Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Preamble Specification for 802.16a OFDM PHY**
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Source(s)	Manoneet Singh Radia Communications, Inc. [mailto: m.singh@ieee.org] Lek Ariyavisitakul Broadband Wireless Solutions, Inc. [mailto: lek@ieee.org] Nico van Waes Nokia [mailto: Nico.vanWaes@Nokia.com]
Re:	Call for Contributions on the Preamble Design for the OFDM-Based PHY, IEEE 802.16.3-01/23
Abstract	This document outlines the format and contents of the preamble for the OFDM Mode of the 802.16 PHY.
Purpose	Improving current 802.16 OFDM PHY standard proposal
Notice	
Release	
Patent Policy and Procedures	

Preamble Specification for 802.16a OFDM PHY

Manoneet Singh, Lek Ariyavisitakul, and Nico Van waes

1. Abstract

During its meeting on 9/11/01 at Denver, the OFDM Preamble ad hoc [1] proposed to recommend a general preamble format with duration equal to *one* OFDM symbol on both the uplink and the downlink. This contribution addresses the specific contents of these preambles within the framework of the above-chosen generic signal format.

2. Description of Proposed Contents

The basic structures of the proposed *one-symbol* preambles in OFDM are shown in Fig. 1 below.

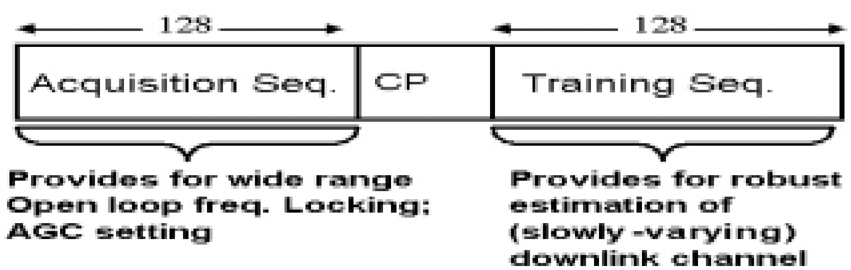

Fig. 1(a) Downlink preamble format (TDD, FDD)

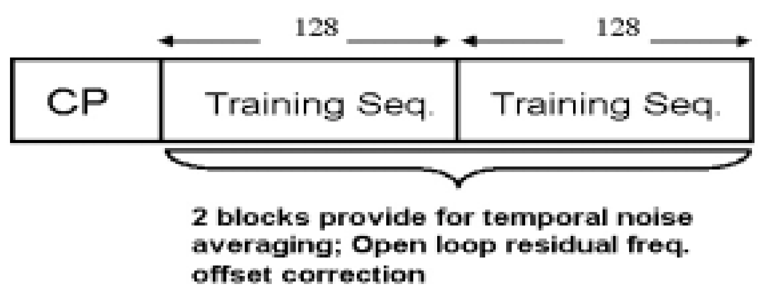

Fig. 1(b) Uplink preamble structure (TDD, FDD)

The preamble on the **downlink** consists of an *acquisition* sequence, consisting of 8 repetitions of a 16-sample OFDM sequence, followed by a *training* sequence of length 128. Note that the training sequence must be preceded by a cyclic prefix whose length is dependent on the specific operating environment, and is set to exceed the channel maximum delay spread observed on the channel. The proposed structure offers the following key benefits:

- Meets the single symbol overhead criterion accepted by the preamble ad hoc.
- Provides an opportunity for fast, open loop frequency acquisition on the downlink, over a very wide lock range. This feature is especially beneficial for networks operating in TDD mode, or for subscriber terminals with large frequency ambiguity (± 20 ppm), seeking intial network access.
- The training sequence provides for a very robust and near-optimal estimator performance [2]; this performance can be further improved by (time) averaging several received preambles on the downlink.

The preamble on the **uplink** consists of *two* repetitions of a *training* sequence of length 128. These sequences are preceded by a single cyclic prefix whose length is dependent on the specific operating environment, and is set to exceed the channel maximum delay spread observed on the channel. This proposed structure offers the following key benefits:

- Meets the single symbol overhead criterion accepted by the preamble ad hoc.
- Since it is assumed that the CPEs are locked in frequency using the downlink transmission, a wide-range acquisition is not required in this case. Nevertheless, the two repetitions of the 128-sample training sequence offer an opportunity for residual offset correction.
- The given structure provides very robust estimator performance by providing an *additional* temporal noise averaging opportunity over two consecutive estimation blocks (This noise averaging gain is in addition to the substantial gains already afforded by frequency domain averaging (interpolation) in a single block).

  Note that the problem of channel estimation on the uplink is slightly different than that on the downlink, since the base station must estimate the channel from each user essentially in a single shot. In other words, the continuous time averaging available to *all* CPEs receiving a stream of periodic downlink preambles in not available to the BS on the uplink.
- Finally, this preamble structure deterministically removes any ambiguity between UL and DL frames in a TDD operation, thus affording clear distinction between the two preambles. We should point out here that the cross-correlation properties of UL-DL preambles that have the *same format* but *different numerical* properties (loading) may not be sufficient to guarantee a clear separation between the two preambles, since these correlation properties will depend on the distance between the target and the spoofing CPE.

Some specific details regarding the design of the above-discussed preamble structures are provided in Section 3 below.

The structure of the preamble that assists MISO transmission is shown in Fig. 2. Since both Tx chains in a Multi-transmit antenna system typically work off the same oscillator, there is a single frequency offset to be detected, which can be done using the initial acquisition sequence shown in the figure. Details about the other advantages and performance results for this format can be found in [2].

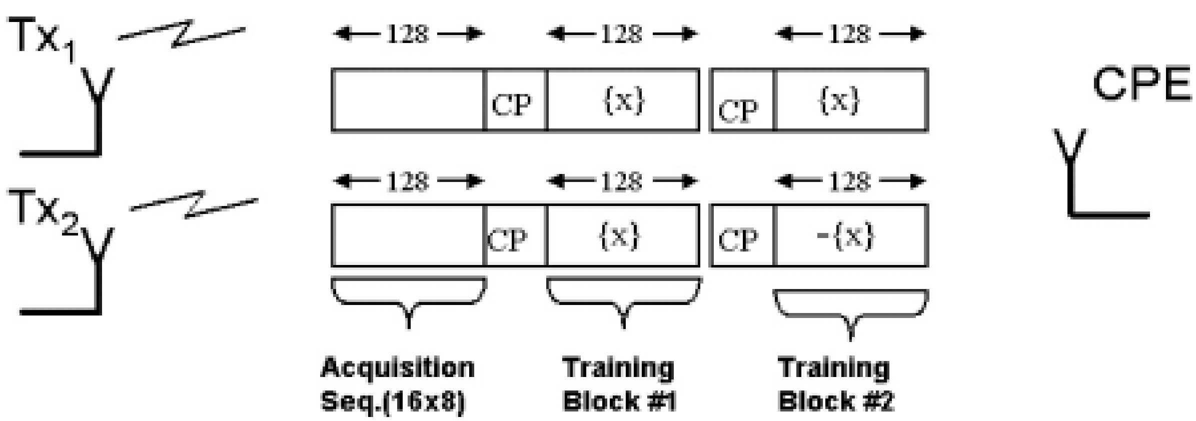

Fig 2 Preamble for Multiple Antenna Transmission (Downlink, TDD, FDD)

Details

One possible loading to create the *acquisition* sequence in Fig. 1(a) is given in [3] as:

$S_{-26\ldots26}=\sqrt{(13/6)}$*{0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, **0**, 0, 0, 0, -1-j, 0, 0, 0, -1-j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0, 0, 1+j, 0, 0}.

Note that the above loading has been specified using a 64-point IFFT, but the corresponding 256-pt equivalent is readily derived as well.

The *training* block on downlink is generated using the following loading on the Tx IFFT, followed by choosing the first 128 of the 256 (repeated) samples at the output [4]:

$SB_{-100\ldots100}$ = √2*{1,0,1,0,1,0,1,0,-1,0,1,0,1,0,1,0,1,0,1,0,1,0,-1,0,1,0,1,0,-1,0,-1,0,-1,0,1,0,-1,0,1,0,-1,0,1,0,1,0,1,0,-1,0,1,0,1,0,1,0,-1,0,-1,0,-1,0,-1,0,1,0,1,0,-1,0,1,0,1,0,-1,0,1,0,-1,0,-1,0,-1,0,1,0,-1,0,-1,0,1,0,1,0,1,0,-1,0,**0,**0,1,0,-1,0,1,0,-1,0,1,0,-1,0,-1,0,1,0,-1,0,-1,0,1,0,1,0,1,0,1,0,1,0,-1,0,-1,0,-1,0,1,0,-1,0,1,0,-1,0,-1,0,-1,0,1,0,1,0,1,0,-1,0,-1,0,-1,0,-1,0,1,0,1,0,1,0,1,0,-1,0,1,0,-1,0,-1,0,-1,0,1,0,1,0,-1,0,1,0,1,0,1,0,-1,0,-1,0,-1,0,1}.

The uplink preamble is generated in a similar manner by a (different) suitable, low PAPR loading at the TX IFFT, followed by transmitting *both* cycles of the repeated signal at the IFFT output. Some choices for a suitable loading sequence are found in [4].

References

[1] IEEE 802.16.3-01/23, *Hikmet Sari*, "Call for Contributions on the Preamble Design for the OFDM-Based PHY", July 2001.
[2] IEEE 802.16abc-01/29 , *Lek Ariyavisitakul*, "Channel Estimation, Diversity and Preamble Requirements for Broadband Wireless Using OFDM", IEEE Tutorial Presentation, Denver, Sept. 2001.
[3] IEEE 802.16 Preamble Ad hoc Contribution, *Shawn Taylor and Ron Murias*, "802.16a Preamble Design", Portland, July 2001.
[4] IEEE 802.16 Preamble Ad hoc Contribution, *Tal Kaitz*, "Preamble Waveforms for OFDM", Denver, Sept. 2001.