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PAPR Reduction in the OFDM signal Using Partial Transmit Sequence

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Abstract— Orthogonal frequency division multiplexing is becoming more and more popular nowadays. OFDM is widely used in 4G technologies in recent time. Main advantage of OFDM is that it uses orthogonal signal so removes intersignal interference. PAPR ratio in OFDM is very high because it uses multicarrier modulation ,which is its main drawback .OFDM is consist of the large number of the independent subcarrier, as a result of which the amplitude of the such a signal can have high peak values as it uses multicarrier modulation. More PAPR ratio means that more power needs to be transmitted from transmitter side .In our work we will try to reduce the PAPR using PARTIAL TRANSMIT SEQUENCE TECHNIQUE. In this technique data blocks are divided into non overlapping sub-block with independent rotation factor. This rotation factor generates time domain data using which it select signal having lowest PAPR. Results will be compared on the basis of the CCDF (complementary cumulative distribution function).

Index Terms—Orthogonal frequency division multiplexing, peak to average power ratio, partial transmit sequence

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I. INTRODUCTION

Multicarrier modulation 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 Multi-carrier modulation 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.

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 [3].

$$\mathrm{PAPR} = \frac{\mathrm{P_{peak}}}{\mathrm{p_{avg}}} = \max[\![\mathrm{x_n}^2]\!] / \mathrm{E}[\![\mathrm{x_n}^2]\!] \qquad (1)$$

Where, x_n = An OFDM signal after IFFT
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 use for the reduce PAPR are partial transmit sequence (PTS), and clipping and coding. Clipping is very simple method which require very less computational time but it introduces the distortion and also degrades BER performance [1]. Coding is also one of the method use for reduces PAPR but it introduced bandwidth expansion and distortion [2]. The partial transmit sequence is the best method for reduces the PAPR with compare to clipping and coding, [3] but in the partial transmit sequence complexity is increase due to number of the IFFT operation.

II .PAPR FOR THE OFDM

A. PAPR CALCULATION

OFDM signal is the sum of the multiple sinusoidal having frequency separation (1/T) where each sinusoidal gets modulated by the independent information $a_{k.}$ Mathematically, the transmit signal is

The PAPR of the transmit signal is defined as

$$x(t) = \sum_{0}^{k-1} a_k \, e^{\frac{j2\pi kt}{T}} \quad (2)$$

Due to the large number of sub-carriers in typical OFDM systems, the amplitude of the transmitted signal has a large dynamic range, leading to in-band distortion and out-of-band radiation when the signal is passed through the nonlinear region of power amplifier.

Peak Power

$$\mathrm{Max}[\, x(t)\, x^*(t)] = \mathrm{Max}[\textstyle\sum_{0}^{k-1} a_k e^{\frac{j2\pi ki}{T}} \sum_{0}^{k-1} a_k^* \, e^{\frac{-j2\pi ki}{T}}\,] \quad (3)$$
$$= K^2$$

Average power

$$E\,[\, x(t)\, x^*(t)] = E\,[\textstyle\sum_{0}^{k-1} a_k e^{\frac{j2\pi ki}{T}} \sum_{0}^{k-1} a_k^* \, e^{\frac{-j2\pi ki}{T}}] \quad (4)$$

$$= K$$

So, mathematically PAPR is given by,

$$\mathrm{PAPR} = K^2 / K = K \quad (5)$$

If we taken the As Per the IEEE 802.16 for the WI-max specification, we used 256 sub-carriers. So, expected maximum PAPR is around 256(Around 24.08db)

B. 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.

PAPR for the of the OFDM is expressed as[4]

$$\mathrm{PAPR} = \frac{P_{peak}}{P_{avg}} = \max[\![x_n{}^2]\!] / E[\![x_n{}^2]\!] \quad (6)$$

The cumulative function of the X_{max} is given as

$$FX\max(x) = P\,(X\max < x) \quad (7)$$

$$\mathrm{CDF} = (1 - e^{\frac{-x^2}{2\sigma^2}}) \quad (8)$$

The probability that the PAPR is below threshold level can be written as[4]

$$P\,(\mathrm{PAPR} \le x) = (\,1 - e^{\frac{-x^2}{2\sigma^2}}\,)^N \quad (9)$$

We consider this as the complementary commutative distribution function[4]

$$\mathrm{CCDF} = 1 - (\,1 - e^{\frac{-x^2}{2\sigma^2}}\,)^N \quad (10)$$

III. PAPR REDUCTION TECHNIQUES

- Clipping and Filtering
- Coding Schemes
- Partial Transmission Sequence (PTS)

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.[2] Let x[n] denote the pass band signal and x_c[n] denote the clipped version of x[n], which can be expressed as

$$x_c(n) = \begin{Bmatrix} -A, & \text{if } x[n] \le -A \\ x[n], & \text{if} -A \le x[n] \le A \\ A, & \text{if } x[n] \ge -A \end{Bmatrix}$$

Where, A is the pre-specified clipping level. [2] However this technique has the following drawbacks:

- Clipping causes in-band signal distortion resulting in Bit Error Rate performance degradation.
- It also causes out-of-band radiation, which imposes out-of-band interference signals to adjacent channels. This out-of-band radiation can be reduced by filtering.
- This filtering of the clipped signal leads to the peak regrowth. That means the signal after filtering operation may exceed the clipping level specified for the clipping operation
- So we came to know that this clipping and filtering technique has some sort of distortion during the transmission of data.

CODING TECHNIQUE

The coding technique is used to select such codewords that minimize or reduce the PAPR. [1] 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.

PARTIAL TRANSMIT SEQUENCE

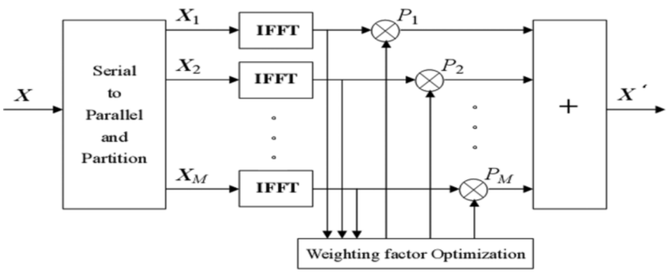

Figure 1 :PTS Block Diagram [3]

In the PTS approach, the input data block is partitioned into disjoint sub-blocks,
There are three partition methods for PTS scheme

- Interleaved
- adjacent
- Pseudo-random.

Among them, pseudo-random partitioned PTS scheme can obtain the best PAPR performance. The sub-carriers in each sub-block are weighted by phase factor rotations. This rotation factor generates time domain data using which it selects signal having lowest PAPR.

At the receiver, the original data are recovered by applying inverse phase factor rotations

TABLE 1: Comparison of the reduction techniques

Different Techniques	Implementation Complexity	Bandwidth Expansion	BER Degradation	Distortion
CLIPPING	Low	No	Yes	Yes
CODING	Low	Yes	No	Yes
PTS	High	No	No	No

IV. WHY THE COMPLEXITY IS HIGH IN THE PTS??

Main complexity issues are

- Number N IFFT operations
- of complex multiplication and summation factors[5]

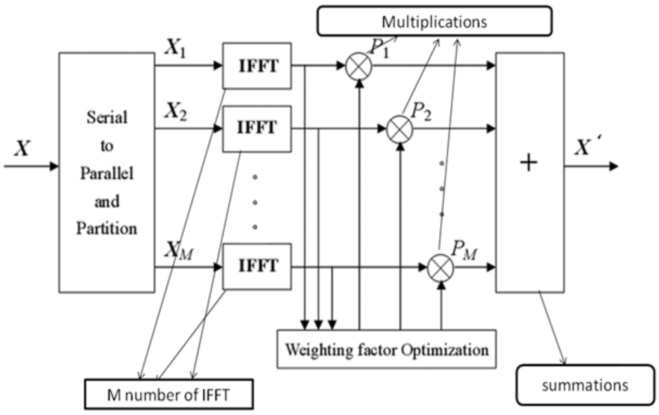

Figure 2: complexity issue

For the measurement of the computational complexity of our PTS, computational complexity reduction ratio (CCRR)[6]. I often employed, defined as complexity can be calculated in terms of complex summation and multiplication.

$$\text{CCDF} = 1 - \left(\frac{\text{complexity of the new PTS}}{\text{complexity of the old PTS}}\right) * 100 \quad (11)$$

That is to say, a large value of CCRR is the more reduction in computational complexity the new-PTS can obtain compared to original-PTS. [6]

V. SIMULATION

TABLE 2 : parameters assumptions for the OFDM

Parameter	Assumption
Number of Symbols	1000
Modulation Scheme	QPSK

FLOWCHART FOR THE OFDM

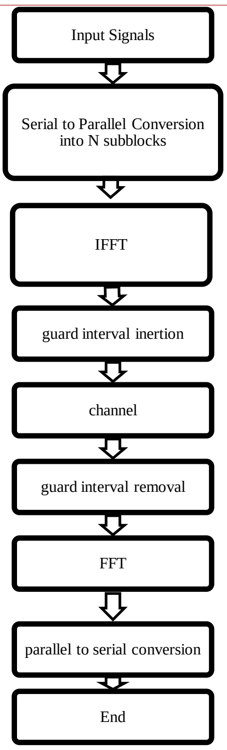

Figure 3: Flowchart for the OFDM

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Simulation result for the OFDM

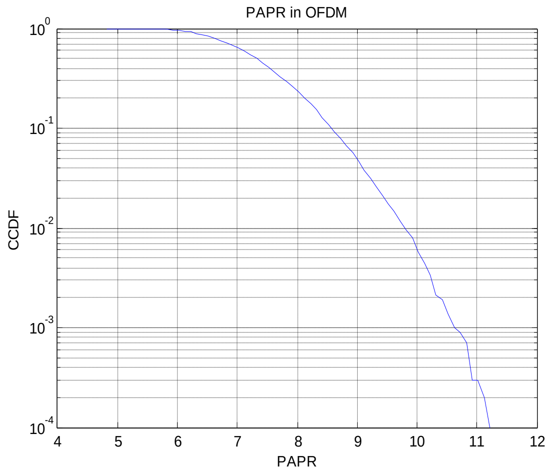

Figure 4: Simulation result for the OFDM

FLOWCHART FOR THE PARTIAL TRANSMIT SEQUENCE

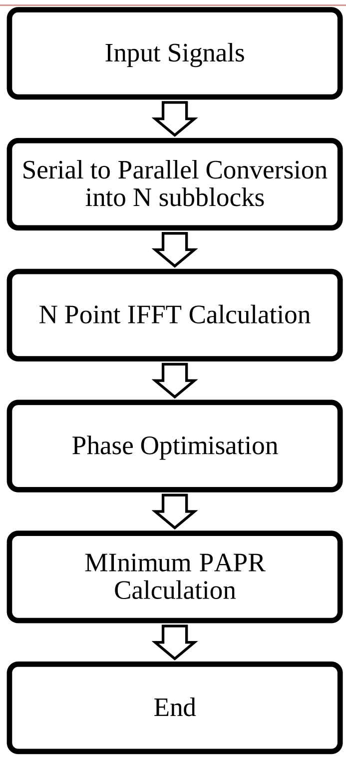

Figure 5: Flowchart for the PTS

PERFORMANCE ALGORITHM:

For all signals do

Covert signals into N sub blocks

For each sub blocks do

1. Calculate IFFT
2. Perform Phase Optimization
3. Combine signals
4. Calculate minimum PAPR

End

End

End

TABLE 3: Parameters assumptions with the PTS

Parameter	Assumption
Number of Symbols	1000
Modulation Scheme	QPSK

Simulation result for the PTS

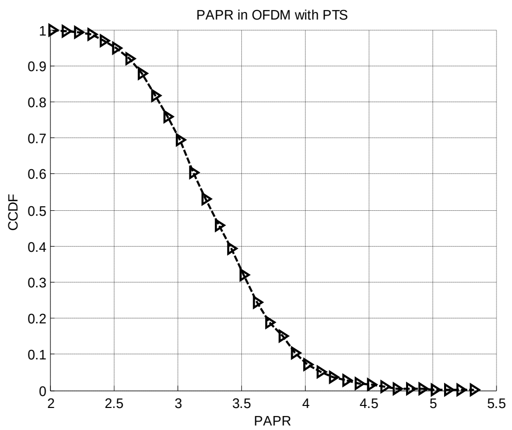

Figure 6: Simulation result for the PTS

COMPARISON

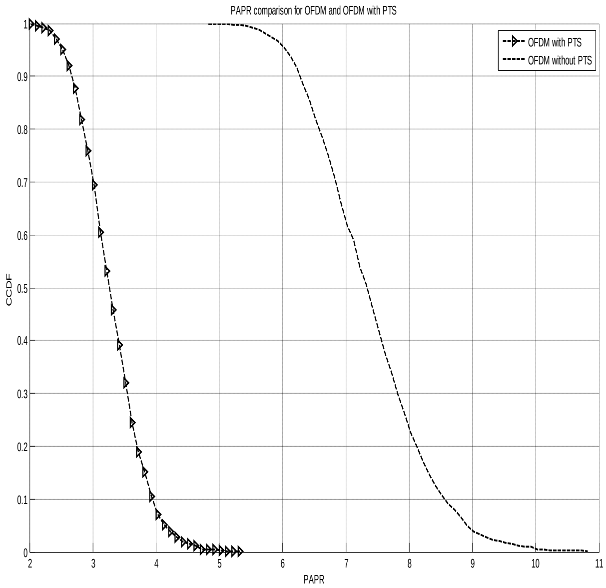

FIGURE 4: Comparison of OFDM with and without PTS

CCDF VALUES COMPARISON				
Algorithm	**PAPR VALUES**			
	2dB	**3dB**	**4db**	**5db**
OFDM	1	1	1	1
OFDM with PTS	1	0.7	0.08	0

In the figure comparison has been shown in terms CCDF between OFDM and without OFDM schemes .It can be seen that CCDF is less in the PTS with compare to conventional PTS.

In table CCDF comparison its shows for the various value of the PAPR which indicates that CCDF of the PAPR is less in OFDM with PTS as compare to conventional OFDM schemes.

VI . CONCLUSION

OFDM is very effective technique used in wireless communication. Peak to Average Power Ration is major drawback of OFDM which has been discussed in this paper. Different schemes for PAPR reduction has also been discussed. Simulation results shows that PTS scheme provides improved performance in PAPR.

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