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PAPR REDUCTION USING ML DETECTOR BY IDENTIFYING A ROTATING VECTOR IN OFDM SIGNALS WITHOUT SI

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ABSTRACT

OFDM is a specialized FDM, the additional constraints being that all carriers signals are orthogonal to one another used as a digital multi-carrier modulator. OFDM requires very accurate frequency synchronization between the receiver and transmitter, with frequency division the sub carrier will no longer be orthogonal, causing inter carrier interference. High PAPR have so far limited OFDM application to terrestrial system and prevent PA from operating in near saturation region reducing the PA efficiency. PTS scheme is magnificent in reducing PAPR. It produces SI as a result of optimization which reduces high PAPR.ML detector dramatically reducing the required complexity which do not transmit SI by identifying rotating vectors. ML detector destroys euclidean distance by providing sectional offset. BER performance is better. PEP analysis is done for good sectional offset.

Key words- Maximum likelihood detector(ML),Orthogonal frequency division multiplexing (OFDM), partial transmit sequence (PTS), Pairwise error probability(PEP),peak-to-average power ratio (PAPR).

I.INTRODUCTION

ORTHOGONAL frequency division multiplexing (OFDM) is a form of signal modulation that divides a high data rate modulating stream placing them onto many slowly modulated narrow band close-spaced sub carriers, and in this way is less sensitive to frequency selective fading. OFDM has developed into a popular scheme for wide band digital communication, digital audio broadcasting, digital video broadcasting, high definition television, etc.. because of its high program broadcasting capacity and end to end transmission system. The main advantages of OFDM are immunity to selective fading, resilience to interference, spectrum efficiency, resilient to narrow band effects, eliminates ISI, simpler channel equalization. The main drawback in OFDM is high peak-to-average power ratio. It is more sensitive to carrier frequency offset and drift than single carrier system. PAPR is the peak values of some of the transmitted signals could be much larger than the typical values.

$$PAPR = 10 \cdot \log_{10} \frac{\text{Max}\left[\left|s\left(\frac{nT_s}{N}\right)\right|^2\right]}{E\left[\left|s\left(\frac{nT_s}{N}\right)\right|^2\right]} (\text{dB})$$

Non linear devices will cause spectral spreading, inter modulation and constellation distortion. PAPR reduction schemes are clipping and filtering, selective mapping (SLM), coding, partial transmit sequence (PTS), tone reservation and tone injection. For better PAPR reduction PTS scheme is used . Bit error rate performance will remain the same over the fading channels and additive white gaussian noise channel without any side informatio.To reduce the average rate of outstanding message delivery, SI need to be sent. We prefer PTS scheme for which no SI needs to be sent. The estimation without additional pilots within the cyclic prefix carried by the redundant information. Fourier transform techniques is used to realize the hardware implementation efficiently. Multi-path channel and transmitted data sequence is done by maximum likelihood estimation. The suggested scheme deals with a post inverse fast fourier transform (IFFT) symbols and thus needs only a individual IFFT processor in the transmitter. The QAM symbols with no SI is demapped by the ML detector exclusively. Simulation results also show that the bit error rate(BER) of the proposed scheme has no loss when the ML detector is used. Phase angles of modulated symbols are changed in PTS to reduce the PAPR. Information about these changes (side information)is critical for the successful operation of PTS. ML detector is used to extract the SI from the received signal and recover the data sequence. Pair wise error probability(PEP) a multi carrier index keying orthogonal frequency division multiplexing system adapting the low complexity greedy detector, especially over K-µ fading channels.

II.TRADITIONAL PTS SCHEME

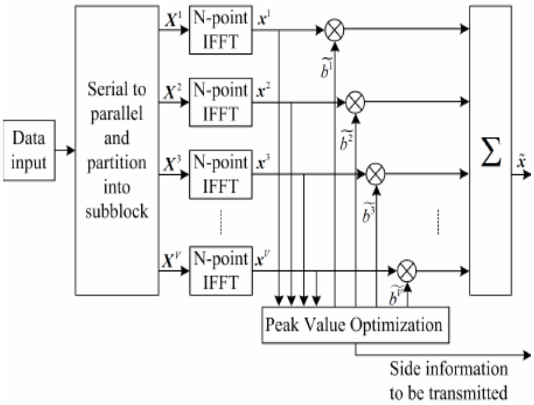
FIGURE 1 shows the basic block diagram for the traditional PTS scheme (T-PTS)scheme. In T-PTS scheme ,the N symbols of X data sequence is evenly divided into V disjoint sub blocks [10] as X=[X1,X2,............XV] and including the complex phase factor.

By applying IFFT ,an OFDM signal sequence X=[X0,X1.....XN-1] is generated,i.e

$$\mathbf{X} = \sum_{v=0}^{V-1} \mathbf{X}_v .$$

Fig1. A block diagram of the traditional PTS schemeBy applying IFFT to X as x=IFFT(X), that is, to X as x = IFFT(X), that is

$$x_n = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi \frac{n}{N} k}, \quad 0 \le n \le N-1,$$



The Uth alternative signal sequence is obtained

$$\mathbf{x}^u = \sum_{v=0}^{V-1} \bar{b}_v^u \mathbf{x}_v.$$

where 0 ≤ u ≤ U − 1. For minimum PAPR transmission, the alternative signal sequence with the optimum rotating vector is obtained by

$$\mathbf{b}^{\tilde{u}} = \arg \min_{\substack{\mathbf{b}^u \in \mathbb{B}^V \\ \text{and } b_0^u = 1}} \left(\max_{0 \le n \le N-1} \left| \sum_{v=0}^{V-1} b_v^u x_{v,n} \right| \right).$$

The PAPR reduction performance is shown by the random sub block partitioning scheme but it has the largest complexity. SI is sent by the transmitter on U to correctly recover the original input sequence at the receiver, but some loss of data transmission occurs.

III.PROPOSED PTS SCHEME 1

3.1 Rotating vectors embedded with SI

To destroy the transmission of SI, we introduce a method to plant the SI into the rotating vectors through phase shifting them by appropriate offset. V-tuple phase offset vector is given as

$$\mathbf{S}^u = \left[S_0^u \; S_1^u \; \cdots \; S_{V-1}^u \right]$$

where, $0 \le v \le V - 1$ and $0 \le u \le U - 1$, implies phase offset 0. The uth modified rotating vector is defined as

$$\begin{aligned}\bar{\mathbf{b}}^u &= \left[\bar{b}_0^u\ \bar{b}_1^u\ \cdots\ \bar{b}_{V-1}^u\right] \\ &= \left[b_0^u e^{j\theta_{S_0^u}}\ b_1^u e^{j\theta_{S_1^u}}\ \cdots\ b_{V-1}^u e^{j\theta_{S_{V-1}^u}}\right]\end{aligned}$$

The proposed PTS scheme 1, the minimum PAPR is selected for transmission.The ecludeian stance of the detected symbol from the signal constellation

$$(Z+1)^V \ge U = W^{V-1}.$$

ML detector is used to estimate the SI and recover the input symbol sequence X by destroying the euclidean distance between the rotated and original signal constellation.

3.2. ML detection for P-PTS 1

In order to recover the input symbol sequence X without using SI the receiver should find the index from the received signal generated by the modified rotating vector. The received symbol R_k at the k th sub carrier which belongs to the v th symbol sub sequence in frequency domain is expressed as

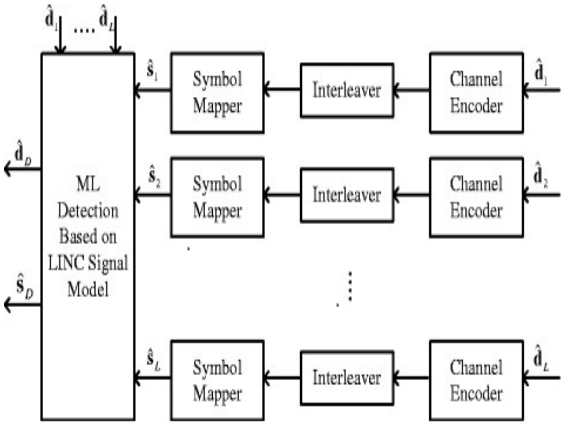
$$R_k = H_k \bar{b}_v^{\tilde{u}} X_k + N_k$$

where the frequency response is H_k and AWGN sample at the k th sub carrier with the variance power dimension $N_0/2$ is N_k it is assumed that the channel is quasi-static rayleigh fading channel and H_k are statistically independent and perfectly known to the receiver, that is, perfect channel state information is assumed.Let

At the receiver, the detected input symbol sequence is finally obtained as

$$\hat{\mathbf{X}}^{\hat{u}} = \sum_{v=0}^{V-1} b_v^{\hat{u}*} \hat{\mathbf{X}}_v^{S_v^{\hat{u}}},$$

The block diagram of the proposed ML detector for the PTS 1 is shown in fig.1. Z smaller than U, if the minimum Z is chosen to satisfy the condition.



3.3 Design criteria of V-tuple phase offset vectors and phase offsets

Note that PEP analysis is widely used for analyzing the error correction performance of communication systems with coding schemes such as trellis codes and space-time codes .

For convenience of PEP analysis, we assume that the adjacent sub block partitioning is used and the similar analysis can be applied to other sub block partitioning methods.We consider that each element of the signal constellation is contracted by a scale factor E_S so that the average energy of the signal constellation is 1, where E_s is the average energy of the transmitted symbols. Therefore, the PEP analysis for the proposed ML detector can be performed independently from the average energy of the signal constellation.

Then, we regard the PEP of the proposed ML detector as the probability to determine X ® B^u when X ® B^u is transmitted where ® denotes the component-wise multiplication of two vectors. Assuming the perfect CSI at the receiver, the probability of transmitting X ® Bu and determining by the proposed ML detector can be well approximated as follows

The independent rayleigh distributions as follows

$$\Pr\left(\mathbf{X}\otimes\mathbf{B}^{\tilde{u}} \to \hat{\mathbf{X}}\otimes\mathbf{B}^{\hat{u}} \middle| H_k, k=0,1,\cdots,N-1\right) \leq \prod_{v\in\mathbb{V}^{\tilde{u}}} \prod_{k=\frac{Nv}{V}}^{\frac{N(v+1)}{V}-1} \exp\left(\frac{-|H_k A_k|^2 E_s}{4N_0}\right)$$

It is easy to check that in order to minimize the PEP, 1

$$\Pr\left(\mathbf{X}\otimes\mathbf{B}^{\tilde{u}} \to \hat{\mathbf{X}}\otimes\mathbf{B}^{\hat{u}} | H_k, k=0,1,\cdots,N-1\right) \leq \exp\left(-\frac{d^2\left(\mathbf{X}\otimes\mathbf{B}^{\tilde{u}}, \hat{\mathbf{X}}\otimes\mathbf{B}^{\hat{u}}\right)E_s}{4N_0}\right)$$

V"1N/V and lAk1^2 should be maximized,

respectively. Thus, the following design criteria for V-tuple phase offset vectors Su and phase offsets are derived.

3.4. Analysis of performance

That is, in low SNR region the failure probability of SI mainly degrades the bit error performance of the OFDM system. Therefore, the proposed scheme is appropriate to OFDM systems operating in high SNR region, where the desirable SNR region can be calculated.

IV.PROPOSED PTS SCHEME II

It is possible to use Z = 1 for B = {±1}, the minimum number of phase offsets for the P-PTS I is Z = 1, which leads to low detection complexity at the receiver. However, in the case of B = {±1,±j}, which can use Z = 1 for the case of B = {±1,±j}. This scheme is called the proposed PTS scheme II (P-PTS II), where we consider the binary phase offsets θ0 = 0 and θ1 = π/4. It is verified in that if Z = 1, the Euclidean distance between two signal constellations Q and Qπ4 is maximized for QAM modulations such as 4-QAM, 16-QAM, and 64-QAM. The key idea of the P-PTS II is to further divide the sub blocks only for assigning different phase offset by using the linearity of FFT. That is, the v-th sub block xv is divided into an even sub block xev = [xe v,0 xe v,1 · · · xe v,N−1] and an odd sub block xov = [xo v,0 xo v,1 · · · xo v,N−1] which are obtained by applying IFFT to the even-indexed symbols and the odd-indexed symbols in frequency domain having N/2 zeros in an interleaved pattern, respectively. It is easy to derive the following relations

$$x^{e}_{v,n} = x^{e}_{v,n+\frac{N}{2}} = \frac{1}{2}\left(x_{v,n} + x_{v,n+\frac{N}{2}}\right)$$
$$x^{o}_{v,n} = -x^{o}_{v,n+\frac{N}{2}} = \frac{1}{2}\left(x_{v,n} - x_{v,n+\frac{N}{2}}\right)$$

$$\Pr(|H_k|) = 2|H_k| \exp\left(-|H_k|^2\right) \quad \text{for } |H_k| \geq 0. \qquad \mathbf{x}^u = \sum_{v=0}^{V-1} b^u_v \left(e^{j\frac{\pi}{4}S^u_{v,e}} \mathbf{x}^e_v + e^{j\frac{\pi}{4}S^u_{v,o}} \mathbf{x}^o_v\right).$$

Therefore, by dividing the subblocks into even-indexed and odd-indexed symbols, the constraint is relaxed to

$$(Z+3)^V \geq U = W^{V-1}.$$

Since the alternative signal sequences for the P-PTS II are generated differently from the P-PTS I, the metric in should be modified as

$$D_{v,S^u_{v,e}} = \sum_{k\in\mathbb{I}^e_v} \min_{X'_k\in\mathcal{Q}} |R_{v,k} e^{-j\theta_{S^u_{v,e}}} - \hat{H}_k X'_k|^2$$
$$D_{v,S^u_{v,o}} = \sum_{k\in\mathbb{I}^o_v} \min_{X'_k\in\mathcal{Q}} |R_{v,k} e^{-j\theta_{S^u_{v,o}}} - \hat{H}_k X'_k|^2$$

By using the partial metrics in Du is calculated as

$$D_u = \sum_{v=0}^{V-1} D_{v,S^u_{v,e}} + \sum_{v=0}^{V-1} D_{v,S^u_{v,o}}.$$

V. SIMULATION RESULTS

In this section,simulation results are given to compare the performance of two proposed PTS schemes in terms of PAPR reduction and BER of the ML detector.The simulation has been done for the OFDM systems which is modulated by QPSK and 16-QAM when N=256.   The PAPR reduction performance of P-PTS I scheme is slightly poor than that of P-PTS II scheme as the average Euclidean distance between the alternative signal sequences in P-PTS I is reduced by using more phase offsets when compared to P-PTS II

Typically,when QPSK is compared with 16-QAM,the gap between the PAPR reduction performance of P-PTS I and P-PTS II is increased since the correlation between alternative signal sequences in P-PTS I increases for QPSK due to less Euclidean distance because the number of phase offsets increases.For 16-QAM, the performance degradation between two proposed schemes is negligible, that is, within 0.1 dB.

Fig.7 analyses the BER performance of two proposed PTS schemes and the conventional PTS with perfect SI when N = 256, and QPSK or 16-QAM are used in the Rayleigh fading channel. In the Rayleigh fading channel,the conventional PTS scheme with PSI performs slightly better than two proposed PTS schemes but the difference looks negligible

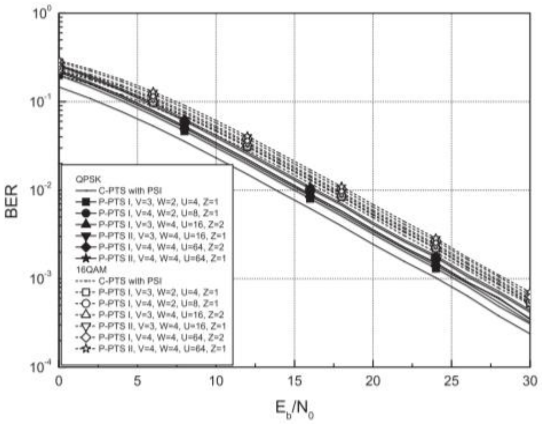


Fig. 7. Comparison of BER of two proposed PTS schemes and the conventional PTS scheme with PSI for $N = 256$ in the Rayleigh fading channel.

VI.CONCLUSION

In this paper,two PTS schemes without SI are proposed for reducing the PAPR of OFDM signals and for increasing the throughput,which does not transmits SI as identifiable phase offset is applied to the elements of each rotating vector.To find SI of the rotating vector and to recover the data sequence at the receiver, the ML detection for the proposed PTS schemes are obtained.The simulation results shows that for QPSK and 16-QAM, the BER performance and PAPR performance of two proposed PTS schemes are negligibly degraded when compared to the conventional PTS with perfect SI.

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