Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
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Re:	Contribution supporting TGe WG ballot #14c
Abstract	This document includes a novel STC scheme that can provide the full-rate full-diversity with a greater coding gain than the existing STC scheme for cellular OFDMA systems. The proposed scheme is applicable to the DL 2xn ($n \geq 2$) antenna case.
Purpose	Adoption of proposed changes into P802.16e
Notice	
Release	
Patent Policy and Procedures	

An Enhanced MIMO Transmission Scheme for OFDMA Systems

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1 Introduction

We propose an enhanced Space-Time code with the full-rate and full-diversity for 2 Tx-rate 2 transmission. While this code is specified as a Space-Time code, it may also be used as a Space-Frequency code or as a hybrid.

2 Proposed STC for 2 Tx-rate 2 transmission

We propose to add the transmission matrix:

$$\mathbf{C}=\begin{pmatrix} 0.6015\cdot s_1 + j0.3717\cdot s_4 & 0.3717\cdot s_2 + 0.6015\cdot s_3 \\ 0.6015\cdot s_2 - 0.3717\cdot s_3 & j0.3717\cdot s_1 + 0.6015\cdot s_4 \end{pmatrix}$$

which is calculated from

$$\mathbf{C}=\frac{1}{\sqrt{2(1+r^2)}}\begin{pmatrix} s_1 + jre^{-j\frac{\phi_1}{2}}\cdot s_4 & jre^{-j\frac{\phi_2}{2}}\cdot s_2 + s_3 \\ s_2 + jre^{j\frac{\phi_2}{2}}\cdot s_3 & jre^{j\frac{\phi_1}{2}}\cdot s_1 + s_4 \end{pmatrix}$$

where $r=\frac{-1+\sqrt{5}}{2}$, $\phi_1=0$, and $\phi_2=\pi$.

The proposed change is managed by the fact that the new transmission matrix C provides the full diversity gain (the diversity order of 2 x no. of the receive antennas in the case of an uncorrelated Rayleigh fading MIMO channel), while maintaining the rate or multiplexing gain of the existing transmission matrix B in Section 8.4.8.3.3. The new matrix C with the full rate of 2 transmits four symbols over two OFDM symbol times (cf., two symbols over one OFDM symbol time in the matrix B). Using the proposed code, the full diversity gain is achieved by transmitting each data symbol so that it experiences all the possible branches in the MIMO channel over two OFDM symbol times while maintaining the code error matrix of rank 2. Then, the code has been designed so that the pairwise error probability between codewords could be minimized in order to maximize the coding gain. The

proposed STC can be applied to all QPSK, 16QAM, and 64QAM. The code admits decoding with a simple decoding algorithm of little more complexity as the typical decoding algorithm for matrix B. Fig. 1 shows the uncoded bit error rate performance of the proposed code compared with that of the known full-diversity full-rate scheme (called tilted-QAM [1]) as well as the matrix B. Additionally Fig.2 shows the comparison of the coded bit error performance between the proposed code and matrix B.

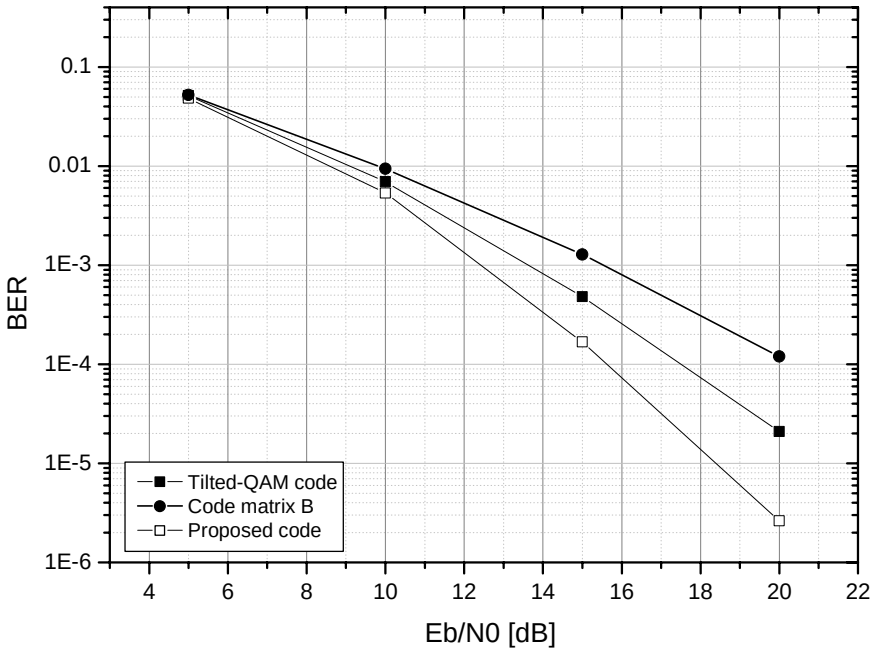

Fig. 1Uncoded bit error rate performance comparison among the proposed code, the tilted QAM code [1] and the code matrix B in an uncorrelated flat Rayleigh fading channel for QPSK modulation (2×2 MIMO system).

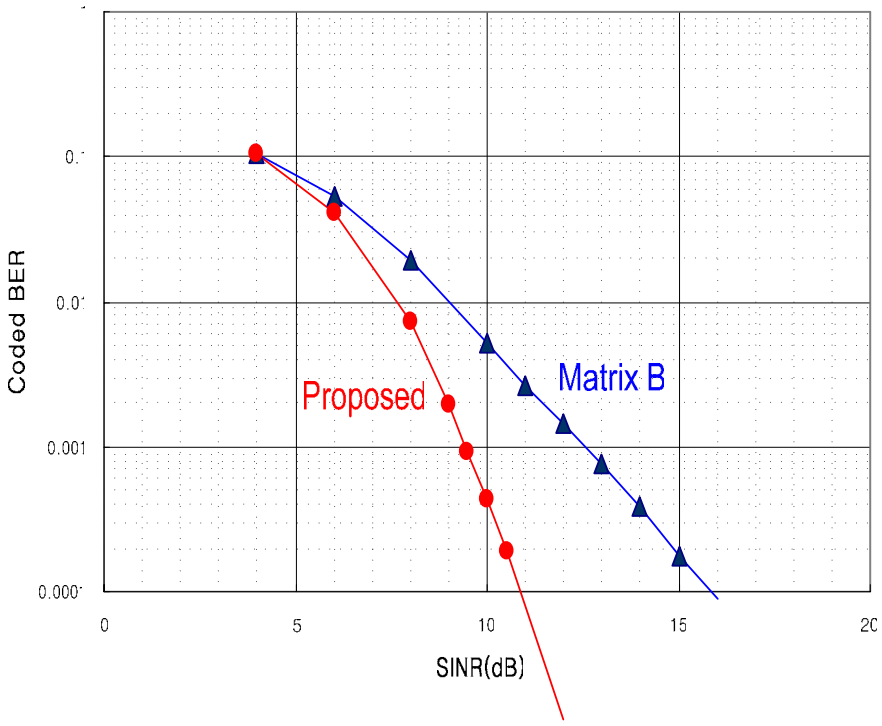

Fig. 2 Coded bit error rate performance comparison between the proposed code and the code matrix B in the Pedestrian-B (10 km/h) channel with QPSK and CTC 2/3.

3 *Specific Text Changes*

[~~Create a new section and insert it after~~ Add the following paragraph at the end of 8.4.8.3.3]

~~**8.4.8.3.4 Transmission schemes for 2-antenna BS and multiple-antenna MSS in DL**~~

The following matrix defines the transmission format to obtain full-rate and full-diversity for 2 transmit antennas in BS and k ($k \geq 2$) receive antennas in MSS. The matrix C provides the full diversity gain of $2k$, while maintaining the multiplexing gain of the existing matrix B in Section 8.4.8.3.3.

$$\mathbf{C} = \begin{pmatrix} 0.6015 \cdot s_1 + j0.3717 \cdot s_4 & 0.3717 \cdot s_2 + 0.6015 \cdot s_3 \\ 0.6015 \cdot s_2 - 0.3717 \cdot s_3 & j0.3717 \cdot s_1 + 0.6015 \cdot s_4 \end{pmatrix}$$

[Change the Table 281a in 8.4.5.3.8 at Page 116 as indicated]

Table 281a – MIMO DL basic IE format

Matrix_indicator	2	STC matrix (see 8.4.8.1.4)
		STC = STC mode indicated in the latest STC_Zone_IE().
		if (STC = 0b00) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		~~10 ~ 11 = Reserved~~
		11 = Reserved
		}
		elseif (STC = 0b01) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}
		elseif (STC = 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

[Change the Table 282a in 8.4.5.3.9 at Page 117 as indicated]

Table 282a – MIMO DL enhanced IE format

Matrix indicator	2	STC matrix (see 8.4.8.1.4)
		STC = STC mode indicated in the latest STC_Zone_IE().
		if (STC = 0b00) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		~~10 ~ 11 = Reserved~~
		11 = Reserved
		}
		elseif (STC = 0b01) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}
		elseif (STC = 10) {
		00 = Matrix A
		01 = Matrix B
		10 = Matrix C
		11 = Reserved
		}

[Change the table in 11.8.4.7.9 at Page 192 as indicated]

OFDMA MSS demodulator for MIMO support

Type	Length	Value	Scope
155	1	~~Bit #0: 2 BS Tx Matrix A~~ ~~Bit #1: 2 BS Tx Matrix B~~ ~~Bit #2: 3 BS Tx Matrix A~~ ~~Bit #3: 3 BS Tx Matrix B~~ ~~Bit #4: 3 BS Tx Matrix C~~ ~~Bit #5: 4 BS Tx Matrix A~~ ~~Bit #6: 4 BS Tx Matrix B~~ ~~Bit #7: 4 BS Tx Matrix C~~ 0: 2 BS Tx Matrix A 1: 2 BS Tx Matrix B 2: 2 BS Tx Matrix C 3: 3 BS Tx Matrix A 4: 3 BS Tx Matrix B 5: 3 BS Tx Matrix C 6: 4 BS Tx Matrix A 7: 4 BS Tx Matrix B 8: 4 BS Tx Matrix C Values 9 ~ 255: Reserved	SBC-REQ (see 6.3.2.3.23) SBC-RSP (see 6.3.2.3.24)

References

[1] H. Yao and G. W. Wornell, “Structured space-time block codes with optimal diversity-multiplexing tradeoff and minimum delay,” Globecom 2003, pp. 1941-1945.