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Correlation-based subblock partition design for PTS approach

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Abstract: In order to exploit the capability of the peak-to-average power ratio (PAPR) reduction afforded by the partial transmit sequences (PTS) approach in orthogonal frequency division multiplexing (OFDM) systems, subblock partition schemes for the PTS approach are studied. The motivation is to establish the relationship between the subblock partition and the capability of PAPR reduction through the periodic autocorrelation functions (ACFs) of partial transmit sequences and the periodic cross-correlation functions (CCFs) of signal candidates. Let Q represent the variation of the square magnitudes of ACFs. It is found that the lower the Q-value is, the better PAPR performance can be achieved, which is introduced as a design criterion for subblock partition. Based on this criterion, four common partition methods are compared and an efficient partition strategy is proposed. It is shown that structured partition schemes with low computational complexity have a large Q-value, leading to a poor PAPR performance. The new strategy can be regarded as a trade-off between PAPR performance and computational complexity. The simulation results show that the strategy can achieve an optimal performance with a relatively low complexity and, moreover, does not increase the amount of side information.

Key words: orthogonal frequency division multiplexing (OFDM); peak-to-average power ratio (PAPR); partial transmit sequences (PTS); subblock partition

Orthogonal frequency division multiplexing (OFDM) has found its way to high-data-rate wireless transmission over fading channels[1]. One of the primary drawbacks of OFDM is the high peak-to-average power ratio (PAPR) of the transmit signal. The OFDM signal with a high PAPR requires a large linear range of system components, which is impractical for most applications. As a result, PAPR reduction of OFDM signals has been an active field of research since Jones et al. [2–3] first described a block coding scheme. Among existing schemes, the partial transmit sequences (PTS) approach is a competitive one[4]. The performance and complexity of the PTS approach mostly rely on a rotation factor selection and a subblock partition scheme[5–7].

Many subblock partition methods such as the adjacent partition (AP), the interleaved partition (IP), the pseudo-random partition (PP), the concatenated pseudo-random partition (CPP) and the enhanced interleaved partition (EIP) [7–9] have been developed to exploit the capability of PAPR reduction. These methods are based on intuitive observations. However, they cannot be precisely evaluated, since no criterion is provided. For example, the PP in Ref. [7] is intuitively expected to have the lowest autocorrelation of each partial transmit sequence, while the EIP in Ref. [9] is enhanced to generate more effective candidates than the IP.

In this paper, we introduce a correlation-based criterion for subblock partition design. Based on the criterion, four common partition methods (IP, AP, PP, EIP) are compared and an efficient partition strategy is presented. It is proved that the criterion is well fit for the evaluation and design of subblock partition.

1 PTS Approach and Subblock Partition

The complex OFDM signal with N subcarriers is given by

$$x(t) = \frac{1}{\sqrt{N}}\sum_{k=0}^{N-1}\hat{x}_k e^{j2\pi k\Delta f t} \qquad 0 \leqslant t < T \tag{1}$$

where $\hat{x}_k$ is the complex data; T is the symbol period and $\Delta f = 1/T$. The PAPR of the OFDM signal is defined as

$$P_{\mathrm{PAPR}} = \frac{\max\limits_{0\leqslant t<T} |x(t)|^2}{E[|x(t)|^2]} \tag{2}$$

More practically, the PAPR can be approximately computed by using $4N$ samples of the OFDM signal[10]. Here, we use Nyquist sampling (N samples). Let $\hat{\boldsymbol{x}}$ be the data vector and $\boldsymbol{x}$ be the signal vector. Denote $\boldsymbol{F}^{-1}$ as an $N\times N$ inverse fast Fourier transform (IFFT) matrix with entries $[\boldsymbol{F}^{-1}]_{r,c} = \exp\left(\frac{j2\pi(r-1)(c-1)}{N}\right)/\sqrt{N}$, where r is the row index and c is the column index. The sampled OFDM signal becomes $\hat{\boldsymbol{x}} = \boldsymbol{F}^{-1}\boldsymbol{x}$. Then, we have the detailed PTS approach as follows.

Step 1 $\hat{\boldsymbol{x}}$ is partitioned into V subblocks, represented by $\hat{\boldsymbol{x}}^{(v)}, v = 1, 2, \dots, V$. Note that $\hat{\boldsymbol{x}} = \sum_{v=1}^{V}\hat{\boldsymbol{x}}^{(v)}$. Each subblock is composed of N/V data elements and $N - N/V$ zero elements.

Step 2 All the IFFT-ed subblocks are phase-rotated and added to construct new signal vectors, represented by $\sum_{v=1}^{V} b^{(v)}\boldsymbol{F}^{-1}\hat{\boldsymbol{x}}^{(v)}$, where $b^{(v)}$ is the rotation factor. All the rotation factors are always selected from a finite set $\Phi = \{e^{j2\pi w/W}, w = 0, 1, \dots, W-1\}$ in practice.

Step 3 The optimum rotation factor is found according to the following optimization:

$$\{b_{\mathrm{opt}}^{(v)}\} = \arg\min_{b^{(v)}\in\Phi}\left(\max_{n\in[0,N)}\left|\left[\sum_{v=1}^{V} b^{(v)}\boldsymbol{F}^{-1}\hat{\boldsymbol{x}}^{(v)}\right]_n\right|\right) \tag{3}$$

The PAPR of the signal with the optimum rotation factors is minimized. The optimization result is transmitted to the receiver through side information. Note that the average power is unchanged.

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As mentioned above, a fundamental issue in the PTS approach is the subblock partition design in step 1. According to the process, we define matrices $\boldsymbol{P}^{(v)}$ with $\hat{\boldsymbol{x}}^{(v)} = \boldsymbol{P}^{(v)}\hat{\boldsymbol{x}}$ ($v = 1, 2, \ldots, N$) as subblock partition matrices. These matrices should have the following properties:

1) Each matrix is a diagonal matrix consisting of 1 s or 0 s;

2) All the matrices have the same number of 1 s;

3) $\sum_{v=1}^{V}\boldsymbol{P}^{(v)} = \boldsymbol{I}$.

The problem of the subblock partition is equivalent to optimizing the partition matrices.

2 Correlation-Based Subblock Partition Design

Now, we introduce a correlation-based criterion to optimize the above-mentioned partition matrices. The motivation for the criterion is to establish the relationship between the subblock partition and the capability of PAPR reduction. It is pointed out in Ref. [7] that subbclock partition plays an important role in periodic autocorrelation functions (ACFs) of partial transmit sequences. Moreover, it is found in Ref. [9] that the performance of PAPR reduction is affected by the number of effective candidates. As a result, the objective is to associate ACFs with effective candidates.

In fact, non-effective candidates can be described by the periodic cross-correlation functions (CCFs) of signal candidates. The CCF is defined as

$$\eta^{(k,l)}[\rho_0] = \frac{1}{\sigma_x^2}E\{(\boldsymbol{x}^k)^{\mathrm{H}}\boldsymbol{R}^{\rho_0}\boldsymbol{x}^l\} \qquad \rho_0 = 0, 1, \ldots, N-1 \tag{4}$$

where $\boldsymbol{R}^{\rho_0} = \begin{bmatrix} \boldsymbol{0} & \boldsymbol{I}_{N-\rho_0} \\ \boldsymbol{I}_{\rho_0} & \boldsymbol{0} \end{bmatrix}$ is a shifting matrix and $\boldsymbol{x}^k$ denotes the k-th signal candidate. Then, non-effective candidates are included in $\{\boldsymbol{x}^n \mid \max_{\rho_0} |\eta^{(k,l)}[\rho_0]| = 1, \forall l \neq n\}$.

In order to simplify the expression of the CCF, we substitute $\boldsymbol{x}^k = \sum_{v=1}^{V} b_k^{(v)}\boldsymbol{F}^{-1}\boldsymbol{P}^{(v)}\hat{\boldsymbol{x}}$ and $\boldsymbol{x}^l = \sum_{v=1}^{V} b_l^{(v)}\boldsymbol{F}^{-1}\boldsymbol{P}^{(v)}\hat{\boldsymbol{x}}$ into the definition, and then we have

$$\eta^{(k,l)}[\rho_0] = \frac{1}{\sigma_x^2}E\Big\{\sum_{v=1}^{V}(b_k^{(v)}\boldsymbol{P}^{(v)}\hat{\boldsymbol{x}})^{\mathrm{H}}\boldsymbol{D}^{\rho_0}\sum_{v=1}^{V}b_l^{(v)}\boldsymbol{P}^{(v)}\hat{\boldsymbol{x}}\Big\}$$

$$\boldsymbol{D}^{\rho_0} = (\boldsymbol{F}^{-1})^{\mathrm{H}}\boldsymbol{R}^{\rho_0}\boldsymbol{F}^{-1}$$

It can be calculated that $\boldsymbol{D}^{\rho_0} = \mathrm{diag}(\mathrm{e}^{\mathrm{j}2\pi\rho_0 n/N})$, $n = 0, 1, \ldots, N-1$ and $(\boldsymbol{P}^{(v_1)})^{\mathrm{H}}\boldsymbol{P}^{(v_2)} = 0$, $\forall v_1 \neq v_2$. Therefore, the definition of the CCF is simplified to

$$\eta^{(k,l)}[\rho_0] = \frac{1}{\sigma_x^2}E\Big\{\sum_{v=1}^{V}(b_k^{(v)})^* b_l^{(v)}\hat{\boldsymbol{x}}^{\mathrm{H}}\boldsymbol{P}^{(v)}\boldsymbol{D}^{\rho_0}\hat{\boldsymbol{x}}\Big\} \tag{5}$$

The ACF can also be simplified to

$$\lambda^{(v)}[\rho_0] = \frac{1}{\sigma_x^2}\{\hat{\boldsymbol{x}}^{\mathrm{H}}\boldsymbol{P}^{(v)}\boldsymbol{D}^{\rho_0}\hat{\boldsymbol{x}}\} \tag{6}$$

It is, therefore, easily found that

$$\eta^{(k,l)}[\rho_0] = \sum_{v=1}^{V}(b_k^{(v)})^* b_l^{(v)}\lambda^{(v)}[\rho_0]$$

From the description of non-effective candidates, low-amplitude CCFs are preferred, so that more effective candidates will be available. Low-amplitude ACFs are also needed to prevent interlock in pursuing peak cancellation[7]. As a matter of fact, the amplitude of the CCF can be approximated as

$$|\eta^{(k,l)}[\rho_0]| \cong \max_{t\in\Psi}\Big\{\sum_{v=1}^{V}|\lambda^{(v)}[\rho_0]|\cos(2\pi t + \phi^{(v)})\Big\} \tag{7}$$

where $\phi^{(v)} = \arg((b_k^{(v)})^* b_l^{(v)}\lambda^{(v)}[\rho_0])$ is the mixed phase and $\Psi = \{t: -0.5 \leqslant t \leqslant 0.5\}$. Low-amplitude ACFs are sufficient for low-amplitude CCFs. Consequently, the objective is transformed to minimize the amplitudes of all ACFs.

For simplicity, we first consider constant modulus constellations. In this situation, the ACF can be rewritten as $\lambda^{(v)}[\rho_0] = \frac{1}{N}\{\boldsymbol{i}^{\mathrm{H}}\boldsymbol{P}^{(v)}\boldsymbol{D}^{\rho_0}\boldsymbol{i}\}$, where $\boldsymbol{i}$ represents the all-one vector. It can be found that the average square amplitude of ACFs satisfies

$$\frac{1}{NV}\sum_{\rho_0=0}^{N-1}\sum_{v=1}^{V}|\lambda^{(v)}[\rho_0]|^2 = \frac{1}{NV} \tag{8}$$

The average square amplitude of ACFs is a constant. As a result, the minimization of the amplitudes of all ACFs is approximately equivalent to the minimization of the variation of these square amplitudes. Here, we obtain a criterion as follows:

$$\arg\min_{\boldsymbol{P}^{(v)}}\Big\{\frac{1}{NV}\sum_{\rho_0=0}^{N-1}\sum_{v=1}^{V}\Big(|\lambda^{(v)}[\rho_0]|^2 - \frac{1}{NV}\Big)^2\Big\} \tag{9}$$

Next, we consider non-constant modulus constellations. Take 16QAM for example. The non-constant modulus constellation can be decomposed into two constant modulus constellations (i. e. $\hat{x} = \hat{y} + \hat{z}$), as shown in Fig. 1. Therefore, the minimization of peak amplitude $\max_{n\in[0,N)}|[\boldsymbol{x}]_n|$ can be approximated by minimizing the sum of $\max_{n\in[0,N)}|[\boldsymbol{y}]_n|$ and $\max_{n\in[0,N)}|[\boldsymbol{x}]_n|$, each of which corresponds to a constant modulus situation. The above criterion can be utilized as well. It is shown by simulations that the approximation is accurate.

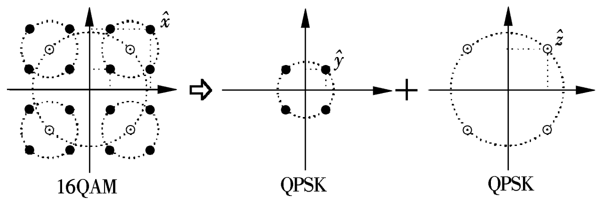

Fig. 1 Construction of square 16QAM constellation from two different π/4-QPSK constellations

3 Comparison of Subblock Partition Methods

Based on the above criterion, common subblock partition methods, including IP, AP, PP and EIP, are compared in this section. For the purpose of comparison, we assume that $N = 8$ and $V = 2$. Let

$$Q = \frac{1}{NV}\sum_{\rho_0=0}^{N-1}\sum_{v=1}^{V}\left(|\lambda^{(v)}[\rho_0]|^2 - \frac{1}{NV}\right)^2$$

$$\lambda^{(v)}[\rho_0] = \frac{1}{N}\{\boldsymbol{i}^{\mathrm{H}}\boldsymbol{P}^{(v)}\boldsymbol{D}^{\rho_0}\boldsymbol{i}\}$$

The ACFs and the Q-value are calculated as follows:

1) IP-PTS Every second carrier is assigned to one subblock, whose partition matrix is diag([1, 0, 1, 0, 1, 0, 1, 0]), and

$$\lambda^{(1)}[\rho_0] = \frac{1}{8}(1 + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}\pi\rho_0} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/2})$$

$$\lambda^{(2)}[\rho_0] = \frac{\mathrm{e}^{\mathrm{j}\pi\rho_0/4}}{8}(1 + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}\pi\rho_0} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/2})$$

$$Q = 0.011\,7$$

2) AP-PTS The first half of the carriers is assigned to one subblock, whose partition matrix is diag([1, 1, 1, 1, 0, 0, 0, 0]), and

$$\lambda^{(1)}[\rho_0] = \frac{1}{8}(1 + \mathrm{e}^{\mathrm{j}\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/4})$$

$$\lambda^{(2)}[\rho_0] = \frac{(-1)^{\rho_0}}{8}(1 + \mathrm{e}^{\mathrm{j}\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/4})$$

$$Q = 0.006\,8$$

3) PP-PTS Carriers are partitioned pseudo-randomly. Here, one of the pseudo-random partition matrices is selected as diag([1, 0, 0, 1, 0, 1, 0, 1]), and

$$\lambda^{(1)}[\rho_0] = \frac{1}{8}(1 + \mathrm{e}^{\mathrm{j}3\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}5\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}7\pi\rho_0/4})$$

$$\lambda^{(2)}[\rho_0] = \frac{1}{8}(\mathrm{e}^{\mathrm{j}\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}\pi\rho_0} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/2})$$

$$Q = 0.005\,4$$

4) EIP-PTS The method is enhanced from IP-PTS. The partition matrix is diag([1, 0, 0, 1, 1, 0, 0, 1]), and

$$\lambda^{(1)}[\rho_0] = \frac{1}{8}(1 + \mathrm{e}^{\mathrm{j}3\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}\pi\rho_0} + \mathrm{e}^{\mathrm{j}7\pi\rho_0/4})$$

$$\lambda^{(2)}[\rho_0] = \frac{1}{8}(\mathrm{e}^{\mathrm{j}\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}\pi\rho_0/2} + \mathrm{e}^{\mathrm{j}5\pi\rho_0/4} + \mathrm{e}^{\mathrm{j}3\pi\rho_0/2})$$

$$Q = 0.007\,8$$

It is known that the PP has the best performance (most of the time), and the AP has a better performance than the IP. Moreover, the EIP has a similar performance as the AP. These performance improvements can be easily evaluated by the criterion (i. e., the lower the Q-value, the better). It can be found that the PP can also lead to structured partition matrices as well, especially when N and V are small. Structured partition matrices lead to a large Q-value. In the above example, there exist $C_8^4/2 = 35$ kinds of partition matrices, 24 of which have $Q = 0.005\,4$. However, others have large Q-values. Thus, we need a strategy to avoid the large Q-values.

4 Efficient Subblock Partition Strategy

In this section, an efficient partition strategy is proposed based on the criterion. First, it should be noted that the PP-PTS always has the best performance when N is reasonably large, since the probability of large Q-values is very low. However, the PP-PTS has the highest computational complexity. In order to reduce the complexity, the CPP proposed in Ref. [8] is a concatenation of the PP and the IP. The algorithm is summarized as follows.

Agorithm 1 Concatenated pseudo-random partition

The data vector is divided into N subblocks: $\hat{\boldsymbol{x}} = \{\hat{x}_0, \ldots, \hat{x}_{N-1}\}^{\mathrm{T}} \rightarrow \hat{\boldsymbol{y}}^{(1)} = \{\hat{x}_0, 0, \ldots, 0\}^{\mathrm{T}}, \ldots, \hat{\boldsymbol{y}}^{(N)} = \{0, \ldots, 0, \hat{x}_0\}^{\mathrm{T}}$.

N subblocks are iteratively assembled into U subblocks:

$M = \log_2 \frac{N}{U}$, $U > V$;

for $m = 1$ to M do

$\hat{\boldsymbol{y}}^{(1)} = \hat{\boldsymbol{y}}^{(1)} + \hat{\boldsymbol{y}}^{(1+N/2^m)}; \ldots, \hat{\boldsymbol{y}}^{(N/2^m)} = \hat{\boldsymbol{y}}^{(N/2^m)} + \hat{\boldsymbol{y}}^{(N/2^m+N/2^m)}$;

end for

Do pseudo-random combination from these U subblocks to V subblocks.

The closer U approaches V, the lower complexity the CPP has. In the limit case, i. e., $U = V$, the CPP is equivalent to the IP. The complexity of the CPP remains low, since it can be regarded as a combination of the IP. The computational complexity of the above-mentioned partition methods is compared in Tab. 1.

Tab. 1 Computational complexity to construct one subblock

Method	Multiplication	Add
IP	$\frac{N}{2V}\log_2\frac{N}{V} + N$	$\frac{N}{V}\log_2\frac{N}{V}$
AP/PP	$\frac{N}{2}\log_2 N$	$N\log_2 N$
EIP	$\frac{N}{2V}\log_2\frac{N}{2V} + \frac{3N}{2}$	$\frac{N}{V}\log_2\frac{N}{2V} + N$
CPP	$\frac{N}{2V}\log_2\frac{N}{U} + N + \frac{N}{2}\log_2\frac{U}{V}$	$\frac{N}{V}\log_2\frac{N}{U} + N\log_2\frac{U}{V}$

In the first step, the ACFs are $\lambda^{(v)}[\rho_0] = \frac{\mathrm{e}^{\mathrm{j}2\pi\rho_0 v/N}}{N}$, $v = 0, 1, \ldots, N-1$. After the second step, the ACFs become $\lambda^{(v)}[\rho_0] = \frac{\mathrm{e}^{\mathrm{j}2\pi\rho_0 v/N}}{N}(1 + \mathrm{e}^{\mathrm{j}2\pi\rho_0 N/(2N)}), \ldots, (1 + \mathrm{e}^{\mathrm{j}2\pi\rho_0 N/(2^u N)}) = \frac{\mathrm{e}^{\mathrm{j}2\pi\rho_0 v/N}}{N} \cdot C_{\mathrm{CONST}}$, $v = 0, 1, \ldots, U-1$, in which

$$C_{\mathrm{CONST}} = \begin{cases} \frac{N}{U} & \rho_0 = \frac{KN}{U};\ k = 0, 1, \ldots, U-1 \\ 0 & \text{others} \end{cases} \tag{10}$$

Then, only UV ACFs need to be considered in the last step. We can find that it is a partition problem from U to V. As mentioned above, the PP in step 3 may result in partition matrices with large Q-values, since $U > V$ and $N \gg U$. As a result, it is preferable to choose a partition method based on criterion (9) in the final step. For instance, when $V = 2$ and $U = 4V$, diag([1, 0, 0, 1, 0, 1, 0, 1]) with $Q = 0.005\,4$ is a good choice. Now, we present an efficient partition strategy as follows:

Step 1 Considering the partition from the N-dimensional vector into U subblocks, do interleaved partition, whose partition matrices are represented by $\bar{\boldsymbol{P}}^{(u)}$, $u = 1, 2, \ldots, U$.

Step 2 Again considering the partition from the U-dimensional vector into V subblocks, find partition matrices with low Q-values based on the criterion above. The resulting matrices are denoted as $\hat{\boldsymbol{P}}^{(v)}$, $v = 1, 2, \ldots, V$.

Step 3 The final partition matrices are obtained by the combination $\boldsymbol{P}^{(v)} = \sum_{u=1}^{U} [\hat{\boldsymbol{P}}^{(v)}]_{u,u} \bar{\boldsymbol{P}}^{(u)}$, $v = 1, 2, \ldots, V$, which are from an N-dimensional data vector into V subblocks.

Note that off-line computation is needed for finding matrices with low Q-values. However, it should be calculated only once for each (U, V) pair.

5 Simulation Results and Discussion

In simulation, 10^5 random OFDM signals with 128 subcarriers are generated to obtain the complement cumulative distribution functions (CCDFs) of PAPR. Note that we use 4-times oversampling for PAPR computation and assume $\Phi = \{\pm 1, \pm j\}$ as a rotation factor set.

Fig. 2 compares the performance of PTS by using IP, AP, PP and the proposed strategy. Simulation results are consistent with the analysis in section 3, which show that the criterion fits for both constant and non-constant modulus constellations. The results also show that the proposed strategy has a better performance in PAPR reduction than the IP and the AP even when $U = 2V$. This performance improvement can be easily evaluated by the criterion in (9).

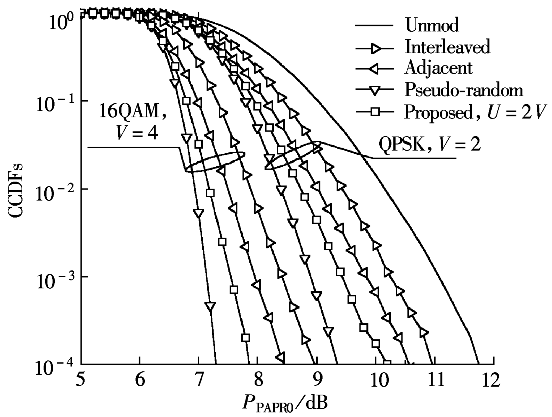

Fig. 2 Performance of PTS by using IP, AP, PP and the proposed strategy with $U = 2V$

In Fig. 3, the performance of PTS by using the proposed strategy is shown as a function of U/V. It is observed that our strategy approaches the PP as U/V increases. It can also be found that there is little improvement in PAPR reduction for further increasing U/V when $U/V > 8$. Moreover, the performance of PTS by using the EIP and the CPP are compared. It is shown that the EIP for $V = 2$ and our strategy with $U/V = 2$ have similar performance, while the CPP with $C = N/8$ and our strategy with $U/V = 4$ have similar performance as well. Note that $C = N/U$.

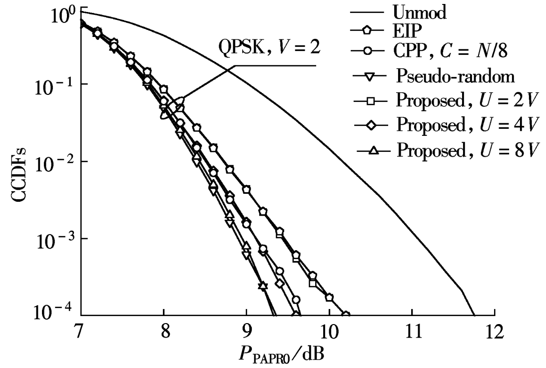

Fig. 3 Performance of PTS by using the proposed strategy with $U = 2V$, $U = 4V$, $U = 8V$

6 Conclusion

In this paper, we introduce a criterion for subblock partition design and compare common subblock partition methods. The correlation-based subblock partition criterion is reasonable and well fit for the performance evaluation. We also give an efficient partition strategy based on this criterion. The strategy can be regarded as an enhancement of the CPP, where partition matrices with large Q-values are avoided. Compared with the PP, the strategy can achieve optimal performance with lower complexity and, moreover, does not need additional side information.

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PTS 方法中基于相关性的子块划分设计

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摘要: 为了提高部分传输序列(PTS)方法在正交频分复用(OFDM)系统中降低峰均功率比(PAPR)的能力, 研究了 PTS 方法中的子块划分问题. 通过 PTS 的自相关函数(ACFs)和备选信号的互相关函数(CCFs), 将子块划分和降低 PAPR 的能力相关联. 这里用 Q 表示 ACFs 的均方幅度的方差. 研究发现 Q 值越小 PTS 方法所能达到的 PAPR 性能越好, 并以此作为子块划分的设计准则. 依据这一准则, 对 4 种常见的分块方法做了比较并提出一种有效的子块划分策略. 比较结果表明具有良好结构性的子块划分方法在具有低运算复杂度的同时 ACFs 的均方幅度方差较大, 因此 PAPR 性能不佳. 新策略可以看作是在 PAPR 性能和运算复杂度间所做的一种折中. 仿真结果表明该策略可以在相对低的复杂度的条件下达到最优性能, 同时也不会增加附加信息.

关键词: 正交频分复用; 峰均功率比; 部分传输序列; 子块划分

中图分类号: TN929. 5; TN919. 3