

Project	<b>IEEE 802.16 Broadband Wireless Access Working Group</b> < <a href="http://ieee802.org/16">http://ieee802.org/16</a> >	
Title	Corrections for downlink STC in OFDMA PHY	
Date Submitted	<b>2004-11-01</b>	
Source(s)	Yuval Lomnitz Yigal Eliaspur Intel.	<a href="mailto:Yuval.Lomnitz@intel.com">Yuval.Lomnitz@intel.com</a> <a href="mailto:Yigal.Eliaspur@intel.com">Yigal.Eliaspur@intel.com</a>
	Yigal Leiba Yossi Segal Runcom Ltd.	<a href="mailto:yigall@runcom.co.il">yigall@runcom.co.il</a> <a href="mailto:yosis@runcom.co.il">yosis@runcom.co.il</a>
Re:	IEEE P802.16REVd/D5-2004	
Abstract	Corrections and clarifications of definitions for STC in OFDMA PHY.	
Purpose	Adopt changes.	
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# Corrections for downlink STC in OFDMA PHY

*Yuval Lomnitz, Yigal Eliaspur (Intel)  
Yigal Leiba, Yossi Segal (Runcom Ltd.)*

## 1. Motivation

There are several errors/undefined issues in the definition of downlink STC for two antennas in OFDMA PHY:

1. Pilot locations for FUSC
2. The order of STC and PRBS is undefined

## 2. Details

### 2.1. Pilot locations for FUSC

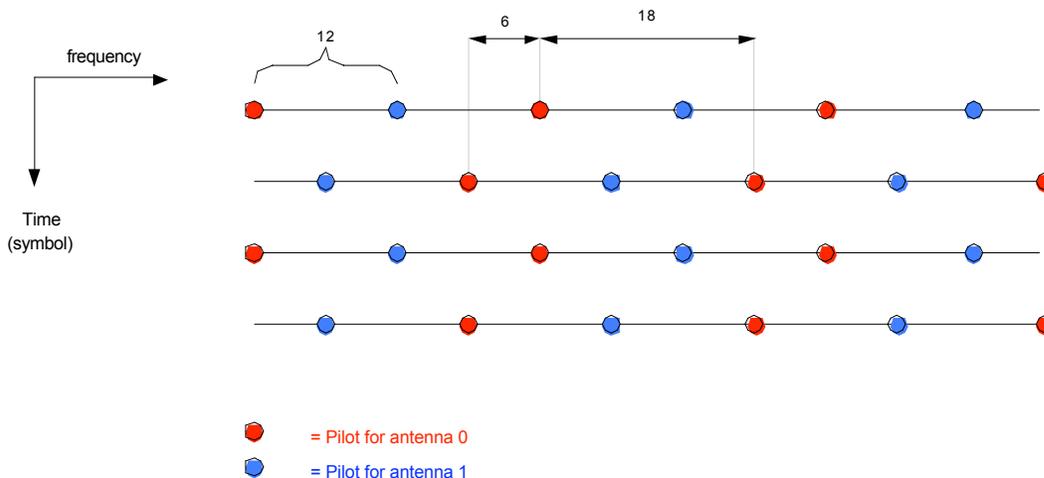
Equation (106) in section 8.4.6.1.2.2 (Symbol Structure for FUSC) defines that FUSC variable pilots are shifted by 6 in each odd symbol. However in STC they shouldn't be shifted by 6 because of the following reasons:

1. Shifting the pilots changes the location of data subcarriers, resulting in the fact that the STC doesn't operate on QAM symbols transmitted in the same frequency. This makes STC combining complex and suboptimal.
2. The operation of STC coding is defined as exchanging tones with the same index for two OFDMA symbols. The STC operation is not well defined when data tones change their locations.
3. The movement of the pilots creates an irregular pilot pattern that doesn't improve channel estimation, as depicted below. It seems that the original intention was merely to exchange pilot-sets between the antennas.

The following diagrams show the pilot patterns

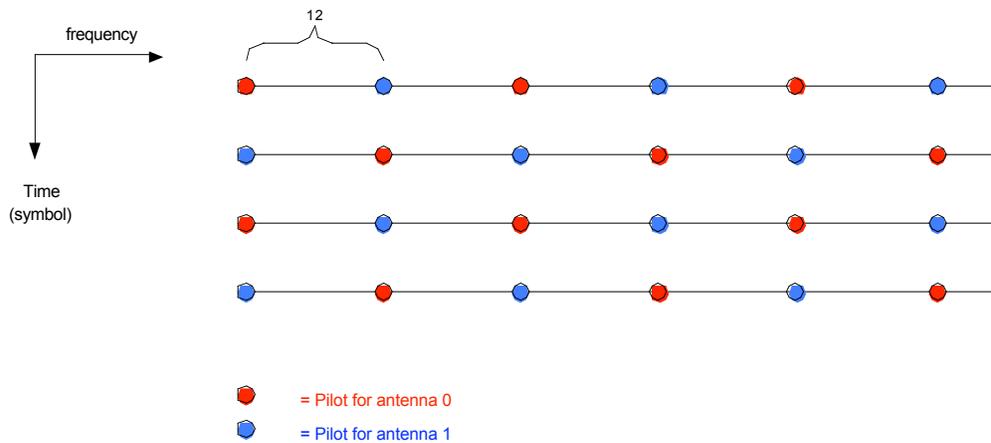
#### Before the proposed change

The maximum pilot spacing over 2 OFDMA symbols is 18 tones (and the minimum is 6 tones)



### After the proposed change

The pilot spacing (from one antenna) in two OFDMA symbols is 12 tones.



## 2.2. The order of STC and PRBS is undefined

It is not defined if STC operates on modulated symbols before or after multiplication by PRBS (defined in 8.4.9.4.1 Permutation definition). Formally, it can be defined either way, however it makes sense to define that STC coding is done before subcarrier randomization (PRBS), because in the reception process, in order to perform STC combining, the channel needs to be estimated, and in order to estimate the channel, the subcarrier randomization (PRBS) has to be removed, at least from the pilots. So the logical order of things in the receiver is: PRBS removal, channel estimation, STC combining. Therefore it makes sense to define that STC coding is done before PRBS.

Note that from BS implementation point of view, if pilots were set aside, it would make sense to place the STC after the PRBS, so that it could be performed after IFFT. This way, IFFT would need to be performed only once per symbol for both antennas (using time inversion to perform complex conjugate in frequency domain). However, because of pilot sharing and since pilots are PRBS-ed (therefore not repetitive), this is not possible.

Following this definition it should be clarified also that the switching between data subcarriers and pilots (in STC for PUSC) is done **before** STC and **before** subcarrier randomization.

In addition, it is not defined anywhere that STC coding operates on subcarriers with the **same index** (frequency) in different symbols, so it is worth clarifying this.

## 3. Changes summary

### 8.4.8.1.2.1 STC encoding

[Add the following text after line 49 in p.583]

STC encoding shall be performed after constellation mapping and before subcarrier randomization defined in 8.4.9.4.1.  $s_1$  and  $s_2$  represent two subcarriers in the same frequency in two different OFDMA symbols (each OFDMA symbol is referred to as a channel use). The STC coding is done on all data subcarriers in the two OFDMA symbols. Pilot subcarriers are not encoded and are transmitted

from either antenna 0 or antenna 1. STC encoding is performed on two adjacent OFDMA symbols for FUSC and two OFDMA symbols which are 2 symbols apart for PUSC.

#### **8.4.8.1.2.1.1 STC using 2 antennas in PUSC**

**[Modify p.583 lines 62-65 as follows]**

The structure shall be modified as depicted in Figure 245 (switching 2 pilot carriers from the odd symbol with 2 data carriers from the even symbols, switching of the data carriers and the pilots carriers shall be performed after constellation mapping and before **STC encoding defined in 8.4.8.1.2.1 and subcarrier randomization defined in 8.4.9.4.1**,

#### **8.4.8.1.2.1.2 STC using using 2 antennas in FUSC**

**[Add the marked text to the first paragraph]**

In FUSC all subchannels shall be used for STC transmission, the pilots within the symbols shall be divided between the antennas, antenna 0 uses VariableSet#0 and ConstantSet#0 for even symbols while antenna 1 uses VariableSet#1 and ConstantSet#1 for even symbols, antenna 0 uses VariableSet#1 and ConstantSet#0 for odd symbols while antenna 1 uses VariableSet#0 and ConstantSet#1 for odd symbols (symbol counting starts at the starting point of the relevant STC zone), defined in 8.4.6.1.2.2. **In STC transmission the variable pilots shall not be shifted according to equation (106)**. The transmission of the data shall be performed in pairs of symbols as illustrated in Figure 247.