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| Abstract | STC modulation for first-zone PUSC with DL-MAP and broadcast messages. |
| Purpose | Adopting of proposed method into P802.16e D7 |
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# Enhancement of DL Map transmission with STC in the first mandatory PUSC zone

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## 1. Problem Statement

The current IEEE802.16e-D6~~5/a~~ standard states that the preamble symbol and the mandatory first PUSC zone transmission in the downlink shall be transmitted from only one antenna (antenna-0). As a consequence, the preamble, FCH, DL-MAP, and broadcast messages and data bursts utilizing DIUC=0 are transmitted via a single antenna. Problem arises when in a typical cellular deployment utilizing transmit diversity in BSs (MIMO/STC), the cell range coverage cannot be improved because the DL-MAP still needs to be transmitted without antenna diversity, unless the DL-MAP uses a high-order of repetition coding to provide extra diversity gain. To provide comparable performance when compared to Alamouti STC transmit diversity in such condition is to increase the number of repetition of the map by four times. Consequently there is a large increase of MAC overhead and degradation of spectral efficiency. Furthermore, the inability to utilize investment of additional transmit antennae severely limits the advantage to be gained from MIMO technology. It exacerbates the situation when indoor coverage is a key consideration.

## 2. Proposed Solution

To provide for backward compatibility, we devise a new STC encoding strategy in the first mandatory PUSC zone where the preamble and FCH subchannels are transmitted via a single antenna (ant 0). The rest of the data carriers are single or STC modulated depending on the information carried in the Coding Indication in the DL Frame Prefix. There is a need to devise a new STC encoding because the current STC PUSC cluster structure is not compatible with the cluster structure of the FCH subchannels. Also the current STC PUSC scheme requires obtaining two slots (four symbols) before data demodulation. It may increases DL-MAP demodulation latency and demands that the size of the STC PUSC zone be of even number of slots. Details of the new First-zone STC modulation scheme are described in Section 3.

Figure 1 shows the simulation results of frame error rate (FER) of data burst reception. The simulation follows the mandatory PUSC permutation in single antenna with and without repetition. The simulation of proposed First-zone STC modulation using two transmit antenna are conducted to compare with the single-antenna case. The simulation incorporates channel estimation errors of preamble symbols as well as non-uniformed channel estimation using pilot tones as devised in the current IEEE802.16-2004. It can be seen that in SUI5 a 2x repetition coding reduces SNR requirement by 6 dB for 1% FER while STC (equal power) reduces the SNR requirement by 9 dB. The difference primarily comes from the additional power that ant 1 provides during STC transmission. To reach comparable performance the DL-MAP needs to employ 4x repetition code in the mandatory PUSC zone modulation. For cellular deployment using MIMO technology, the 4x repetition requirement on DL-MAP, and broadcast messages using DIUC=0 present a big problem on MAC overhead.

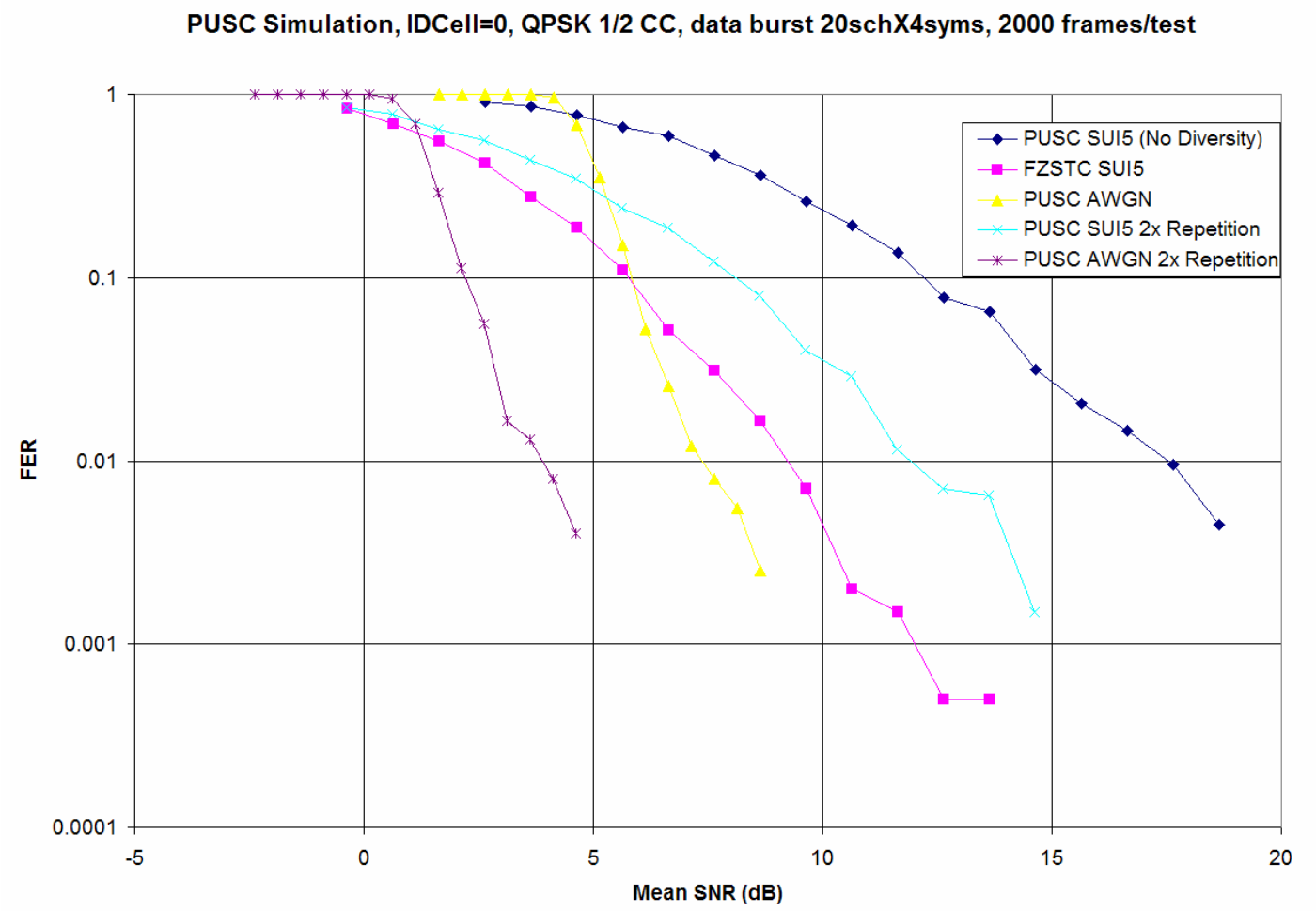


**Figure 1. System-level simulations of FER of PUSC permutation using repetition and proposed FZSTC.**

## 3. Proposed Text Change

*[Modify Table 266a]*

**Table 266a-OFDMA downlink Frame Prefix format**

| Syntax | Size | Notes |
|---|---|---|
| DL_Frame_Prefix_Format() { | | |
| **Used subchannel bitmap** | 6 bits | Bit #0: Subchannels 0-11 are used Subchannel group 0<br>Bit #1: Subchannels 12-19 are used Subchannel group 1<br>Bit #2: Subchannels 20-31 are used Subchannel group 2<br>Bit #3: Subchannels 32-39 are used Subchannel group 3<br>Bit #4: Subchannels 40-51 are used Subchannel group 4<br>Bit #5: Subchannels 52-59 are used Subchannel group 5 |
| **Ranging_Change_Indication** | 1 bit | |

| | | |
|---|---|---|
| **Repetition_Coding_Indication** | 2 bits | 00 - No repetition coding on DL-MAP<br>01 - Repetition coding of 2 used on DL-MAP<br>10 - Repetition coding of 4 used on DL-MAP<br>11 - Repetition coding of 6 used on DL-MAP |
| **Coding_Indication** | 3 bits | 0b000 - CC encoding used on DL-MAP<br>0b001 - BTC encoding used on DL-MAP<br>0b010 - CTC encoding used on DL-MAP<br>0b011 = ZT CC used on DL-MAP<br>~~0b100 to 0b111 Reserved~~<br>0b100 = First-zone STC CC encoding used on DL-MAP<br>0b101 = First-zone STC BTC encoding used on DL-MAP<br>0b110 = First-zone STC CTC encoding used on DL-MAP<br>0b111 = First-zone STC ZT CC encoding used on DL-MAP |
| **DL-MAP_Length** | 8 bits | |
| *reserved* | 4 bites | Shall be set to zero. |
| } | | |

*[Add text to 8.4.4.3 in the Coding Indication with the text marked blue]*

Coding_Indication

Indicates the FEC encoding code used for the DL-MAP. The DL-MAP shall be transmitted with QPSK modulation at FEC rate 1/2. Note that the BS must ensure that DL-MAP (and other MAC messages required for SS operation) are sent with the mandatory coding scheme often enough to ensure uninterrupted operation of SS supporting only the mandatory coding scheme. To enhance DL-MAP transmission in a two-TX configuration, the BS may use the First-zone STC modulation scheme described in 8.4.8.1.2.1.3.

*[Modify text in 8.4.5.3.4 with text marked in blue]*

In the DL-MAP, a BS may transmit DIUC=15 with the TD_ZONE_IE() to indicate that the subsequent allocations shall use a specific permutation, or be transmit diversity encoded. The downlink frame shall start in PUSC mode with IDcell = 0 and either no transmit diversity or employing First-zone STC modulation (8.4.8.1.2.1.3) specified in the DL Frame Prefix. Allocations subsequent to this IE shall use the permutation and transmit diversity mode it instructs.

*[Add Section 8.4.8.1.2.1.3]*

**8.4.8.1.2.1.3 First-zone STC modulation using 2 antennae in PUSC**

In the First-zone PUSC that contains DL-MAP, substantial performance improvement can be obtained for BSs equipped with transmit diversity capability (8.3.8). Enabling of STC operation allows range improvement and reduction of MAC overhead by reducing the need for repetition coding in the DL-MAP.

The clusters comprising the subchannels used by the First-zone STC modulation shall be allocated and subcarriers numbered as defined in 8.4.6.1.2.1. The cluster structure is depicted in Figure xxx. With an exception of FCH subchannels, encoding of the First-zone STC is depicted in Figure yyy. The FCH subchannels shall not be STC encoded. The First-zone STC mode is enabled via Coding Indication contained in the DL Frame Prefix (8.4.4.3). For preamble symbols and FCH subchannels transmission, antenna 1 transmits null data in the corresponding data tones. Demodulation of DL Frame Prefix that contained in FCH subchannels is thereby unaffected from the single-antenna TX configuation and is fully compatible with the mandatory PUSC modulation.

The pilot tones in the first slot (first two OFDMA symbols after the preamble symbol) shall be transmitted by antenna 1 for use in channel estimation. Thereafter the pilot tones are divided between antenna 0 and 1. Modulation of pilot tones are depicted in Figure yyy.

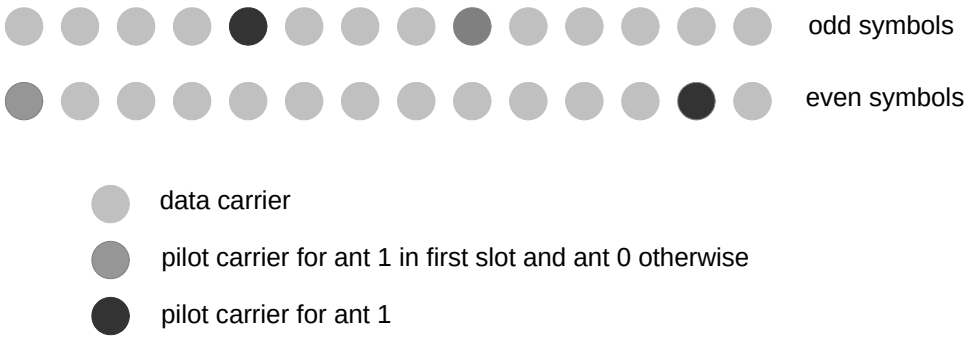


**Figure xxx- Cluster structure for First-zone STC.**

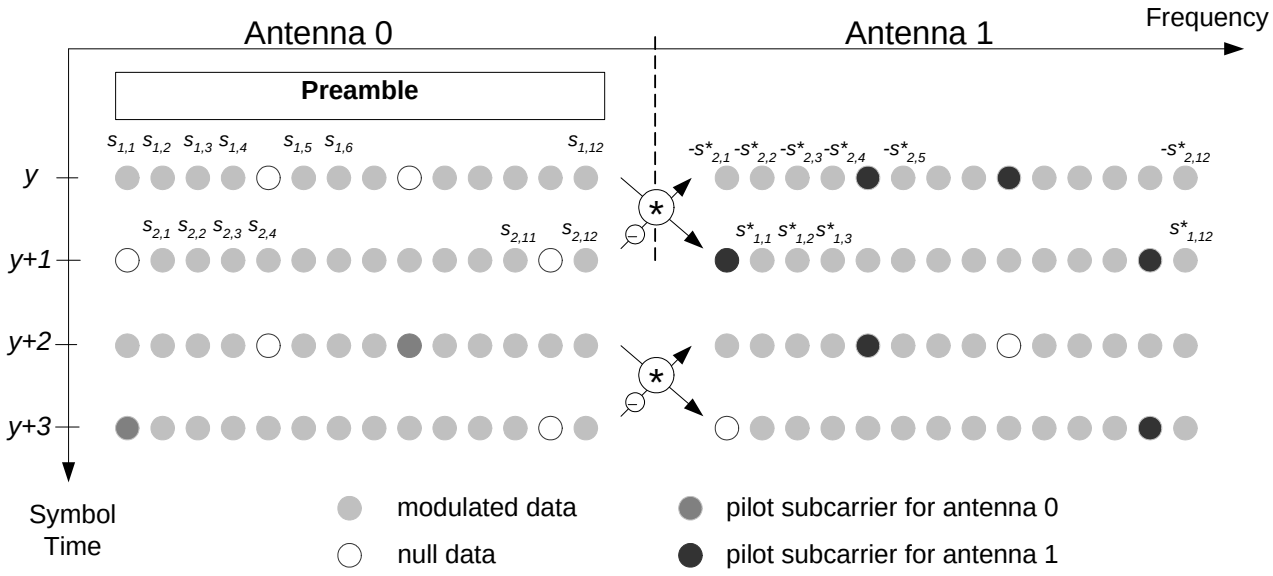


**Figure yyy. Encoding of STC for use with First-zone PUSC.**

## References

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

[2] IEEE P802.16-REVe/D6-2005 Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Band.