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Title	Enhancement for rate 2, 4-transmit antenna STC
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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.
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## Enhancement for rate 2, 4 transmit antenna STC

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### 1. Background

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

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

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  $\mathbf{B}$ , 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  $\mathbf{B}$  matrix. With circulation, the received signal within a coding block experiences additional time variations thus improving the diversity and coding gain compared to a fixed  $\mathbf{B}$  matrix. We propose that the following  $\mathbf{B}$  matrix to be adopted in the 16e standard.

$$\begin{aligned} \mathbf{B}_1 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix}, & \mathbf{B}_2 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, & \mathbf{B}_3 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix}, \\ \mathbf{B}_4 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}, & \mathbf{B}_5 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, & \mathbf{B}_6 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix} \end{aligned}$$

### 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.

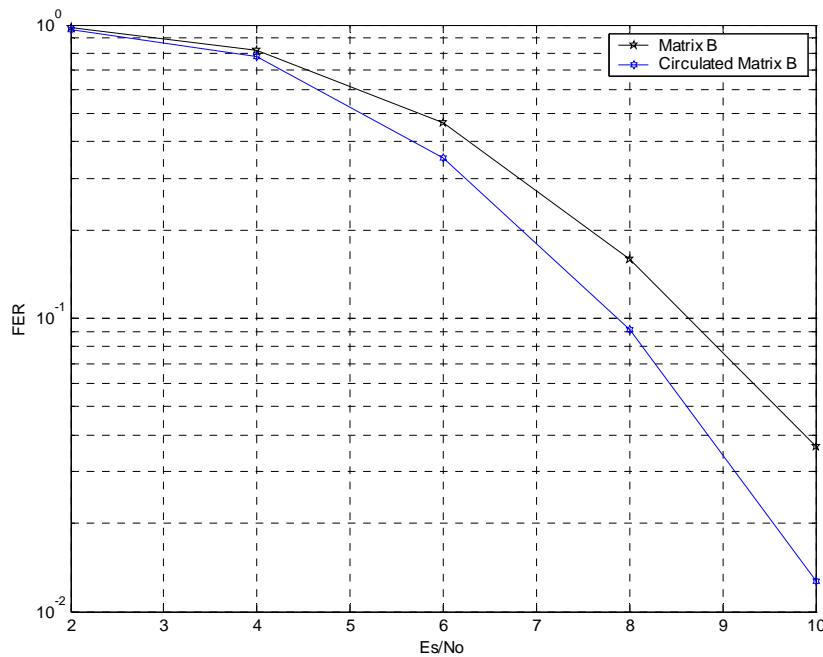


Figure1: FER performance of circulated matrix B

### 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:](#)

$$\begin{aligned}
\mathbf{B}_1 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix}, & \mathbf{B}_2 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, & \mathbf{B}_3 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_4 & S_3^* & S_8 & S_7^* \end{bmatrix}, \\
\mathbf{B}_4 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}, & \mathbf{B}_5 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_2 & S_1^* & S_6 & S_5^* \\ S_3 & -S_4^* & S_7 & -S_8^* \end{bmatrix}, & \mathbf{B}_6 &= \begin{bmatrix} S_1 & -S_2^* & S_5 & -S_6^* \\ S_4 & S_3^* & S_8 & S_7^* \\ S_3 & -S_4^* & S_7 & -S_8^* \\ S_2 & S_1^* & S_6 & S_5^* \end{bmatrix}
\end{aligned}$$

The choice of subscript k to determine the matrix  $B_k$  is given by the following formula:  $k = \text{mod}(\text{floor}(\text{logical data sub carrier number for first tone of code}/2), 6) + 1$ , where  $\text{logical data sub carrier number for first tone of code} = 1, 2, 3, \dots, \text{Total \# of data sub-carriers}$ .

## 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.