Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Rotated Codebooks for Closed-loop MIMO**
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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

Rotated Codebooks for Closed-loop MIMO

1. Introduction

Four codebooks tabulated in Section 8.4.5.4.11 in D7 standard contain undesirable beamforming vector [1 0…0]T, where the accepted contribution C80216e-05_50r7 is not reflected yet. This may cause switch on/off problem and power imbalance at transmitter. This problem can be solved by rotating the whole codebooks by constant angles, where the rotation doesn't change the distance property or PER performance. Since all matrix codebooks except the one for 4x2 3 bit are generated from vector codebooks, the consequent matrix codebooks are equivalently rotated by constant angles. Therefore, the consequent codebooks maintain the original distance property and get rid off the undesirable vector [1 0…0]T as a part of the codeword.

2. New Vector Codebooks

Let us assume that BS has 4 Tx antennas and MS has 1 Rx antenna. In addition, the system will use 3 bit quantized beamforming mechanism. In this case, BS and MS shall use the V(4,1,3) as following

Table 298l—*V(4,1,3)*

Vector index	1	2	3	4	5	6	7	8
v1	1	0.3780	0.3780	0.3780	0.3780	0.3780	0.3780	0.3780
v2	0	-0.2698 - *j*0.5668	-0.7103 + *j*0.1326	0.2830 – *j*0.0940	-0.0841 + *j*0.6478	0.5247 + *j*0.3532	0.2058 - *j*0.1369	0.0618 – *j*0.3332
v3	0	0.5957 + *j*0.1578	-0.2350 – *j*0.1467	0.0702 – *j*0.8261	0.0184 + *j*0.0490	0.4115 + *j*0.1825	-0.5211 + *j*0.0833	-0.3456 + *j*0.5029
v4	0	0.1587 - *j*0.2411	0.1371 + *j*0.4893	-0.2801 + *j*0.0491	-0.3272 - *j*0.5662	0.2639 + *j*0.4299	0.6136 - *j*0.3755	-0.5704 + *j*0.2113

After multiplying the unitary matrix, the codebook would be rotated while the property of the codebook is same.

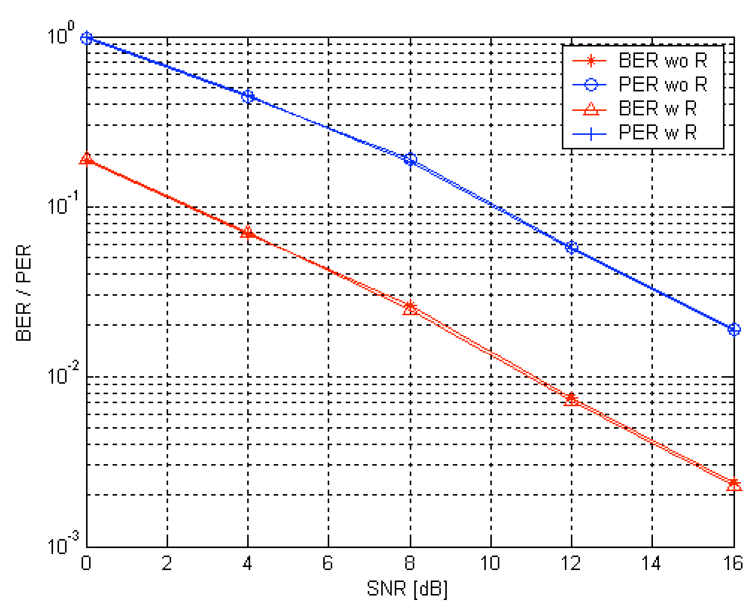

Fig 1. BER/FER Performance for Codebook based CL-MIMO w/wo Rotation Matrix R

(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 different vector codebooks 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

Table 298j—$V(2,1,3)$

Vector index	1	2	3	4	5	6	7	8
v1	1	0.7940	0.7940	0.7941	0.7941	0.3289	0.5112	0.3289
v2	0	-0.5801 + j0.1818	0.0576 + j0.6051	-0.2978 - j0.5298	0.6038 + j0.0689	0.6614 + j0.6740	0.4754 - j0.7160	-0.8779 - j0.3481

Vector Index	1	2	3	4	5	6	7	8
v1	0.7071	0.5997 – j0.4281	0.1506 - j0.1262	0.9882 - j0.0512	0.3532 + j0.3758	-0.3867 + j0.2497	0.7006 + j0.5043	0.6975 - j0.4793
v2	0.7071	0.9896 + j0.0382	0.6876 - j0.4109	0.6127 + j0.4267	0.1857 - j0.2084	-0.0172 - j0.6193	-0.1428 + j0.3391	0.7119 + j0.4649

Table 298k—$V(3,1,3)$

Vector index	1	2	3	4	5	6	7	8
v1	1	0.500	0.500	0.500	0.500	0.4954	0.500	0.500
v2	0	-0.7201 - j0.3126	-0.0659 + j0.1371	-0.0063 + j0.6527	0.7171 + j0.3202	0.4819 - j0.4517	0.0686 - j0.1386	-0.0054 - j0.6540
v3	0	0.2483 - j0.2684	-0.6283 - j0.5763	0.4621 - j0.3321	-0.2533 + j0.2626	0.2963 - j0.4801	0.6200 + j0.5845	-0.4566 + j0.3374

Vector Index	1	2	3	4	5	6	7	8
v1	0.5774	0.4036 - j0.3068	0.2513 + j0.4263	-0.3823 - j0.2007	0.1701 + j0.3080	0.1035 + j0.4319	0.3330 - j0.4245	0.9628 + j0.1903
v2	0.5774	0.8147 + j0.3177	0.3329 - j0.5503	0.7605 - j0.2937	-0.2337 - j0.3254	0.2461 + j0.0594	0.2360 + j0.5505	-0.1770 + j0.3014
v3	0.5774	-0.2482 + j0.3232	0.3685 + j0.5572	0.3112 + j0.0945	0.8286 - j0.3156	-0.1654 - j0.2818	0.2154 - j0.5590	0.2628 - j0.0929

Table 298l—$V(4,1,3)$

Vector index	1	2	3	4	5	6	7	8
v1	1	0.3780	0.3780	0.3780	0.3780	0.3780	0.3780	0.3780
v2	0	-0.2698 - j0.5668	-0.7103 + j0.1326	0.2830 – j0.0940	-0.0841 + j0.6478	0.5247 + j0.3532	0.2058 - j0.1369	0.0618 – j0.3332
v3	0	0.5957 + j0.1578	-0.2350 – j0.1467	0.0702 – j0.8261	0.0184 + j0.0490	0.4115 + j0.1825	-0.5211 + j0.0833	-0.3456 + j0.5029
v4	0	0.1587 - j0.2411	0.1371 + j0.4893	-0.2801 + j0.0491	-0.3272 - j0.5662	0.2639 + j0.4299	0.6136 - j0.3755	-0.5704 + j0.2113

Table 298l $V(4,1,3)$

Vector index	1	2	3	4	5	6	7	8
v_1	-0.5324+ j0.0491	-0.4145 + j0.2002	-0.4024 + j0.3518	-0.3961 - j0.1619	0.5377 - j0.0330	-0.4337 - j0.3348	-0.1327 + j0.4921	-0.1617 - j0.3909
v_2	-0.4583 - j0.2699	0.4270 + j0.3232	-0.1342 - j0.5173	0.1026 - j0.4810	-0.2965 - j0.3589	-0.3284 + j0.2624	-0.4699 - j0.0660	-0.5218 + j0.1248
v_3	-0.4820 - j0.0582	-0.4533 - j0.0588	0.4701 + j0.1829	-0.4808 + j0.2762	-0.4422 - j0.1070	0.0461 - j0.4807	-0.3214 - j0.4517	-0.0981 + j0.4847
v_4	0.4352 - j0.0786	0.5111 + j0.1768	0.4173 - j0.0121	-0.3520 - j0.3791	0.4346 - j0.3117	0.0834 - j0.5320	-0.2304 + j0.3932	0.2815 + j0.4577

Table 298p—3-bit 4x2 code-book V(4,2,3)

Matrix index	Column1	Column2	Matrix index	Column1	Column2
0b000	1	0	0b100	0.1918 - j0.0472	-0.3651 - j0.0228
	0	1		-0.3047 + j0.1116	0.0237 + j0.7606
	0	0		-0.7347 - j0.2076	0.1887 + j0.0124
	0	0		0.1028 + j0.5121	-0.3741 + j0.3338
0b001	-0.2654 + j0.2992	-0.5775 - j0.1061	0b101	0.5901 + j0.1973	-0.0758 - j0.0492
	-0.1726 - j0.1816	-0.4013 - j0.3587		-0.2801 - j0.2880	0.3914 + j0.3838
	-0.3061 - j0.0744	0.4080 + j0.4140		0.1873 - j0.1430	-0.1034 - j0.7246
	-0.4903 + j0.6616	0.1638 - j0.0302		0.1643 - j0.6074	0.3233 - j0.2259
0b010	0.0757 - j0.3932	-0.4334 - j0.3347	0b110	-0.382 + j0.5649	-0.2255 - j0.0721
	-0.4725 - j0.3610	0.1349 + j0.1587		-0.4605 - j0.2626	0.1865 + j0.1422
	-0.0623 - j0.0840	-0.0411 - j0.7644		-0.1984 - j0.0946	-0.8401 + j0.4105
	0.4387 + j0.5317	-0.2402 + j0.1144		-0.159 - j0.4246	0.0852 + j0.0860
0b011	-0.4279 + j0.1357	-0.2098 + j0.1569	0b111	0.6863 + j0.1884	-0.3818 - j0.1527
	-0.6872 + j0.0817	-0.2829 + j0.1676		-0.2705 - j0.2542	0.1367 - j0.1581
	-0.4579 - j0.1706	0.4212 + j0.3038		-0.1384 - j0.2577	0.4864 - j0.0528
	0.2782 + j0.0583	-0.3991 + j0.6279		0.1499 + j0.4976	0.5162 + j0.5304

Table 298p $V(4,2,3)$

Matrix index	Column 1	Column 2	Matrix index	Column 1	Column 2
0b000	-0.2708 + 0.8679i	-0.0944 + 0.0112i	0b100	0.0751 - 0.1422i	0.1846 - 0.4631i
	-0.0600 - 0.1530i	0.2193 - 0.3085i		0.0938 - 0.4576i	0.1671 + 0.4407i
	-0.0516 - 0.2875i	0.1492 + 0.5635i		-0.3732 - 0.7764i	-0.1388 + 0.0367i
	0.1353 + 0.2069i	0.7124 + 0.0194i		0.0469 + 0.1080i	0.1857 + 0.6886i
0b001	-0.0073 - 0.5940i	0.1045 - 0.3673i	0b101	-0.3026 + 0.7382i	0.1155 + 0.0479i
	-0.1109 - 0.1173i	-0.4875 + 0.5234i		0.0382 - 0.0432i	0.9120 - 0.1901i
	0.3992 - 0.6292i	0.0392 + 0.1304i		0.1598 + 0.0426i	-0.2180 + 0.2586i

	0.1580 + 0.2021i	-0.2646 - 0.5040i		-0.5367 - 0.2115i	0.0423 - 0.0150i
0b010	0.2297 + 0.0535i	0.6464 - 0.2850i	0b110	-0.2263 - 0.3800i	0.0557 - 0.4473i
	-0.1360 + 0.1466i	0.6718 + 0.0154i		-0.0183 - 0.1668i	-0.3082 - 0.6856i
	-0.3051 - 0.6848i	0.1863 - 0.0591i		0.3656 - 0.0189i	-0.4433 + 0.0438i
	0.0929 - 0.5777i	0.0853 + 0.0616i		-0.7961 - 0.0918i	0.1289 + 0.1294i
0b011	0.0564 - 0.5185i	-0.0774 - 0.3896i	0b111	-0.3209 + 0.4112i	0.0016 - 0.2893i
	0.1022 - 0.1047i	-0.3252 + 0.6537i		0.0833 - 0.1153i	0.1442 + 0.5480i
	-0.3537 - 0.4371i	0.1804 - 0.3426i		0.0177 - 0.8201i	-0.1520 - 0.0435i
	-0.6013 - 0.1697i	0.2059 + 0.3420i		0.1439 - 0.1184i	0.4718 - 0.5896i

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End text proposal

References:

[1] IEEE P802.16-REVd/D7-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems