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Abstract	Corrections and clarifications of definitions for STC in OFDMA PHY.
Purpose	Adopt changes.
Notice	
Release	
Patent Policy and Procedures	

Simplification of downlink STC in PUSC

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1. Motivation

There are several reasons for changing the pilot structure for STC in PUSC:

1. Large distance between pilots (12 tones) degrades channel estimation performance, especially due to the fact that the channel is estimated per cluster (and there are only 2 pilots in the cluster).
2. The solution of exchanging pilot and data tones after the permutation is complex and vaguely defined.
3. In current definition the STC operation is performed on each two slots (4 symbols). However better performance and reduced delay can be obtained if STC is performed over two symbols (instead of slots).

There seems to be no good reason for the additional complexity, reduced performance and increased delay that exist in the current definition.

2. Details

2.1. Channel estimation performance

Since there are only 2 pilots in each cluster for each antenna, the channel estimation can be only linear interpolation. For estimating the central tone at frequency f0 which is exactly between the two pilots, the estimate would be:

$H_{est}(f0) = (Pilot(f0+6\cdot\Delta f) + Pilot(f0-6\cdot\Delta f))/2$

Under ideal conditions (no noise), Pilot(f)=H(f), therefore

$H_{est}(f0) = (H(f0+6\cdot\Delta f) + H(f0-6\cdot\Delta f))/2$

The normalized channel estimation distortion would be:

$D = \Delta H_{est} / H = (H(f0) - Hest(f0)) / H(f0) = (H(f0) - (H(f0+6\cdot\Delta f) + H(f0-6\cdot\Delta f))/2) / H(f0)$

For a simple delay channel $h(t) = \delta(t-T)$, we'll have:
$H(f) = \exp(j\cdot 2\pi\cdot T\cdot f)$
$D(T)= (H(f0) - (H(f0+6\cdot\Delta f) + H(f0-6\cdot\Delta f))/2) / H(f0) = 1 - (\exp(j\cdot 2\pi\cdot T\cdot 6\cdot\Delta f) + \exp(-j\cdot 2\pi\cdot T\cdot 6\cdot\Delta f))/2 = 1 - \cos(2\pi\cdot T\cdot 6\cdot\Delta f)$.

For example, for Δf=11Khz (which is the carrier spacing for 20Mhz/2048 FFT) the results are:

Delay (T)	Distortion (dB)

0.5us	-16.7dB
1us	-10.7dB
2us	-4.9dB
3us	-1.7dB

In actual channel which is composed of several multipath elements, the channel estimation distortion will be a weighed sum of the distortions for each of the taps.

2.2. Complexity

The definitions of STC coding for 2 antennas in downlink PUSC are overly complex, without any apparent reason. The definition by which data subcarriers are switched with pilots is difficult to understand and creates unnecessary complexity (a two layer permutation created by combintation of PUSC permutation and subcarrier switching in STC).

Currently for FUSC, the pilot locations in the permutation definition are changed in order to accommodate STC, and STC encoding/combining is done on two adjacent symbols.

However in PUSC, the pilot locations in the permutation definition stay the same, but are then switched as part of the STC definition, and STC is done over two symbols. The switching was done in order to accommodate the fact that in the definition of STC the number of data subcarriers per cluster in odd and even symbols is not the same (the PUSC permutation is defined only for 12 data subcarriers per cluster per symbol). But a simpler definition is to use a constant number of data carriers per symbol and avoid the switching.

2.3. Delay

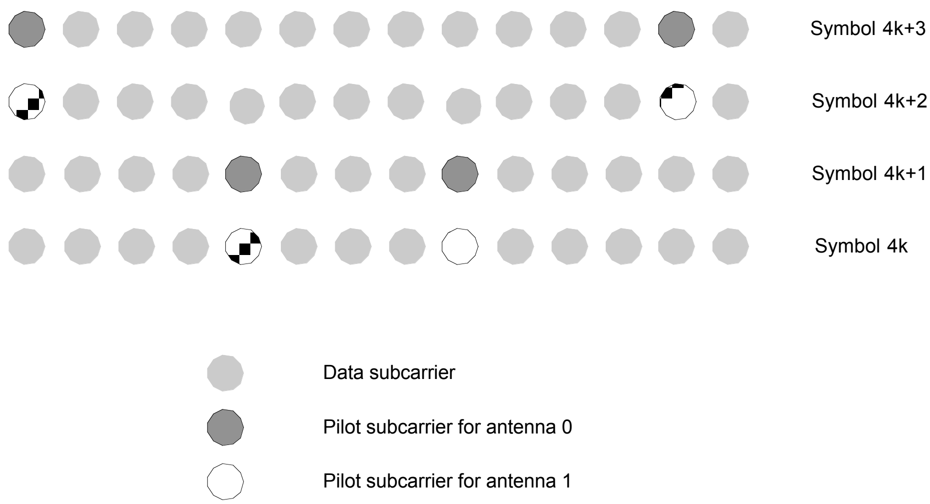
In addition, in the current definition STC is done over slots, which inserts an unnecessary delay and sensitivity to phase noise, puts an unnecessary constraint of the length of the STC zone (STC zone is required to be a multiple of 4 symbols instead of 2 – waste of up to 2 symbols) and differentiates between STC for FUSC and for PUSC.

2.4. Proposed solution

We propose to simplify the definitions by defining different pilot locations for PUSC, that will not necessitate subcarrier switching, and will make STC combining similar for PUSC and FUSC.

3. Proposed solution

We propose that for STC in PUSC the pilot locations in the cluster will be changed as follows:



In this way:

- The number of data subcarriers per cluster is constant, and therefore there is no need for additional switching between tones.
- This keeps the original PUSC permutation for odd and even symbol. The only change is to use the pilot locations of the odd symbol for two symbols, and then the even symbol for two symbols.
- The channel can be estimated from one cluster over 2 symbols, or alternatively from 4 symbols for better channel estimation. There is not additional delay because of working in 4 symbol blocks, because for the 6^{th} symbol the channel can be estimated using symbols 2,3,4,5, etc.
- STC combining can be done on the data subcarriers in two adjacent symbols (as in FUSC).

4. Changes summary

8.4.8.1.2.1.1 STC using 2 antennas in PUSC

[Replace the contents of the sub-section with the following text]

In PUSC the data allocation to cluster is changed (Figure 245) to accommodate two antennas transmission with the same estimation capabilities, each cluster shall be transmitted from each antenna.

Figure 245 replaces Figure 234 in the definition of PUSC permutation when STC is enabled. The pilot locations change in period of 4 symbols.

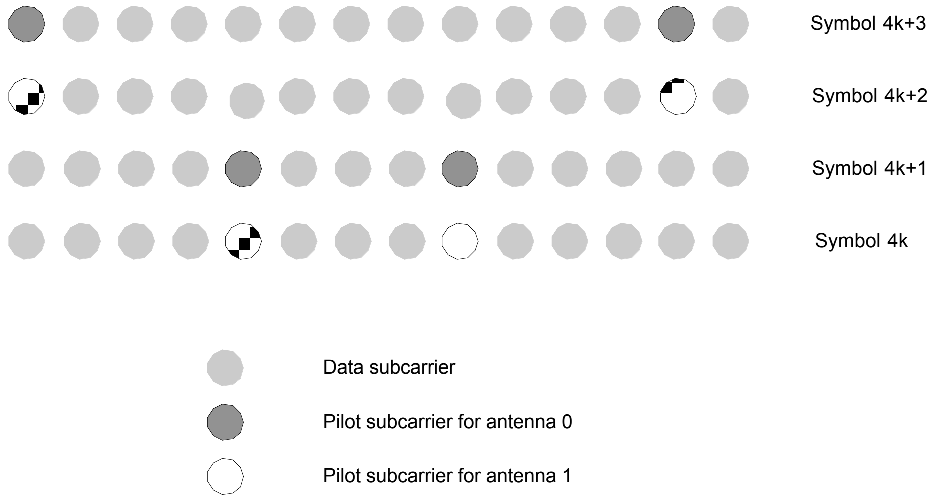


Figure 245 – Cluster structure for STC PUSC using 2 Antennas

STC encoding is performed on the two symbols of the PUSC slot (Each even symbol with following odd symbol).

8.4.8.2.1 STC for 4 antennas using PUSC

[Change the text as follows]

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

[Replace figure 251]

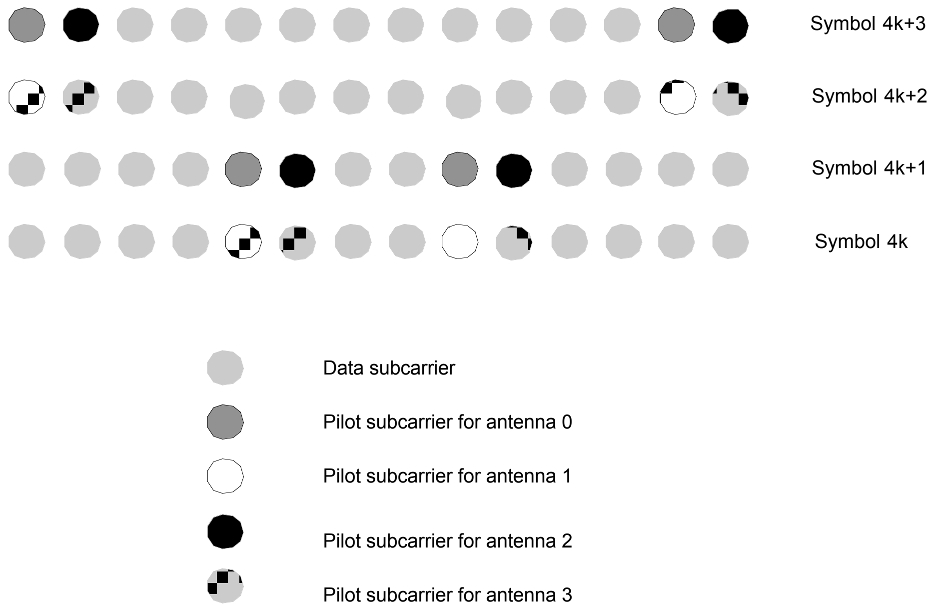


Figure 245 – Cluster structure for STC PUSC using 4 Antennas