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Abstract	Enhancements with MIMO Midambles for Cellular OFDMA Systems
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Enhancements with MIMO Midambles for Cellular OFDMA Systems

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1. Introduction

Current draft standard specifies preamble only for single antenna transmission, and does not provide a way to efficiently estimate channels from multiple BS antennas. The ability to measure the channel quality in the entire bandwidth is particularly needed for band AMC operation, where each SS scans the entire frequency bandwidth and selects the best band to be used in the subsequent frames. Since the channels seen from different transmit antennas are more or less uncorrelated, choosing the best band based only on a channel from a single transmit antenna is far from being optimal.

In this contribution, this problem is addressed by introducing midamble at the first symbol in a specialized zone such as STC zone in the downlink. This new set of midambles for different FFT sizes are differentiated by different transmit antennas as well as different BS, and an indicator bit is inserted in STC_Zone_IE to indicate the presence of this midamble.

2. MIMO Midamble

2.1. STC Zone IE format

[Modify the Table 277a in Section 8.4.5.3.4 in page 73 in [1]]

Table 277a -OFDMA downlink STC_ZONE IE format

Syntax	Size (bits)	Notes
STC_ZONE_IE() {		
Extended DIUC	4	STC/ZONE=0x01
Length	4	Length = 0x02
Permutation	2	00 = PUSC permutation 01 = FUSC permutation 10 = Optional FUSC permutation 11 = Optional adjacent subcarrier permutation
Use All SC indicator	1	0 = Do not use all subchannels 1 = Use all subchannels
STC	2	00 = No STC 01 = STC using 2 antennas 10 = STC using 4 antennas 11 = FHDC using 2 antennas
Matrix indicator	2	Antenna STC/FHDC matrix (see 8.4.8) 00 = Matrix A 01 = Matrix B 10 = Matrix C (applicable to 4 antennas only) 11 = Matrix D (applicable to 4 antennas only) ~~Reserved~~
IDcell	6	

Midamble presence	1	0 = not present 1 = present at the first symbol in STC zone
Reserved	23	Shall be set to zero
}		

2.2. MIMO Midamble Sequences

[Add a new section 8.4.8.3.5]

8.4.8.3.5 MIMO Midamble Sequences

For the optional FUSC and optional AMC zones in the downlink, a midamble may be inserted at the first symbol in the STC zone defined by STC_Zone_IE() in order to measure channel quality from different BS antennas. In spectrum perspective a midamble comprises the subcarriers with even-numbered Frequency Offset Indices. The frequency locations and corresponding values of the subcarriers in a midamble are defined as in the following formula.

$$P_{ID_{cell},s}[k_{foi}] = \begin{cases} \sqrt{2} * (1 - 2q_{ID_{cell},S}[m]) & k_{foi} = 2m - \frac{N_{used}}{2}, m = 0,1,\mathrm{L}\ , \frac{N_{used}}{4} - 1 \\ \sqrt{2} * (1 - 2q_{ID_{cell},S}[m-1]) & k_{foi} = 2m - \frac{N_{used}}{2}, m = \frac{N_{used}}{4} + 1, \frac{N_{used}}{4} + 2, \mathrm{L}\ , \frac{N_{used}}{2} \\ 0, & otherwise \end{cases}$$

$$ID_{cell} \in \{0,1,\mathrm{L}\ ,126\}, s \in \{0,1,\mathrm{L}\ ,7\}, k_{foi} \in \{-N_{FFT}/2, -N_{FFT}/2+1, \mathrm{L}\ , N_{FFT}/2-1\}$$

The frequency-domain sequence $P_{ID_{cell},s}[k_{foi}]$ in the above equation has a property that, when applied to IFFT at a transmitter, it is transformed to a time-domain sequence, the latter half of which is a replica of the first one. The factor $\sqrt{2}$ is used to maintain the average power of a downlink midamble to the same level of that of other non-midamble OFDMA symbols. $q_{ID_{cell},s}[m]$ is defined as follows.

[FFT size = 2048]

[FFT size = 1024]

[FFT size = 512]

A sequence $T(m)$ is determined by IDcell and s and should be chosen to achieve low PAPR. $w_n^s \in \{0,1\}$ denotes the n-th value of the s-th Walsh sequence of length 8, where n is [0,7]. s is the antenna index. $H_{128}(i,j)$ denotes the number at (i, j) of a 128 by 128 Walsh Hadamard matrix, where $i, j = 0,1,\ldots 127$. The first row vector of H_{128} is the all-one sequence and shall not be used. is the l-th value of the -the permutation out of three predefined permutations shown in Table aaa.

Table aaa – Permutation

	1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 0
	25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 0
	71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 0
	69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 0

[illegible]	102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 0
[illegible]	70, 35, 80, 40, 20, 10, 5, 67, 96, 48, 24, 12, 6, 3, 64, 32, 16, 8, 4, 2, 1, 65, 97, 113, 121, 125, 127, 126, 63, 94, 47, 86, 43, 84, 42, 21, 75, 100, 50, 25, 77, 103, 114, 57, 93, 111, 118, 59, 92, 46, 23, 74, 37, 83, 104, 52, 26, 13, 71, 98, 49, 89, 109, 119, 122, 61, 95, 110, 55, 90, 45, 87, 106, 53, 91, 108, 54, 27, 76, 38, 19, 72, 36, 18, 9, 69, 99, 112, 56, 28, 14, 7, 66, 33, 81, 105, 117, 123, 124, 62, 31, 78, 39, 82, 41, 85, 107, 116, 58, 29, 79, 102, 51, 88, 44, 22, 11, 68, 34, 17, 73, 101, 115, 120, 60, 30, 15, 0

References:

[1] IEEE P802.16e/D3 Air Interface for Fixed and Mobile Broadband Wireless Access Systems – Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands