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Title	PN Sequences for Uplink Channel Sounding for TDD OFDMA
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Re:	IEEE P802.16e/D4-2004
Abstract	In contribution C80216e-04_263r1 a method for uplink sounding was proposed. This contribution completes C80216e-04_263r1 by specifying the identity of the sequences used for the sounding mechanism.
Purpose	Adopt into P802.16e.
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PN Sequences for Uplink Channel Sounding for TDD OFDMA

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1. Introduction

In a separate contribution a capability called CSIT was proposed and a mechanism was created, so that a CSIT capable mobile may inform the BS with his downlink channel using TDD reciprocity by transmitting sounding symbols that occupy all the subcarriers in a specified sounding region within an OFDMA symbol. The discrimination among transmit devices (MSS or MSS antenna) and BSs is done using the cyclic shift separability, meaning that each BS is associated with a single sequence (frame number dependent and cell ID dependent) and separability of users is done by cyclic shift in the time domain (equivalently, multiplication by a phase rotation at the frequency domain).

This contribution completes the aforementioned contribution by specifying the way the sequence per BS is produced. The sequences are based on the theory of complementary sequences and are obtained by the Golay rule for length expansion [1]. A PAPR of about 5dB is achieved for the cyclic shift pilot occupation method, and about 6dB for the pilot decimation method.

2. Specific Text Changes

[After accepting changes in latest revision of contribution C80216e-04_263 the following changes must be made over it.]

2.1. First change

[Modify in Section 8.4.6.2.7 the following]

Instead of

The sequence $s_u(k)$ is parameterized by u, the latter being a function of the UL_IDcell and the Frame Number.

Write

The sequence $S_u(k)$, whose length equals to L_S (a multiple of 18), is obtained as a cyclic shift of the sequence $S(k)$ by an offset equal to u such that the variable u stands for the decimal value of the number represented by the binary digits b5...b0 and

b5..b3 = Three least significant bits of UL_IDcell.
b2..b0 = Three least significant bits of the frame number.

The sequence $S(k)$ is the binary subsequence of the Golay sequence given in Table 1, starting from location $Offset(L_S)$, the latter given by Table 2. The PAPR for any of these subsequences is approximately 5dB.

Table 1: Golay sequence of length 2048

0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0x243b, 0x25c5, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0x243b, 0xda3b, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0x243b, 0x25c5, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0x243b, 0x25c5, 0x243b, 0xda3b, 0x243b, 0x25c5, 0xdbc5, 0x25c5, 0x243b, 0x25c5, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0xdbc5, 0x25c5, 0xdbc5, 0xda3b, 0x243b, 0xda3b, 0x243b, 0x25c5, 0x243b, 0xda3b, 0xdbc5, 0xda3b, 0x243b, 0xda3b

Table 2: Length dependent offsets in the Golay sequence of Table 1

Length	Offset	Length	Offset	Length	Offset	Length	Offset	Length	Offset	Length	Offset
18	44	306	1512	594	264	882	1426	1170	961	1458	352
36	119	324	446	612	767	900	639	1188	542	1476	369
54	140	342	424	630	423	918	314	1206	1727	1494	354
72	3	360	1502	648	1667	936	313	1224	1720	1512	342
90	376	378	340	666	1171	954	561	1242	1541	1530	1350
108	478	396	799	684	1154	972	1170	1260	1537	1548	1343
126	32	414	1473	702	1153	990	1557	1278	384	1566	1344
144	478	432	96	720	1151	1008	1295	1296	882	1584	1347
162	102	450	28	738	1135	1026	509	1314	800	1602	1342
180	191	468	1423	756	682	1044	377	1332	442	1620	1322
198	744	486	587	774	671	1062	1264	1350	407	1638	1300
216	764	504	519	792	671	1080	1270	1368	406	1656	1289
234	98	522	1536	810	641	1098	1183	1386	410	1674	1277
252	324	540	187	828	640	1116	164	1404	387	1692	1279
270	505	558	1510	846	639	1134	959	1422	376	1710	1261
288	16	576	736	864	1407	1152	1537	1440	367	1728	1600

The pilot subcarriers shall be modulated according to Equation (130) in Section 8.4.9.4.3 where $w_k = S_u(k)$.

2.2. Second change

[Modify in Section 8.4.6.2.7 the following]

Instead of

If the separability type is one, then a spacing of D is maintained between every two occupied subcarriers associated with the same transmit device. Let $\hat{d}$ be the value of the decimation offset d plus the relative offset in the CID list, then the first occupied subcarrier for any transmit device corresponds to $\left(p\left((BaseID + Frame\ Number) \bmod 32\right) + \hat{d}\right) \bmod D$, where $p(x)$ is the value in PermutationBase as defined by Table 309 ("OFDMA downlink carrier allocations") at the location x. This pseudo-random cyclic shift is used to combat inter-cell interference.

Write

If the separability type is one, then a spacing of D is maintained between every two occupied subcarriers associated with the same transmit device. The occupied subcarriers for each transmit device shall be modulated by BPSK symbols in the same manner as done in Section 8.4.9.4.3, Equation (130). The relevant value of w_k is taken from the Golay sequence in Table 1 with offset given according to Table 3. Let $\hat{d}$ be the value of the decimation offset d plus the relative offset in the CID list, then the first occupied subcarrier for any transmit device corresponds to $\left(p\left((BaseID + Frame\ Number) \bmod 32\right) + \hat{d}\right) \bmod D$, where $p(x)$ is the value in PermutationBase as defined by Table 309 ("OFDMA downlink carrier allocations") at the location x. This pseudo-random cyclic shift is used to combat inter-cell interference.

Table 3: Offsets for the decimated pilots method.

FFT size	Offset	PAPR [dB]
2048	1922	6.3
1024	393	6.1
512	140	5.8
128	15	5.1

3. Reference

[1] R. Van Nee and R. Prasad, *OFDM For Wireless Multimedia Communications*, Artech House Publishers, 2000.