

PEAK TO AVERAGE POWER RATIO IN OFDM SYSTEMS REDUCTION

*Asst.Prof. Mr. .G. Vishal Babu¹, Dept of Mining Engineering, Malla Reddy Engineering College
(Autonomous) Maisammaguda, Dhullapally post, via Kompally, Secunderabad-500100 India*

*Asst.Prof. Mr. Vinjamuri Saineesh³, Dept of Mining Engineering, Malla Reddy Engineering College
(Autonomous) Maisammaguda, Dhullapally post, via Kompally, Secunderabad-500100 India*

Abstract

Orthogonal Frequency Division Multiplexing (OFDM) has become the popular modulation technique in high speed wireless communications. It is more advantageous over other technologies. But despite its advantages it has some obstacles also. The high peak-to-average ratio is the main obstacle which causes non-linearity at the receiving end. In this paper we discuss about the PAPR in the OFDM system, its effect and name some techniques which can be used to reduce the PAPR according to the requirement.

Keywords: Multicarrier, OFDM , PAPR , BER , ICI

1. Introduction

New techniques for digital transmission have developed to meet the increasing demand for higher data rates in communications which can be used in both wired and wireless environments. To meet out the high spectral efficiency and high data rate, an efficient modulation scheme is to be employed. A promising modulation technique that is increasingly being adopted in the telecommunication field is Orthogonal Frequency Division Multiplexing (OFDM). Orthogonal Frequency Division Multiplexing (OFDM) is a Multi-Carrier Modulation technique in which a single high rate data-stream is divided into multiple low rate data-

streams and is modulated using subcarriers which are orthogonal to each other. OFDM is a “Multi-Carrier Transmission Scheme.” OFDM is a good solution for high speed digital communications. In this the data to be transmitted is speeded over a large number of orthogonal carriers, each being modulated at a low rate. The carriers can be made orthogonal by appropriately choosing the frequency spacing between them. Orthogonal frequency division multiplexing (OFDM) is a widely used modulation and multiplexing technology, which has become the basis of many telecommunications fields. Therefore OFDM is an advanced modulation technique which is suitable for high-speed data transmission due to

its advantages in dealing with the multipath propagation problem, high data rate and bandwidth efficiency.

OFDM have several attractive features which make it more advantageous for high speed data transmission over other data transmission techniques. These features include.

- (i) High Spectral Efficiency
- (ii) Robustness to channel fading
- (iii) Immunity to impulse interferences
- (iv) Flexibility
- (v) Easy equalization

But in spite of these benefits there are some obstacles in using OFDM:

- (i) OFDM signal exhibits very high Peak to Average Power Ratio (PAPR)
- (ii) Very sensitive to frequency errors (Tx.&Rx.offset)
- (iii) Inter carrier Interference (ICI) between the subcarriers

Multiple Access Techniques:

Multiple access schemes are used to allow many simultaneous users to use the same fixed bandwidth radio spectrum. In any radio system, the bandwidth, which is allocated to it, is always limited. For mobile phone systems the total bandwidth is typically 50 MHz, which is split in half to provide the forward and reverse links of the system. Sharing of the spectrum is required in order increase the user capacity of any wireless network. FDMA, TDMA and CDMA

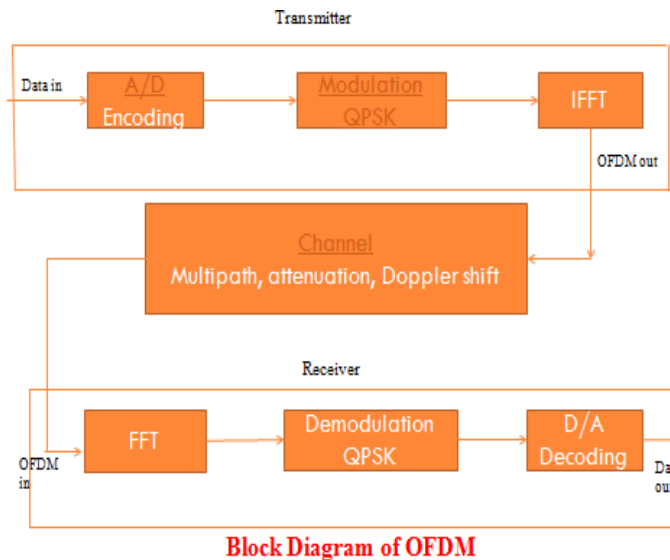
are the three major methods of sharing the available bandwidth to multiple users in wireless system. There are many extensions, and hybrid techniques for these methods, such as OFDM, and hybrid TDMA and FDMA systems. However, an understanding of the three major methods is required for understanding of any extensions to these methods. The hybrid technique for these methods is **OFDM (Orthogonal Frequency Division Multiplexing)**

It is a multi carrier transmission technique, which divides the available spectrum into many carriers, each one being modulated by a low rate data stream.

- It depends on Orthogonality
- It is a special form of MCM.
- It is implemented by using FFT

In previous system, it has been proven that OFDM outperforms other transmission schemes in many aspects of multiple access transmission.

1. Suppression of Inter-Symbol Interference (ISI)
2. Allows many more users
3. Flexible bandwidth allocation
4. Higher Data rates
5. Long distance communication
6. Multi Carrier Modulation (MCM)



PAPR -Peak to Average Power Ratio

The PAPR is the relation between the maximum powers of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. PAPR occurs when in a multicarrier system the different sub-carriers are out of phase with each other. At each instant they are different with respect to each other at different phase values. When all the points achieve the maximum value simultaneously; this will cause the output envelope to suddenly shoot up which causes a 'peak' in the output envelope. Due to presence of large number of independently modulated subcarriers in an OFDM system, the peak value of the system can be very high as compared to the average of the whole system. This ratio of the peak to average power value is termed as Peak-to-Average Power Ratio.

Peak to average power ratio can be written as

$$\text{PAPR} = 10 \log_{10} \frac{\max[|x(t)|^2]}{\frac{1}{T} \int_0^T |x(t)|^2 dt} \quad (\text{dB})$$

High PAPR causes many serious issues in the communication system.

$$f(x) = \beta \cdot \text{sign}(x) \cdot [\text{airy}(0) - \text{airy}(\alpha \cdot |x|)]$$

Those are

1. Increases the complexity of analog-to-digital (A/D)
2. Increases the complexity of digital-to-analog (D/A) converters
3. Lowers the efficiency of power amplifiers.
4. Degrades the system performance and throughput

2. Related Work

2.1 Existing Methods

In the past decades researchers have developed many algorithms for the reduction of PAPR. The paper describes few of them, those are:

- a. Selective Level Mapping (SLM)
- b. Tone reservation
- c. Clipping

Among all the existing techniques the simplest solution is to clip the transmitted signal when its amplitude exceeds a desired threshold. Clipping is a highly nonlinear process, however. It produces significant out-of-band interference

(OBI), A good remedy for the OBI is the so-called companding. The technique 'soft' compresses, rather than 'hard' clips, the signal peak and causes far less OBI.

2.2 Proposed Methodology

Here we proposed a new companding algorithm using a smooth function, namely the airy special function. The companding function is as follows:

where,

$\text{airy}(\cdot)$ is the airy function of the first kind.

α is the parameter that controls the degree of companding (and ultimately PAPR).

β is the factor adjusting the average output power of the compander to the same level as the average input power:

$$\beta = \sqrt{\frac{E[|x|^2]}{E[|\text{airy}(0) - \text{airy}(\alpha \cdot |x|)|^2]}}$$

Where

$[\cdot]$ denotes the expectation.

The decompounding function is the inverse of (x) :

$$f^{-1}(x) = \frac{1}{\alpha} \cdot \text{sign}(x) \cdot \text{airy}^{-1} \left[\text{airy}(0) - \frac{|x|}{\beta} \right]$$

Where the superscript -1 represents the inverse operation.

Notice that the input to the decompander is a quantized signal with finite set of values.

Applications

- Military HF modems
- Voice band modems
- Digital Broadcasting (DAB and DVB-TV)
- WLANs (IEEE 802.11 & Hyper LAN II)
- Cable modems
- WDM fiber optics

Advantages

1. Makes efficient use of the spectrum by allowing overlap.
2. Computationally efficient by using FFT techniques to implement the modulation and demodulation functions.
3. Preservation of orthogonality in severe multipath.
4. Used for higher data rates and higher speed applications.
5. Eliminates ISI through use of a cyclic prefix.
6. Modulation can be done by multiple carriers instead of single carrier.

Disadvantages

1. Peak to Average Power Ratio (PAPR)
2. It is more sensitive to carrier frequency offset.

3. It is sensitive to co-channel interferences.

4. Inter Carrier Interference (ICI)

The main aim of the research is to propose a new algorithm or a technique to reduce the PAPR, which will improve the performance analysis of OFDM systems by increasing the efficiency of RF-HPA. This research work will help us to find the lower PAPR values which will reduce the complexity of DAC and ADC converters and also increases the efficiency of RF-HPA.

3. Implementation

3.1 Proposed Model:

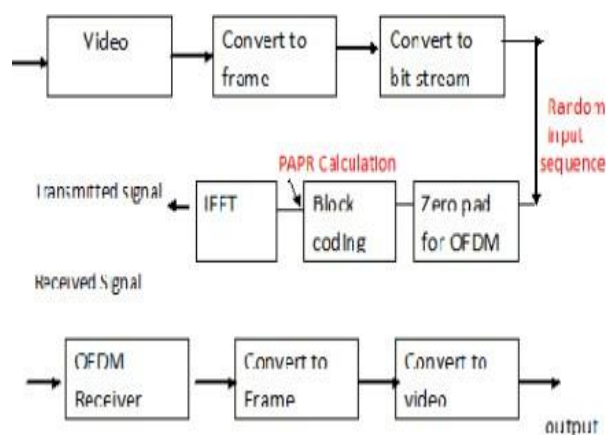


Fig.2. Block diagram

In this model, we will transmit video which consists of frames. This frame is converted into bit stream which is passed through OFDM transmitter. We will calculate PAPR without applying any method. Then after applying Block Coding Technique we will calculate the

PAPR. Further the signal is received by the OFDM receiver.

4. Experimental Work

In this section, a BPSK OFDM system is assumed to be used for SBCC to compare with some well-known results of CBC, SBC, MSBC, SOPC and cyclic coding (CC). It is an example to see the PAPR reduction improvement for SBCC over CBC in OFDM systems, where $N = 16$ and each with '®' stands for one complementally bit, and coding rate $R = 3/4$ as shown in Fig. 3.

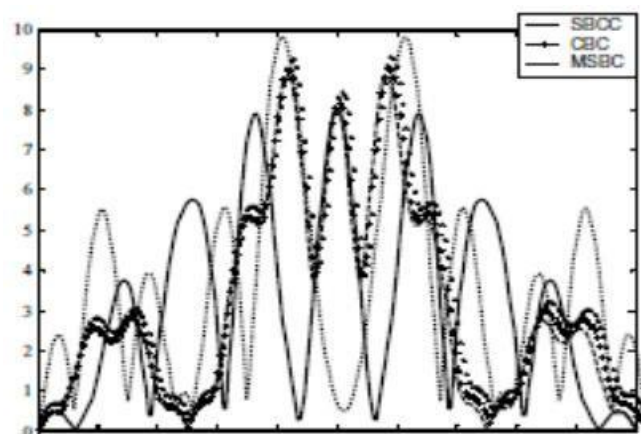


Fig.3. Performance improvement by using SBCC with frame load 0101®®010101®®01, with two sub-blocks.

The PAPR reduction $\Delta\text{PAPR} = 6.03$ (dB) when the SBCC is used, and the $\Delta\text{PAPR} = 5.15$ (dB) for CBC [7], and the $\Delta\text{PAPR} = 4.78$ (dB) for MSBC and SBC [5] [6]. In order to be directly perceived the SBCC effective through the sense, the PAPRs maximum of different frame sizes obtained by SBCC with the same coding rate $R = 3/4$ and, the each OFDM

frame is divided to different sub-blocks are shown in Fig.4 and detailed values are given in Table. Some results of the maximum PAPR and the maximum PAPR reduction obtained with SBCC are given in Table where n is the number of sub-blocks in each frame. In order to make comparisons, some results of PAPR and PAPR reduction obtained with CBC [7], MSBC [5], SBC [5] [6], SOPC [6] and CC [2], are also presented. From these tables, it can be observed that, under the same coding rate $3/4$, the performance of the proposed scheme (SBCC) is almost the same as that of the cyclic coding. But under the same coding rate, such as $7/8$ or $3/4$, the PAPR reduction obtained by the proposed scheme SBCC is better than the rest schemes, like CBC and MSBC.

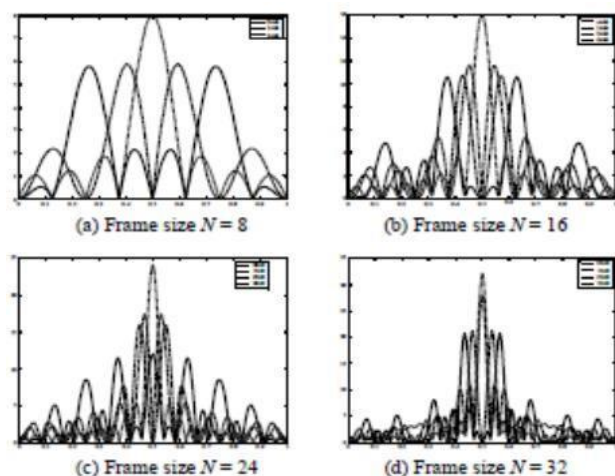


Fig.4. the maximum PAPR obtain by SBCC with the same coding rate $3/4$ and the OFDM frame divided into different sub-blocks

5. Conclusion

Multicarrier systems are proving better in transmission than single carrier systems. OFDM is a digital multi-carrier modulation method where a large number of closely spaced orthogonal subcarriers are used to carry data. One of the serious drawbacks of OFDM systems is that the composite transmit signal can exhibit a very high PAPR when the input sequences are highly correlated. In this paper, we described several important aspects related to the PAPR & its overall effect on the OFDM system & give names several techniques adopted by the system according to the requirement. These techniques to reduce PAPR can be used to reduce the PAPR at the cost of loss in data rate, transmit signal power increase, BER performance degradation, computational complexity increase, and so on.

6. References

- [1]. R.W Chang, "Orthogonal Frequency Division Multiplexing," *U.S Patent 3388455*, Jan 6, 1970, Filed Nov.4.1966.
- [2]. Ramjee Prasad "OFDM for Wireless Communications systems", Artech House Publishers, 2004.
- [3]. B. S. Korngold and D. L. Jones, "PAR reduction in OFDM via active constellation extension," *IEEE Trans. Broadcast.*, vol. 49, no. 3, pp. 258–268, Sep. 2003.
- [4]. L. Wang and C. Tellambura, "An adaptive-scaling algorithm for OFDM PAR reduction

using active constellation extension, “in *Proc. IEEE Veh. Technology Conf.* Sep. 2006, pp. 1–5.

[5]. Y. Kou, W.-S. Lu, and A. Antoniou, “New peak-to-average power ratio reduction algorithms for multicarrier communications,” *IEEE Trans. Circuits and Syst.*, vol. 51, no. 9, pp. 1790–1800, Sep. 2004.

[6]. X. Li and L. J. Cimini Jr., “Effects of clipping and filtering on the performance of OFDM,” *IEEE Communication Letters*, vol. 2, pp. 131–133, May 1998

[7]. T. A. Wilkinson and A. E. Jones, “Minimization of the peak to mean envelope

power ratio of multicarrier transmission schemes by block coding,” *Proc. IEEE 45th Vehicular Technology Conference*, Chicago, July 1995, pp 825–829

[8]. A. E. Jones, T. A. Wilkinson, and S. K. Barton, “Block coding scheme for reduction of peak-to-mean envelope power ratio of multicarrier transmission schemes,” *Electronics Letters*, vol. 30 pp. 2098–2099, 1994

[9]. K. G. Paterson, V. Tarokh, “On the Existence and Construction of Good Codes with Low Peak-to-Average Power Ratios,” *Transaction on Information Theory*, vol. 46 pp. 1974–1987, September 2000