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基于 MBM 的未编码空时标记分集技术

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摘要:

(QAM)

(USTLD)

USTLD

(MBM) USTLD

USTLD MBM

USTLD MBM

USTLD

USTLD MBM

50%.

关 键 词:

中图分类号: TN911.23

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Uncoded Space-Time Labeling Diversity Based on MBM

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Abstract: Aiming at the problem that the envelope of the uncoded space time labeling diversity (USTLD) system based on quadrature amplitude modulation (QAM) constellation is not constant and the spectrum efficiency is low, the design method of mappers for phase shift keying (PSK) constellation and the USTLD system based on media based modulation (MBM) is proposed respectively. A bound of the average bit error probability of the proposed system is derived. Due to the high detection complexity of the USTLD MBM system, a low complexity detection algorithm for the system is given. Simulations show that the error performance of the USTLD MBM system is better than that of the USTLD system under the same spectral efficiency. In the USTLD MBM system, the bit error performance (BER) of the sphere decoding algorithm is almost identical to the maximum likelihood (ML) algorithm, and the complexity is reduced by about 50%.

Key words: uncoded space time labeling diversity; media based modulation; performance analysis

2016 Xu^[1]

(STBC, space time block code)

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$r_2 = N_t \quad m_{\text{rf}}, \quad k$
 MAP $l_i^k, \quad l_i^k \in \{1, 2, \dots, N_m\},$ USTLD MBM $\eta = \text{lb}M + N_t \quad m_{\text{rf}}.$
 USTLD MBM $\mathbf{X} \in \mathbb{C}^{(N_t \times N_m) \times N_t}$

$\mathbf{X} =$

$$\begin{bmatrix} \underbrace{0 \dots x_{q1}^1 \dots 0}_1^{l_1^1} & \underbrace{0 \dots x_{q2}^1 \dots 0}_2^{l_2^1} & \dots & \underbrace{0 \dots x_{qN_t}^1 \dots 0}_{N_t}^{l_{N_t}^1} \\ \dots & \dots & \dots & \dots \\ \underbrace{0 \dots x_{q1}^2 \dots 0}_1^{l_1^2} & \underbrace{0 \dots x_{q2}^2 \dots 0}_2^{l_2^2} & \dots & \underbrace{0 \dots x_{qN_t}^2 \dots 0}_{N_t}^{l_{N_t}^2} \\ \dots & \dots & \dots & \dots \\ \underbrace{0 \dots x_{q1}^{N_t} \dots 0}_1^{l_{N_t}^{N_t}} & \underbrace{0 \dots x_{q2}^{N_t} \dots 0}_2^{l_{N_t}^{N_t}} & \dots & \underbrace{0 \dots x_{qN_t}^{N_t} \dots 0}_{N_t}^{l_{N_t}^{N_t}} \end{bmatrix}^T$$

(1)

USTLD MBM

方案 1

$\mathbf{X} \in \mathbb{C}^{N_t \times N_t},$
 $\eta = \frac{m_{\text{rf}}}{N_t} + \text{lb}M.$

方案 2

$\mathbf{X} \in \mathbb{C}^{N_t \times N_t},$
 $\eta = m_{\text{rf}} + \text{lb}M.$

$$\mathbf{y}_k = \sqrt{\frac{\rho}{N_t}} \mathbf{H}_k \mathbf{x}_k + \mathbf{n}_k \quad (2)$$

ρ
 $\mathbb{C}^{N_r \times (N_m \times N_t)}$
 \mathbf{x}_k
 \mathbf{X}
 k
 \mathbf{H}_k
 \mathbf{y}_k
 k
 \mathbf{n}_k
 σ^2

USTLD MBM

$$\hat{\mathbf{X}} = \arg \min_{\mathbf{X}_k} \min_{\mathbf{X}_{\text{USTLD MBM } k=1}^{N_t}} \left\| \mathbf{y}_k - \sqrt{\frac{\rho}{N_t}} \mathbf{H}_k \mathbf{x}_k \right\|^2 \quad (3)$$

$\mathbf{X}_{\text{USTLD MBM}}$ USTLD MBM
 $\mathbf{X}_{\text{USTLD MBM}}$
 $1, A = 1;$ $2, A = N_t,$ ML
 $M^{N_t} \quad N_m^A,$ ML
 A

1.2 基于 PSK 星座的映射器设计

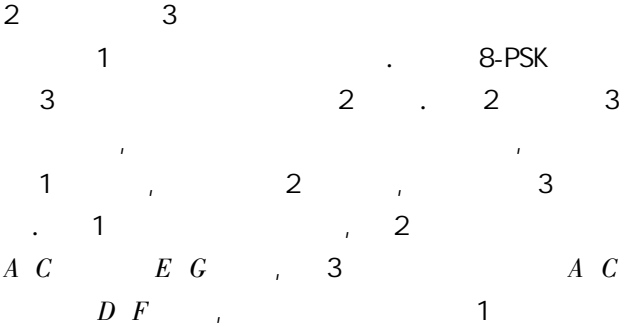
[1], USTLD

$$(\boldsymbol{\Omega}_2^M, \boldsymbol{\Omega}_3^M, \dots, \boldsymbol{\Omega}_{N_t}^M) = \arg \max_{(x_{q1}^k, \hat{x}_{q1}^k)} \left\{ \min_{\chi} \sum_{k=1}^{N_t} |x_{q1}^k - \hat{x}_{q1}^k|^2 \right\}$$

χ $(\mathbf{x}_2, \mathbf{x}_3, \dots, \mathbf{x}_{N_t})$

$[2],$ $3,$ $(M!)^{N_t-1}$

$[1]$



1

3

3

3

3

3

3

3

3

3

3

3

3

3

3

2 USTLD-MBM 系统性能分析

ML (ABEP, average bit error probability) . ABEP

$$P_{\text{ABEP}}(\rho) = \frac{1}{(2^{m_{\text{rf}}})^A M^{N_t}} \int_{\mathbf{X}} \int_{\hat{\mathbf{X}}} \frac{N_{\text{X}} \hat{\mathbf{X}} P(\mathbf{X} | \hat{\mathbf{X}})}{N_{\text{t}} \ln M + A m_{\text{rf}}} d\mathbf{X} d\hat{\mathbf{X}} \quad (5)$$

$$P(\mathbf{X} | \hat{\mathbf{X}}) = \frac{1}{2^L} \prod_{k=1}^L P(x_k | \hat{x}_k) \quad (2)$$

$$\mathbf{y}_k = \sqrt{\frac{\rho}{N_t}} \sum_{i=1}^{N_t} \mathbf{H}_k^i x_{qi}^k \mathbf{e}_{l_i}^i + \mathbf{n}_k \quad (6)$$

$$\mathbf{H}_k^i \in \mathbb{C}^{N_r \times N_m} \quad k=1, \dots, i$$

$$[\mathbf{H}_k^1, \dots, \mathbf{H}_k^i, \dots, \mathbf{H}_k^{N_t}] \cdot \mathbf{e}_{l_i}^i \in \mathbb{R}^{N_m \times 1} \quad l=1, \dots, i$$

$$\mathbf{0} \leq \mathbf{y}_k \leq \mathbf{1} \quad (2)$$

$$P(\mathbf{X} | \hat{\mathbf{X}} | \mathbf{H}_1, \dots, \mathbf{H}_{N_t}) = \prod_{k=1}^L \left\| \mathbf{y}_k - \sqrt{\frac{\rho}{N_t}} \sum_{i=1}^{N_t} \mathbf{H}_k^i x_{qi}^k \mathbf{e}_{l_i}^i \right\|_F^2$$

$$\mathbf{n}_1^2 + \dots + \mathbf{n}_{N_t}^2 \quad (7)$$

$$P(\mathbf{X} | \hat{\mathbf{X}} | \mathbf{H}_1, \dots, \mathbf{H}_{N_t}) = Q \left(\sqrt{\frac{\rho}{12}} \sum_{k=1}^{N_t} \mathbf{H}_k^2 \mathbf{x}_k^2 \right) \quad (8)$$

$$\hat{\mathbf{x}}_k = \mathbf{X} - \hat{\mathbf{X}} \quad k=1, \dots, L \quad (2)$$

$$Q(\varphi) = \frac{1}{2c} \left[\frac{1}{2} \exp \left(-\frac{\varphi^2}{2} \right) + \sum_{k=1}^{c-1} \exp \left(\frac{-\varphi^2}{2 \sin^2 \left(\frac{k}{2c} \right)} \right) \right] \quad (9)$$

: c

c = 10,

$$P(\mathbf{X} | \hat{\mathbf{X}}) = \frac{1}{2c} \left[\frac{1}{2} \sum_{k=1}^{N_t} M_k \left(\frac{1}{2} \right) + \sum_{i=1}^{c-1} \sum_{p=1}^{N_t} M_p \left(\frac{1}{2 \sin^2 \left(\frac{i}{2c} \right)} \right) \right] \quad (10)$$

$$M_k(s) = \left(\frac{1}{1 + 2\sigma_{\alpha_k}^2 s} \right)^{N_r}, \sigma_{\alpha_k}^2 = \frac{\rho}{12} \hat{\mathbf{x}}_k^2.$$

3 低复杂度检测算法

3.1 Rx-SD 检测算法

USTLD MBM (Rx SD, receiver centric sphere decoding) [9],

$$[\hat{\mathbf{I}}_{\text{MAP}}, \hat{\mathbf{X}}_{\text{sym}}] = \arg \min_{\substack{\mathbf{X}_{\text{sym}} \in \mathbb{C}^{N_r \times N_t} \\ \mathbf{I}_{\text{MAP}} \in \mathbb{C}^{N_r \times N_t}}} \left\| \mathbf{y}_k - \sqrt{\frac{\rho}{N_t}} \mathbf{H}_{\text{I}_{\text{MAP}}}^k \mathbf{x}_{\text{sym}}^k \right\|^2 \quad (3)$$

$$[\hat{\mathbf{I}}_{\text{MAP}}, \hat{\mathbf{X}}_{\text{sym}}] = \arg \min_{\substack{\mathbf{X}_{\text{sym}} \in \mathbb{C}^{N_r \times N_t} \\ \mathbf{I}_{\text{MAP}} \in \mathbb{C}^{N_r \times N_t}}} \left\| \mathbf{y}_k - \sqrt{\frac{\rho}{N_t}} \mathbf{H}_{\text{I}_{\text{MAP}}}^k \mathbf{x}_{\text{sym}}^k \right\|^2 \quad (11)$$

$$\mathbf{X}_{\text{sym}} \in \mathbb{C}^{N_r \times N_t} \quad \mathbf{X}_{\text{USTLD}} \in \mathbb{C}^{N_r \times N_t}$$

$$\mathbf{H}_{\text{I}_{\text{MAP}}}^k \in \mathbb{C}^{N_r \times N_m} \quad \mathbf{H}_{\text{I}_{\text{MAP}}}^k \in \mathbb{C}^{N_r \times N_m}$$

$$\mathbf{I}_{\text{MBM}} \in \mathbb{C}^{N_r \times N_t} \quad \mathbf{H}_{\text{I}_{\text{MAP}}}^k \in \mathbb{C}^{N_r \times N_m}$$

$$\mathbf{H}_{\text{I}_{\text{MAP}}}^k \in \mathbb{C}^{N_r \times N_m} \quad \mathbf{H}_{\text{I}_{\text{MAP}}}^k \in \mathbb{C}^{N_r \times N_m}$$

USTLD MBM Rx SD

$$[\hat{\mathbf{X}}_{\text{sym}}] = \arg \min_{\substack{\mathbf{X}_{\text{sym}} \in \mathbb{C}^{N_r \times N_t} \\ \mathbf{I}_{\text{MAP}} \in \mathbb{C}^{N_r \times N_t}}} \left\{ \sum_{k=1}^{N_t} \left\| \mathbf{y}_k - \sqrt{\frac{\rho}{N_t}} \mathbf{H}_{\text{I}_{\text{MAP}}}^k \mathbf{x}_{\text{sym}}^k \right\|^2 + R_{\text{SD}}^2 \right\} =$$

$$\arg \min_{\substack{\mathbf{X}_{\text{sym}} \in \mathbb{C}^{N_r \times N_t} \\ \mathbf{I}_{\text{MAP}} \in \mathbb{C}^{N_r \times N_t}}} \left\{ \sum_{b=1}^L \sum_{k=1}^{N_t} \left| y_k(b) - \sqrt{\frac{\rho}{N_t}} \mathbf{H}_{\text{I}_{\text{MAP}}}^k(b, :) \mathbf{x}_{\text{sym}}^k \right|^2 + R_{\text{SD}}^2 \right\} \quad (12)$$

$$\mathbf{H}_{\text{I}_{\text{MAP}}}^k(b, :) \in \mathbb{C}^{N_r \times N_m} \quad \mathbf{H}_{\text{I}_{\text{MAP}}}^k(b, :) \in \mathbb{C}^{N_r \times N_m}$$

$$b = 1, \dots, L \quad b = 1, \dots, L$$

$$; L \quad ; 1 \dots L \quad N_r; R_{\text{SD}}$$

$$[9] \quad R_{\text{SD}}^2 = 2\alpha N_r \sigma_n^2,$$

α

3.2 复杂度分析

USTLD MBM ML Rx SD

() .

$$\mathbf{M}_t = \left(\sum_{k=1}^{N_t} \left\| \sqrt{\frac{\rho}{N_t}} \mathbf{H}_{t_{\text{MAP}}}^k \mathbf{x}_{\text{sym}}^k \right\|^2 \right)^{-1} \mathbf{M}_t \left(4N_r N_t + 2N_r \right) \mathbf{M}_t$$
$$C_{\text{ML}} = N_t (N_m)^A M^{N_t} (4N_r N_t + 2N_r).$$

Rx SD : , Rx SD

$$N_t (4N_t + 2) , C_{\text{SD}} = (N_m)^A M^{N_t} [N_t (4N_t + 2)] L_{\text{avg}},$$

L_{avg} , $1 L_{\text{avg}} N_r$.

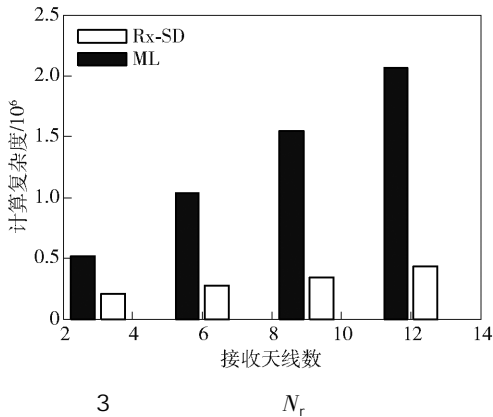
3 $N_t = 3, m_{\text{rf}} = 3, \rho = 10 \text{ dB},$

8-PSK, N_r , ML

Rx SD . , Rx SD

ML 50% ,

N_r , 2 .



4 仿真结果与分析

$N_r = 3,$ 8 PSK , 4

$N_t = 2^{[1]}$ $N_t = 3$ USTLD

4 , 10^{-4} , 3

USTLD 2 USTLD

16 PSK , 8 PSK

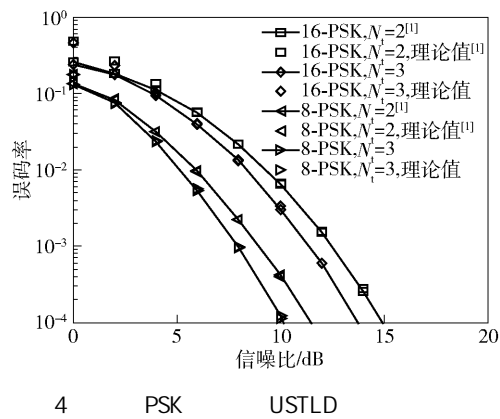
3 5 dB, ,

[1] USTLD

5 $N_t = 3, N_r = 3, \eta = 12$

USTLD USTLD MBM

USTLD 16 PSK.



USTLD MBM , 1 , $m_{\text{rf}} = 3,$

8 PSK; 2 , $m_{\text{rf}} = 1,$ 8

PSK. 10^{-4} , USTLD ,

USTLD MBM 2 3 dB

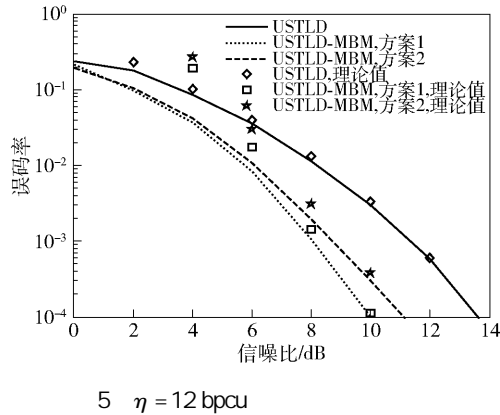
USTLD

1 2

1 dB, 1 ,

MAP

(5)



5 $\eta = 12 \text{ bpcu}$

6 $\eta = 15$ USTLD

USTLD MBM USTLD

32 PSK. USTLD MBM

1 , $m_{\text{rf}} = 6,$ 8 PSK; 2 ,

$m_{\text{rf}} = 2,$ 8 PSK. 10^{-4}

USTLD , USTLD MBM 2

7 dB , RF

USTLD MBM ,

USTLD

5 1

