Reduction Of PAPR Using HADAMARD SLM In SFBC MIMO-OFDM System

G. P. Florence[1], U. V. Ratna Kumari[2]
PG Scholar in UCEK, JNTU KAKINADA,
ASST.PROFESSOR in UCEK, JNTU KAKINADA,

Abstract

This paper contains the Hadamard Transform in the SLM for the reduction of high peak to average power ratio (PAPR) in MIMO-OFDM systems. In this technique, the input sequence is multiplied by a set of phase rotation vectors respectively and then applies the Hadamard Transform to the each resulting sequence based on SFBC. After that perform the Inverse Fast Fourier Transform in order to get the time domain signal. The equivalent SFBC encoding operations in the time domain for generating candidate signal sets is performed, where one with the lowest maximum PAPR is selected for transmission. The proposed method has lower computation complexity and reduces the PAPR. The experimental results shows that the PAPR reduction performance of Hadamard SLM technique and compare with the PIIM, SLM and with the Simplified SLM techniques.

Keywords-*Multiple-input Multiple output (MIMO); orthogonal frequency division multiplexing (OFDM); peak-to-average power ratio (PAPR) reduction; space frequency block coding (SFBC); Selected mapping (SLM) and Polyphase interleaving and inverse method(PIIM).*

I. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) has been recently seen rising popularity in wireless applications. For wireless communications, an OFDM-based system can provide greater immunity to multi-path fading and reduce the complexity of equalizers [1]. Now OFDM have been included in digital audio/video broadcasting (DAB/DVB) standard in Europe and IEEE 802.11, IEEE 802.16 wireless broadband access systems, etc. On the other hand, the major drawback of OFDM signal is its large peak-to-average power ratio (PAPR), which causes poor power efficiency or serious performance degradation to transmit power amplifier [2]. To reduce the PAPR, many techniques have been proposed. Such as clipping, coding, partial transmit sequence (PTS), selected mapping (SLM), interleaving [3][4], nonlinear companding transforms[5] [6], Hadamard transforms[7] and other techniques etc. These schemes can mainly be categorized into signal scrambling techniques, such as PTS and signal distortion technique es 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. Hadamard transform may reduce PAPR of OFDM signal while the error probability of system is not increased [8]. In this paper, an efficient technique used to reduce the PAPR is proposed this proposed scheme is called Hadamard SLM.

The organization of this paper is as follow. Section II presents the simplified SLM. Hadamard SLM is introduced in section III. In section IV, CCDF and PAPR calculations. Simulation results are reported in section V and conclusions are presented in VI.

II. SIMPLIFIED SLM

In the past time spatial SLM technique contain K transmit antennas. In this technique it requires N_T N point IFFT operations. So, computation complexity is high. To reduce the computation complexity simplified SLM is developed because it uses some properties of the IFFT. This technique generate a large number of candidate signal sets in the time domain without performing an extra IFFT calculation. Instead of using N_T N point IFFTs in traditional SFBC MIMO-OFDM systems, this method requires only N_T N/K-point IFFTs, which substantially decreases the system complexity.

In this technique, the input sequence is first multiplied by the phase rotation vector Pv. Then, we decompose the resulting sequence into K sub-sequences after that perform N/K-point IFFT on k-sub-sequence can result in a large number of candidate signal sets.

In conclusion, the signal set with the lowest PAPR is chosen for transmission.

$$\mathrm{PAPR}(X) = \mathrm{argmax}(\mathrm{PAPR}(X_k))$$

III. HADAMARD SLM TECHNIQUE

In this technique to reduce the occurrence of the high peaks compared to the Simplified SLM. The idea to use the Hadamard 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 Hadamard Transform. We assume H is the Hadamard Transform matrix of N orders, and Hadamard matrix is standard orthogonal matrix. Every element of Hadamard matrix only is 1 or -1. The Hadamard matrix of 2 orders is stated by

$$H2 = \frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$$

Hadamard matrix of order N may be constructed by

$$H2N = \frac{1}{\sqrt{2N}}\begin{pmatrix} Hn & Hn \\ Hn & -Hn \end{pmatrix}$$

After the sequence X=[X1, X2…Xn] is transformed by Hadamard matrix of N order, the new sequence is

Y=HX

The coming input data stream is firstly transform by the Hadamard Transform then the transformed data stream is applied as input to IFFT signal processing unit.

The system block is show at Figure.1. The signal processing step is below:

1. The sequence X is transformed by Hadamard matrix, i.e. Y=HX
2. Apply inverse IFFT i.e y=IFFT (Y)
3. The equivalent SFBC encoding operations in the time domain for generating candidate signal sets is performed, where one with the lowest maximum PAPR is selected for transmission.

The block diagram of Hadamard SLM is shown below.

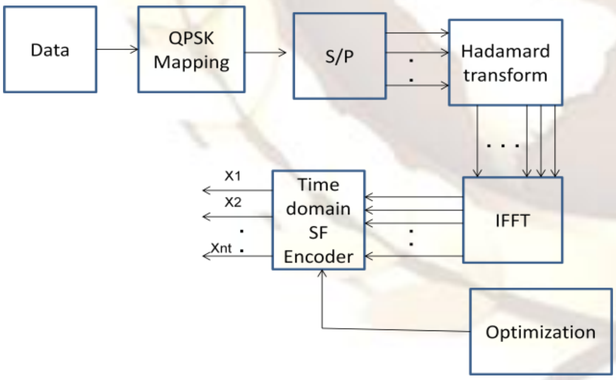

Fig.1. Block Diagram of HADAMARD SLM

IV. CCDF AND PAPR CALCULATION

In the case of two transmit antennas, the each of *N*-dimensional OFDM symbol is transmitted from antenna 1 and antenna 2 respectively. Generally, the PAPR of the transmitted OFDM signal is defined as

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

Where l means the transmit antenna number and $E[\bullet]$ means the expectation operation.

When calculating PAPR using discrete sampled signals, we cannot find the accurate PAPR because the true peak of continuous time OFDM signal may be missed in the Nyquist sampling. So, we use 4 times over-sampling to improve accuracy of discrete PAPR. Besides, to show statistical characteristics of PAPR, we use CCDF (Complementary Cumulative Distribution Function), which is the probability that PAPR of OFDM/CIOFDM signal exceeds a certain threshold $PAPR_0$. The CCDF is defined as

$$\begin{aligned} CCDF^l &= \Pr\left(PAPR^l > PAPR_0\right) \\ &= 1 - \Pr\left(PAPR^l \le PAPR_0\right) \\ &= 1 - \prod_{n=1}^{N}\left[1 - \exp\left(-PAPR_0 \times \frac{P_{avg}^l}{P_n^l}\right)\right] \\ &= 1 - (1 - \exp(-PAPR_0))^{\alpha N} \end{aligned}$$

Where P_n^l is the average sample power of l^{th} transmit antenna signal, $P_{avg}^l = (1/T)\int_0^T \left|S^l(t)\right|^2 dt$ is the average power of l^{th} transmit antenna signal, here, when oversampling is done, $P_n^l = P_{avg}^l$ is nearly satisfied. Commonly, α is 2.8 in most cases. We define the observed CCDF of MIMO transmitter is

$$CCDF = \max_{0 < l \le L}\left(CCDF^l\right)$$

V. EXPERIMENTAL RESULTS

The OFDM system we used in the simulations has N = 128 subcarriers with QPSK modulation format, where L = 4 times oversampling is used to approximate the true PAPR. The phase rotation vectors adopted in our simulations were randomly selected from the set {±l, ±j} and perfectly known at the receiver, i.e., the side information was assumed to be correctly detected at the receiver. For comparison, we considered both Simplifed SLM and Hadamard SLM in our simulations. The number of assessed candidate signal sets is denoted as USSLM/PII/HSLM.

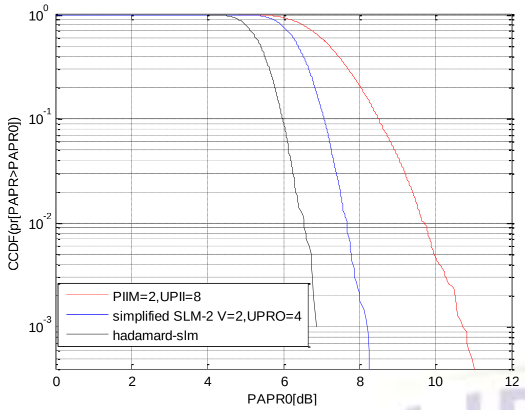

Fig.2. Comparison of PAPR reduction performance for the PIIM, Simplified SLM and Hadamard SLM with 2-space frequency block code

This figure 2 shows that the PAPR reduction performance of HADAMARD SLM is increases compared with the PII and Simplified SLM method in case of 2-space frequency block code.

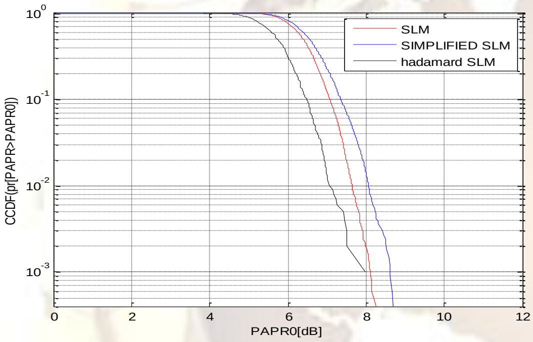

Fig.3. Comparison of PAPR reduction performance for the SLM, Simplified SLM and Hadamard SLM with 4×4-space frequency block code

This figure 3 shows that the PAPR reduction performance of HADAMARD SLM is increases compared with the SLM and Simplified SLM in case of 4-space frequency block coding.

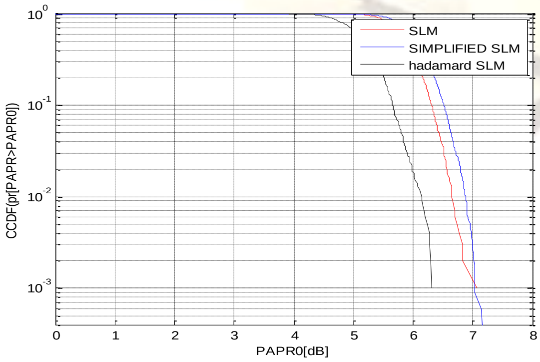

Fig.4. Comparison of PAPR reduction performance for the SLM, Simplified SLM and Hadamard SLM with 16×16-space frequency block code

This figure 4 shows that the PAPR reduction performance of HADAMARD SLM is increases compared with the SLM and Simplified SLM in case of 16-space frequency block coding.

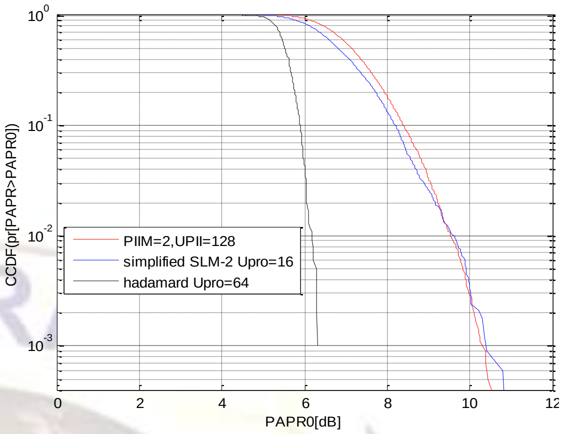

Fig.5. Comparison of PAPR reduction performance for the PIIM, Simplified SLM and Hadamard SLM with 4-space frequency block code

This figure 5 shows that the PAPR reduction performance of HADAMARD SLM is increases compared with the PIIM and Simplified SLM in case of 4-space frequency block coding.

VI. CONCLUSION

In this paper, a PAPR reduction scheme by using Hadamard Transform in the SLM is proposed. Simulation results show that the PAPR reduction performance is improved compared with the PII and Simplified SLM. The Hadamard SLM has lower computational complexity; and this Hadamard SLM requires no side information to be transmitted at the receiver. The proposed scheme achieves comparable PAPR reduction performance compared with the simplified SLM and PII scheme.

REFERENCES

[1] A. R. Bahai and B. R. Saltzberg, “Multi-Carrier Digital Communications: Theory and Applications of OFDM,” Kluwer Academic/Plenum Publishes, New York, NY, USA, 1999.

[2] H. Rohling, T. May, K. Bruninghaus, and R. Grunheid, “Broadband OFDM radio transmission for multimedia applications,”Proc.IEEE, vol.87,pp.1778-1789,Oct.1999.

[3] T. Jiang and Y. Imai, “An overview: peak-to-average power ratio reduction techniques for OFDM signals,” IEEE Trans. On Wireless Communications, June 2008, pp. 56-57

[4] S.H. Han, J. H. Lee, “An overview of peak-to-average power ratio reduction techniques for Multicarrier transmission,” IEEE

Transaction on Wireless Communication, April 2005, pp. 56-65.

[5] Xiao Huang, J H Lu, Jun Li Zhen, etal. "Companding Transform for Reduction in Peak-to-Average Power of OFDM signals[J], IEEE transactions on wireless communications", VOL.03, NO.06, Nov,2004,pp. 2030-2039.

[6] Xiao bin Wang, "Reduction of peak-to-average power ratio of OFDM system using A companding technique," IEEE Transaction on Broadcasting, Vol.45, No.3, Sep 1999, pp.303-307.

[7] Park, M., Heeyong, J., Cho, N., Hong, D, and Kang, C., "PAPR reduction in OFDM transmission using Hadamard transform", IEEE International Conference o Communications, Vol.1, Jun 2000, pp.430-433.

[8] Xiaodong zhu, Guangxi Zhu, Tao Jiang, "Reducing the peak-to-average power ratio using unitary matrix transformation". IET Communications,2009,3(2),pp.161-171.