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Review Article

An Overview on Comparative Study of Various Kind of Techniques to Reduce PAPR in OFDM Communication System

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Abstract

Orthogonal Frequency Division Multiplexing (OFDM) uses multicarrier modulation technique that transfer data at high rate. OFDM has various main advantages like lower Inter symbol Interference (ISI), High spectral efficiency, High Power Efficiency, more immune to multipath fading, efficient usage of bandwidth. Due to these advantages it is suitable to be used in 4G and 4.5G communications. Along with these advantages, high PAPR in OFDM system leads a major consideration as it greatly affects the system performance. In this paper, we are going to have an overview on various PAPR reduction techniques.

Keywords: *OFDM, PAPR, SLM, PTS, TR, TI, PRC, ES.*

1. Introduction

OFDM generally has application in digital video and audio broadcasting and also useful in wireless communication. The basic idea used in OFDM is that the entire bandwidth is subdivided into subcarriers/subchannels (L. Cimini, 1985). To achieve high data rate and to reduce ISI, subcarriers are transmitted parallely (Y.G. Li *et al*, 2006). OFDM system increases the bandwidth efficiency, system capacity and hence provides reliable transmission (Wang Yi, 2009).Therefore OFDM is an attractive scheme for communication. A basic block diagram of OFDM system is illustrated in Figure 1.

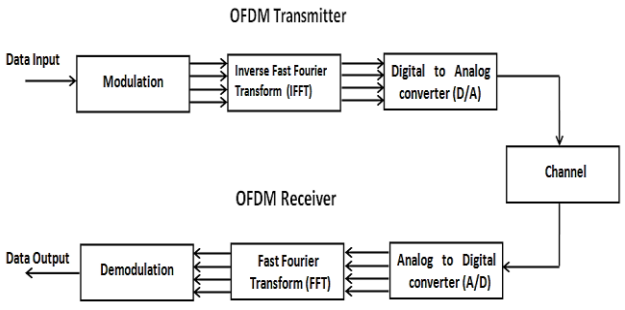

Figure 1: Basic OFDM System

In OFDM system as the number of subcarriers increases, correspondingly PAPR also increases because the addition of positive and negative phases of large number of sub carriers resulting in large amplitude. High PAPR is one of the most common disadvantage of OFDM system. Because of this high PAPR, complexity of A/D converter and D/A converter increases, efficiency of power amplifiers decreases. For efficient communication high PAPR must be reduced. To reduce PAPR different kind of techniques are used. In this paper we will describe PAPR reduction techniques which are used in OFDM system.

2. PAPR with its reduction techniques

PAPR is defined as ratio of peak/maximum output power divided by the average output power. PAPR in OFDM system is given as

$$\text{PAPR} = \frac{\text{peak output power}}{\text{average output power}}$$

PAPR reduction techniques are mainly categorized into two parts (Malhar chauhan *et al*, 2012; Md. Ibrahim Abdullah *et al*, 2011; Dalvir singh *et al*, 2014).

(i) Signal scrambling techniques
(ii) Signal Distortion techniques

2.1 Signal scrambling techniques

Main types of this technique are as given below

2.1.1 Selective mapping technique
2.1.2 Block coding techniques
2.1.3 Partial transmit Sequence technique

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2.1.4 Interleaving technique
2.1.5 Tone Injection technique
2.1.6 Tone reservation technique

2.2 Signal Distortion techniques

Main types of this technique are as given below

2.2.1 Peak windowing technique
2.2.2 Peak reduction Carrier (PRC) technique
2.2.3 Clipping and filtering technique
2.2.4 Envelope Scaling (ES) technique

2.1 Signal scrambling techniques

2.1.1 Selective mapping (SLM) technique

SLM is a reliable technique for PAPR reduction in case of OFDM system. Less distortion effect and no power raise is introduced in OFDM communication while using this technique. A data rate loss is also observed during PAPR reduction. SLM uses Phase rotation method. To generate an alternative input symbol sequences, input data blocks multiplied with phase sequences. Now these alternative input symbol sequences are passed through IFFT and after that signal having lowest PAPR is selected and then used for transmission (Celina Antony *et al*, 2014). It is favorable technique but have a main drawback that the side information is to be transmitted with the chosen signal.

2.1.2 Block coding technique

Block coding technique helps in PAPR reduction in OFDM communication system. Information sequence is divided into sub blocks that is why this technique is named as block coding technique. Now these divided sub blocks are encoded with the help of system on a programmable chip (SOPC). In this technique there is low distortion effect and no power raise takes place. PAPR reduction can be achieved with data rate loss. Basic idea of this technique is that between all messages symbol those who have low peak power will be chosen with the help of valid code words and after that they are used for transmission; thus helpful for large PAPR reduction.

2.1.3 Partial transmit Sequence (PTS) technique

PTS is modified scheme and provides better performance as compared to Selective mapping technique. It is observed that there is less distortion effect and no power raise found in this technique. During PAPR reduction there is possibility of data rate loss. In PTS input data block are partitioned into sub blocks (Sonu Singh Kaurav *et al*, 2014). After that on each sub block scrambling (rotating phase independently) is applied. After passing through IFFT each sub block are multiplied with corresponding complex phase factor and then choose one which has lowest PAPR. Unlike SLM, in PTS there is no need to transmit side information.

2.1.4 Interleaving technique

This technique is similar with SLM except that interleavers are used in this technique. In this technique distortion effect is less and no power raised. During PAPR reduction a loss of data rate is observed. To reduce PAPR this technique uses interleavers because of this it named as interleaving technique. Other name of this technique is adaptive symbol selection method. By applying interleaving on input sequences, multiple OFDM symbols are generated. Now select the one which has lowest PAPR.

2.1.5 Tone Injection (TI) technique

This method is based upon the concept of adaptive method for the reduction of PAPR. By applying adaptive method on multicarrier signal, without data rate loss, we can achieve appropriate PAPR reduction. Distortion effect is reduced and power gets raised during PAPR reduction. In this method original constellation points are mapped with a set of equivalent active constellation points to reduce PAPR. This method is more complex and requires side information to be transmitted.

2.1.6 Tone reservation (TR) technique

For PAPR reduction this method utilizes small set of tones. In this method we add data blocks with time domain signal to reduce high peak. The value of PAPR reduction depends upon the number of factors like location of reserve tones, amount of complexity, number of reserve tones etc. In this technique the possibility of power raised, data rate loss and less distortion effect found during PAPR reduction. TR is a simple method that does not require side information to be transmitted, without having additional complexity at the receiver side.

2.2 Signal Distortion techniques

2.2.1 Peak windowing technique

This technique gives better spectral properties during PAPR reduction. Distortion is introduced, power gets raised and no loss of data rate is possible during PAPR reduction process. This method is helpful in removal of large peaks but there is possibility of self-interference and increase in Bit error rate. Here large peak signals are multiplied with different types of window like Hamming, Kaiser, Cosine window etc. The resulting spectrum is the convolution of original OFDM spectrum and applied window spectrum. The band of window should be narrow, if it is too long in time domain, it will cause increase in Bit error rate.

2.2.2 Peak reduction Carrier (PRC) technique

In this technique we use data bearing peak reduction carrier that is why it is named as peak reduction carrier technique. This technique has distortion effect and no data rate loss. Power gets raised during PAPR reduction. In this technique to represent a lower order modulation symbol we use a higher order modulation scheme. By doing this, overall bit error rate maintained and transmission efficiency increases (Tan, C.E. *et al*, 2003). By representing a lower order modulation symbol with the help of higher order modulation scheme we can reduce PAPR to an appropriate level.

2.2.3 Clipping and filtering technique

This method is one of the simplest approach to reduce PAPR in OFDM system. Distortion effect is introduced and no power raise takes place during PAPR reduction. In this scheme PAPR reduction is achieved without loss of Data rate. In this technique the part of the signal which are outside from the allowed region are clipped. If a signal envelope exceeds from the predefined threshold level, then it is clipped by employing a soft limiter, otherwise it allow signal to pass without change. Clipping uses concept of non-linear process which causes in-band distortion and out-band radiation in OFDM communication systems because of this degradation of BER and spectral efficiency takes place. To improve BER performance and spectral efficiency, filtering is used after clipping. But filtering causes peaks regrowth. To minimize peak regrowth we use repeated clipping and filtering operation, thus we can achieve reduced level of PAPR in OFDM communication systems.

2.2.4 Envelope Scaling (ES) technique

In this technique we apply scaling on subcarriers to reduce PAPR. There is chance of data rate loss and less distortion effect. No power raise is found in this technique during PAPR reduction. Here scaling is applied on input envelope for subcarriers before they are applied to IFFT in OFDM communication system (Aman Dhillon *et al*, 2013). The basic idea of this technique is that scaling of input envelope of subcarriers is done before IFFT, to obtain smallest PAPR at the output terminal of IFFT. At the receiver there is no need of side information for the purpose of decoding of received sequence. This technique is helpful to minimize PAPR value in OFDM system.

Overall analysis of various techniques

Parameters like distortion, power raised and data rate loss of all PAPR reduction techniques are summarized below in Table1.

Table 1: Comparison of various PAPR reduction techniques

Name of techniques	Parameters		
	Distortion Less / Decrease distortion	Power Increase / raise	Data rate Loss
SLM	YES	NO	YES
Block Coding	YES	NO	YES
PTS	YES	NO	YES
Interleaving	YES	NO	YES
Tone Injection	YES	YES	NO
Tone Reservation	YES	YES	YES
Peak windowing	NO	YES	NO
Peak reduction carrier	NO	YES	NO
Clipping And Filtering	NO	NO	NO
Envelope Scaling	YES	NO	YES

Conclusion

Nowadays OFDM seems to be an attractive scheme because of having its features like high data rates, high spectral efficiency and its immunity to multipath fading. Beside of these features, main drawback of OFDM system is high PAPR. In this paper, our topic of concern is PAPR and we gone through different PAPR reduction techniques like signal scrambling and signal distortion techniques. We found that all PAPR reduction techniques are helpful in case of PAPR reduction. But no single technique gives best result under all circumstances in OFDM communication system. In the selection of a particular PAPR reduction technique a compromise is to be made according to system requirements and available resources. Thus chose a proper PAPR reduction carefully as per requirements.

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