DHT precoded AMS scheme for PAPR reduction in SFBC OFDM systems

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Abstract

The Orthogonal frequency division multiplexing (OFDM) is a special form of multicarrier modulation in which it modulates the data symbols in parallel on orthogonal subcarriers.This is achieved by placing the carrier exactly at the nulls in the modulation spectra of each other.The non-linear distortion caused by high peak-to-average power ratio (PAPR) of transmitted signal is a major drawback in the OFDM systems .In this paper,a Discrete-Hartley-Transform(DHT) Precoded alternative multisequences (AMS) scheme is used for the PAPR reduction in OFDM systems with space frequency block coding (SFBC).The main aim of the proposed scheme is keeping the advantage of the SFBC structure to generate some alternative multi-sequences by combining the signals at different transmit antennas to reduce the PAPR.The simulation results validate that the proposed scheme has the ability to provide PAPR reduction SFBC OFDM systems.

***Keywords*—OFDM,SFBC,PAPR,AMS, DHT.**

I . Introduction

Lately,multicarrier (MC) communications techniques and especially Orthogonal Frequency Division Multiplexing (OFDM) have gained large recognition due to their well known advantages . Orthogonal Frequency Division Multiple Access (OFDMA) and its precoded derivatives are now used by current proposals for the air interface of Beyond Third Generation (B3G) and Fourth Generation (4G) cellular systems .

Even if MC techniques are very popular and very effective in the downlink of wireless communications systems, they have a main drawback: The high peak to average power ratio (PAPR), problem which is particularly bothering in the uplink. In order to avoid nonlinear effects, the input signal should lie in the linear region of the high power amplifier (HPA). Increased linear dynamic range requirements impose the use of very costly HPAs. Whereas the use of such HPAs can be envisioned in downlink, the problem is much more delicate in the uplink of cellular systems, where low cost terminals and long battery life are required. Many PAPR reduction techniques have been developed, but they do not always yield significant gains in practical applications. Space-time coding is a communications technique for wireless systems that realizes spatial diversity (and coding gain) by introducing temporal and spatial correlation into the signals transmitted from different transmit antennas Many space-time trellis and block codes have been proposed for flat fading channels.

Most significantly, Alamouti in [1] discovered a very simple space-time block code (STBC) for transmission with two antennas guaranteeing full spatial diversity and full rate Space-frequency coding basically extends the theory of space-time coding for narrowband flat fading channels to broadband time-variant and frequency selective channels. The application of classical space-time coding techniques for narrowband flat fading channels to OFDM seems straightforward, since the individual subcarriers can be seen as independently flat fading channels, thus SFBC-OFDM is a more appropriate transmission scheme for multipath time-variant fading channels. A large number of PAPR reduction techniques have been proposed in the literature. Among them, schemes like clipping and filtering, Partial Transmit Sequence (PTS) [2], Precoding based Selected Mapping (PSLM) [3], precoding based techniques[4] and Selected Mapping (SLM) [5] , AMS[6] scheme are popular.

II.System model

A. Space Frequency block Coding (SFBC).

It is a frequency domain adaptation of renowned Space-time Block Coding (STBC) where encoding is done in antenna/ frequency domains rather than in antenna/time domains. STBC is also recognized as Alamouti coding [7].The advantage of SFBC over STBC is that in SFBC coding is done across the subcarriers within the interval of OFDM symbol while

STBC applies coding across the number of OFDM symbols equivalent to number of transmit antennas.

The operation of SFBC is carried out on pair of complex valued modulation symbols. Hence, each pair of modulation symbols are mapped directly to OFDM subcarriers of first antenna while mapping of each pair of symbols to corresponding subcarriers of second antenna are reversely ordered, complex conjugated and signed reversed. The symbols transmitted from two transmitted antennas on every pair of neighboring subcarriers are characterized in as follows

Frequency →

$$X = \begin{bmatrix} x^{(0)}(1) & x^{(1)}(1) \\ x^{(0)}(2) & x^{(1)}(2) \end{bmatrix} = \begin{bmatrix} S_0 & -S_1^* \\ S_1 & S_0^* \end{bmatrix} \downarrow \text{space}$$

Where x^ ((p)) (k) denotes the symbols transmitted from antenna port 'p' on the kth subcarrier.

B. AMS scheme for PAPR reduction in SFBC-OFDM systems.

The key idea of the proposed scheme is keeping the advantage of the SFBC structure to generate some AMSs via combining the signals at different transmit antennas. Specifically, when the proposed scheme is employed in SFBC MIMO OFDM systems with quadrature-amplitude modulation (QAM) For convenience and simplicity, the Alamouti space–frequency block coding (SFBC) is employed in MIMO-OFDM systems in this paper original data sequences at two antennas are partitioned into several pairs of sub blocks, and each pair of sub blocks multiplies by different factors to generate different pair of sub blocks. Then, the obtained new sub blocks are combined to generate AMSs, which keep the structure and the diversity capability of the Alamouti SFBC. Finally, the pair of alternative sequences with the smallest PAPR is chosen to be transmitted.

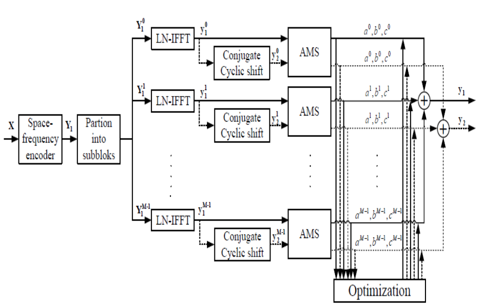

Fig.1.Novel AMS scheme

Peak to Average power Ratio is defined by,

$$PAPR = \frac{\max_{0 \le n \le N} |S(n)|^2}{E\{|S(n)|^2\}} \qquad (1)$$

Complementary Cumulative Distribution Function (CCDF) for an OFDM signal can be written as

$$\Pr\{PAPR > PAPR0\} = (1 - (1 - e^{-PAPR0})^N).$$

III. Proposed model

A. The Precoding Based OFDM system.

In the Precoding Based OFDM system ,Precoding matrix P of dimension N x N is multiplied before the IFFT to reduce the PAPR.

The Precoding matrix P of dimension N × N before the IFFT to reduce the PAPR is given by ,

$$P = \begin{bmatrix} p_{00} & p_{01} & p_{0(N-1)} \\ p_{10} & p_{11} & p_{1(N-1)} \\ . & . & . \\ . & . & . \\ p_{(N-1)0} & p_{(N-1)1} \dots & p_{(N-1)(N-1)} \end{bmatrix}$$

where P is a Precoding Matrix of size N× N is shown in equation .

The modulated OFDM vector signal with N subcarriers as.

$$x_n = \text{IFFT}\ \{P.X_K\}$$

B. DHT precoded AMS scheme .

Fig. 2 shows the block diagram of Precoded AMS scheme based SFBC-OFDM System.We implemented the DHT precoder of size N x N.

The DHT is a linear transform. In DHT real numbers $x_0, x_0, \ldots x_{N-1.}$ are transformed in to N real numbers $H_0, H_1, \ldots H_{N-1}$.

The descrete Hartley transform (DHT) is used as a precoding before IFFT operation.The encoded symbols from the SFBC encoder are precoded using DHT (P*) to maintain the individuality from neighboring symbol.

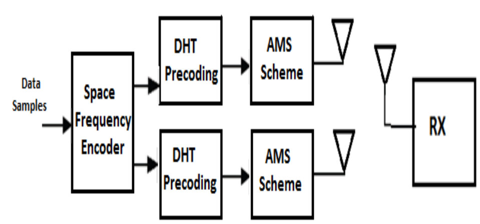

Fig 2.Block diagram of DHT precoded AMS scheme .

According to [8] the N-point DHT can be defined as

$$Hk = \sum_{n=0}^{N-1} x(n) \left[\cos\left(\frac{2\pi nk}{N}\right) + \sin\left(\frac{2\pi nk}{N}\right) \right].$$

$$and\ \ k = 0,1, \ldots N-1$$

$$p_{m,n} = \mathrm{cas}\left(\frac{2\pi mn}{N}\right)$$

$$\text{where, } \mathrm{cas}\theta = \cos\theta + \sin\theta$$

P is precoding matrix of size N×N shown in equation , m and n are integers from 0 to N-1.

The DHT is also invertible transform which allows us to recover the xn from Hk and inverse can be obtained by simply multiplying DHT of Hk by 1/N.

IV.Simulation results

We performed extensive simulations in MATLAB R2013$_a$, in order to evaluate the performance of DHT-Precoder based SFBC-OFDM system. To show the PAPR analysis of DHT-Precoded AMS scheme for SFBC-OFDM system, data is generated randomly then modulated by M QAM.We compared our simulation results with general SFBC-OFDM systems and Novel AMS scheme based SFBC OFDM systems.To show the PAPR analysis in the MATLAB R2013$_a$ we considered M-QAM (M=4,16) for N=1024 It is also to be noted that M-QAM has itself PAPR.

Comparison :

Here L=4,N=1024 and Subblocks =4 are employed in 16-QAM.

No.of samples	PAPR before AMS $PAPR_{0(dB)}$=	PAPR after AMS $PAPR_{1(dB)}$=	PAPR after precoding and AMS $PAPR_{db}$
1024	28.1405	15.3567	7.2250
	28.2978	15.0728	7.0939
	28.2280	15.3606	7.2487

Table.1

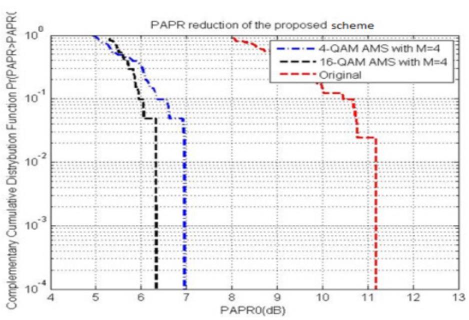

Fig.3 PAPR analysis for DHT precoded AMS Scheme with 4-QAM and 16-QAM

Fig 3.shows the CCDF comparision of original SFBC-OFDM systems and DHT-precoded AMS scheme based SFBC-OFDM systems, when Prob{PAPR>PAPR$_0$}=10^{-4}, the 4.9dB and 4.2dB reductions are obtained for16-QAM and 4-QAM respectively.

The Table.1 in which the 3 executions steps are considered and it shows that a good amount of PAPR is achieved in the proposed scheme.

Conclusion

OFDM is a very important technique for Multicarrier transmission and has become one of the standard choices for high-speed data transmission over a communications channel . It has various advantages , but also has one major drawback i.e High peak-to-average power ratio (PAPR) .

The DHT Precoded AMS scheme is proposed to reduce the peak-to-average power ratio (PAPR) of SFBC-OFDM signals, which could provide good PAPR reduction with low-computational complexity and no side information to be sent for the receiver.

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