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Title	**Rotation Matrix R for the Codebook based CL MIMO Scheme**
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Re:	
Abstract	
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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Rotation Matrix R for the Codebook based CL MIMO Scheme

1. Introduction

In the current standard, a codebook based CL-MIMO scheme is considered for better link performance. But, this CL-MIMO has a power imbalance problem since some antennae are switched off for special cases (when the number of TX antennae is larger than the number of streams). In this contribution, we propose a rotation matrix R for the codebook based CL-MIMO scheme for solving the power imbalance problem.

2. Rotation Matrix R

Let us assume that BS has 3 Tx antennae and MS has 2 Rx antennae. In addition, the system will use 3 bit quantized beamforming mechanism. In this case, BS and MS shall use the V(3,2,3) as following

Table 1. 3bit 3x2 codebook V (3, 2, 3)

Index	Column1	Column2
w1	0	0
	1	0
	0	1
w2	-0.7201 + j0.3126	0.2483 + j0.2684
	-0.2326	0.1898 + j0.5419
	0.1898 - j0.5419	0.7325
w3	-0.0659 - j0.1371	-0.6283 + j0.5763
	0.9537	0.0752 + j0.2483
	0.0752 - j0.2483	-0.4537
w4	-0.0063 - j0.6527	0.4621 + j0.3321
	0.1477	0.4394 - j0.5991
	0.4394 + j0.5991	0.3522
w5	0.7171 - j0.3202	-0.2533 - j0.2626
	-0.2337	0.1951 + j0.5390
	0.1951 - j0.5390	0.7337
w6	0.4819 + j0.4517	0.2963 + j0.4801
	0.1354	-0.7127 - j0.1933
	-0.7127 + j0.1933	0.3692
w7	0.0686 + j0.1386	0.6200 - j0.5845
	0.9522	0.0770 + j0.2521
	0.0770 - j0.2521	-0.4522
w8	-0.0054 + j0.6540	-0.4566 - j0.3374
	0.1446	0.4363 - j0.6009
	0.4363 + j0.6009	0.3554

At the worst case, the MS will select w1 for every frame so antenna 1 will not be used at all. The disadvantage of this case is switching off of antenna 1 for every channel use. It will cause power imbalance. The power imbalance problem is solved by left multiplying the codebook by Vandemonde matrix.

$$\mathbf{R}_2 = \begin{bmatrix} 0.7071 & -0.5 - j0.5 \\ 0.7071 & 0.5 + j0.5 \end{bmatrix} \quad \text{for } N_T = 2$$

$$\mathbf{R}_3 = \begin{bmatrix} 0.5774 & -0.5 + \text{j}\,0.2887 & 0.2887 - \text{j}0.5 \\ 0.5774 & \text{j}0.5774 & -0.5774 \\ 0.5774 & 0.5 + \text{j}0.2887 & 0.2887 + \text{j}0.5 \end{bmatrix} \quad \text{for } N_T = 3$$

$$\mathbf{R}_4 = \begin{bmatrix} 0.5 & -0.1913 + \text{j}0.4619 & -0.3536 - \text{j}0.3536 & 0.4619 - \text{j}0.1913 \\ 0.5 & -0.4619 - \text{j}0.1913 & 0.3536 + \text{j}0.3536 & -0.1913 - \text{j}0.4619 \\ 0.5 & 0.1913 - \text{j}0.4619 & -0.3536 - \text{j}0.3536 & -0.4619 + \text{j}0.1913 \\ 0.5 & 0.4619 + \text{j}0.1913 & 0.3536 + \text{j}0.3536 & 0.1913 + \text{j}0.4619 \end{bmatrix} \quad \text{for } N_T = 4$$

or

$$\mathbf{R}_{N_T} = \frac{1}{\sqrt{N_T}} \begin{bmatrix} 1 & \alpha_0 & \mathsf{L} & \alpha_0^{N_T-1} \\ 1 & \alpha_1 & \mathsf{L} & \alpha_1^{N_T-1} \\ \mathsf{M} & \mathsf{M} & \mathsf{O} & \mathsf{M} \\ 1 & \alpha_{N_T-1} & \mathsf{L} & \alpha_{N_T-1}^{N_T-1} \end{bmatrix}$$

where, $\alpha_i = \exp\left(j2\pi(i+1/4)/N_T\right), i = 0,1,\ldots,N_T-1$, N_T is the number of TX antennas at BS.

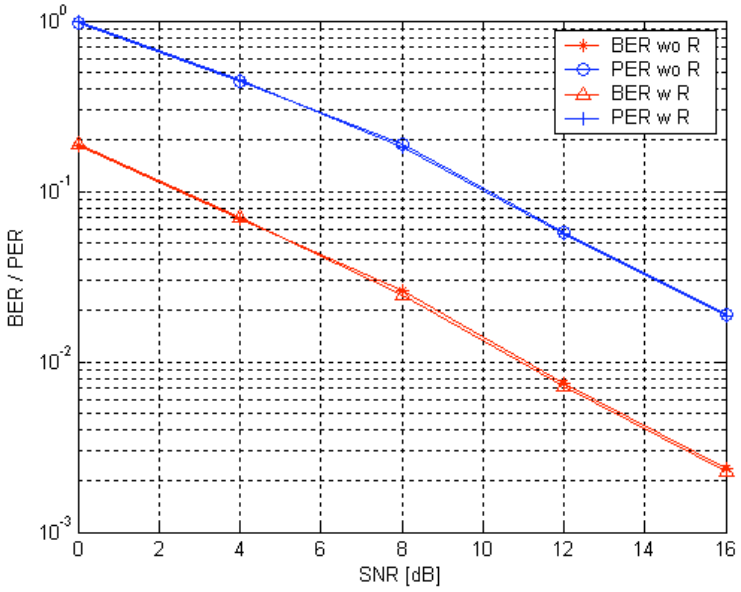

Fig 1. BER/FER Performance for Codebook based CL-MIMO w/wo Rotation Matrix R (Ped A, 3km/h, BandAMC, QPSK, LDPC R=1/2).

Fig. 1 shows the long term BER/FER performance for codebook based closed-loop MIMO system with/without rotation matrix R mentioned above. As can be seen, there is no performance difference at all. In addition, all transmit antenna will be used for every channel use.

3. Specific Text Changes

[Modify the section 8.4.8.3.4.1 as follows]

8.4.5.4.11 MIMO feedback for transmit beamforming

(Codebook Tables)

There is a distinct rotation matrix, R, specified for each codebook table that should be used for power balancing, where R is an N_t by N_t matrix and it is multiplied on the left with each codeword matrix in the codebook .

$$\mathbf{R}_{N_t} = \frac{1}{\sqrt{N_t}} \begin{bmatrix} 1 & \alpha_0 & \mathsf{L} & \alpha_0^{N_t-1} \\ 1 & \alpha_1 & \mathsf{L} & \alpha_1^{N_t-1} \\ \mathsf{M} & \mathsf{M} & \mathsf{O} & \mathsf{M} \\ 1 & \alpha_{N_t-1} & \mathsf{L} & \alpha_{N_t-1}^{N_t-1} \end{bmatrix}$$

where, $\alpha_i = \exp\left(j2\pi\left(i+1/4\right)/N_t\right), i = 0,1,\ldots,N_t-1$

End text proposal

References:

[1] IEEE P802.16-REVd/D6-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems