
Title: Enhanced Pilot allocation of PUSC in downlink STC that can be compatible with Non-STC

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Re: Response to the call for comments 802.16maint-04/10 Corrigendum to IEEE 802.16-2004

Abstract: Adopt proposed changes to TGmaint document

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Enhanced Pilot allocation of PUSC in downlink STC
that can be compatible with Non-STC

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1. Statement of the problem

Let $B_c$ denote the coherent bandwidth of the transmission channel. According to the sampling theory, if the sampling rate in the frequency domain fulfills the following inequality:

$$L\Delta f < B_c$$

(1)

The channel frequency response of the whole carriers can be calculated by interpolation, where $\Delta f$ and $L\Delta f$ are the carrier spacing and the pilot spacing respectively. Unfortunately, for some channel models, inequality (1) is not always satisfied for downlink OFDMA systems when STC is adopted.

The following is an example.

Suppose the allocated bandwidth is 20 MHz, and FFT size is 2048 with SUI-5 channel model. Then, $\Delta f$ is about 10kHz. Since the coherent bandwidth $B_c$ is about 70kHz supposing the correlation coefficient is equal to 0.5. Apparently,

$$L\Delta f > B_c$$

(2)

As a result of it, a significant channel estimation loss will appear in the presence of channels with relatively high delay spread (delay spread that is however much smaller than the maximum supported cyclic prefix length) when using pilot-aided estimation approaches.

Hence, an improved set of pilots allocation schemes is proposed for the downlink transmission here.

2. Proposed solution

2.1. PUSC mode

In the PUSC mode, pilots are allocated within clusters, as shown in figure-1 and figure-2 for two and four transmit antennas, respectively.
According to figure-1 and figure-2, we can find the pilots spacing is 12 carriers for each antenna and inequation (1) is not satisfactory. Hence, we propose one improved pilot allocations for two and four antennas, respectively.

For two antennas, pilot locations within the cluster shall be defined depending on the symbol index within each quartar of symbols, as following:
Here is an example:
Assuming both the pilots at the 4-th carrier during symbol 0 interval transmitted by antenna 0 and antenna 1 is $P$ (according to 802.16-2004, $P$ is a real number).

The transmission matrix of STC is

$$A = \begin{bmatrix} s_1 - s_2^* \\ s_2^* \\ s_1 \\ s_2 \end{bmatrix}$$

After the spacing time coding (STC), the pilot at the 4-th carrier during symbol 2 interval transmitted by antenna 0 is $-P$. The pilots at the 4-th carrier during symbol 2 interval transmitted by antenna 1 is $P$.

At the receiver, the received symbol $R_0$ during symbol 0 interval can be expressed as:

$$R_0 = P \times H_0 + P \times H_1 + N_0$$

the received symbol $R_2$ during symbol 2 interval can be expressed as:

$$R_2 = -P \times H_0 + P \times H_1 + N_2$$

where:

$H_0$ is the channel frequency response at the 4-th carrier between transmitter antenna 0 and receiver.

$H_1$ is the channel frequency response at the 4-th carrier between transmitter antenna 0 and receiver.

$N_0$ and $N_1$ is the noise.

The LS estimate of $H_0$ and $H_1$ can be expressed as:

$$\hat{H}_0 = (R_0 - R_2) / 2P = H_0 + (N_0 - N_1) / 2P$$

$$\hat{H}_1 = (R_0 + R_2) / 2P = H_1 + (N_0 + N_1) / 2P$$

The scheme mentioned above can also be extended to four antennas. For four antennas, the carriers is allocated as following figured. It should be noted that the data subcarriers which overlap with pilots allocated to antennas 2,3 are punctured.
Compared with the pilot allocation currently in 802.16-2004, 3dB gain in SNR can be obtained based on our proposal because pilots are encoded in our scheme. What is more, our scheme is compatible with non-STC mode. When we insert the pilot into the symbol, after STC, it can be converted automatically. For example, according to the above matrix of formula (3). Firstly, the antenna 0 and antenna 1 transmit pilot set P; secondly, antenna 0 transmits the pilot set –P and antenna 1 transmits the pilot set P, and the conversion can be realized automatically with STC. So, by the way, can we improve the performance of channel estimation and realize the channel estimation more easily.

3 Specific text change

8.4.8.1.2.1.1 STC using 2 antennas in PUSC

Replace figure 245 with Figure-3.
Replace figure 246 with Figure-5.
In PUSC the data allocation to cluster is as same as the one antenna transmission with the same estimation capabilities, each cluster shall be transmitted twice from each antenna.

The clusters composing the subchannels used by the STC mode shall be allocated and subcarriers numbered as defined in 8.4.6.2. The cluster structure of the subchannels allocated for STC is slightly modified to fit the STC requirements. The structure shall be modified as depicted in Figure 245. In this scheme, transmission on regular subchannels and STC subchannels is possible and is determined by the MAC layer (the allocation is performed by allocating major groups of subchannels for regular or STC transmission). The transmission of the data shall be performed in pairs of symbols as illustrated in Figure 246.

**8.4.8.4.8.2.1 STC using 2 antennas in PUSC**

Replace figure 251 with Figure-4.

For this configuration the basic cluster structure is changed as indicated in Figure 251 to accumulate the transmission from 4 antennas (pilots for antennas 2/3 override data subcarriers in the even symbols and odd symbols, erasing of the data subcarriers shall be performed after constellation mapping, therefore maintaining all the encoding scheme and the subchannel allocation scheme).