Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Enhancement for rate 2, 4-transmit antenna STC
Date Submitted	**2005-1-20**
Source(s)	Jianzhong (Charlie) Zhang, Kiran Kuchi, Anthony Reid Nokia 6000 Connection Drive Irving, TX 75039 Voice: 972-374-0958, 972-374-1862 Fax: 972-894-5937 charlie.zhang@nokia.com, kiran.kuchi@nokia.com
Re:	IEEE 802.16e D5 Draft
Abstract	Proposes an enhancement to rate 2, 4-transmit antenna space time code
Purpose	To incorporate the changes proposed here into the 802.16e D5 Draft.
Notice	
Release	
Patent Policy and Procedures	

Enhancement for rate 2, 4 transmit antenna STC

Jianzhong (Charlie) Zhang, Kiran Kuchi, Tony Reid
Nokia

1. Background

The current 802.16e standard defines a rate 2, 4-antenna space-time-frequency code matrix

$$B = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_7^* \\ S_2 & S_1^* & S_6 & -S_8^* \\ S_3 & -S_4^* & S_7 & S_5^* \\ S_4 & S_3^* & S_8 & S_6^* \end{bmatrix},$$

Where the consecutive columns of the code span two OFDMA symbols and two sub-carriers respectively. In this proposal we propose a modification to the 4-antenna matrix B, which increases the coding gain up to 1.0 dB. The proposed enhancement requires few changes to the transceiver specification and does not require knowledge of channel state information at the transmitter.

2. Antenna Circulation Method for rate 2, 4-antenna STC

In order to fully exploit the diversity from all 4-antennas, we propose a circulated version of the B matrix. With circulation, the received signal with in a coding block experiences additional time variations thus improving the diversity and coding gain compared to a fixed B matrix. We propose that the following B matrix to be adopted in the 16e standard.

$$B_1 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix}, \quad B_2 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, \quad B_3 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix},$$

$$B_4 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}, \quad B_5 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, \quad B_6 = \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}$$

3. Performance

In Figure 1, we compared the FER performance of the circulated code to Matrix A for 4 Tx and 2 Rx case in for Ped A channel, rate 1/2 convolutional code, QPSK modulation using LMMSE receiver. We notice an increase in coding gain up to 1.0 dB. Similar gains are observed for other modulation and coding modes.

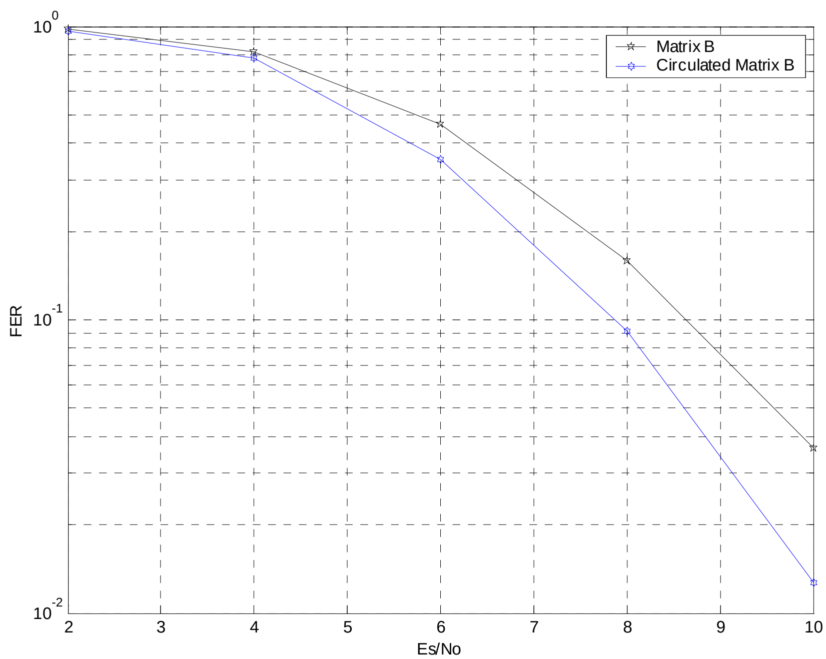

Figure1: FER performance of circulated matrix B

4. Proposed Text Change

8.4.8.3.5 Transmission schemes for 4-antenna BS

The proposed Space-Time-Frequency code (over two OFDMA symbols and two sub-carriers) for 4Tx-Rate 2 configuration is given in six permuted versions:

$$\mathrm{B}_1=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix},\quad \mathrm{B}_2=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix},\quad \mathrm{B}_3=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix},$$

$$\mathrm{B}_4=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix},\quad \mathrm{B}_5=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix},\quad \mathrm{B}_6=\begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}$$

The choice of subscript k to determine the matrix B_k is given by the following formula: k =mod(floor(logical_data_sub_carrier_number_for_first_tone_of_code/2),6)+1. where logical_data_sub_carrier_number_for_first_tone_of_code = 1,2,3,…,Total # of data sub-carriers.

5. References

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