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Performance Analysis of SLM Techniques for PAPR Reduction in ALAMOUTI MIMO-OFDM System

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ABSTRACT

Multi-Input Multi-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) with Space-Frequency Block Coding (SFBC) is widely used as a promising technique for next generation broadband wireless applications. As encountered for multicarrier systems, a major challenge of SFBC MIMO-OFDM transmission systems is the problem of high peak-to-average power ratio (PAPR), which leads to severe distortion at the output of power amplifier. To overcome this problem, a variety of PAPR reduction methods for OFDM systems have been presented.

The techniques for reducing the PAPR are clipping and filtering, Selective Linear Mapping (SLM), and Partial Transmit Sequences (PTS). In this SLM is the most effective reduction of PAPR without distorting OFDM signals. SLM techniques are Conventional SLM (C-SLM) and it requires transmitting Side Information (SI) for signal recovery at the receiver, resulting in the degradation of bit error rate (BER). Blind SLM (B-SLM) method is proposed for increasing the data rate. Based on analysis and comparison of SLM improvements, DSLM algorithm is proposed to reduce the PAPR effectively with less number of computations which increases data rate.

KEYWORDS: ***MIMO-OFDM, PAPR, SLM, Side Information.***

1. INTRODUCTION:

Multi Input multi output orthogonal frequency division multiplexing (MIMO-OFDM) systems have drawn significant interests because of its potential in accomplishing high information rate and providing reliable performance of diversity and spatial multiplexing. Orthogonal Frequency Division Multiplexing(OFDM) became fundamental transmission technology, in order to satisfy the recent demand for high data-rate transmission. In higher data-rate transmission, each transmission symbol must be sent in a shorter amount of time, which results in increasing amounts of degradation in the quality of the received signal due to factors like reflection from buildings. OFDM uses multiple low-speed sub-carriers bundled together, making it robust with respect to the effects of these types of reflections.

However, implementation of OFDM has an issue in that signal peaks can occur that are extremely high compared to the average power of the transmission signal. Inputting these excessively large signals in to a transmission amplifier can result in signal distortion at its output and degradation of transmission quality, or splatter to nearby systems. The signal distortion can be reduced by using devices with excellent input/output characteristics, but this also results in increased power consumption. Because of this, it is desirable to decrease the levels of peaks occuring in the transmission signal.

A novel phase offset SLM scheme, called as the P-SLM is proposed to decrease the PAPR without SI in Alamouti MIMO-OFDM systems. For the P-SLM scheme, there is a phase offset compares signals at different transmit antennas and the phase offset corresponds to the phase rotation sequence. Then, at the receiver, a MED decoder is also proposed, and the phase offset with the minimum Euclidian distance is chosen as the indication of the phase revolution sequence used at the transmitter. Along these lines, the SI can be acquired by evaluating the phase offset, since they are one-to-one correspondence. Therefore, the P-SLM scheme does not need to reserve bits for the transmission of the SI resulting in the increase of the data rate.

2. PAPR IN ALAMOUTI MIMO-OFDM SYSTEMS

2.1Alamouti MIMO-OFDM Systems

In this the Alamouti space-frequency block coding (SFBC) is employed for Alamouti MIMO-OFDM systems without two transmit antennas.

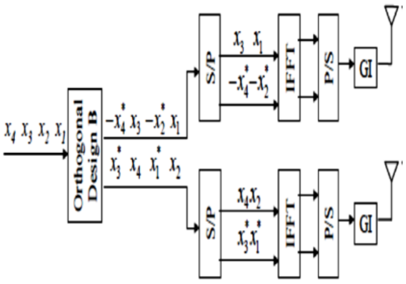

Fig.1: Space- Frequency Block Coding

The input data block X= [X (k), k= 1, 2, ⋯, N] is encoded in to two vectors X_1 and X_2

X1=[X(1), -X*(2), ⋯, X(N-1),X*(N)],

X2=[X(2), X*(1),⋯, X(N),X*(N-1)],

Where X(k) is balanced by a given signal constellation Q, N is the number of sub carriers, and (.)* denotes the complex conjugate operation.

After Inverse Fast Fourier Transform (IFFT) operation, the time domain signal

x_i=[$x_i(0)$,x_i (1),x_i (2),………, $x_i(JN-1)$] is

$$x_i(n)= \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1} xi(k)\, e^{\frac{j2\pi kn}{JN}},$$

where i=1,2 and n=0,1,……….,JN-1. The oversampling factor J is an integer.

In general, the PAPR of the MIMO-OFDM signals at each antenna is defined as

$$\mathrm{PAPR}_i = \frac{\max\limits_{0\le n\le JN-1} |xi(n)|^2}{E[\,|xi(n)|^2]}$$

Where E [.] represents the expectation. Therefore, the PAPR of the Alamouti MIMO-OFDM signals is defined as

$$\mathrm{PAPR} = \max_{i=1,2} \{PAPR_i\}$$

2.2 The C-SLM Scheme

For the CSLM scheme, the U phase rotation sequences are generated as

$$P^U = \{P^U(k), k = 0,1, \dots \dots \dots, N-1\} \quad u=0, 1,\cdots, U-1$$

Where$P^U(k) = e^{j\Psi^u(k)}$,

j=$\sqrt{-1}$ and $\Psi^u(k)\epsilon[0,2\pi)$.Therefore, the input data **X** is multiplied by $\mathbf{P^U}$ to generate the alternative signal $\mathbf{X^U}$ as

$$X^U(K)=P^U(k)X(k)$$

After being operated by the Alamouti SFBC, the alternative signal $\mathbf{X^U}$ **is** encoded into two vectors X_1^UandX_2^U as

X_1^U= [P^u (0)X(0), -P^{u*}(1)X*(1) , … , P^u(N-2)X(N-2),- P^{u*}(N-1)X*(N-1)]

X_2^U = [P^u(1)X(1), P^{u*}(0)X*(0) , … , P^u(N-1)X(N-1), P^{u*}(N-2)X*(N-2)] .

Then, the alternative frequency domain signals X_i^U are transformed into time domain signals X_i^U via the IFFT operation and the ideal set with the minimum PAPR of the two signals is chosen as

$$\hat{u} = \arg \min_{0\le u\le U-1} \left(\max_{i=1,2} \max_{0\le n\le JN-1} |x_i^u(n)| \right)$$

Generally, the U phase rotation sequences P^U should be transmitted to the receiver as the SI with $\log_2 U$ bits.

3. THE P-SLM SCHEME

A novel Phase Offset SLM scheme, called as the P-SLM, is proposed to decrease the PAPR without SI in Alamouti MIMO-OFDM systems. For the P-SLM scheme, there is a phase offset compares the signals at different transmit antennas, and the phase offset corresponds to the phase rotation sequence. Then, at the receiver, a MED decoder is also proposed, and the phase offset with the minimum Euclidian distance is chosen as the indication of the phase revolution sequence used at the transmitter. Figure 2 represents block diagram of P-SLM scheme.

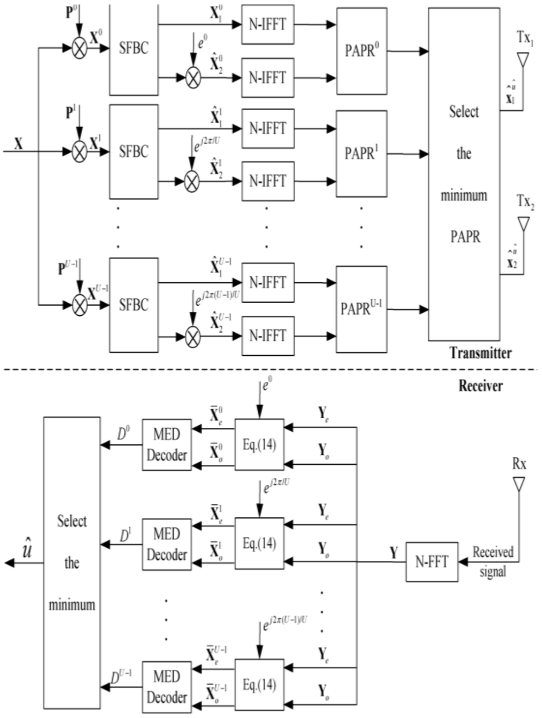

Fig.2: Block diagram of P-LSM scheme

For the PSLM scheme U, different phase offsets $\{e^{\frac{j2\pi u}{U}}, u = 0,1, \dots\dots\dots, U-1\}$ are generated for the U phase rotation sequences P^U, the data at the first antenna X_1^U keeps unchanged, while the data at the second antenna X_2^U is multiplied by the phase offset$e^{\frac{j2\pi u}{U}}$.

Denote $X_e^U = [X^U(0), X^U(2), \dots\dots, X^U(N-4), X^U(N-2)]$ (1) and

$$X_o^U = [X^U(1), X^U(3), \dots\dots, X^U(N-3), X^U(N-1)] \quad (2)$$

are even and odd parts respectively. Therefore, the odd and even parts of the data blocks at two transmit antennas can be expressed as

$$\hat{x}^u_{1,e} = X^u_e \quad (3)$$

$$\hat{x}^u_{1,o} = -X^{u*}_o \quad (4)$$

$$\hat{x}^u_{2,e} = e^{\frac{j2\pi u}{U}} X^u_o \quad (5)$$

$$\hat{x}^u_{2,o} = e^{\frac{j2\pi u}{U}} X^{u*}_e \quad (6)$$

Then, the space frequency matrix **C** can be expressed as

$$C=\begin{pmatrix} X^u(2l) & -X^{u*}(2l+1) \\ e^{\frac{j2\pi u}{U}} X^u(2l+1) & e^{\frac{j2\pi u}{U}} X^{u*}(2l) \end{pmatrix} \quad (7)$$

Where l = 0, 1,⋯ , N/2-1. Substituting (6) into (10), it is obvious that the matrix C is orthogonal, since that

$$CC^H = (|X^u(2l)|^2 + |X^u(2l+1)|^2)\, I_{2\times 2} \quad (8)$$

Where $(.)^H$ represents Hermitian transpose, and I_{2x2} is an identity matrix. Therefore, the P-SLM scheme maintains the structure of the Alamouti SFBC, thus, full diversity can be achieved at the receiver.

When these kind of alternate vectors are usually developed directly into time domain signals along with through IFFT operation, the optimal signals and with the minimum PAPR are sent to the receiver.

At the receiver, immediately doing away with the cyclic prefix along with employing the FFT operation, the received vector $Y = [Y(0), Y(1), \dots\dots, Y(N-1)]$ could be expressed as

$$Y(k) = H_1(k)\,X_1^{\hat{u}}(k) + H_2(k)\,X_2^{\hat{u}}(k) + W(k) \quad (9)$$

$$Y_e(l) = H_{1,e}(l)X_e^{\hat{u}}(l) + e^{\frac{j2\pi}{U}}H_{2,e}(l)X_o^{\hat{u}}(l) + W_e(l) \quad (10)$$

$$Y_o(l) = -H_{1,o}(l)X_o^{\hat{u}*}(l) + e^{\frac{j2\pi\hat{u}}{U}}H_{2,o}(l)X_e^{\hat{u}*}(l) + W_o(l)$$
(11)

For the P-SLM scheme, the file of the ideal phase arrangement should be firstly distinguished at the receiver. As appeared in Fig, we need to attempt distinctive phase offsets to get the proper, since is unknown at the receiver. Therefore, we propose a MED decoder for the P-SLM scheme as follows

$$X_e^{\prime u}(l) = H_{1,e}^{*}(l)\,Y_e(l) + e^{\frac{j2\pi u}{U}}H_{2,o}(l)\,Y_o^{*}(l)$$

$$X_o^{\prime u}(l) = e^{\frac{-j2\pi u}{U}}H_{2,e}^{*}(l)\,Y_e(l) \mp H_{1,o}(l)\,Y_o^{*}(l) \quad (12)$$

Moreover, as stated in [3,4,5,6], the channel coefficients are assumed to be the same for two adjacent subcarriers in Alamouti MIMO-OFDM systems, i.e.,

$$H_{1,e}(l) \approx H_{1,o}(l) \quad (13)$$

$$H_{2,e}(l) \approx H_{2,o}(l) \quad (14)$$

Substituting (10,11) and (13,14) into (12), we can obtain (15),

$$\frac{X_e^{\prime u}(l)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)} - X_e^{\hat{u}}(l) = W_e^{u}(l) + \frac{\left(e^{\frac{j2\pi(u-\hat{u})}{U}} - 1\right)\left(|H_{2,e}(l)|^2\right)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)}X_e^{\hat{u}}(l) + \frac{\left(e^{\frac{j2\pi\hat{u}}{U}} - e^{\frac{j2\pi u}{U}}\right)H_{1,e}^{*}(l)H_{2,e}(l)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)}X_o^{\hat{u}}(l)$$

$$\frac{X_o^{\prime u}(l)}{\left(\left|H_{1,e}(l)\right|^2 + \left|H_{2,e}(l)\right|^2\right)} - X_o^{\hat{u}}(l) = W_o^{u}(l) + \frac{\left(e^{\frac{j2\pi(\hat{u}-u)}{U}} - 1\right)\left(\left|H_{2,e}(l)\right|^2\right)}{\left(\left|H_{1,e}(l)\right|^2 + \left|H_{2,e}(l)\right|^2\right)}X_o^{\hat{u}}(l) + \frac{\left(-e^{\frac{-j2\pi\hat{u}}{U}} + e^{\frac{-j2\pi u}{U}}\right)H_{2,e}^{*}(l)H_{1,e}(l)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)}X_e^{\hat{u}}(l) \quad (15)$$

When $u = \hat{u}$, (15) can be rewritten as follows,

$$\frac{X_e^{\prime u}(l)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)} - X_e^{\hat{u}}(l) = W_e^{u}(l)$$

$$\frac{X_o^{\prime u}(l)}{\left(|H_{1,e}(l)|^2 + |H_{2,e}(l)|^2\right)} - X_o^{\hat{u}}(l) = W_o^{u}(l)$$

We can conclude that when, the recovered signals and will attain the actual minimum amount of Euclidian distances through the signal constellation. Assuming that the channel coefficients are arbitrary, when the minimum Euclidian distance is accomplished, can be nearly perfectly detected. Thus, the MED decoder can obtain from

$$\hat{u} = \arg \min_{\substack{0 \le u \le U-1 \\ X_e^{\hat{u}}(l)X_o^{\hat{u}}(l) \in Q}} \left\{ \sum_{l=0}^{N/2-1} \left(\left| \frac{X_e^{\prime u}(l)}{\left(\left|H_{1,e}(l)\right|^2 + \left|H_{2,e}(l)\right|^2\right)} - X_e^{\hat{u}}(l) \right|^2 + \left| \frac{X_o^{\prime u}(l)}{\left(\left|H_{1,e}(l)\right|^2 + \left|H_{2,e}(l)\right|^2\right)} - X_o^{\hat{u}}(l) \right|^2 \right) \right\}$$

4. SIMULATION RESULTS

This chapter explains about the simulation results for PAPR reduction techniques using SLM techniques (CSLM,BSLM,PSLM) for Alamouti MIMO-OFDM Systems obtained using MATLAB.

Blind SLM:

A Maximum Likelihood (ML) based Blind SLM (B-SLM) method for Alamouti MIMO-OFDM systems are proposed in, which does not need the SI transmission. However, the phase factors can only be chosen as 1 or -1 in, which is limited and not suitable for many scenarios. Figure3 represents the PAPR in BSLM Scheme with QPSK MODEM.

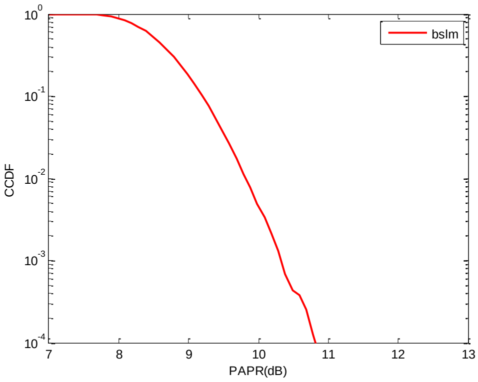

Fig.3. PAPR in BSLM Scheme with QPSK MODEM

Figure.4 represents the PAPR in BSLM Scheme with QAM MODEM

QAM Modulation:

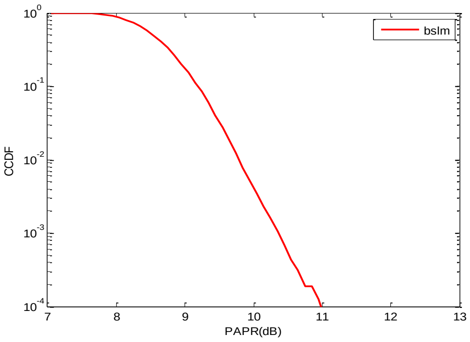

Fig.4. PAPR in BSLM Scheme with QAM MODEM

Phase Offset SLM Scheme:

A novel Phase Offset SLM scheme, called as the P-SLM, is proposed to decrease the PAPR without Side Information in Alamouti MIMO-OFDM systems. Figure.5 represents the PAPR in PSLM Scheme with QPSK MODEM.

QPSK Modulation:

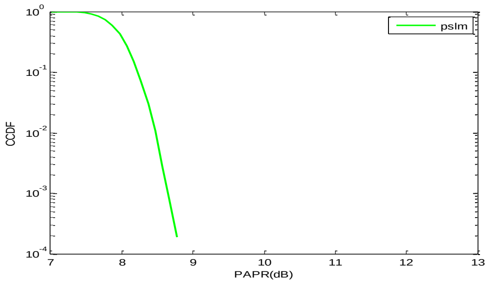

Fig.5. PAPR in PSLM Scheme with QPSK MODEM

Figure.6 represents the PAPR in PSLM Scheme with QAM MODEM

QAM Modulation:

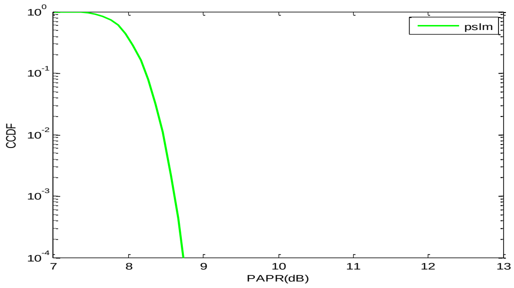

Fig.4.6. PAPR in PSLM Scheme with QAM MODEM

5.1 Comparison of PAPR Reduction in SLM techniques for QPSK:

Simulations have been conducted to evaluate the ability of the proposed scheme including PAPR reduction at different modulation schemes. Figure.7 represents comparison of PAPR for SLM techniques with QPSK.

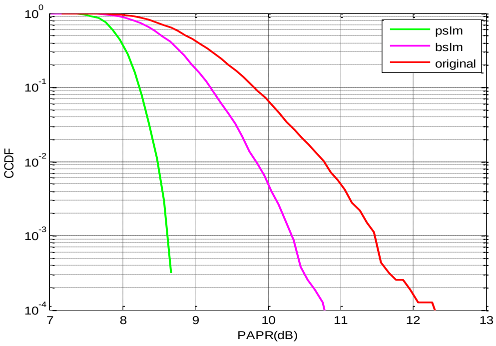

Fig.7: Comparison of PAPR for SLM techniques with QPSK

This plot demonstrates the complementary cumulative distribution functions (CCDF) of the PAPR for unique signals and different signals obtained by BSLM, PSLM scheme respectively using QPSK modulation. It is clear that PSLM scheme can offer the same PAPR reduction performance as that of CSLM scheme, and PSLM scheme can offer preferable PAPR reduction performance than BSLM and original signal without SLM schemes. Figure.8 shows comparison of PAPR for SLM techniques with QAM.

5.2 Comparison of PAPR Reduction in SLM techniques for QAM:

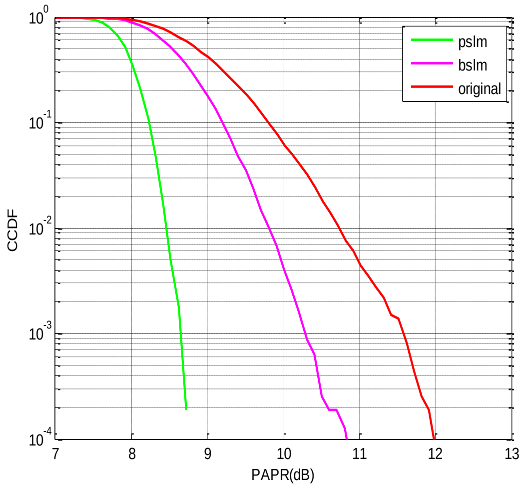

Fig.5.2 comparison of PAPR for SLM techniques with QAM

This plot demonstrates the complementary cumulative distribution functions (CCDF) of the PAPR for unique signals and different signals obtained by BSLM, PSLM scheme respectively using QAM modulation. It is clear that PSLM scheme can offer the same PAPR reduction performance as that of CSLM scheme, and PSLM scheme can offer better PAPR reduction performance than BSLM and original signal without SLM schemes. All of the schemes using QAM can offer better PAPR reduction than using QPSK schemes because of having minimum Euclidean distance decoder.

It is clear that PSLM scheme can offer the same PAPR reduction performance as that of CSLM scheme, and the PSLM scheme can offer preferable PAPR reduction performance than the BSLM scheme. Due to the absence of side information in PSLM at the transmitter, there is an increase in data rates.

In side CSLM scheme, the actual fed SI could possibly be recovered incorrectly at the receiver in practice, as a result, the actual recommended SLM scheme without SI may attain performance with high data rates and low bit error rate.. Moreover, for the BSLM scheme, the actual phase factors could be selected coming from {1,-1}, while the phase factors can be chose from any number in $\{e^{j\varphi}|\varphi \in [0,2\pi)\}$ for the PSLM scheme. Consequently, the actual PSLM scheme could be given more cases.

6.1 Conclusion:

A novel Phase Offset SLM scheme, referred to as the P-SLM, can be proposed to decrease the PAPR without SI in Alamouti MIMO-OFDM systems. For the P-SLM scheme, there is a phase offset between the signals at different transmit antennas and also the phase offset corresponds to the phase rotation sequence. At that point, at the receiver, a MED decoder is also additionally proposed, and the phase offset with the minimum Euclidian distance is chosen as the sign of the phase rotation sequence used at the transmitter. Along these lines, the SI can be obtained by evaluating the phase offset, since they are coordinated correspondence. Therefore, the P-SLM scheme does not need to reserve bits for the transmission of the SI, resulting in the increase of the data rate.

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