International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
(Vol. 14, Issue 01) and (Publishing Month: June 2014)
(An Indexed, Referred and Impact Factor Journal)
ISSN (Online): 2319-6564
www.ijesonline.com

Modified Partial Transmitting Sequence Technique in OFDM System

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Abstract

This paper proposes a technique that modifies the existing PTS technique to reduce PAPR. The proposed technique modifies the PTS technique by using a logarithm function. The final signal obtained using the PTS technique is processed by using the logarithm function. It is necessary to apply inverse of this function at the receiver end to obtain the original signal. The results after modifications, shows that the PAPR is reduced to a great extent by the proposed techniques.

Keywords: *OFDM, PAPR, SLM, PTS.*

I. Introduction

Orthogonal frequency division multiplexing (OFDM) is a promising technique for high data rate transmission because of its high spectral efficiency and immunity to interferences caused by the multi-path channels. However, one major drawback of OFDM is the high peak-to-average power ratio (PAPR) of the transmitted signal. Due to the large number of subcarriers, the amplitude of the transmitted signal has a large dynamic range, leading to inter-modulation distortion and out-of-band radiation when it is passed through the power amplifier. There are a number of methods proposed for PAPR reduction in OFDM systems, e.g. clipping, coding, selected mapping (SLM), and partial transmit sequences (PTS) [1], interleaving , nonlinear companding transforms, hadamard transforms and other techniques etc. these schemes can mainly be categorized into signal scrambling techniques, such as PTS [2], and signal distortion techniques such as clipping, companding techniques. Among those PAPR reduction methods, the simplest scheme is to use the clipping process. However, using clipping processing causes both in-band distortion and out-of-band distortion and further causes an increasing of error bit rate of system. As an alternative approach, a companding shows better performance than clipping technique because the inverse companding transform (expanding) is applied in receiver end to reduce the distortion of signal. Hadamrd transform may reduce PAPR of OFDM signal while the error probability of system is not increased [3].

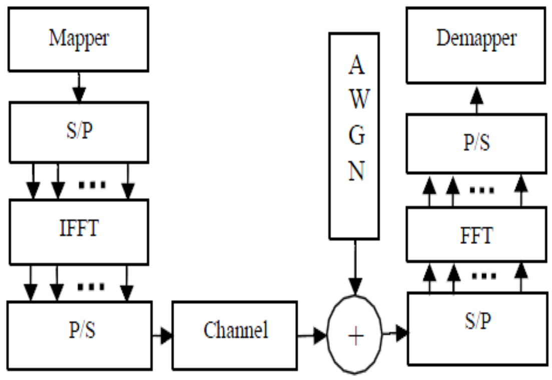

Figure 1: Block diagram of General OFDM system [4]

II. PAPR Problem in OFDM

The main drawback of OFDM is its high peak-to-average power ratio (PAPR) which causes serious degradation in performance when nonlinear power amplifier (PA) is used.

If we consider N modulated data symbols from a particular signaling constellation, $X_k = (X_0, X_1, \ldots, X_{N-1})$, over a time interval [0, T], the OFDM symbol can be written as [5]:

$$x(t) = \sum_{k=0}^{N-1} X_{k^{e^{2\pi k f_0 t}}} \qquad (1)$$

where: $f0 = 1/T$.

Replacing $t = nTb$, where $Tb = T/N$, we arrive at the discrete time version given by:

$$x(t) = \sum_{k=0}^{N-1} X_{k} e^{2\pi kn/N} \quad (2)$$

The PAPR of the signal, $x(t)$, is then given as the ratio of the peak instantaneous power to the average power, written as:

$$PAPR = max_{0 \le t \le T} \frac{|x(t)|^2}{E[|x(t)|^2]} \quad (3)$$

where E is the expectation operator. If N is large enough, based on the central limit theorem, the real and imaginary parts of $x(t)$ have Gaussian distribution and its envelope will follow a Rayleigh distribution. This implies a large PAPR. Equivalently, we can think of this as N sinusoids adding constructively to give a PAPR as large as N.

III. Various Techniques to Reduce PAPR

Several techniques have been proposed in the literature to reduce the PAPR. These techniques a mainly be categorized in to signal scrambling techniques and signal distortion techniques. Signal scrambling techniques are all variations on how to scramble the codes to decrease the PAPR. Coding techniques can be used for signal scrambling. Golay complementary sequences, Shapiro-Rudin sequences, M sequences, Barker codes can be used efficiently to reduce the PAPR. However with the increase in the number of carriers the overhead associated with exhaustive search of the best code would increase exponentially. More practical solutions of the signal scrambling techniques are block-coding, Selective Level Mapping (SLM) and Partial Transmit Sequences (PTS). Signal scrambling techniques with side information reduces the effective throughput since they introduce redundancy [6,7]. The signal distortion techniques introduce both In-band and Out-of-band interference and complexity to the system. The signal distortion techniques reduce high peaks directly by distorting the signal prior to amplification. Clipping the OFDM signal before amplification is a simple method to limit PAPR. However clipping may cause large out-of-band (OOB) and in-band interference, which results in the system performance degradation. More practical solutions are peak windowing, peak cancellation, Peak power suppression, weighted multicarrier transmission, companding etc.

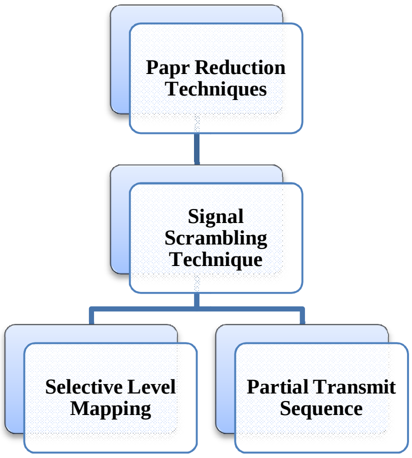

Figure 2: Various Techniques of PAPR Reduction [7].

a) Selected Mapping (SLM)

Selective mapping (SLM) is a popular PAPR reduction scheme for OFDM systems. Like PTS, SLM provides good PAPR reduction capability without distorting the shape of the OFDM signal. Frequency domain OFDM signal, after multiplication with phase sequence set, generates a set of alternative OFDM signals and one of them with lowest PAPR is selected for transmission. But, like PTS scheme, it also suffers from the requirement of SI transmission, which results in data rate loss. In SLM based PAPR reduction schemes the PAPR reduction capability increases with the number of alternative OFDM signals. But, by increasing the number of alternative OFDM signals, the computational complexity of system increases due to the increase in number of IFFT operations and the number of multiplications required to multiply the frequency domain OFDM signal with phase sequence. It has been reported, that SLM based OFDM systems using different types of phase sequence sets, have different PAPR performances for same number of alternative sequences. Hence, for achieving good PAPR reduction and to limit the computational complexity, it is essential to select a good phase sequence set.

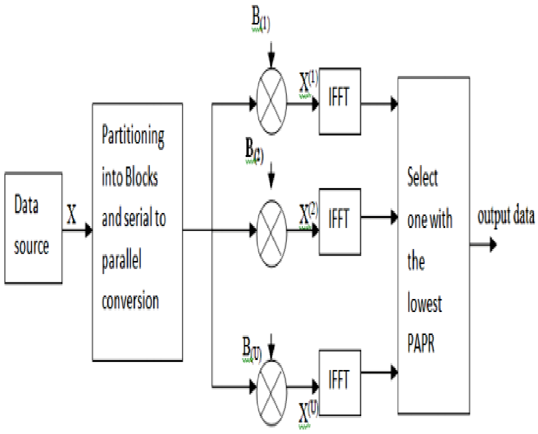

Figure 3: Block Diagram of OFDM transmitter with the SLM Technique [8].

b) Partial Transmit Sequence (PTS)

In PTS approach, the input data block is partitioned into disjoint sub-blocks. The sub-carriers in each sub-block are weighted by phase rotations. The phase rotations are selected such that the PAPR is minimized. At the receiver, the original data are recovered by applying inverse phase rotations. In the PTS technique, an input data block of K symbols is partitioned into disjoint sub-blocks. The subcarriers in each sub-block are weighted by a phase factor for that sub-block. The phase factors are selected such that the PAPR of the combined signal is minimized. In order to implement this idea, the input data block of K symbols is partitioned into M pair wise disjoint blocks X_k, k = 1, ..., Mainly, the total number of subcarriers included in any one of these sub-blocks Xk is arbitrary, but sub-blocks of equal size have been found to be an appropriate choice. All subcarrier positions in Xk, which are already represented in another sub-block, are initialized to zero, so that X=∑_(k=1)^M/X_k .M.

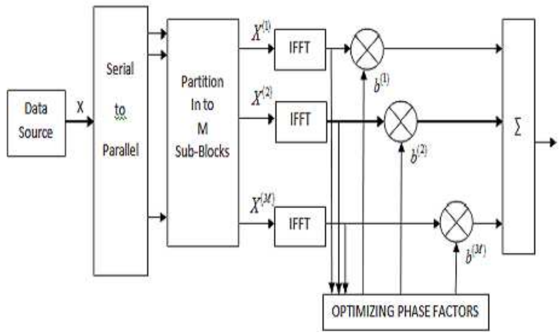

Figure 4: Block diagram of PTS technique [9]

IV. Proposed Work

The proposed technique modifies the PTS technique by using a logarithm function. The final signal obtained using the PTS technique is processed by using the logarithm function. It is necessary to apply inverse of this function at the receiver end to obtain the original signal. The Logarithm Function (log) loge(1+kx) modify the signal then the PAPR is analyzed. The whole process is explained by the following algorithm:

Proposed Algorithm

Step-1: Load modulated Data bits as the input.
Step-2: Partition the input in to block.
Step-3: Convert each block symbol in to time domain by taking IFFT
Step -4: update each sub-block by using the phase generated from [1 -1 j -j].
Step - 5: Apply Logarithm Function to final signal
$C(x) = \log_e(1+kx)$
Where k is an constant
Step-6: Calculate the PAPR..

The proposed algorithm modifies PTS technique. The proposed algorithm will reduce the PAPR due to the logarithm function used. The implementation of the proposed technique is done using the MATLAB given in next section

V. Results

In this section the PAPR reduction performance of the proposed technique is analyzed. This Proposed technique is also compared with the PTS technique.

Simulation has been done in MATLAB and following parameters have been considered for simulation purpose:

Simulation has been done in MATLAB and following parameters have been considered for simulation purpose: Number of subcarriers (N) - 64,32 ; Oversampling factor(L) - 4,2 ;Modulation Scheme –QPSK; Phase factor - [1,-1,j,-j]

In simulations, an OFDM system is considered with number of sub-carriers (N=64) and N=32, over-sampling factor (*L*=2) and L=4 and QPSK Modulation. The phase factor is chosen as {1,-1, j, -j}.

Figure 5 to Figure 8 shows the graphs for the complement cumulative distribution function (CCDF) of PAPR in original PTS and Proposed technique for the different cases of N=64 and L=4 , N=32 and L=4 , N=64 and L=2, N=32 and L=2 respectively.

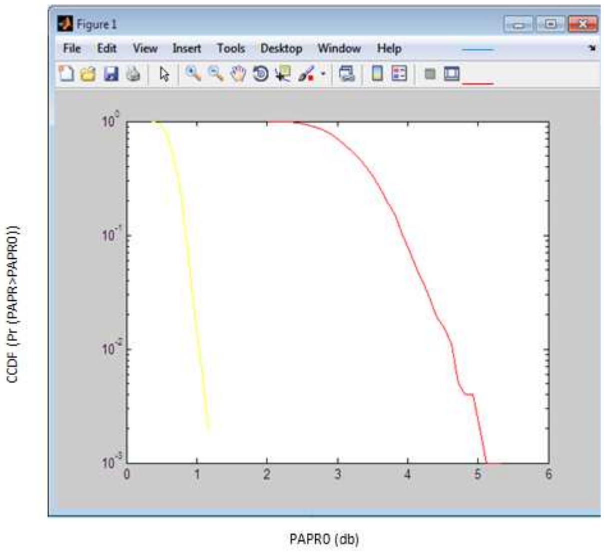

Figure 5: CCDF Of PAPR In Proposed Technique Versus Standard PTS With N=64 And L=4 And QPSK Modulation

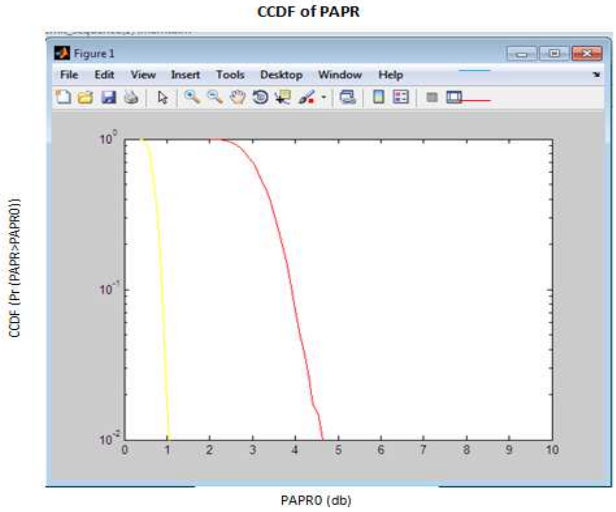

Figure 6: CCDF Of PAPR In Proposed Technique Versus Standard PTS With N=64, L=2, QPSK Modulation

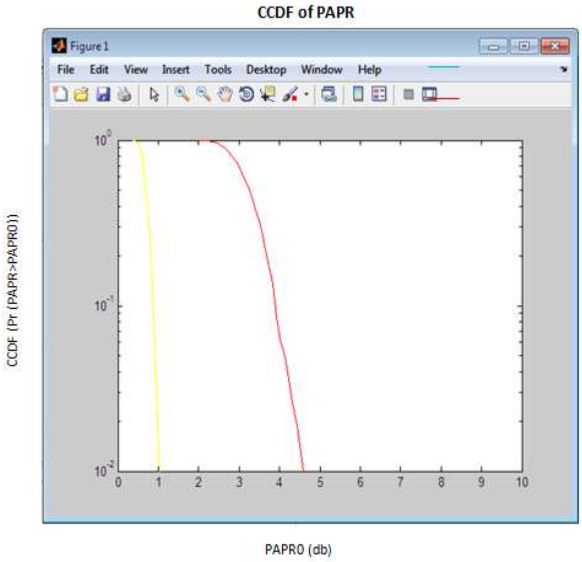

Figure 7: CCDF Of PAPR In Proposed Technique Versus Standard PTS With N=32, L=2, QPSK Modulation

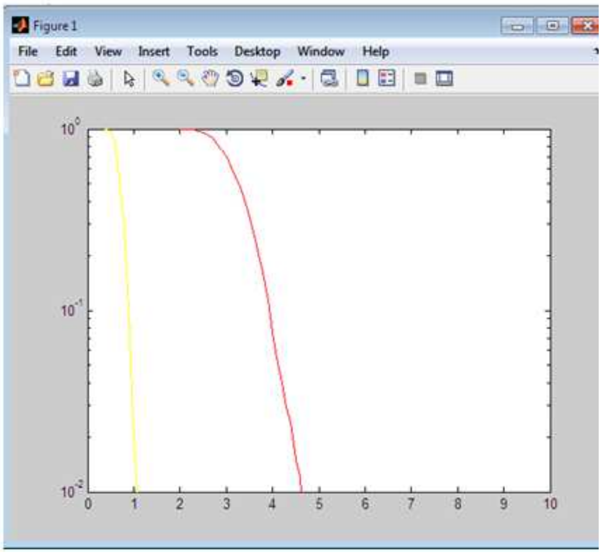

Figure 8: CCDF of PAPR in Proposed Technique versus Standard PTS with N=32, L=4, QPSK Modulation

The comparison shows that the PAPR is reduced to a great extent by the proposed techniques . The comparison is done on the N=64 and N=32 sub bands with oversampling factor 2,4. In all cases the PAPR is reduced more than 50 % of the PAPR of PTS technique. The PTS technique already have reduced PAPR, this confirms the better performance of the proposed algorithm. Moreover, the proposed algorithm doesn't increase the complexity of system. So the PAPR is reduced without increasing the complexity of the system.

VI. Conclusion

The proposed technique modifies the PTS technique by using a logarithm function. The final signal obtained using the PTS technique is processed by using the logarithm function. It is necessary to apply inverse of this function at the receiver end to obtain the original signal. The Logarithm Function (*log*) modifies the signal then the PAPR is analyzed. The comparison shows that the PAPR is reduced to a great extent by the proposed techniques. The comparison is done on the sub bands and oversampling combinations. In all cases the PAPR is reduced more than 50 % of the PAPR of PTS technique. The PTS technique already have reduced PAPR, this confirms the better performance of the proposed algorithm. Moreover, the proposed algorithm doesn't increase the complexity of system. So the PAPR is reduced without increasing the complexity of the system. In future, the proposed technique can be modified to reduce BER. The proposed technique can be analyzed over other simulation scenarios. The proposed technique can be modified to use the neural network to enhance the performance.

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