Time Domain Optimization using Hadamard Matrix Based Phase Sequence and DCT with Classic Frequency Domain Partition Partial Transmitted Sequence (CFDP-PTS) Scheme for the Reduction of Peak to Average Power Ratio (PAPR) in OFDM System

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Abstract

Partial transmitted sequence (PTS) is the most important technique for the minimization of problem peak to average power ratio (PAPR) found in multicarrier system i.e., Orthogonal Frequency Division Multiplexing (OFDM). But PTS scheme undergo a very difficult and complex process of designing random phase sequences which are used for optimization of sub-blocks of data stream in time domain after applying Inverse Fast Fourier Transform (IFFT) so that the problem PAPR can be minimized. Hence in this paper we are proposing a technique in which we have used hadamard matrix for the optimization of sub-blocks of data stream in time domain after IFFT along with discrete cosine transform. So this proposed technique drastically reduced the complexity of designing phase sequence and help in recovering the same information back at the receiver side with the help of index of individual rows of hadamard matrix. Simulation results are presented under multiple sub carriers (N)=64,128 and 256, classic frequency domain partition partial transmitted sequence (CFDP-PTS)=3 and 4 shows a significant gain (dB) of around 3.8 and 1.4 in comparison of conventional OFDM system and traditional PTS technique respectively under N=128 and CFDP=4.

Keywords: Classic Frequency Domain Partition Partial Transmitted Sequence (CFDP-PTS), Complementary Cumulative Distributive Function (CCDF), Peak to Average Power Ratio (PAPR)

1. Introduction

OFDM technique is a multicarrier transmission scheme which is used to provide very high date rate and also highly spectrally efficient technique that’s why it has been adopted as the basis for 4G, digital audio and video broadcasting. In this multicarrier transmission technique complete information is being divided into lower data stream and finally transmitted through multiple subcarriers which are orthogonal to each other hence justify the spectral efficiency of OFDM system. But apart from its advantage, it has a major draw back of a problem which known as Peak to Average Power Ratio (PAPR). The reason behind reducing this problem is that, it make the amplifier behave non-linearly and hence, distort the data in the transmitter side itself therefore several techniques have been proposed in the recent past in order to reduce this problem. Conventional PTS technique

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in which information signal is first partitioned into several sub-blocks and then passed through IFFT block so that it can be converted into corresponding time domain sequence and optimized using these random phase sequences. Finally, the sequence which generate minimum PAPR is selected for the transmission from transmitter side to receiver side and at receiver side it uses index of rows of phases sequence for the recovery of same information. Another important technique is known as Selected Mapping (SLM) in which information is optimized in frequency domain itself using multiple phase sequence of same data length which is very difficult and complex to design, and passed through IFFT at last the sequence which create minimum PAPR is selected for the transmission and same phase sequence are used at the receiver side for the recovery of same information back. Clipping technique is used for the reduction of PAPR. This technique clips the sequence which generate maximum PAPR and hence creates distortion in the data. Coding technique uses various code like BCH code in order to generate several scramblers which are added to data sequence in frequency domain and after transformation by IFFT they stored hence require very large look up tables finally, choose the sequence which generate minimum PAPR. SLM technique along with Discrete Cosine Transform (DCT) is used for the minimization of PAPR in which just before transformation by IFFT, DCT is used and each phase sequence is stored so that at last minimum PAPR sequence can be selected for the transmission. Another technique is highly optimized SLM in which highly optimized phases are designed in order to reduce the PAPR problem. Henceforth, this reduces designing complexity drastically,

\[
s[n] = \frac{1}{N} \sum_{k=0}^{N-1} S[k] e^{j \frac{2\pi nk}{N}} \quad 0 \leq n \leq N - 1
\]

Where \( k, n \) and \( N \) represent frequency index, time index and number of subcarriers.

Peak to average power ratio is defined as the ratio of maximum power to the average power depicted by expectation operator is shown below [9],

\[
PAPR[s[n]] = \frac{\max(|s[n]|)^2}{E[|s[n]|^2]}
\]

Complementary Cumulative Distribution Function (CCDF) calculate the PAPR of information signal which is found to larger than specific threshold shown below [9],

\[
CCDF(PAPR(s[n]) = \frac{\text{Prob}(PAPR(s[n]) > PAPR_0))}{\text{Prob}}
\]

where \( \text{Prob} \) is probability, \( PAPR_0 \) is certain threshold.

Discrete Cosine Transform (DCT) creates a sequence of some finite data as a addition of cosine function at multiple frequencies and is represented as,

\[
d_l = \sum_{n=0}^{N-1} d_n \beta_l \cos \left( \frac{2\pi n l}{N} \right)
\]

Where \( d_l \) is the data symbol, \( \beta_l = 0.707 \) for \( n=0 \), \( \beta_l = 1 \) for \( n\neq0 \).

Now, for \( n=0 \) initially transformed coefficient is calculated and termed as DC co-efficients. Generally, basis functions have various waveforms which are orthogonal to one another.

Walsh hadamard matrix [16] can be generated by a methodology of selvester and rows of this matrix will be preferred for optimization in time domain for PTS technique. Henceforth, this reduces designing complexity drastically,

\[
W_{2N} = \begin{bmatrix} H_N^W & H_N^W \\ H_N^W & (-1)^{N} H_N^W \end{bmatrix} \quad \text{and} \quad H_N^W = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}
\]

3. Proposed Scheme for PAPR reduction

Proposed scheme is detailed as under:

(i) Input data sequence of several subcarriers is defined as shown below,
\( S = \{ S(0), S(1), \ldots, S(N - 1) \} \)

Where sub-carriers = N

(ii) Data sequence generated in equation (1) is modulated by 32-Phase shift keying (PSK) shown below,

\[ G = \{ S_m(0), S_m(1), \ldots, S_m(N - 1) \} \]

(iii) Above defined data sequence is partitioned in frequency domain and represented as,

\[ G = \left[ g_0, g_1, g_2, \ldots, g_{D-1} \right] \]

\[ G = \sum_{z=0}^{D-1} g_z \]

where \( D \) = total number of partition

(iv) After partitioning information sequence is transformed using DCT shown below,

\[ R(t) = \frac{1}{\sqrt{N}} \sum_{l=0}^{N-1} b_l g_l \cos \left( \frac{\pi t^{*} l^{*}}{T} \right) \]

(v) Now, transformed sequence is converted into time domain using IFFT is depicted as,

\[ r = \text{IFFT} \left[ \sum_{b=0}^{D-1} f_b R(t) \right] \]

(vi) Time domain optimization is performed using several rows of hadamard matrix and at last, the sequence which generate minimum PAPR value will be selected for the transmission from transmitter side to the receiver side which given by,

\[ y = \sum_{d=0}^{D-1} f_d \text{IFFT} (r(t)) \quad \text{and} \quad y = \sum_{d=0}^{D-1} f_d \]

Where \( f_d \) = rows of phase sequence selected from above defined matrix

### 4. Simulations, Results and Discussion

Simulations results are generated and presented for proposed scheme in comparison with conventional OFDM system and PTS where number of subcarriers (N) are 64, 128 and 256, oversampling factor=4, total number of OFDM symbol=10000 and modulation scheme=32-PSK.

![Figure 1](image1.png)

**Figure 1.** Comparative analysis of conventional OFDM system, PTS, Proposed scheme under N=64, partition=3, oversampling=4.

In the above Figure 1, results are presented at CCDF=10^{-3} depicts PAPR in dB for Conventional OFDM, PTS and Proposed Scheme at N=64, Number of partition=3, over sampling=4, modulation scheme=32-PSK are 10.2, 8.3, 7.1 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

![Figure 2](image2.png)

**Figure 2.** Comparative analysis of conventional OFDM system, PTS, Proposed scheme under N=64, partition=4, oversampling=4.

In the above Figure 2, results are presented at CCDF=10^{-3} depicts PAPR in dB for Conventional OFDM, PTS and
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Proposed Scheme at N=64, Number of partition=4, over sampling=4, modulation scheme=32-PSK are 10.3, 8.1, 7.0 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

Proposed Scheme at N=256, Number of partition=4, over sampling=4, modulation scheme=32-PSK are 10.8, 8.9, 7.1 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

\[
d_{\text{optmz}} = \arg\min(PAPR(d^n))
\]

Figure 3. Comparative analysis of conventional OFDM system, PTS, Proposed scheme under N=128, partition=3, oversampling=4.

In the above Figure 3, results are presented at CCDF=10-3 depicts PAPR in dB for Conventional OFDM, PTS and Proposed Scheme at N=128, Number of partition=3, over sampling=4, modulation scheme=32-PSK are 10.6, 8.6, 7.2 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

In the above Figure 5, results are presented at CCDF=10-3 depicts PAPR in dB for Conventional OFDM, PTS and Proposed Scheme at N=128, Number of partition=4, over sampling=4, modulation scheme=32-PSK are 10.9, 8.5, 7.1 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

In the above Figure 6, results are presented at CCDF=10-3 depicts PAPR in dB for Conventional OFDM, PTS and Proposed Scheme at N=256, Number of partition=3, over sampling=4, modulation scheme=32-PSK are 10.8, 9.3, 7.1 respectively. Henceforth, it can inferred that minimum PAPR value is obtained by our proposed scheme which shows the remarkable performance of our proposed scheme.

In the above Figure 7, results are presented at CCDF=10-3 depicts PAPR in dB for Conventional OFDM, PTS and Proposed Scheme at N=256, Number of partition=3, over sampling=4.
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5. Conclusion

Classic frequency domain partition partial transmitted sequence (CFDP-PTS) scheme is proposed in this paper for the reduction of peak to average power ratio in OFDM system. In this work we have preferred N=64,128 and 256, frequency domain partition=3 and 4 with oversampling factor=4. Since the conventional scheme suffer in designing appropriate phase sequence so our proposed work do it very efficiently and at the same time in each and every case presented in simulation and results section clearly show the gain, efficiency and remarkable performance of our proposed work for the minimization of PAPR problem.

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7. References

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