PTS and CCM Based PAPR Reduction in OFDM

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Abstract—

OFDM) is an attractive technique for achieving high-bit-rate wireless data communication. It has been applied extensively to digital transmission, such as in wireless local area networks and digital video/audio broadcasting systems. Moreover, it has been regarded as a promising transmission technique for fourth-generation wireless mobile communications. However, due to its multicarrier nature, the major drawback of the OFDM system is the high peak-to-average power ratio (PAPR), which may cause high out-of-band radiation when the OFDM signal is passed through a radio frequency power amplifier.

OFDM systems have the inherent problem of a high peak to average power ratio (PAPR). OFDM Suffers as the no of Subcarriers operating in the large dynamic range operates in the non-linear region of amplifier due to OFDM suffer the PAPR problem Application of high power amplifiers results in increased component cost. In general, there has been a trade-off between PAPR reduction and computational complexity in partial transmits sequence (PTS) OFDM.

This paper modifies the PTS technique of PAPR reduction in OFDM. This can be done by using the CCM. The existing work used PTS to reduce the PAPR .The simulation is done by using the MATLAB and the results are compared by varying the number of symbol.

Index Terms— CCM, PAPR, PTS, OFDM.

INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has drawn explosive attention in a number of wireless communication standards including the IEEE 802.11 a/g, the IEEE 802.16 and 3GPP LTE, due to the advantages of high spectral efficiency, and robustness to the fading channel. However, it suffers from high peak-to-average power ratio (PAPR) and thus causes in-band distortion and out-of-band radiation. Therefore, many PAPR reduction techniques have been presented, such as distortion scheme clipping and filtering and distortion-less scheme selective mapping (SLM), PTS and coding scheme. Among them, distortion-less scheme is a promising PAPR reduction scheme. However, it requires large number of inverse fast Fourier transform (IFFT) at the transmitter, causing high complexity. Therefore, in this existing, a novel cyclic constellation mapping method is proposed to reduce the PAPR with low computational complexity. By moving the original constellation to the properly position, it can significantly improve the PAPR performance [1].

1 PAPR IN OFDM

Orthogonal frequency division multiplexing (OFDM) is one of the most popular modulation techniques because of its high efficiency and robustness against frequency-selective fading. However, the major drawback is that its signal waveform has a high peak-to-average power ratio (PAPR). Nonlinear power amplification of such signals results in generation of noticeable out-of-band spectra, which may contribute to prohibitive adjacent channel interference (ACI). Therefore, power amplifier (PA) must be operated with a large back-off and this operation reduces the PA efficiency.

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The low PA efficiency indicates that most of the supplied energy to PA is dissipated as a heat (resulting in an increase of thermal noise level), and due to this energy loss, the received power will be considerably reduced [1].
However, one of the major drawbacks of OFDM signals is the high peak to average power ratio (PAPR) of the transmitted signal. The high peaks of an OFDM signal occur when the subsymbols for each subcarrier are added up coherently. So OFDM signals can cause serious problems including a severe power penalty at the transmitter which is particularly not affordable in portable wireless systems. Several solutions have been proposed in recent years. It is known that clipping is the simplest method, but it degrades the bit-error-rate (BER) of the system, and results in out-of-band noise and in-band distortion. Although coding [2] can offer the best PAPR reductions, the associated complexity and data rate reduction limit the application of such a technique. On the other hand, selected mapping (SLM) technique modifies the phases of the original information symbols in each OFDM block and selects the phase-modified OFDM block with the best PAPR performance for transmission. However, the requirement of multiple IFFT operations increases the implementation complexity [3].

An OFDM signal consists of a number of independently modulated sub carriers, which can give a large peak-to-average power (PAP) ratio when added up coherently. When N signals are added with the same phase, they produce a peak power that is N times the average power. High PAPR of the transmitted signals results in clipping noise, non–linear distortions of power amplifiers, BER performance degradation, energy spilling into adjacent channels, inter modulation effects on the sub carriers, warping of the signal

constellation in each sub channel, increased complexity in the analog to digital and digital to analog converter [4].
In OFDM , a block of N data symbols, $X_K = (X_0, X_1 \ldots X_{n-1})$ is formed with each symbol modulating the corresponding subcarrier from a s et of subcarriers. The N subcarriers are chosen to be orthogonal, that is, T is the original data symbol period, and $f_0 = 1/T$ is the frequency spacing between adjacent subcarriers. The complex baseband OFDM signal for N subcarriers can be written as [5]

$$x(t) = \frac{1}{\sqrt{N}} \sum_{K=0}^{N-1} X_K e^{j2\pi K f_0 t} \qquad 0 \le t \le T$$

Replacing t=n Tb, where Tb =T/N, gives the discrete time version denoted by

$$x(n) = \frac{1}{\sqrt{N}} \sum_{K=0}^{N-1} X_K e^{j2\pi K/LN} \qquad n = 0,1, \ldots NL-1$$

where, L is the oversampling factor. The symbol-spaced sampling sometimes misses some of the signal peaks and results in optimistic results for the PAPR. The sampling can be implemented by an inverse fast Fourier transform (IFFT).
The PAPR of the transmitted OFDM signal, x(t), is then given as the ratio of the maximum to the average power, written as

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

where E[ ] is the expectation operator.

From the central limit theorem, for large values of N, the real and imaginary values of () xt becomes Gaussian distributed. The amplitude of the OFDM signal, therefore, has a Rayleigh distribution with zero mean and a variance of N times the variance of one complex sinusoid. The complementary cumulative distribution function (CCDF) is the probability that the PAPR of an OFDM symbol exceeds certain threshold PAPR0, which can be expressed as [5]

$$CCDF(PAPR(x(n))) = P_r(PAPR(x(n))) > PAPR_0$$

Due to the independence of the N samples, the CCDF of the PAPR of single input single output (SISO) OFDM as a data block with Nyquist rate sampling is given by

$$P = P_r\left(PAPR\left(x(n)\right)\right) > PAPR_0 = 1 - (1 - e^{-PAPR_0})^N$$

This expression assumes that the N time domain signal samples are mutually independent and uncorrelated and it is not accurate for a s mall number of subcarriers. Therefore, there have been many attempts to derive more accurate distribution of PAPR .

2 PAPR REDUCTION TECHNIQUES

PAPR reduction techniques vary according to the needs of the system and are dependent on various factors. PAPR reduction capacity, increase in power in transmit signal, loss in data rate, complexity of computation and increase in the bit-error rate at the receiver end are various factors which are taken into account before adopting a PAPR reduction technique of the system. [6].The PAPR reduction techniques on which we would work upon and compare in their later stages are as follows:

3 PARTIAL TRANSMIT SEQUENCE (PTS)

Partial Transmit Sequence (PTS) technique has been proposed by Muller and Hubber in 1997. This proposed method is based on the phase shifting of sub-blocks of data and multiplication of data structure by random vectors. This method is flexible and effective for OFDM system. The main purpose behind this method is that the input data frame is divided into non-overlapping sub blocks and each sub block is phase shifted by a constant factor to reduce PAPR. PTS is probabilistic method for reducing the PAPR problem. It can be said that PTS method is a modified method of SLM. PTS method works better than SLM method. The main advantage of this scheme is that there is no need to send any side information to the receiver of the system, when differential modulation is applied in all sub blocks

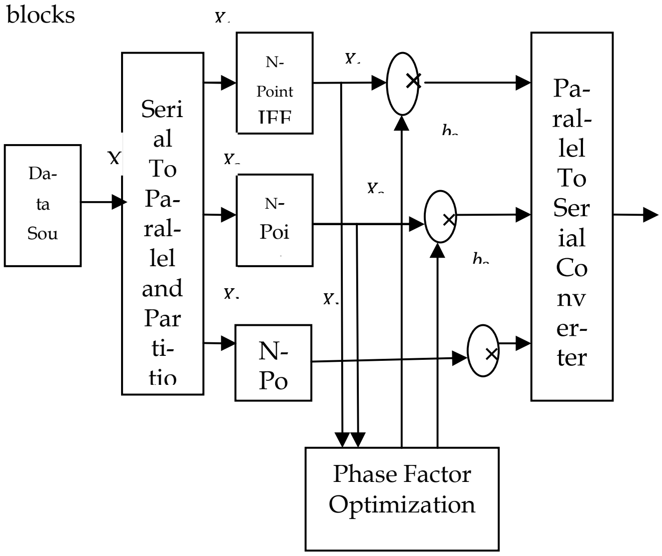

Figure 1: Basic approach of PTS scheme.

4 THE CYCLIC CONSTELLATION MAPPING METHOD

In a typically OFDM system, the original -QAM constellation has a fixed mapping method, i.e., the square 64-QAM shown in Figure 4.2a. The main idea of CCM is to cyclically move the mapping constellation, shown in Figure 4.2b. Thus, these extra move can be exploited to reduce the PAPR. Equation (1) illustrates this modification. In this equation $M' = \frac{\log_2 M}{2} - 1$, and (Xn) denote the minimum distance between constellation points and the new mapping constellation when the cyclic move number equals to , respectively. Note that this operation is only applied to the data carriers.

SmXnSm−1(Xn)+d
ReSm−1Xn<M'd−ReSm−1Xn+j.ImSm−1Xn−d
Re{Sm−1Xn<M'd&>−M'd−Sm−1(Xn) otherwise&
$Im\{S_{m-1}(X_n)\}$ (4.1)

Figure 4.1: The Cyclic Constellation Mapping Method.
Therefore, the new transmit signal can be given by

$$x_m(k) = \frac{1}{\sqrt{N}}\sum_{n=1}^{N} S_m(X_n) e^{j\frac{2\pi}{JN}nk} \quad (4.2)$$

and the PAPR reduction problem can be written as the following integer optimization problem
$m^{(opt)} = \min_m PAPR(x_m)$ (4.3)
Where E (.) is the optimal move of the constellation.

5 PROPOSED WORK

In the existing work the PTS is used to reduce the PAPR. The peak to average power ratio can be further reduced by using CCM technique. This work performs the hybridization of the PTS and CCM to reduce the PAPR. The input data is partitioned in to N blocks. The data of each block is converted to time domain by using the IFFT. This data is multiplied with the phases then converted to serial to get the PAPR vale. The process is repeated for each symbol and the minimum value is taken as the reduced PAPR value. This process can be explained by the following block diagram:

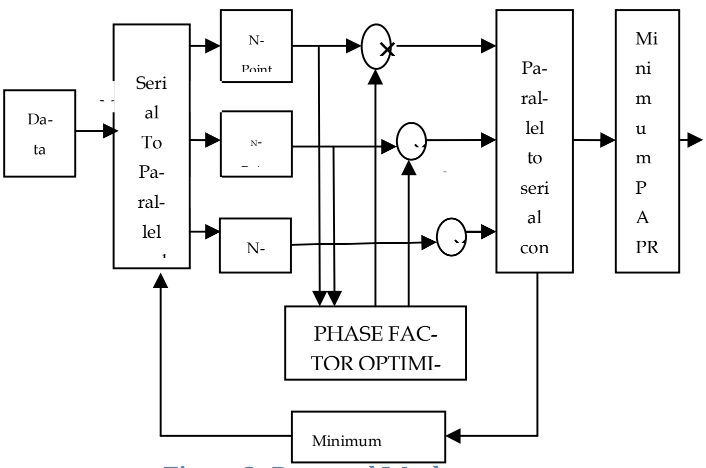

Figure 2: Proposed Work

Table 1: Parameter Analysis Between PAPR (Existing) and PTS+CCM (Proposed)

Number of Symbols	Average PAPR(PTS)	Average PAPR(PTS+CCM)
10000	3.8637	3.3088
1000	3.9030	3.3361
100	3.8423	3.3148
10	4.0032	3.2953

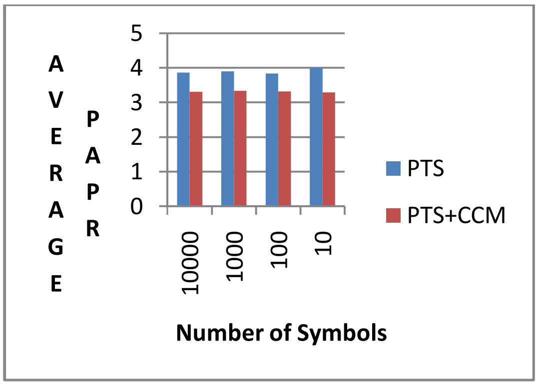

Figure 3: Comparison of Average PAPR

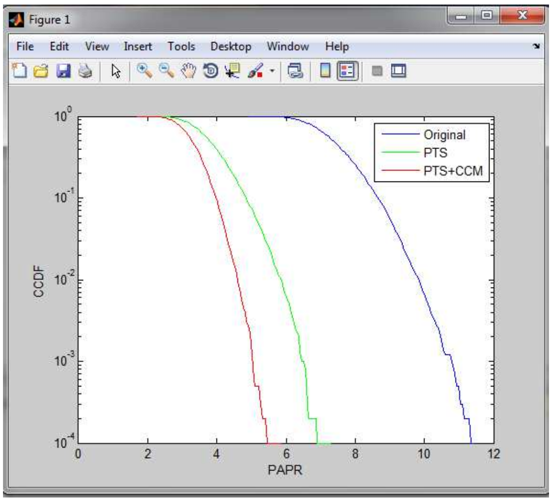

Figure 4: Comparison of CCDF At 10000symbol

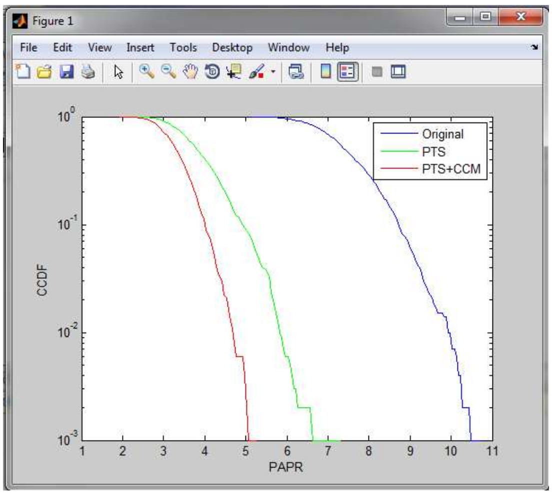

Figure 5: Comparison of CCDF at 1000symbol.

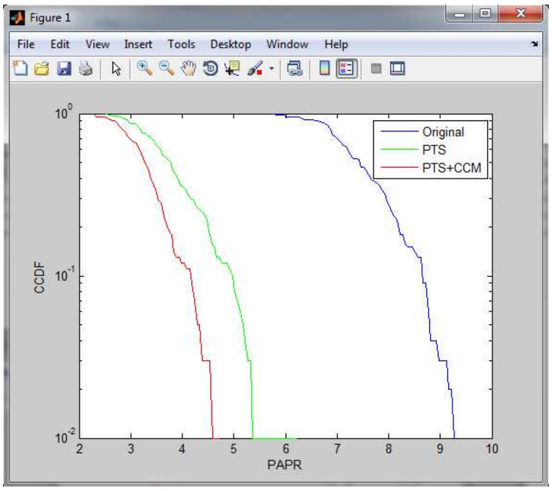

Figure 5: Comparison of CCDF at 100 Symbol

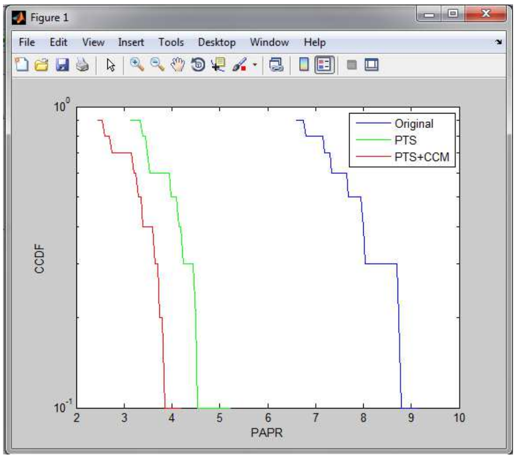

Figure 6: Comparison of CCDF at 10 Symbol

The comparison of average PAPR and CCDF between the PTS and the proposed shows the better performance of the proposed in each case.

6 CONCLUSION

This Paper modifies the PTS technique of PAPR reduction in OFDM by using the CCM. In the existing work the PTS is used to reduce the PAPR. The peak to average power ratio can be further reduced by using CCM technique. This work performs the hybridization of the PTS and CCM to reduce the PAPR. The input data is partitioned in to N blocks. The data of each block is converted to time domain by using the IFFT. This data is multiplied with the phases then converted to serial to get the PAPR vale. The process is repeated for each symbol and the minimum value is taken as the reduced PAPR value. The simulation is done by using the MATLAB and the results are compared by varying the number of symbols. The comparison of average PAPR and CCDF between the PTS and the proposed shows the better performance of the proposed in each case.

REFERENCES

[1] Lee, Taewoo, and Hideki Ochiai. "Experimental Analysis of Clipping and Filtering Effects on OFDM Systems." Communications (ICC), 2010 IEEE International Conference on. IEEE, 2010.

[2] Wang, Y., and Z. Luo. "Optimized iterative clipping and filtering for PAPR reduction of OFDM signals." Communications, IEEE Transactions on 59.1 (2011): 33-37.

[3] Yajun Wang, Wen Chen, and Chintha Tellambura, "A PAPR Reduction Method Based on Artificial Bee Colony Algorithm for OFDM Signals", VOL. 9, NO. 10, OCTOBER 2010.

[4] Gupta, K., Kushwaha, M., Sharma, A. P., & Panwar, A. S. (2013). PAPR reduction of OFDM using a new phase sequence in SLM technique. International Journal of Advanced Electrical and Electronics Engineering, 2, 2.

[5] Mukunthan, P., & Dananjayan, P. (2011, June). Modified PTS with FECs for PAPR Reduction in MIMO-OFDM system with different subcarriers. In Humanities, Science & Engineering Research (SHUSER), 2011 International Symposium on (pp. 89-94). IEEE.

[6] Dash, A. A. (2010). OFDM systems and papr reduction techniques in OFDM systems (Doctoral dissertation, National Institute Of Technology, Rourkela).