International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-3, Issue-6, June 2015

PAPR Reduction Using ESLM Technique

Gaurav Bishnoi, Baljit Kaur

***Abstract*— Orthogonal Frequency Division Multiplexing (OFDM) systems are adopted as a powerfully potential candidate for next-generation mobile communications systems. OFDM communication systems have a serious drawback that the peak signal value can exceed higher than the average signal value. High Peak to Average Power Ratio (PAPR) makes the signal peaks move into the non-linear region of the RF power amplifier which reduces the efficiency of the RF power amplifier. High PAPR requires a high resolution digital to analog convertor (DAC) at the transmitter and high resolution analog to digital converter (ADC) at the receiver. Any non-linearity in the signal will cause distortion such as inter-carrier interference (ICI) and inter symbol interference (ISI) which is not desired.**

In this paper, we propose ESLM (Enhanced SLM) Technique, a hybrid technique based on Selected Mapping (SLM) and Tone Reservation (TR) for the reduction of high PAPR, in OFDM systems. In OFDM system, we generally get 14 db PAPR but after implementing ESLM technique, PAPR is reduced to 4.8 db which is better for data transmission in OFDM and provides reduced BER with less power consumption.

***Index Terms*—OFDM, PAPR Reduction, SLM, TR.**

I. Introduction

In wireless communication systems, the OFDM technique is a widely popular and attractive scheme for high-data-rate transmission because it can cope with frequency selective fading channels. The modulators and demodulators of OFDM systems can be simply implemented by employing inverse fast Fourier transform (IFFT) and FFT to make the overall system efficient and effective. In present time, it has been adopted as a powerfully potential candidate for next-generation mobile communications systems. In basic communication system, the blocks of data are modulated onto a single carrier frequency. The freely available bandwidth is then totally occupied by each symbol. This type of system can lead to ISI in case of frequency selective channel. The basic concept of OFDM is to divide the available spectrum into several orthogonal sub channels so that each narrow band sub- channel experiences almost flat fading. OFDM technique is becoming the chosen modulation technique for wireless communications. OFDM technique can provide large data rates with sufficient robustness to radio channel deterioration. Latest researches are ongoing in research centers in the world by specialized teams working on the optimization of OFDM systems. In OFDM system, a large number of orthogonal, narrow band, overlapping sub-carriers are transmitted in parallel. These parallel carriers divide the available transmission bandwidth. The channel separation between the subcarriers is such that there is a very compact spectral utilization. In OFDM systems, it is possible to have overlapping sub channels in the frequency domain, thus increasing the transmission data rate. The main attraction of OFDM systems is mainly because of its way of handling the multipath interference at the receiver. Due to multipath phenomenon, generates ISI and frequency selective fading. OFDM technique is most attractive candidate for fourth generation (4G) wireless communication. OFDM systems effectively combat with the multipath fading channel and improve the bandwidth efficiency. It also increases system capacity so as to provide a reliable transmission.

Gaurav Bishnoi, Technical Education Department, Panchkula, Haryana, India, +919468075810.

Baljit Kaur, Sri Sukhmani Institute of Engineering & Technology, Derabassi, Distt. Mohali, Punjab, India.

OFDM technique uses the principles of Frequency Division Multiplexing (FDM) but in much more controlled manner, by allowing an improved spectral efficiency. The idea behind the basic principle of OFDM is to split a high-rate data stream into a number of lower rate streams that are transmitted simultaneously over a number of subcarrier channels. These subcarrier channels are overlapped with each other. Due to the increase in symbol duration for lower rate parallel subcarrier channels, the relative amount of dispersion in time caused by multipath delay spread is decreased. Inter-symbol interference (ISI) is eliminated almost completely by introducing a guard time in every OFDM symbol. The basic OFDM, orthogonal frequency division multiplex is a rather different format for modulation to that used for more traditional forms of transmission systems used earlier. OFDM system utilizes many carriers together to provide many advantages over simpler modulation formats. The main problem one faces while implementing OFDM system is the high peak – to – average power ratio. High PAPR increases the complexity of digital to analog converter (DAC) and reduces the efficiency of the radio frequency (RF) power amplifier.

II. PAPR in OFDM

OFDM signal exhibits a very high PAPR which is due to the summation of sinc waves and non constant envelope. Due to this reason, RF power amplifiers have to be operated in a very large linear region. Otherwise, the OFDM signal peaks get into non-linear region causing signal distortion due to which inter modulation is introduced among the subcarriers and out-of-band radiation occurs. PAPR is a very important factor in the communication system because it has big effects on the transmitted data signal. Low PAPR makes the transmit RF power amplifier works efficiently, otherwise high PAPR makes the signal peaks move into the non-linear region of the RF power amplifier which reduces the efficiency of the RF power amplifier. Also, high PAPR requires a high resolution DAC at the transmitter end, high resolution analog to digital converter (ADC) at the receiver end. Any non-linearity in the signal will cause distortion such as inter-carrier Interference (ICI) and inter symbol interference (ISI). The Cumulative Distribution Function (CDF) is used to measure the efficiency of any PAPR reduction technique. The Complementary CDF (CCDF) is used instead of CDF, which enable us to measure the probability that the PAPR of a certain data block exceeds the given threshold. By implementing the Central Limit Theorem for a multicarrier signal with a large number of sub carriers, real and imaginary part of the time domain signals have a variance of 0.5 and mean of zero and thus follow a Gaussian distribution. So, central chi-square distribution with two degrees of freedom is followed for the power distribution of the system, whereas a Rayleigh distribution is followed for the amplitude of the multicarrier signal. The high PAPR is currently viewed as an important implementation issue in communication systems. Specifically, for wireless cellular systems the price of the mobile unit is required to remain low. This means that a limited PAPR can be supported. High PAPR in OFDM signals need to be reduced so that it can reduce BER and power consumption of the power amplifiers can be reduced.

III. Conventional PAPR Reduction Techniques

Many techniques have been suggested for PAPR reduction with different levels of success and complexity. These techniques are divided into two groups - signal scrambling techniques and signal distortion techniques which are as follows:

A. Signal Scrambling Techniques

- Block Coding Techniques
- Block Coding Technique with Error Correction
- Selected Mapping (SLM)
- Partial Transmit Sequence (PTS)
- Interleaving Technique
- Tone Reservation (TR)
- Tone Injection (TI)

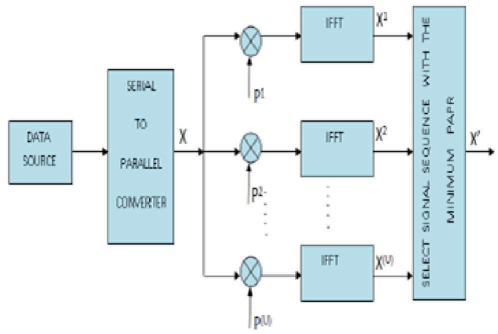
B. Signal Distortion Techniques

- Peak Windowing
- Envelope Scaling
- Peak Reduction Carrier
- Clipping and Filtering

C. Selected Mapping (SLM) Technique

Using SLM, input data is portioned into sub data blocks of length N, and is given by

$$X = [X_0, X_1, X_3, \dots X_{N-1}]$$



Block diagram of the SLM scheme

Then input serial data is converted into the parallel data stream using serial to parallel converter (SIPO). When the data is parallel converted then OFDM data block is multiplied element by element with phase sequence given as

$$P^u = [P^1, P^2, P^3, \dots P^U]$$

Where u= [0, 1, 2….U], to make OFDM data blocks to be phase rotated. Therefore X (u) expressed as,

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

$$= [P_0^{(u)} X_0, P_1^{(u)} X_1, \dots\dots P_{N-1}^{(u)} X_{N-1}]^T$$

$$= P^{(u)} X$$

After data blocks are phase rotated then the rotated OFDM data blocks represents similar information which are unmodified OFDM data blocks provided with known phase sequence. Block diagram of the SLM technique is shown in above Fig. Now, frequency domain signal is converted into the time domain X (u), by the help of IFFT. Figure below, shows a butterfly of radix-2 decimation in frequency for a 16-point IFFT algorithm.

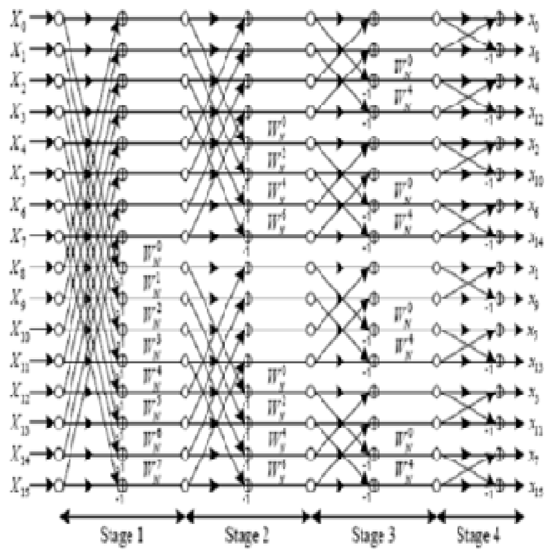


Illustration of butterfly diagram of Raix-2 decimation in frequency for a 16 point IFFT.

D. Tone Reservation (TR) Technique

In order to reduce the peak-power of the transmit signal, common PAPR reduction techniques either introduce

(i) Distortion of the information carrying signal,
(ii) Redundancy which leads to rate-loss, and/or
(iii) An increase of average transmit power

The idea of tone reservation is to define two sets, I+ and I−, of D+ active and D− reserved subcarriers, respectively, with D+ + D− = D. Both index sets are predetermined and common to transmitter and receiver and\ must fulfill the following conditions:

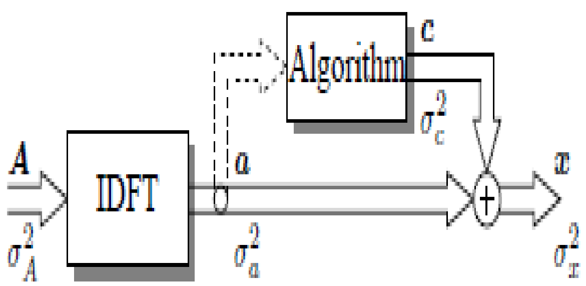
$I_+ \cup I_- = \{1, . . ., D\}$ and $I_+ \cap I_- = \varnothing$.

The information carrying signal is only transmitted over the active subcarriers, i.e., Ad = 0 for d ∈ I−. The signal of the reserved subcarriers C = [Cd] with Cd = 0 for d ∈ I+ can be chosen arbitrarily. The time-domain OFDM frame is now given by

x = a + c = IDFT {A + C}

In time domain, the additive signal c influences the whole information carrying signal a. Hence, the aim is to choose the frequency-domain additive signal C such that it minimizes the PAPR of x.

A block diagram of this PAPR reduction scheme is depicted in Fig.



As I+ and I− are disjoint sets, after discrete Fourier transform at the receiver it is possible to distinguish between information carrying signal A and additive signal c. Hence, no signal distortion is occurs.

However, as a number D− of subcarriers is not used for transmission of information it can be regarded as introduced redundancy. Noteworthy, the additive signal c can arbitrarily be chosen, i.e., the norm //c// 22 is not restricted and, moreover, an increase of average transmit power occurs. In order to compare the impact of these issues on different setups of the PAR reduction system we regard the long-term power efficiency.

$$\eta_{TR} \overset{\text{def}}{=} \frac{\sigma_a^2 D_+}{\sigma_x^2 D} = \frac{\sigma_a^2 D_+}{\sigma_a^2 D_+ + \sigma_c^2 D_-} = \frac{1}{1 + \frac{\sigma_c^2}{\sigma_a^2} \cdot \frac{D_-}{D_+}} ,$$

The fraction between (long-term) average power σ2 a = E_|ak|2_ of the information carrying signal a and the average power σ2x = E_|xk|2_ of the transmit signal x. The long-term average power of the additive signal is given by σ2 c = E_|ck|2_. The peak-to-average power ratio of a given OFDM frame after applying the TR technique is defined by

$$\mathrm{PAR} \overset{\text{def}}{=} \frac{\|x\|_\infty^2}{\|x\|_2^2}$$

In this definition the power of the additive signal c is considered. Definition is reasonable, as we are interested in the PAPR of the actual transmitted signal x. Other definitions in literature dealing with the TR technique do not incorporate the additive signal in order to take solely the peak-reducing characteristics of TR into account and may rather be characterized as peak-power

Reduction Schemes: Review of the TR Convex Optimization Problem Subsequently, we address the problem to find a suitable additive signal c. According to the PAPR reduction problem can be formulated as a convex optimization problem: min p

$$\text{subject to} \quad (a_k + q_k^T C)(a_k + q_k^T C)^* \le p \quad \forall k ,$$

i.e., qk = [qk,d] with qk,d

Optimization problems of this type are extensively discussed in literature. According to a solution can, e.g., be found by application of interior-point methods. Unfortunately, finding an optimum solution of the additive signal c is quite computational exhaustive. Although low complex implementations do exist, the complexity is one serious drawback of TR. In addition to that, the complexity is not fixed for each OFDM frame but may vary for different information carrying signals a. As the additive signal C has to be calculated for every OFDM frame individually, the (short-term) average power of one transmitted OFDM frame varies strongly.

The basic idea of the tone reservation technique is to calculate the additive time-domain signal c which reduces the PAPR of the actual transmit signal x. This calculation is done in an optimum way by solving the convex optimization problem. The additive signal c has two effects on the transmit signal: on the one hand it decreases the peaks but on the other hand the average transmit power is increased. However, both effects are beneficial on the PAPR but an increased average power lowers the power efficiency. Assuming the transmission system tolerates some loss on the power efficiency, it is possible to design a novel PAPR reduction technique which can be regarded as a combination of the ideas of selected mapping and tone reservation. Instead of applying different mappings on the original OFDM frame it is also possible to create the U multiple signal representations by adding arbitrary chosen signals with support restricted to the I− reserved subcarriers to the initial signal a and select the best one for transmission. The huge benefit of this technique is that these U additive signals can a-priori be chosen and transformed into time domain. Thus only one IDFT has to be calculated per OFDM frame (instead of U calculations required for the SLM technique), whereby the number U of assessed signal candidates might be much larger than with SLM. The subsequent approaches use U arbitrarily chosen complex sequences c. Approach I: The D− subcarriers (index in I−) are drawn from identically distributed (IID) complex Gaussian random variables with variance σ2 aD+/D−. Numerical results showed, that a simple addition of c, i.e., considering candidates x = a + c, does not lead to mentionable gains in PAR reduction.

Approach II: Next, we introduce a weighted addition of c with the complex scaling factor γ. The transmit signal is hence given by x = a + γc. In order find the best scaling factor γ for a given sequence c and optimization over its absolute value |γ| and its phase arg(γ) has to be accomplished. Numerical simulations of this scheme were conducted, whereby a search over a sufficiently large number of points γ within the complex plane has been performed. The points have been chosen with equally distributed phase (in the range 0, . . . , 2π) and absolute value (in the range starting from |γ| = 0 linearly increasing to |γ| = _ξD/D− + 1, whereby ξ represents again the worst-case power increase per OFDM frame).

Noteworthy, the total number of assessed candidates is given by the product of U with the number of assessed values γ. Now, the results of numerical simulations showed a better performance in PAR reduction. However, it appears that almost all chosen values of γ exhibited the maximum possible absolute value whereby the phase is equally distributed.

IV. PROPOSED TECHNIQUE

High PAPR is the major problem in OFDM system, so certain measures should be taken to minimize this. Due to high PAPR problems that arose are: complexity of the systems is increased in the analog to digital and digital to analog converter, more BER, less average power etc.

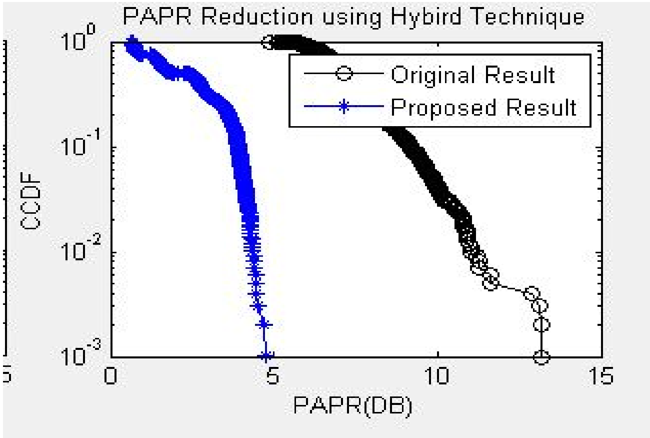
So, we need to propose a new technique that will reduce the high PAPR thereby reducing these problems. To reduce the PAPR, several techniques have been proposed such as Clipping, Coding , Peak Windowing, Tone Reservation but most of these methods are unable to achieve simultaneously a large reduction in PAPR with low complexity without performance degradation.

So, we are proposing a new technique Enhanced SLM (ESLM) technique that will reduce the effect of PAPR in OFDM systems. The paper we are presenting is based on hybridization of techniques like Clipping, Filtering, SLM and Tone Reservation.

Flow chart for the hybrid ESLM PAPR reduction technique is as under:

V. SIMULATION RESULTS

The results of the simulations are presented in this part. To implement the PAPR reduction of a signal MIMO-OFDM space–time block code (STBC), we generated OFDM symbols of length 1024 samples 301and 601 tones are used for data transmission and PAPR reduction. Every data carrying tones uses a QPSK modulation, an oversampling factor of L = 6 is applied and in our simulation 1000 randomly selected tone sets are generated. The results of PAPR reduction in the simulations are presented as the Complementary Cumulative Density Function (CCDF) of the PAPR of the STBC MIMO-OFDM signals.



VI. CONCLUSION

Hence, our proposed ESLM Technique not only reduces the computational complexity but also achieves the improved PAPR reduction to 4.8db compared to as that of the conventional systems which has PAPR value near to 14db.

ACKNOWLEDGMENT

I, would like to thank Ms. Baljit Kaur, who had been guiding through out to complete the paper work successfully on "*PAPR Reduction Using ESLM Technique*".

REFERENCES

[1] Suverna Sengar, Partha Pratim Bhattacharya, "Performance Improvement in OFDM System by PAPR Reduction", SIPIJ Vol.3, No.2, April 2012.

[2] Zhongpeng Wang, "Reduction PAPR of OFDM Signals by Combining SLM with DCT Transform", International Journel of Communications Network and System Sciences, Vol.3 No.11, pp. 888-892, November 2010.

[3] Tianjiao Liu, Xu Li, Cheng Chen, Shulin Cui, Ying Lui, "PAPR Reduction for 802.16e by Clipping and Tone Reservation Based on Amplitude Scale Factor", Springer Berlin Heidelberg, Vol.7719, pp.339-349, November 2012.

[4] Christian Siegl, Robert F.H. Fischer, "Tone Reservation for Peak-to-Average Power Ratio Reduction in OFDM under Different Optimization Constraints", In Proceedings of 13th International OFDM Workshop, Hamburg, Germany, August 2008.

[5] Seung Hee Han, "Modified Selected Mapping Technique for PAPR Reduction of Coded OFDM Signal" , IEEE Transaction on broadcasting,Vol. 50, No. 3, *pp*. 335-341. September 2004.

[6] Leman Dewangan, Mangal Singh, Neelam Dewangan, "A Survey of PAPR Reduction Techniques in LTE-OFDM System", IJRTE, Volume-1, Issue-5, November 2012.

[7] R. Divya Kanti and R.V. Ch. Sekhar Rao, "Systematic Comparison of Different PAPR Reduction Methods in OFDM Systems", IJECE, Vol.7, No.1, pp. 21-30, November 2014.

[8] Reshma Elizabeth Regi, Haris P.A, "Performance of PAPR Reduction in OFDM System with Complex Hadamard Sequence using SLM and Clipping" , IJEAT, Vol.3, No.4, pp. 381-384, April 2014.

Gaurav Bishnoi, Bachelor of Engineering in Electronics & Telecommunications, Lecturer , Electronics & Communications, Technical Education Department, Haryana, India.

Baljit Kaur, Masters of Technology in Electronics & Communications, Assistant Professor, Sri Sukhmani Institute of Engineering & Technology, Derabassi, Distt. Mohali, Punjab, India.