



Journal Homepage: - www.journalijar.com
**INTERNATIONAL JOURNAL OF
 ADVANCED RESEARCH (IJAR)**

Article DOI: 10.21474/IJAR01/5660
 DOI URL: <http://dx.doi.org/10.21474/IJAR01/5660>



RESEARCH ARTICLE

REDUCTION OF THE PAPR EFFECT IN OFDM SYSTEMS USING SELECTIVE MAPPING TECHNIQUE.

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Manuscript Info

Manuscript History

Received: 19 August 2017
 Final Accepted: 21 September 2017
 Published: October 2017

Key words:-

OFDM, PAPR Effect, Selective Mapping.

Abstract

The high peak-to-average power ratio (PAPR) of the transmitted signal in Orthogonal Frequency Division Multiplexing (OFDM) system. It leads to problems as which distorts the signal if the transmitter contains nonlinear components such as power amplifiers and causes some deficiencies such as inter-modulation, spectral spreading and changing in signal constellation. The favorite properties of OFDM signal is it has high spectral efficiency, robustness to channel fading, immunity to impulse interference, uniform average spectral density, capability of handling very strong echoes and less nonlinear distortion. Even though here are many advantages of OFDM, it has two main drawbacks, they are high PAPR and frequency offset. The result of the PAPR effect in OFDM system is investigated and proposed a novel approach to reduce PAPR effect using selective mapping (SLM) technique.

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Introduction:-

Orthogonal frequency division multiplexing (OFDM) technique has been applied into many applications such as digital audio broadcasting (DAB) systems, digital video broadcasting terrestrial TV (DVB-T) systems, asymmetric digital subscriber lines (ADSL), wireless local area networks (WLAN), broadband wireless access (BWA) networks and ultra-wideband systems.

Moreover, it could be expected to be the standard for the Fourth Generation (4G) cellular system. However, OFDM signal passes through a non-linear high-power amplifier (HPA) before it is transmitted over the channel. When the input signal exceeds a certain value, the output of the amplifier becomes saturated and, then, the OFDM signal results a great degradation caused by the HPA. The HPA is commonly considered be memoryless, which means that the current output depends on the current input only.

For applications with wider signaling bandwidths, however, the memory effects of the whole system cannot be ignored. Especially, OFDM signal with a high PAPR is sensitive to the non-linear distortions caused by the HPA. The non-linear distortion in the HPA results in such negative factors as constellation warping which increase the bit error rate (BER) in the system spectrum outgrowth resulting in adjacent channel interference (ACI).

In order to reduce the non-linear distortion, many schemes have been proposed to reduce the PAPR of transmitted signal. Among those PAPA reduction schemes, the simplest method is to use the clipping process. However, using clipping process causes both in-band distortion and out-of-band distortion. These undesired effects could be avoided

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with a linear peak cancellation technique. Besides, the forward-error-control coding applied scheme is another solution to the PAPR reduction. Moreover, based on the scrambling each OFDM symbol with different phase, the small PAPR selection is provided by symbol scrambling methods, such as selective mapping (SLM) method, partial transmitted sequence (PTS) method and sub-block phase weighting (SPW) method.

In this paper, a new PAPR reduction scheme with the help of the selective mapping scheme is proposed. The corresponding symbol patterns are chosen with a low PAPR in the expanded signal space. The scheme could be realized as a signal mapping from the original information symbols to the corresponding patterns. With the selection of the corresponded symbol patterns, the PAPR could be greatly reduced. In the following section, the OFDM system with the proposed signal mapping scheme is described.

Selective Mapping:-

In selective mapping (SLM) the phase sequences are generated randomly from set $\{\pm 1, \pm j\}$. Generation of phase sequence, which is one of the important aspects of SLM technique, is very random in existing phase sequences sets. The row vectors of normalized Riemann matrix are selected as phase sequence set for PAPR reduction in SLM technique. Riemann matrix has a definite structure. In this approach rows of normalized Riemann matrix (B) are used as phase rotation vectors. The Riemann matrix [4] is obtained by removing the first row and first column of the matrix A, where,

$$A(i, j) = \begin{cases} i - 1, & i \text{ divides } j \\ -1, & \text{otherwise} \end{cases}$$

In the selected mapping (SLM) approach, m independent candidates of the sequence X_k are generated and the one with the lowest PAPR is transmitted. To generate these candidates, we multiply the modulation symbol S_n by randomly generated unit magnitude constants b_n . These constants b_n are also known as rotation factors. In the SLM, the input data sequences are multiplied by each of the phase sequences to generate alternative input symbol sequences. Each of these alternative input data sequences is made the IFFT operation, and then the one with the lowest PAPR is selected for transmission. Figure 2.1 shows the block of the SLM technique. X is the OFDM data block, u is the phase vectors and u is the modified data vectors in the frequency domain. So, the time domain signals B_x .

$$x_u(t) = \frac{1}{N} \sum_{k=0}^{k=N-1} X_k \cdot B_{u,k} \cdot e^{j2\pi k \Delta f t}, 0 \leq t \leq NT$$

Where, $u=1, 2, \dots, u$ and is length of X , also the number of subcarriers N .

Among the modified data blocks, the one with the lowest PAPR is selected for transmission. The amount of PAPR reduction for SLM depends on the number of phase sequences U and the design of the phase sequences.

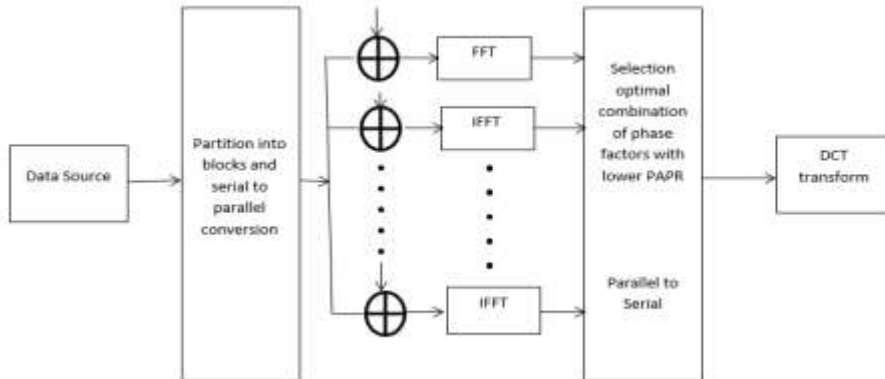


Figure 2.1:- SLM Approach for OFDM Systems

DCT Transform:-

The Discrete Cosine Transform (DCT) is a Fourier like transform. The idea to use the DCT transform is to reduce the autocorrelation of the input sequence to reduce the peak to average power problem and it requires no side information to be transmitted to the receiver. In the section, we briefly review DCT transform.

The formal definition of the DCT of one dimensional of length N is given by the following formula:

$$X_c(k) = \alpha(k) \sum_{n=0}^{N-1} x(n) \cdot \cos \left[\frac{\pi(2n+1) \cdot k}{2N} \right]$$

For $k=0, \dots, N-1$

Similarly, the inverse transformation is defined as,

$$x(n) = \alpha(k) \sum_{k=0}^{N-1} \alpha(k) \cdot X_c(k) \cdot \cos \left[\frac{\pi(2n+1) \cdot k}{2N} \right]$$

For $n=0, \dots, N-1$.

The row (or column) of the DCT matrix C_N are orthogonal matrix vectors. Then we can use this property of the DCT matrix and reduce the peak power of OFDM signals.

Simulation Result:-

The transmitter block is showed in Figure 2.1. In the transmit end, the data stream is firstly transformed by DCT matrix, then the transformed data is processed by the SLM unit. If data block passed by DCT matrix before IFFT, the autocorrelation coefficients of IFFT input is reduced, then the PAPR of OFDM signal could be reduced.

DCT matrix after SLM to further reduce the PAPR of signal. In this fashion, the autocorrelation of the signal, which has been processed by SLM, is reduced by DCT matrix transform. The PAPR of fine output signal is further reduced. The block of transmitter is showed in Figure 2.1.

In this section, computer simulations are used to evaluate the peak-to-average ratio reduction capability with proposed scheme. The channel is modeled an additive while Gaussian noise (AWGN). In simulation, an OFDM system is considered with subcarrier $N=128$ and QPSK modulation. In SLM unit, U different random phase sequences are used.

The results of original SLM are given in Figure 3.2. We can see that the reduction effect is improved with the increasing of sub-block number U . We see that our proposed scheme 1 and scheme 2 for QPSK have better performance.

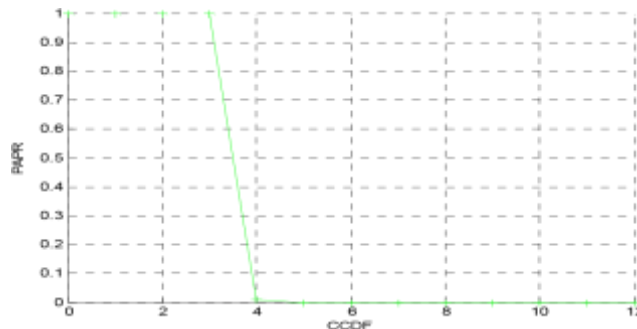


Figure 3.1:- PAPR analysis using CCDF

In Fig. 3.1, the analysis of PAPR effect with respect to the complementary cumulative density function (CCDF), from the simulation. The mean and variance of PAPR of the whole data block for normalized Riemann sequence set is very less compared to other phase sequence sets.

If we use Clipping technique for reduce the PAPR effect the clipped signals after and before the Power Amplifier (HPA) stages given in Figure 3.2 and Figure 3.3 respectively.

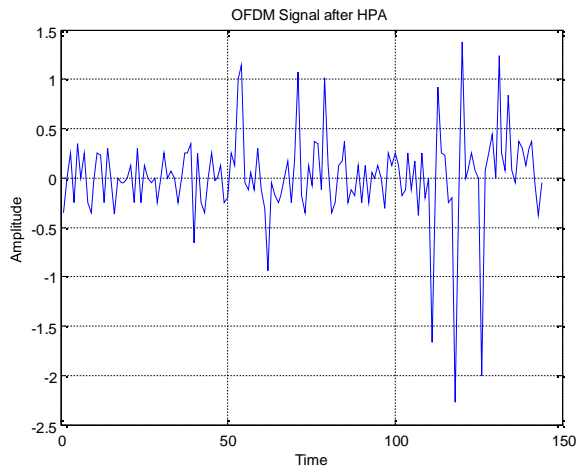


Figure 3.2:- OFDM signals after HPA

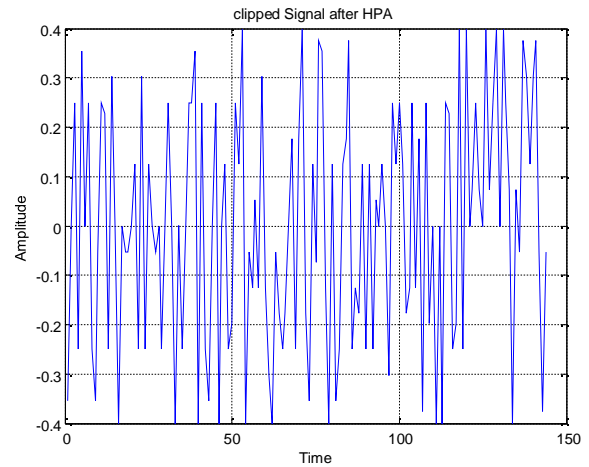


Figure 3.3:-Clipped signal after HPA

The Selective Mapping (SLM) technique with phase shift of 10 degree for every stage of IFFT input. The simulation result shows that the amplitude variations for phase shifts are equal shown in Figure 3.4.

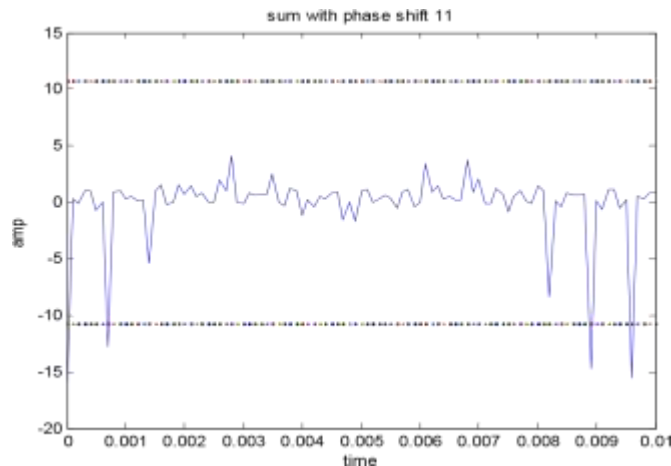


Figure 3.4:- Selective Mapping with each stage phase shift of 10o

Result and Discussions:-

In this paper, techniques for PAPR reduction of OFDM signals have been proposed. These techniques combine the SLM technique and DCT transform. The scheme 1 is composed of DCT matrix transform followed by conventional SLM, while DCT transform is used before conventional SLM processing unit in proposed scheme 2. The PAPR reduction performances are evaluated by computer simulation. Simulation results state that the PAPR reduction performance is greatly improved compared to clipping based Peak Average Power Reduction. The SLM based reduction of PAPR in OFDM system preserve an best part when it combined with Turbo coder as error control coder.

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