proportional to the peak power.

3. PAPR Reduction Techniques

For the reduction of PAPR generally, there are two types of techniques: Signal Distortion and Signal Scrambling techniques.

3.1 Signal Distortion Techniques

It includes clipping[4,5,6], peak windowing[4,7] and envelope scaling.

3.1.1 Clipping

The simple and easiest way to reduce the PAPR is clipping in which the peak amplitude of the signal is made limited to some chosen level. Since clipping resembles the easiest way of reducing PAPR, it also has some limitations:

(i) Altering OFDM signal amplitude creates a type of interference (in-band noise) which degrades the PAPR.

(ii) The non-linear distortion of the OFDM signal leads to increase in out of band radiations which reduce the spectral efficiency.

Multiplication of large signal peaks with certain non-rectangular windows can be a remedy for the out of band radiation problem in clipping. But the window ought to not be too outsized in time domain so that it may affect many sample signals, which can increase the BER.

3.1.2 Peak Windowing

This is another different approach of multiplying huge signal peaks with a definite window function. For the maintenance of out of band radiations up to a certain level, the increase in window length will come forward. But the window length ought to not be too lengthy as long window length will distress various signal samples due to which BER performance will be affected. Examples of windows can be Hamming Window, Hanning Window, Kaiser Window, Cosine Window etc.

Generally Kaiser Window is applied because of its ease to shape spectrum by varying window length and shape. Kaiser window function having window length M+1 and shape parameter β is mathematically represented by,

$$w(n) = 0.54 - 0.46\cos\left(2\pi\frac{n}{N}\right), 0 \le n \le N \quad (3)$$

The peak windowing can be determined by multiplying the input signal with scale function,

$$x_s(n) = s(n)x(n) \quad (4)$$

$s(n)$ represents scale function which can decrease the peak level of signal which is given as,

$$s(n) = 1 - \sum_{k=-\infty}^{\infty} c(k)w(n-k) \quad (5)$$

This technique can decrease the PAPR level up to 4db.

3.1.3 Envelope Scaling

Here we have 256 sub-carriers along with QPSK modulationused to create envelopes which are same for all sub-carriers. To get small PAPR, the input envelopes of some sub-carriers are scaled at IDFT output because of this no side information is used for the decoding purpose at receiver. PAPR can be reduced to 4db with this technique.

3.2 Signal Scrambling Techniques

It includes tone injection[8], selective mapping[4,9], partial transmit sequence[9,10] and coding techniques.

3.2.1 Tone Injection

For original constellation points, a set of equivalent constellation points is used by tone injection to minimize PAPR. This scheme is used to expand constellation so that each point present in main constellation map to some other corresponding points in the expanded constellation. The mapped constellation points are useful for PAPR reduction. It is based on the method of adding of data blocks and the time domain signals and no extra information is needed at the receiver level. The data block is reliant on the original multicarrier signal for decreasing high peaks. At transmitter side, the time domain signal can be considered and removed at the receiver. But this technique has limitation of complexity for finding appropriate symbol space and it increases signal power due to injection of time domain signal.

3.2.2 Selective Mapping

It resembles as a phase rotation technique to decrease PAPR. Signals from different phase sequences having small PAPR level is selected having similar information at transmitter. The model is shown in Figure 1.

Let input data blocks be,

$$X = [X_0, X_1, \ldots\ldots, X_{N-1}]^T \quad (6)$$

When multiplying with independent phase sequences,

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

Where 'u' denotes the total of phase sequences. Applying IFFT to obtain data block having not the samephase sequence and PAPR,

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

Select one with lowest PAPR and transmit. In SLM, the CCDF (of PAPR) can be given by,

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

Where N denotes the no. of sub-carriers, PAPR0 denotes the threshold value; U is independent phase sequence and α is the oversampling factor.

3.2.3 Partial Transmit Sequence

For decreasing PAPR, PTS is a mostly used method. In this scheme, the original signal is alienated into disjoint sub-blocks and then phase optimization or rotation is done to create the corresponding signals. The time domain data

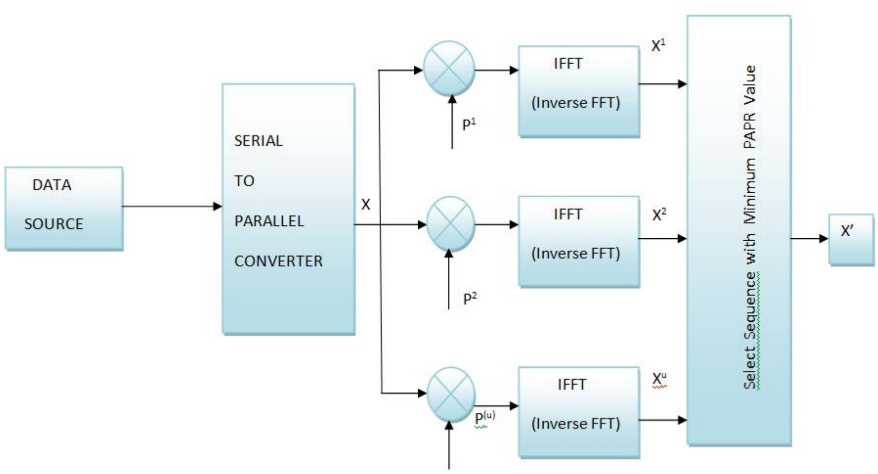

Figure 1. Block diagram of SLM technique[3].

is generated from this rotation factorfrom and the signal with lowermost PAPR is chosen.

Let input data blocks $X = X_k, k = 1,2,...,N-1$ and N denotes no. of sub-carriers. In frequency domain make N data sequence X^τ, where $\tau = 1,2,...,N$ multiply by phase sequences

$$P^\tau = P_k^\tau, \{k = 0,1,2,...,M-1\} \quad (10)$$

The following results will be provided with X elements as,

$$X^\tau = [P_0^\tau X_0, P_1^\tau X_1, ..., P_{M-1}^\tau X_{N-1}], \tau = 1,2,...,N \quad (11)$$

ϕ_k^τ is equally distributed from 0 to 2π and $P_k^\tau = \exp(j\phi_k^\tau)$. The N corresponding signals can be developed in time domain using IDFT,

$$x^\tau = IDFT\{X^\tau\} \quad (12)$$

The corresponding signal with low PAPR in X^τ is transmitted. The system block is shown in Figure 2.

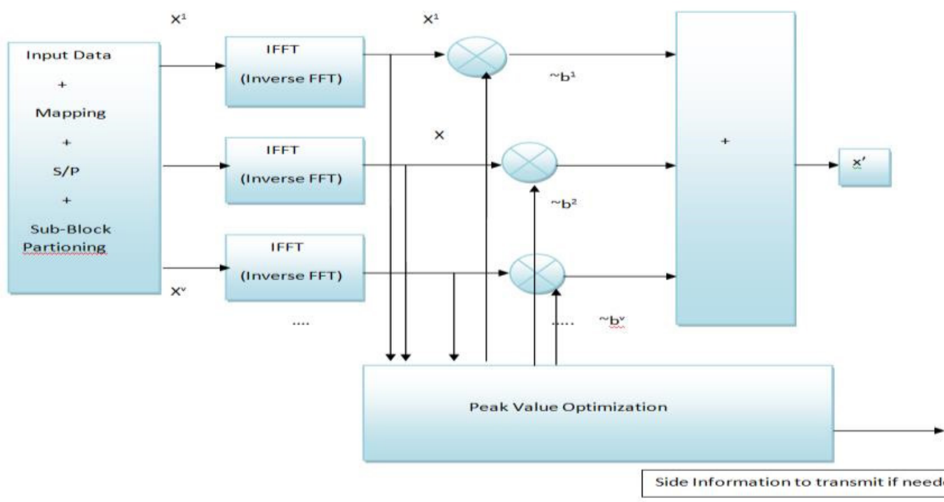

Figure 2. Conventional PTS scheme[3].

3.2.4 Coding Technique

Coding techniques are popular techniques as these do not induce any out of band radiation and in band radiation. Basic idea is to select code words which are coded by means of all probable symbols having lower peak power. The QPSK modulation will provide '2N' bits and '2^{2N}' messages for 'N' sub-carriers.

To produce encoded output, (n, k) block code is used to encode the 'k' bit data block at the transmitter along with phase rotator vector and generation matrix G. The large information sequence is alienated in to various sub-blocks and are encoded with (SOPC) System On Programmable Chips, to decrease PAPR to large extent[3].

FEC (Forward Error Correction) codes are separated into block and convolution codes. The OFDM system features Cyclic Encoder, BCH encoder, Convolution encoder and RS encoder in FEC channel code, in accordance with distinctive arrangements of digital modulation[11].

4. Simulation Results

Figure 3 demonstrates the BER performance of the OFDM system using PTS (Partial Transmit Sequence) technique with different code rates and PTS groups. The simulation result not only improves the BER but also the convergence speed in order to perform less decoding iterations.

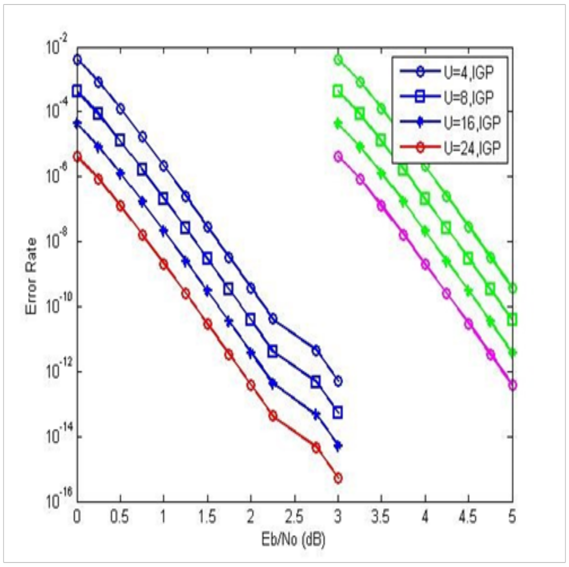

Figure 3. BER performance of OFDM system using PTS technique.

Figure 4 shows the PAPR by plotting complementary cumulative distribution functions (CCDF) with PTS and different partition groups. The simulation is employed with QPSK modulation showing same PAPR performance with IGP and pseudorandom partition.

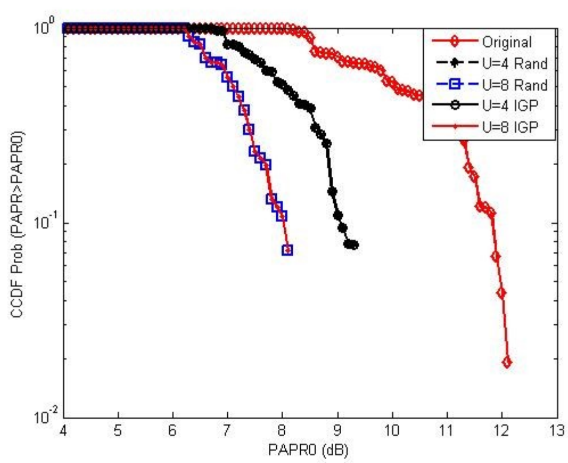

Figure 4. PAPR performance in OFDM system using PTS technique.

5. Conclusion

In this paper, the studyof different techniques to reduce PAPR on the basis of different parameters examined and simulation results are given for PTS scheme. We observed that Partial Transmit Sequence is an efficient technique to decrease PAPR up to greater extent and improves BER of the OFDM system.

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