ISSN: 2277-5528
Impact Factor: 2.745 (SIJF)

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & MANAGEMENT

NEW PHASE SEQUENCE PTS AND COMPANDING USED TO REDUCE PAPR IN OFDM SYSTEM

Vasim Khan[1], Pravin Patidar[2]
Department of Electronics and Communication Engineering
Lakshmi Narain College of Technology Indore (M.P.), India
vasimkhan87@yahoo.co.in[1]

Abstract

Orthogonal Frequency-division multiplexing or multicarrier transmission scheme is an attractive technique for high-bit-rate communication systems. It has been widely used in modern wireless communication because of its high data rate, immunity to delay spread and frequency spectral efficiency and other advantages. Besides these advantages, one of the major drawbacks of OFDM is the high Peak-to- average-power ratio (PAPR) of the Transmitter's output signal, as it restricts the system performance. One of the effective methods used for reducing peak to average power ratio (PAPR) in OFDM systems is partial transmit sequence (PTS). In the conventional PTS (CPTS) several inverse fast Fourier transform (IFFT) operations and complicated calculation to obtain optimum phase sequence, increase the computational complexity of C-PTS. In this paper, we propose new a technique i.e., new phase sequence PTS and companding in cascaded form. First new phase sequence is used to reduce the number of IFFT operations to half at the expense of a slight PAPR degradation. Simulations are performed with QPSK modulation with OFDM signal and Saleh model power amplifier. The effects of digital pre-distortion (DPD) to increase the linearity and efficiency of the Saleh model power amplifier (PA) are also examined and then next we will add companding techniques which will again used to reduce PAPR in OFDM.

Keywords: Orthogonal Frequency-division multiplexing (OFDM), Peak-to-average-power ratio (PAPR), companding, Inverse Fast Fourier Transform (IFFT), Partial Transmit Sequence (PTS).

I. INTRODUCTION

The technology of Orthogonal Frequency Division Multiplexing (OFDM) is a multi-carrier digital communication modulation technique which makes use of multiple sub-carriers and the frequency of overlapping technology. OFDM is mainly used in digital audio broadcasting (DAB), digital video broadcasting-terrestrial (DVB-T), mobile multimedia access communication (MMAC), IEEE802.11a, IEEE802.16 and IEEE 802.20. However, as the OFDM symbol is modulated by the sum of a number of independent sub-carrier signal, and the subcarriers are statistically independent, when the number of subcarriers comes to a certain extent, the peak to average power is much larger than the single-carrier system, which requires the system power amplifier, A/D and D/A converter with a larger linear dynamic range. So that the OFDM system can easily lead to interference between adjacent channels, and the orthogonal is destroyed. It is therefore important to minimize the PAPR. The high PAPR feature will cause poor efficiency of power consumption, in band distortion, and spectral spreading when an OFDM signal is passed through a nonlinear power amplifier.

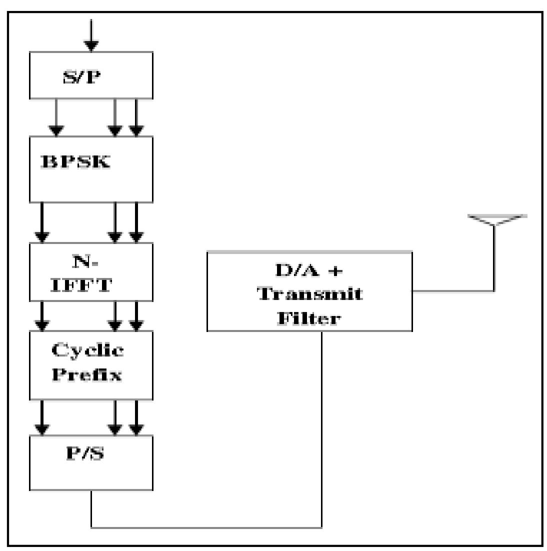

Fig. 1: Basic OFDM Transmitter Structure

II. REDUCTION TECHNIQUES

A. Partial Transmit Sequence (PTS)

The data stream is partitioned into non-overlapping sub blocks of equal size. Each sub block is multiplied by a weight. The weight is chosen as per convenience and a hit and trial method is used to obtain the weights to optimize the algorithm. The side information must be provided at the receiver. The performance of BER will be less degraded.

B. New Phase Sequence PTS

B.1 Conventional PTS (C-PTS)

Let X denotes random input signal in frequency domain with length N. X is partitioned into V disjoint subblocks $Xv=[X_{v,0},X_{v,1},\ldots,X_{v,N-1}]^T$, $v=1,2,\ldots,V$ such that $\sum X_v=X$ where summation varies from v=1 to V and then these subblocks are combined to minimize the PAPR in time domain. The subblock partition is based on interleaving in which the computational complexity is less compared to adjacent and Pseudo-random, however it has the worst PAPR performance among them [4]. By applying the phase rotation factor $b_v=e^{j\theta}$, v=1,2,3......V to the IFFT of the v_{th} subblock Xv, the time domain signal after combining is given by: $X'(b)=\sum b_v x_v$ where summation varies from v=1 to V Here, $X'(b)=[x'_0(b),x'_1(b),\ldots\ldots x'_{NL-1}(b)]^T$ and L is the oversampling factor. The objective is to find the optimum signal $X'(b)$ with the lowest PAPR.

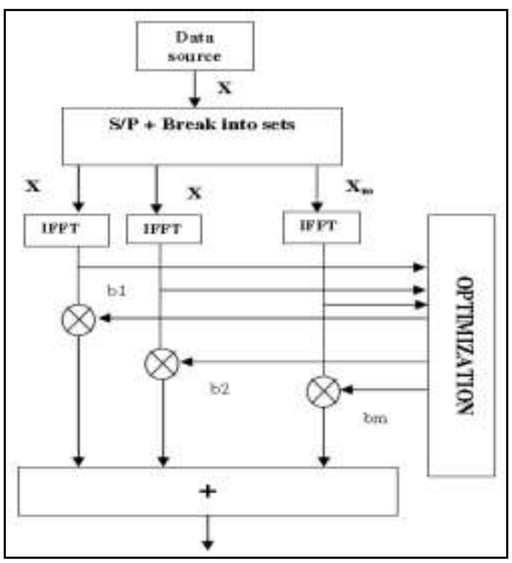

Fig. 2: Block Diagram for PTS

Both b and x can be shown in matrix form as follows:

$$b=\begin{bmatrix} b_1, & b_1, & \ldots, & b_1 \\ \vdots & \vdots & & \vdots \\ b_V, & b_V, & \ldots, & b_V \end{bmatrix}_{V\times N} \qquad (1)$$

$$x=\begin{bmatrix} x_{1,0}, & x_{1,1}, & \ldots, & x_{1,NL-1} \\ \vdots & \vdots & & \vdots \\ x_{V,0}, & x_{V,1}, & \ldots, & x_{V,NL-1} \end{bmatrix}_{V\times NL} \qquad (2)$$

It should be noted that all the elements of each row of matrix b are of the same values and this is in accordance with the C-PTS method. It should be noted that in order to have exact PAPR calculation, at least 4 times oversampling is necessary . As the oversampling of x, add zeros to the vector, hence the number of phase sequence to multiply to matrix x will remain the same. Now, the process is performed by choosing the optimization parameter $\tilde{b}$ with the following condition:

$$\breve{b} = argmin(\max_{0\le k\le NL-1} |\sum_{v=1}^{V} b_v x_v|) \qquad (3)$$

After finding the optimum $\tilde{b}$ then the optimum signal is transmitted to the next block.

For finding the optimum $\tilde{b}$, we should perform exhaustive search for (V-1) phase factors since one phase factor can remain fixed, $b_1=1$. Hence to find the optimum phase factor, W^{V-1} iteration should be performed, where W is the number of allowed phase factors.

B.2 New Phase sequence PTS

One of the effective methods used for reducing peak to average power ratio (PAPR) in OFDM systems is partial transmit sequence (PTS). In the conventional PTS (CPTS) several inverse fast Fourier transform (IFFT) operations and complicated calculation to obtain optimum phase sequence, increase the computational complexity of C-PTS. In this paper, we propose a technique to reduce the number of IFFT operations to half at the expense of a slight PAPR degradation. Simulations are performed with QPSK modulation with OFDM signal and Saleh model power amplifier. The effects of digital pre-distortion (DPD) to increase the linearity and efficiency of the Saleh model power amplifier (PA) are also examined.

A new phase sequence is proposed here in order to decrease computational complexity of the C-PTS technique. As mentioned in earlier, the total complexity of C-PTS is more than SLM because of the high number of iterations for finding the optimum phase sequence. With this new phase sequence, we can have less complexity compared to C-PTS while PAPR reduction is almost the same. The new phase sequence is based on the generation of N random values from the possible phase factors {1 -1}, if we consider the number of allowed phase factor W=2. Therefore the new phase sequence can be constructed as follows:

$$\hat{b} = \begin{bmatrix} b_{1,1}, & b_{1,2}, \ldots, & b_{1,N} \\ \vdots & \vdots & \vdots \\ b_{V,1}, & b_{V,2}, \ldots, & b_{V,N} \end{bmatrix}_{V\times N} \tag{4}$$

Where N is the number of subcarriers and V is the number of subblocks partitioning.

As mentioned in before, matrix x has VxNL elements and each row consists of NL elements, after oversampling by L. As oversampling will add zeros to the vector, then after multiplying phase sequence b with x, the only section that counts in the multiplying will be N elements, hence the new phase sequence matrix above still has N rows and the oversampling factor does not have any effect on that. In above matrix, N random phase sequence is generated periodically V times. The new phase sequence matrix has N different random values while each row of phase sequence in matrix of C-PTS is with the same value. These values are randomly selected from the allowed phase factors. For example in the case of number of allowed phase factors W=2, then phase sequence can be chosen from {1,-1} and when W=4 then {1,j,-1,-j}. The time domain signal from the new phase sequence that is based on (6), can be obtained from the phase sequence matrix in (10) multiplies point-wise with matrix in (8).

In C-PTS, it was mentioned that for searching the optimum phase factor, $WV-1$ iteration is required. It means that, if for example W=2 and V=4, then we need 8 iterations to find the optimum phase sequence. For the new phase sequence format, the way to find the optimum phase factor will be different. In this case, first N different random phase sequence is generated and this is continued V times according to (10), hence the optimum phase factor is each row of this matrix. But for finding the optimum phase factor, matrix in (10) should be randomly generated several times. We constrain the number of times that the matrix would be generated to be the same as in C-PTS for fair comparison. Hence for the case of W=2 and V=4, the C-PTS has 8 iterations and therefore (10) should be generated 8 times. For example in this case we have 8 possibilities, because the first bit is fixed, {1,1,1}, {1,1,-1}, {1,-1,1}, {1,-1,-1},{-1,1,1},{-1,-1,1},{-1,1,-1},{-1,-1,-1}. The optimum phase factor will be chosen from these 8 phase sequences. In our proposed method, because there are N different random phase factors, to search for the optimum phase sequence it requires N8 iterations which is not practical. But here, we only apply the same iteration as was applied in C-PTS and later it will be shown through simulations, that good PAPR performance is achieved, and it is also possible to have less iteration while keeping the PAPR performance the same as C-PTS but with reduced complexity.

Hence the matrix equation in (4) can be extended as follows:

Where P is the number of iterations that should be set in accordance with the number of iterations of the C-PTS. The value of P can be calculated as follows:

$P=DW^{V-1}$. Where $D=1,2,\ldots\ldots,D_N$

Where D is the coefficient that can be specified based on the PAPR reduction and complexity and DN is the amount that is specified by user. The value of P explicitly depends on the number of subblocks V if assuming the number of allowed phase factor is constant.

$$\hat{b} = \begin{bmatrix} b_{1,1} & \ldots, & b_{1,N} \\ \vdots & \vdots & \vdots \\ b_{V,1} & \ldots, & b_{V,N} \\ b_{V+1,1} & \ldots, & b_{V+1,N} \\ \vdots & \vdots & \vdots \\ b_{P,1} & \ldots, & b_{P,N} \end{bmatrix}_{[P\times N]} \tag{4}$$

There is a tradeoff for choosing the value of D, the higher D leads to higher PAPR reduction but at the expense of higher complexity; while lower D gives smaller PAPR reduction but with less complexity. For example if W=2 and V=4, then in C-PTS there are 8 iterations and hence P=8D. If D=2 then P=16 and both methods have the same number of iterations. But when D=1 then number of iterations to find the optimum phase factor will be reduced to 4 and this will result in complexity reduction. The main advantage of this method over C-PTS is the reduction of complexity while at the same time maintaining the same PAPR performance.

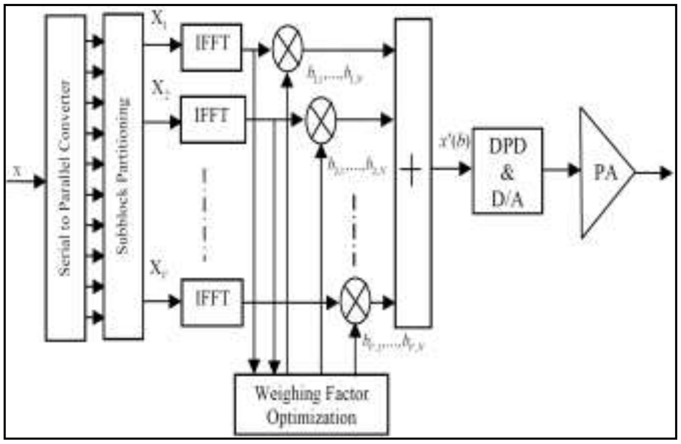

Fig.3: New Phase Squence PTS

C. *Companding*

Any invertible function with compression feature can be used for companding. Here we apply the transformation. Because the transformation is invertible, the signal can be recovered in the receiver. First a Quadrature demodulator generates the estimate of transformed signals with the aid of receiver signal level control and low pass filter. Using the inverse function of compression, the nonlinear distortion introduced by the compressor is corrected after reconstruction at the receiver with an expander.

III.CONCLUSION

According to the different literature survey, in this paper had we proposed a scheme that is A new phase sequence of PTS and companding in cascaded form. In this approach matrix of possible random phase factors are first generated and then multiplied point-wise with the input signal. By applying this technique the number of IFFT operation is halved which results in lower complexity compared to C-PTS at the expense of slightly PAPR degradation. The performance of the out-of-band distortion is also examined with the existence of nonlinear PA. By applying both PAPR reduction and DPD the PSD of the output signal is further suppressed. After getting the output from the new phase sequence PTS the data is send to the companding as an input. The proposed method can be applied in recent wireless communications systems such as WiMAX and long term evolution (LTE).

REFERENCES

[1] S. H. Han and J. H. Lee, "An overview of peak-to-average power ratio reduction techniques for multicarrier transmission," *IEEE Wireless Communication.*, vol. 12, no. 2, pp. 56-65, Apr. 2005.

[2] L. J. Cimini and N. R. Sollenberger, "Peak-to-average power ratio reduction of an OFDM signal using partial transmit sequences, *IEEE Commun. Lett.*, vol. 4, no. 3, pp. 86-88, March-2000.

[3] R. Buml, R. Fischer, and J. Huber, "Reducing the Peak to Average Power Ratio of Multicarrier Modulation by Selected Mapping," *Elect. Lett*, vol. 32, no. 22, pp. 2056-2057, October 1996.

[4] L. Yang, R. S. Chen, Y. M. Siu, and K. K. Soo, "PAPR reduction of an OFDM signal by use of PTS with low computational complexity," *IEEE Trans. Broadcast.*, vol. 52, no. 1, pp. 83-86, March 2006.

[5] S. G. Kang, J. G. Kim, and E. K. Joo, "A novel subblock partition scheme for partial transmit sequence OFDM," *IEEE Trans. Broadcast.*, vol. 45, no. 3, pp. 333–338, September 1999.

[6] N.T Hieu., S.W. Kim and H.G Ryu, "PAPR Reduction of the Low Complexity Phase Weighting Method in OFDM Communication System", *IEEE Trans. on Consumer Electronics*, vol. 51, no. 3, pp. 776-782, 2005.

[7] H. G Ryu., and K. J Youn, "A new PAPR reduction scheme: SPW (subblock phase weighting)," *IEEE Trans. on Consumer Electronics*, vol. 48, no. 1, pp. 81 – 89, 2002.

[8] C. Tellambura, "Improved phase factor computation for the PARP reduction of an OFDM signal using PTS," *IEEE Commun. Lett.*, vol. 5, no. 4, pp. 135-137, Apr. 2001.

[9] S. Muller, R. Bauml, R. Fischer, and J. Huber, "OFDM with reduced peak-to-average power ratio by multiple signal representation", Annals of Telecommunications, vol. 53, pp. 58–67, February 1997.

[10] L. J. Cimini Jr. and N. R. Sollenberger, "Peak-to-average power ratio reduction of an OFDM signal using partial transmit sequences", IEEE Commun. Lett., vol. 4, no. 3, pp. 86–88, March 2000.