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Title	**[Simple Preamble Design for OFDM/OFDMA]**
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Re:	OFDM preamble structure analysis and proposal
Abstract	This document contains analysis and proposal for the OFDM preamble design for the 802.16ab system.
Purpose	This proposal should be used for the OFDM preamble design
Notice	
Release	
Patent Policy and Procedures	

Simple Preamble Design for OFDM

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References

[1] IEEE 802.16ab-01/01. IEEE 802.16ab merged document. 2001-06-18

[2] Preamble design for OFDM. Breezecom, Kaitz, Tal, 2001-06-13

Introduction

In this contribution, a simple design method for preamble sequences is proposed for OFDM mode.

Background

We agree to the preamble waveforms should be:

1. Enable joint parameters estimation. Estimated parameters should include channel response frequency and time offsets.
2. Insure low peak to average power ratio (PAPR) to allow distortion free estimation.
3. Easy construction of the preamble adaptation to multiple FFT modes.

The design should enable a simple synchronization mechanism, by which a new SS can acquire the parameters of the downlink transmission, both in FDD and TDD situations. Both from the editorial and implementation consideration the preamble waveform is described under the OFDM frame structure. The first and second properties are suitable to the OFDM preamble structure and effective to PAPR problem.

In [2] they show the Golay complementary sequence(GCS) adapts to Preamble of OFDM has advantages in the PAPR problem. And We think it is advisable to use it in OFDM mode. The sub-carrier's phases can be systematically designed using such GCS generating method. Also the GCS ensure a PAPR of 3dB.

In this document we propose the easy method of adaptation of the GCS in the preamble of OFDM mode A. The third property is proposed in this document for easy preamble designing that exhibits more flexibility in frame structure variation and express robust time/frequency error correction property.

Proposed Golay complementary sequence generation

We propose simplified generation method of GCS and obtain various preambles in multiple FFT mode systematically. The breezecom proposes that GCS can be used as input of IFFT and the output express good PAPR property and time/frequency error correction and channel estimation in [1]. And according to our simulation result the GCS adapted preamble shows good properties as they prescribed. And in figure 1 shows the process of recursively generating GCS. It provides easy and best way of generating such GCS codes systematically and recursively with some registers and mux.

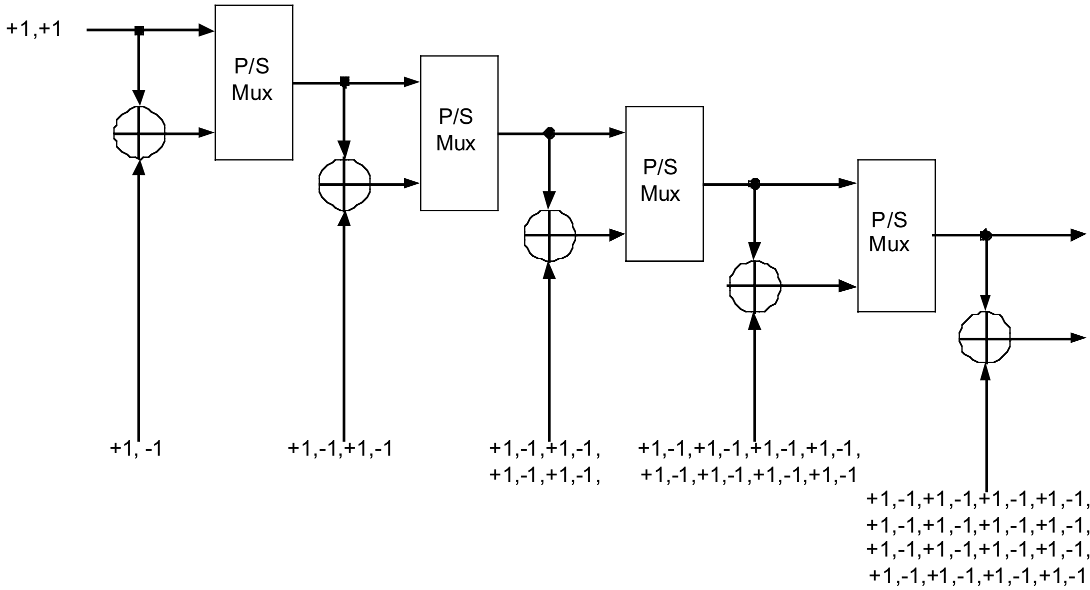

Figure 1. Recursively Generated Golay Complementary Sequences

Proposed preamble pattern

All sequences can be generated over the OFDM frame structure. Preamble sequences shorter then the FFT sizes are generated by create a regular subset of sub-carriers periodically. Then the output of IFFT will be sliced to the desired length. For downlink and uplink preambles the Length of GCS is $N_{FFT}/4$. And interpolate with zero padding. Then the obtained length N_{FFT} sequences put into the IFFT input to get the short preamble of periodically repeated pattern as output sequences.

For example, if we want to generate a 64 point short preamble sequence in a 256 FFT mode. First, generate a periodic sub-carriers 4*n, n*=1,2,3...The resulting time domain signal has a periodicity of 64 points. Then we take one period as the desired short preamble sequence.

The Long sequence is also can be generated under similar GCS generation rule. The long sequence is not periodically repeating itself during one OFDM symbol intervals. So we should provide long Golay complementary sequence suitable to any OFDM modes. But the process to obtain such long sequence is not a trivial job. The submitted proposal provides easy solution to use such long sequences.

If we need long sequence for length N_FFT=512, we just perform 8 recursively cascading of the structure given in figure 1. Under given N_FFT parameter the sequence can be applied to the appropriate IFFT block. Obtained long sequences should be continuously repeating themselves for downlink only. For uplink we do not repeating the symbol block. Cyclic prefix should be added before such two continuous concatenated OFDM symbol blocks. This long symbol structure ensure fine-tuning of timing and frequency offset.

Downlink Preamble

The downlink header should allow simple synchronization on the down link start time. Additionally, large initial frequency offsets should be resolved. Using the frame structure of figure 1 facilitates this.

S	S	S	S	CP	L	L

Figure 2 Downlink preamble structure

The downlink preamble is lineup of 4 repetitions of short sequences and 2 repetitions of long sequences. The short sequences are used for initial frequency offsets, and initial timing error corrections. The long sequences are used for fine frequency/timing offset and channel estimation. The two long sequences are used for fine frequency offset estimation. They also can be averaged to produce reliable channel estimation. Since the two sequences are a cyclic continuation of each other, sensitivity to initial timing error is small. The table 1 shows all possible DL frame structure proposed in this document.

Table 1. Frame structure of the DL preamble in multiple FFT mode (written in sample number)

N_FFT	N_Short Burst	N_Long Burst	CP(when Tg/Tb=1/8)
64	16	64	16
128	32	128	32
256	64	256	64
512	128	512	128

Uplink Preamble

The uplink preamble should allow mainly channel estimation. Fine frequency and timing estimation should also be supported, but the initial ambiguity is far less severe then in the downlink case, since in the uplink the station had already learnt the parameters and had pre-adjusted its transmission. These considerations lead to the following structure, shown in figure 3.

CP	L

Figure 3 Uplink Long Preamble Frame Structure

The preamble is composed of a single long sequence and its cyclic extension. The cyclic extension is used to recover from initial timing errors, and to estimate residual frequency errors. The table 2 shows all possible UL frame structure proposed in this document

It is recommended that the long sequence for the uplink will differ from that of the downlink. This will ease initial synchronization in TDD situations, where the station hears the BS as well as other CPEs.

Table 2. Frame structure of the UL preamble in multiple FFT mode (written in sample number)

N_FFT	N_Long Burst	CP(when Tg/Tb=1/8)
64	64	16
128	128	32
256	256	64
512	512	128