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Re:	
Abstract	Enhancement to 3 Tx Open-loop MIMO Transmission
Purpose	Adoption of proposed changes into P802.16e ~~Crossed-out indicates deleted text,~~ underlined blue indicates new text change to the Standard
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Enhancement to 3 Tx Open-loop MIMO Transmission

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1. Introduction

A modified performance criterion that can be used for improving the performance of existing space-time codes for 3 Tx BS is presented. Using parameter comparison and simulation results, the proposed criterion results in a different encoding parameter than the current standard which uses conventional determinant criterion in predicting the performance of 3 Tx antenna STC. Based on our design criterion, we propose a modified STC for three transmit antennas.

2. Design Criteria

2.1 Conventional Criterion

This section reviews the well-known rank and determinant criteria [1] for STC. Assume that a codeword $\mathbf{S}$ is transmitted. Given that the receiver constructs a linear ML estimate of the transmitted codeword, the probability that the receiver mistakes the transmitted codeword $\mathbf{S}$ for another codeword $\mathbf{S}'$, given knowledge of the channel realization at the receiver which is referred to as the pairwise error probability(PEP) is

$$P(\mathbf{s} \to \mathbf{s}') \le \prod_{k=1}^{r} \left(\frac{1}{1 + SNR \cdot \lambda_k / 4N_T} \right)^{N_R} \tag{1}$$

where λ_k are the non-zero eigenvalues of $\mathbf{s} \to \mathbf{s}'$, N_T and N_R is the number of transmit and receive antennas, respectively. In high SNR regime, Eq. (1) may be further simplified as

$$P(\mathbf{s} \to \mathbf{s}') \le \frac{1}{\left(\prod_{k=1}^{r} \lambda_k\right)^{N_R}} \left(\frac{SNR}{4N_T} \right)^{-rN_R} \tag{2}$$

Eq. (2) leads us to the two well-known criteria for STC construction, namely the "rank criterion" and "determinant criterion" [1].

[Rank Criterion]
The rank criterion optimizes the spatial diversity extracted by a STC. We omit the explanations due to lack of space, the interested reader may refer to [1].

[Determinant Criterion]
The determinant criterion optimizes the coding gain. It is clear that coding gain depends on the term $\left(\prod_{k=1}^{r} \lambda_k\right)^{N_R}$ in (2). Hence, for high coding gain, one should maximize the minimum of the determinant of $\mathbf{s} \rightarrow \mathbf{s}'$ over all possible pairs of codeword matrices. Fig. 1 shows the minimum coding advantage as a function of phase θ. [2]

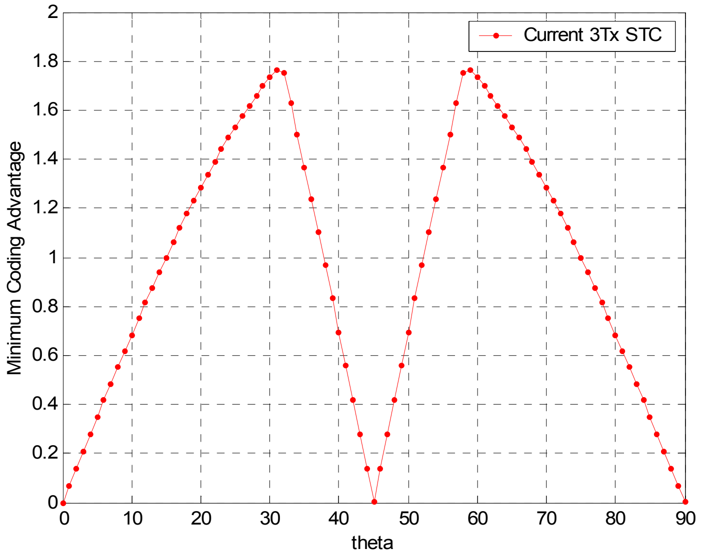


Fig 1. Minimum coding gain as a function of θ

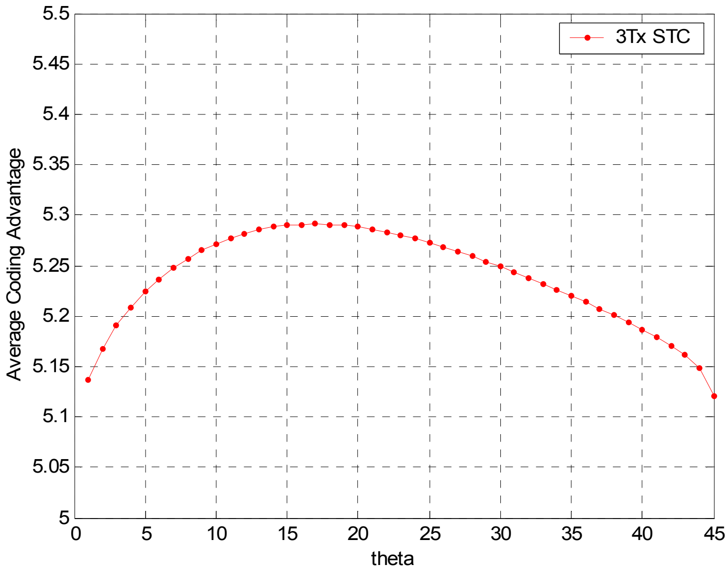


Fig 2. Average coding gain as a function of θ

2.2 ~~Conventional~~ Proposed Design Criterion

For the current full diversity full rate code for 3-Tx antenna BS, Tarokh's determinant criterion for optimizing the STC was employed. In further developments it was found that Tarokh's determinant criterion is not exact to optimize the coding advantage. Motivated by this fact, a new design criterion is used to optimize the FDFR STC for 3Tx system as follow

$$\arg\max_{\theta} avg(CodingGain) \quad (3)$$

Using Eq. 3, one can find the value of the phase θ that maximizes the mean coding gain. Fig.2 shows the BER/FER performance using various values of the phase θ. As can be seen, phase θ which is determined by new design criterion exhibits the best performance.

Proposed phase rotator : $\theta =$ atan(1/3) for QPSK, $\theta =$ atan(2/7) for 16QAM, $\theta =$ atan(1/8) for 64QAM

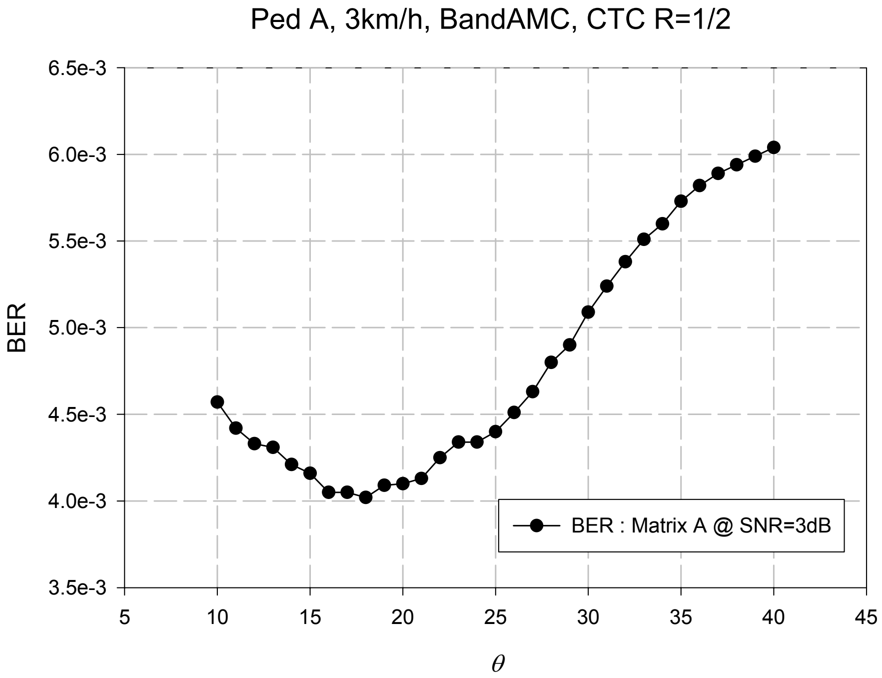
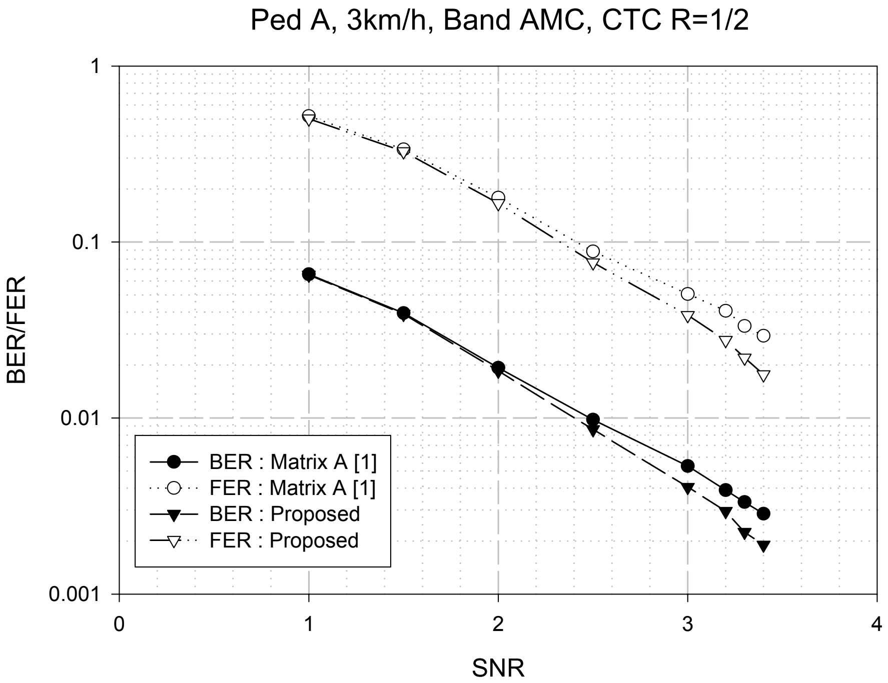
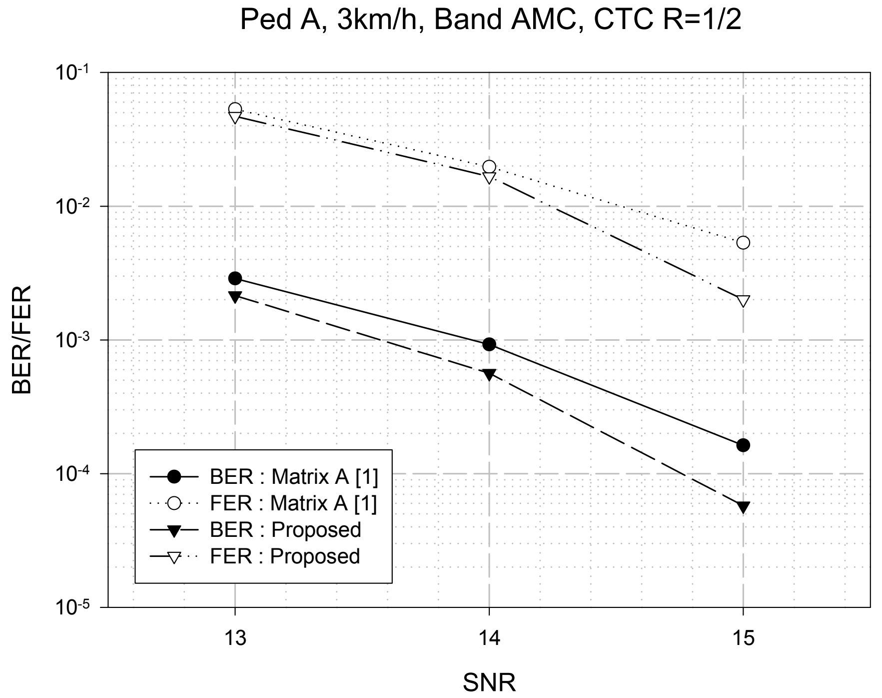


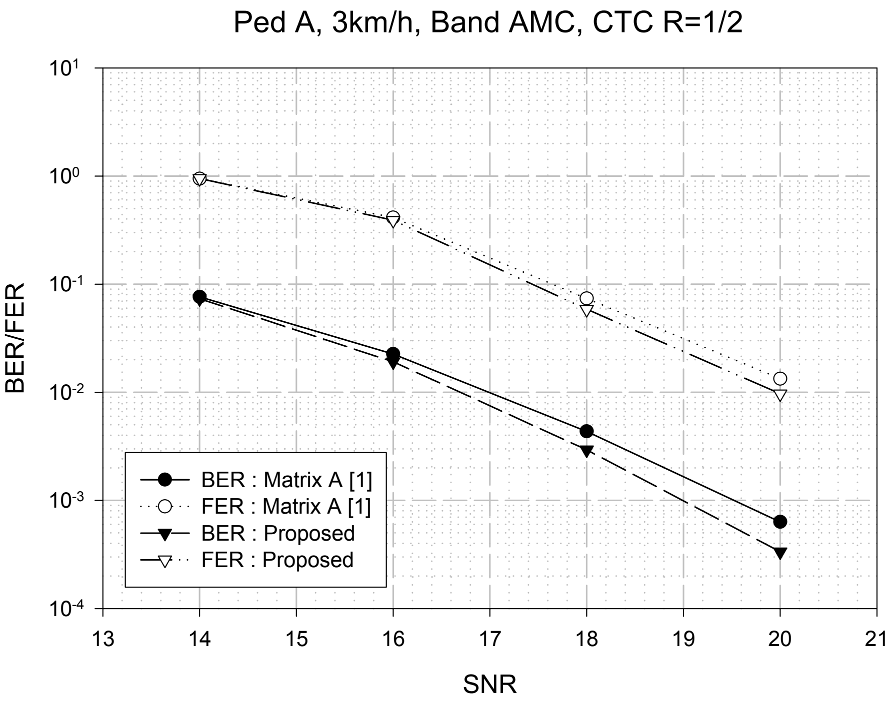
Fig. 3 BER performance using various phase θ (QPSK)



(a) QPSK



(b) 16QAM



(c) 64QAM

Fig. 4 BER/FER performance

3. Specific Text Changes

[Modify the 8.4.8.3.4 Transmission schemes for 3 antenna BS]

8.4.8.3.4 Transmission Schemes for 3 Antenna BS

STC for 3Tx-Rate 1, 2, and 3:

For three antenna BS, one of the three transmission matrices A, B or C, shall be used.
Let the complex symbols to be transmitted be x1, x2, x3, x4 which take values from a square QAM constellation. Let $s_i = x_i e^{j\theta}$ for i=1,2,…,5, where ~~$\theta = \frac{1}{2}\tan^{-1}(2)^o$~~ ~~$\theta = \frac{1}{2}\tan^{-1} 2$~~ ~~for QPSK, for 16QAM, and for 64QAM~~ $\theta =$ atan(1/3) for QPSK, $\theta =$ atan(2/7) for 16QAM, $\theta =$ atan(1/8) for 64QAM and let

$\tilde{s}_1 = s_{1I} + js_{3Q}$; $\tilde{s}_2 = s_{2I} + js_{4Q}$; $\tilde{s}_3 = s_{3I} + js_{1Q}$; $\tilde{s}_4 = s_{4I} + js_{2Q}$; $\tilde{s}_5 = s_{5I} + js_{7Q}$ where $s_i = s_{iI} + js_{iQ}$.

The proposed Space-Time-Frequency code (over two OFDMA symbols and two sub-carriers) for 3Tx-Rate 1 configuration with diversity order 3 is given in three permuted versions:

$$A_1 = \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & 0 & 0 \\ \tilde{s}_2 & \tilde{s}_1^* & \tilde{s}_3 & -\tilde{s}_4^* \\ 0 & 0 & \tilde{s}_4 & \tilde{s}_s^* \end{bmatrix}$$

$$A_2 = \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & \tilde{s}_3 & -\tilde{s}_4^* \\ \tilde{s}_2 & \tilde{s}_1^* & 0 & 0 \\ 0 & 0 & \tilde{s}_4 & \tilde{s}_s^* \end{bmatrix}$$

$$A_3 = \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & 0 & 0 \\ 0 & 0 & \tilde{s}_3 & -\tilde{s}_4^* \\ \tilde{s}_2 & \tilde{s}_1^* & \tilde{s}_4 & \tilde{s}_s^* \end{bmatrix}$$

where the ML decoding can be achieved by symbol-by-symbol decoding.

The matrix B is

$$B_1 = \begin{bmatrix} \sqrt{\frac{3}{4}} & 0 & 0 \\ 0 & \sqrt{\frac{3}{4}} & 0 \\ 0 & 0 & \sqrt{\frac{3}{2}} \end{bmatrix} \begin{bmatrix} \tilde{s}_1 & -\tilde{s}_2^* & \tilde{s}_5 & -\tilde{s}_6^* \\ \tilde{s}_2 & \tilde{s}_1^* & \tilde{s}_6 & \tilde{s}_5^* \\ \tilde{s}_7 & -\tilde{s}_8^* & \tilde{s}_3 & -\tilde{s}_4^* \end{bmatrix}$$

$$B_2 = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} B_1$$

$$B_3 = \begin{bmatrix} 0 & 0 & 1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} B_1$$

where the definition for the remaining variables are as follows:

$\tilde{s}_6 = s_{6I} + js_{8Q}$; $\tilde{s}_7 = s_{7I} + js_{5Q}$; $\tilde{s}_8 = s_{8I} + js_{6Q}$

The matrix C is used for spatial multiplexing.

$$C = \begin{bmatrix} s_1 \\ s_2 \\ s_3 \end{bmatrix}$$

References:

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems

[2] Tarokh et al, "Space-time codes for high data rate wireless communication: performance criteria and code construction," *IEEE Trans. Inf. Theory*, 1998