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PAPR Reduction in the OFDM Signal Using Selective Mapping

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Abstract*:* Nowadays Orthogonal Frequency Division Multiplexing is becoming more and more popular Because of it is attractive techniques for high data rate transmission. OFDM is widely used in 4G technologies in recent times. Main advantage of OFDM is that it uses orthogonal signals so removes inter-signal interference. PAPR ratio in OFDM is very high because it uses Multicarrier modulation, which is its main drawback. High PAPR means more power need at transmission side. PAPR can be decreased using various techniques such as clipping, selective mapping, etc. In this paper, criterion for new scheme selective mapping is introduced for PAPR reduction in OFDM.

Index Term*:* *OFDM, PAPR, Selective Mapping*

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I. INTRODUCTION

Multi-carrier modulation (MCM) has recently gained fair degree of prominence among modulation schemes due to its intrinsic robustness in frequency selective fading channels. This is one of the main reason to select MCM a candidate for systems such as Digital Audio and Video Broadcasting (DAB and DVB), Digital Subscriber Lines (DSL), and Wireless local area networks (WLAN), metropolitan area networks (MAN), personal area networks (PAN), home networking, and even beyond 3G and 4G wide area networks (WAN). Orthogonal Frequency Division Multiplexing (OFDM), a multi-carrier transmission technique that is widely adopted in different communication applications. OFDM systems support high data rate transmission [6].

The Orthogonal Frequency Division Multiplexing (OFDM) is one of the very efficient and often used modulation techniques used in broadband wireless communication systems like 4G, Wi-MAX, DVB-T. One of the main issues of the OFDM based systems is the Peak-to-Average Power Ratio (PAPR) of the transmitted signal. Due to the time-domain superposition of the many data subcarriers which composes the OFDM signal, the PAPR may reach high values. Due to the large number of subcarriers,

the resulting time-domain signal exhibits Rayleigh- like characteristics and large time-domain amplitude

Variations. These large signal peaks requires the high power amplifiers (HPA) to support wide linear dynamic range. The increased signal level causes nonlinear distortions leading to an inefficient operation of HPA causing inter-modulation products resulting unwanted out-of-band power. In order to reduce the PAPR of OFDM signals, many solutions have been proposed and analyzed. These methods can be characterized by various parameters like non-linearity, amount of processing and size of side information needed to be sent to receiver.

Some of the well-known linear methods are selective mapping (SLM), partial transmit sequence (PTS), and tone reservation (TR). The SLM method performs several vector rotations of the Original frequency-domain OFDM signal, based on a set of predefined vector arrays. For each signal variant obtained, its corresponding PAPR is evaluated. The one with the lowest PAPR is chosen for the transmission. The efficiency of the SLM and PTS methods increases with the number of phases from the considered set. The efficiency of the PTS method also increases when a higher number of blocks are used. The drawback is that a better efficiency requires an increased amount of computation at the transmitter's and receiver's sides. The clipping method is another well-known non-linear PAPR reduction technique, where the amplitude of the signal is limited to a given threshold.

Peak to Average Power Ratio

PAPR means peak to average power it's define as the ratio of the peak power to average power. The OFDM have higher PAPR that is main drawback. Due to high PAPR we need more transmit power at transmitter side [1].

The complex baseband OFDM signal for N subcarriers represented as,

$$s_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} x_k e^{j\frac{2\pi}{N}nk} \qquad (1)$$

Then, The PAPR of OFDM signal x(t) is defined as,

$$\text{PAPR} = \frac{P_{peak}}{P_{avg}} = max[\![x_n{}^2]\!]/E[\![x_n]\!] \qquad (2)$$

Where, x_n= An OFDM signal after IFFT

Peak Power

$$\mathrm{Max}[x(t)\,x^*(t)] = \mathrm{Max}[\textstyle\sum_0^{k-1} a_k e^{\frac{j2\pi kt}{T}} \sum_0^{k-1} a_k^* e^{\frac{-j2\pi kt}{T}}] = K^2 \quad (3)$$

Average power

$$E[x(t)\,x^*(t)] = E[\textstyle\sum_0^{k-1} a_k e^{\frac{j2\pi kt}{T}} \sum_0^{k-1} a_k^* e^{\frac{-j2\pi kt}{T}}] = K \quad (4)$$

So, mathematically PAPR is given by,

$$\mathrm{PAPR} = K^2 / K = k$$

Per the IEEE 802.11a specification, we used 52 sub-carriers. So, expected maximum PAPR is around 52(Around 17db). It is so high for OFDM.

Effect of High PAPR

Higher PAPR causes clipping of an OFDM signal by the high power amplifier (HPA), producing non-linearity's in HPA output. Hence, the OFDM spectrum may have severe in-band and out-of-band distortion which degrade the bit error rate (BER) performance. A high PAPR also lead to low HPA power efficiency.

Performance Parameter of PAPR

The cumulative distribution function (CDF) of the PAPR is one of the important used performance measures for PAPR reduction techniques. CDF stands for Cumulative Distribution Function. If Y is a random variable then the CDF of y is defined as the probability of the event {Y ≤ y}. So the Complementary Cumulative Distribution Function (CCDF) [3] is defined as the probability of the event {Y > y}. With using this density function it is easy to analyze the PAPR reduction performance. Let us consider x is the transmitted OFDM signal then from we got the theoretical CCDF of PAPR i.e. to find the probability of the event {PAPR{x}>z} which is given as,

$$\Pr(\mathrm{PAPR}\{x\}>z) = 1-(1-e^{-z})^N \quad (5)$$

II. PAPR Reduction Techniques

1. Distortion Techniques

It is difficult to precisely sort PAPR reduction schemes into distortion and distortionless categories. Here, we consider schemes that introduce spectral reproduction to be distortion techniques. Distortion techniques are the most straightforward PAPR reduction methods. In general, they do not require any side information to be sent which mean the data rate is unchanged even after PAPR reduction and they have low complexities compared to the distortionless techniques. However, the price paid for using a distortion technique is distortion noise which adversely affects the error rate of the system. Furthermore, these techniques distort the spectrum, which makes conforming to regulatory spectral masks difficult. This spectrum distortion or spectral reproduction can be corrected by filtering, but the filtering will likely reproduce the peaks that were originally reduced. The problem can be thought of as trying to plug two holes with only one plug. That is, the PAPR can be reduced at the expense of spectral reproduction or the spectral reproduce can be reduced at the expense of PAPR [7].

Clipping& Filtering

This is a simplest technique used for PAPR reduction. Clipping means the amplitude clipping which limits the peak envelope of the input signal to a predetermined value. Let x[n] denote the pass band signal and x_c[n] denote the clipped version of x[n], which can be expressed as

$$x_c(n) = \begin{cases} -A, & x[n] \le -A \\ x[n], & x[n] < A \\ A, & x[n] \ge A \end{cases} \quad (6)$$

Where, A is the pre-specified clipping level. However this technique has the following drawbacks:

Companding

Another distortion technique is companding is a composite word that com-bines compress and expand. It was first used as a technique to expand the dynamic range of DACs and was later adopted as a perspective PAPR reduction technique. The basic idea is to employ a compressing function in the transmitter and apply it to the OFDM symbol *x* so that F(*x*) is transmitted, where the range of F(*x*) is less than the range of *x*. In the receiver, the expanding function is applied to the received symbol *y* so that approximates the original symbol. The drawback to companding is that when the received symbol is expanded, so is any distortion from the channel, which means detection rates are degraded. Also, there will be spectral reproduction in the compressed signal.

2. Distortionless Techniques

In this section we introduce distortionless PAPR-reduction techniques. While none of these reduction techniques introduce spectral reproduction, some of them do introduce additional noise to the system thereby increasing the error rate. Other techniques require overhead information bits to be sent along with the transmitted signal so that the receiver can reverse the PAPR reduction transformation and recover the data. This has the negative effect of decreasing the useful data throughput [7].

Coding

The coding technique is used to select such codewords that minimize or reduce the PAPR. It causes no distortion and creates no out-of-band radiation, but it suffers from bandwidth efficiency as the code rate is reduced. It also suffers from complexity to find the best codes and to store large lookup tables for encoding and decoding, especially for a large number of sub carriers.

Tone Reservation

In this scheme, some OFDM subcarriers are reserved. These reserved subcarriers don't carry any data information, are only used for reducing PAPR. This method is called Tone

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Reservation. This technique includes number of set of reservation of tones. By using this technique reserved tones can be used to minimize the PAPR. This method is used for multicarrier transmission and also shows the reserving tones to reduce the PAPR. This technique depends on amount of complexity. When the number of tones is small reduction in PAPR may represent non negligible samples of available bandwidth. Advantage of this tone reservation is very positive that no process is needed at receiver end. And also do not need to transmit the side information along with the transmitted signal. According to this technique the transmitter does not send data on a small subset of subcarriers that are optimized for PAPR reduction. Here the objective is to find the time domain signal to be added to the original time domain signal such that the PAPR is reduced.

Partial Transmit Sequence

In the Partial Transmit Sequence (PTS) technique, an input data block of N symbols is partitioned into disjoint sub blocks. The sub-carriers in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected such that the PAPR of the combined signal is minimized. But by using this technique there will be data rate loss.

Selected Mapping (SLM) Technique

The basic idea of this technique is first generate a number of alternative OFDM signals from the original data block and then transmit the OFDM signal having minimum PAPR. But data rate loss and complexity at the transmitter side are two basic disadvantages for this technique. This technique has been described exhaustively simulation chapter.

The performance comparisons for all the PAPR reduction techniques described above are being shown in the table.

Techniques	Distortion	Complexity	Data Rate lost
Clipping & Filtering	Yes	Low	No
Companding	Yes	Low	No
Coding	No	High	Yes
Tone reservation	No	High	Yes
Partial transmit sequence(PTS)	No	High	Yes
Selective mapping(SLM)	No	High	Yes

TABEL I Comparison of Different Techniques

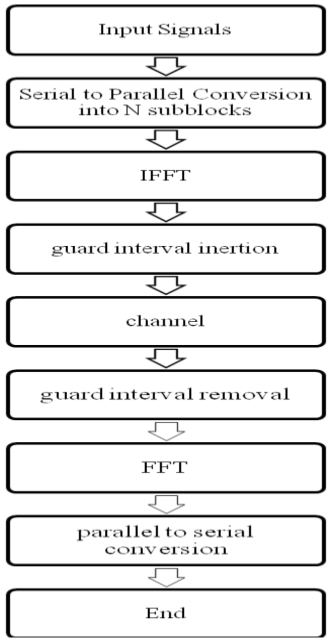
III. SIMULATION PART

PAPR in OFDM

Parameters assumptions:

Parameter	Assumption
Number of Symbols	1000
Modulation Scheme	QPSK
Number of Sub-Carriers	64

TABEL II Performance Parameter



Flowchart of OFDM

Simulation Result

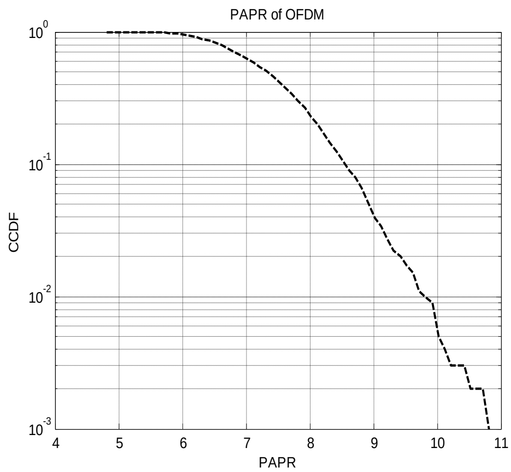


Figure 1 PAPR in OFDM

PAPR Performance of OFDM with SLM

Performance algorithm:

For all signals do

Covert signals into N sub blocks

For each sub blocks do

1. Multiplication with phase sequence
2. Calculate IFFT
3. Calculate minimum PAPR

End

End

End

Simulation Result

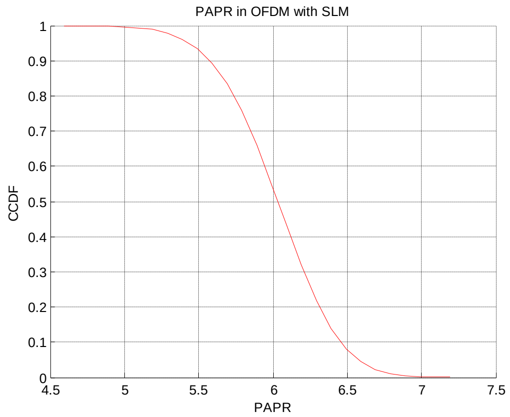


Figure 2 PAPR in OFDM using SLM

Comparison

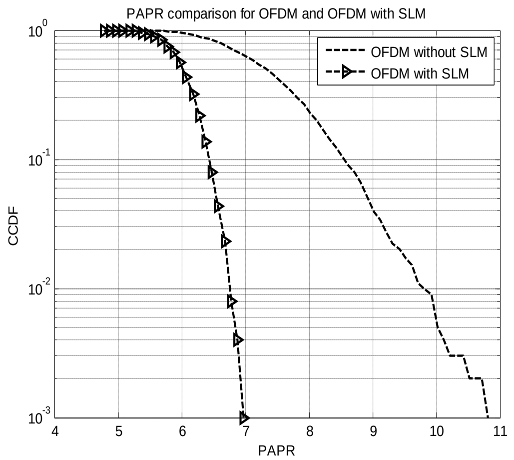


Figure 3 PAPR comparisons for OFDM and OFDM with SLM

Conclusion

Based on comparison made in this work it can be concluded that SLM provides best performance in terms of PAPR reduction using BPSK modulation technique. The technique is to all types of subcarrier modulation in selective mapping but complexity is very high because number of IFFT, multiplication and addition operations. And there computation time will also be more in SLM due to complexity. So, future work is reduce the complexity using decrease the number of IFFT , multiplication and addition.

REFERENCES

[1] Y. Wu, IEEE member, K. L. Man, IEEE member, y. wang, IEEE student member "Optimum Selective Mapping for PAPR Reduction," IEEE 2011.

[2] Chin-Peng, Sen-Hung Wang, and Chin-Liang Wang, "Novel Low-Complexity SLM Scheme for PAPR Reduction in OFDM System", IEEE transactions on wireless communications, vol. 58, no. 5, may 2013.

[3] Kee-Hoon Kim , Hyun-Bae , Dong-Joon Shin, "Low-complexity selected mapping scheme using cyclic-shifted inverse fast Fourier transform for peak-to-average power ratio reduction in orthogonal frequency division multiplexing systems", IET Communication 2013, Vol.7, Iss. 8, pp. 774-782.

[4] Jyh-Horng Wen,Gwo-Ruey Lee, Chih-Chung Kung, Cheng-Ying Yang , "Coding Schemes Applied to Peak-to-Average Power Ratio (PAPR) Reduction in OFDM Systems", IEEE 2008.

[5] Wen-Xiang Lin, Jia-Chin Lin and Yu-Ting Sun, "Modified Selective Mapping Technique for PAPR Reduction in OFDM Systems", 2012 12th international conference on ITS communication.

[6] Himanshu Bhusan Mishra, "PAPR Reduction of OFDM Signals Using Selected Mapping Technique", Department of Electronics and Communication Engineering National Institute of Technology Rourkela.

[7] Robert J. Baxley, "Analyzing Selected Mapping for Peak-to-Average Power Reduction in OFDM", School of Electrical and Computer Engineering Georgia Institute of Technology May 2005.