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| Re: | |
| Abstract | Framework for Enabling Closed-loop MIMO for OFDMA |
| Purpose | Adoption of proposed changes into P802.16e<br><br>underlined blue indicates new text change to the Standard |
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**Revision History:**

| Author(s) | Date | Version | Additions |
|---|---|---|---|
| Wonil Roh | ? | 1.0 | First version |
| Many Authors | - | 1.1-1.x | Various additions |
| Minnie Ho (Intel) | Jan 20, 2005 | 2.0 | Text for the CL-MIMO codebook |
| Erik Lindskog (Beceem) | Jan 24, 2005 | 2.1 | Corrected messenging for short term precoding information life span in Table 7b.<br><br>Added Table for life span of short term precoding information – Table Z2.<br><br>Added messenging to allow feedback of multiple precoders for different bands in band AMC in Table 298a.<br><br>Added capability bit for long term precoding in table in Section 11.8.3.7.7. |
| Minnie Ho | Jan 25, 2005 | 2.2 | Added paragraph on multiple band precoders<br><br>Changed Table Z2 for lifespan of long-term precoding<br><br>Added two new DL IEs (normal MAP and enhanced IE)<br><br>Added per-stream power loading text<br><br>Fixed references to the tables in the codebook section<br><br>Added codebook length to the CQICH IE<br><br>Added ABL<br><br>Added CID and cyclic delays to the uplink sounding |
| | | | |

# Framework for Enabling Closed-loop MIMO for OFDMA

## 1. Introduction

In this contribution, a framework which enables closed-loop MIMO (CL-MIMO) for OFDMA systems is provided. A suite of solutions is described in this document in order to cover various channel conditions and operational scenarios. The suite of solutions includes antenna selection, antenna grouping, vector/matrix codebooks, and direct channel coefficient feedback. It includes redefinition of CQICH feedback mechanism, the required changes of payload, and clarification of precoding operation and the necessary text changes on the relevant sections in the standard.

The organization of the contribution is shown as follows



## 2. MIMO Related Basic Capabilities

When SS reports its capabilities through the SBC_REQ message, it should be allowed to report all its MIMO capabilities, including closed-loop ones if any.

***[Insert the following sections as indicated]***

### 11.8.3.7.6 OFDMA SS Demodulator for MIMO Support

This field indicates the MIMO capability of OFDMA SS demodulator. A bit value of 0 indicates “not supported” while 1 indicates “supported”.

| Type | Length | Value | Scope |
|---|---|---|---|
| 155 | 1 | Bit #0 Two receive antennas<br>Bit #1 Three receive antennas<br>Bit #2 Four receive antennas<br>Bit #3 Capable of transmit diversity<br>Bit #4 Capable of spatial multiplexing<br>Bit #5-#7 Always set to zero | SBC-REQ (See 6.3.2.3.23)<br>SBC-RSP (See 6.3.2.3.24) |

### 11.8.3.7.7 OFDMA SS Closed-Loop Feedback Demodulator for MIMO Support

This field indicates the closed-loop MIMO capability of OFDMA SS demodulator. A bit value of 0 indicates “not supported” while 1 indicates “supported”.

| Type | Length | Value | Scope |
|---|---|---|---|
| 156 | 1 | Bit #0 Capable of calculating precoding weight<br>Bit #1 Capable of adaptive rate control<br>Bit #2 Capable of calculating channel matrix<br>Bit #3 Capable of antenna grouping<br>Bit #4 Capable of antenna selection<br>Bit #5 Capable of code book based precoding<br>Bit #6 Capable of long term precoding<br>Bit #7 Reserved. | SBC-REQ (See 6.3.2.3.23)<br>SBC-RSP (See 6.3.2.3.24) |

**11.8.3.7.8 OFDMA SS Modulator for MIMO Support**

This field indicates the MIMO capability of OFDMA SS modulator. A bit value of 0 indicates “not supported” while 1 indicates “supported”.

| Type | Length | Value | Scope |
|---|---|---|---|
| 15~~5~~7 | 1 | Bit #0 Two transmit antennas<br>Bit #1 Capable of transmit diversity<br>Bit #2 Capable of spatial multiplexing<br>Bit #3 Capable of beamforming<br>Bit #4 Capable of adaptive rate control<br>Bit #5-#7 Always set to zero | SBC-REQ (See 6.3.2.3.23)<br>SBC-RSP (See 6.3.2.3.24) |

***[End of ‘Insert the following sections as indicated’]***

# 3. CQICH Signaling for CL-MIMO

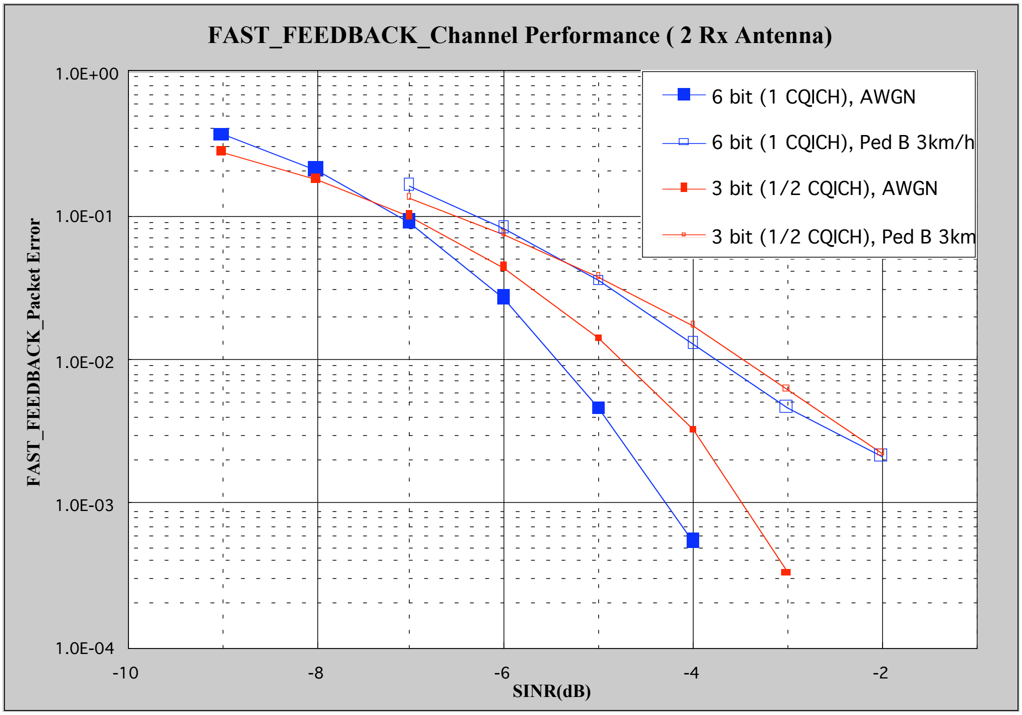
In this section a three-bit feedback scheme using a half of CQICH is proposed. Each 3bit-MIMO Fast feedback consists of a half CQICH slot mapped in a manner similar to the mapping of ACK Channel. The 3-bit fast feedback slot uses QPSK modulation on the 24 data sub-carriers it contains, and can carry a data payload of 3 bits. Table 1 defines the mapping between the payload bit sequences and the subcarriers modulation for 3 bit payload.

**Table 1—3bit-MIMO Fast-feedback channel subcarrier modulation**

| 3 bit payload | Fast Feedback vector indices per Tile<br>Even = {Tile(0), Tile(2),Tile(4)} or<br>Odd = {Tile(1), Tile(3),Tile(5)} |
|---|---|
| 0b000 | 0,0,0 |
| 0b001 | 1,1,1 |
| 0b010 | 2,2,2 |
| 0b011 | 3,3,3 |
| 0b100 | 4,4,4 |

| | |
|---|---|
| 0b101 | 5,5,5 |
| 0b110 | 6,6,6 |
| 0b111 | 7,7,7 |

**Figure 1 Channel Performance of 3-bit CQICH**




*[Modify Section 8.4.5.4.10.4 as indicated in the following]*

**8.4.5.4.10.4 Enhanced FAST FEEDBACK Channels**

Enhanced Fast feedback slots may be individually allocated to an MSS for transmission of PHY related information that requires fast response from the MSS. The allocations are done either in a unicast manner through the FAST_FEEDBACK MAC subheader (see 6.3.2.2.6), or through the CQICH_Control IE() (see 6.3.2.3.43.5), or through the CQICH_Alloc_IE() (see 8.4.5.4.12), or through the CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.12.1), or through the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7), and the transmission takes place in a specific UL region designated by UIUC = 0.

Each enhanced 3bit-MIMO Fast-feedback slot consists of 1/2 OFDMA slots mapped in a manner similar to the mapping of ACK Channel. An enhanced Fast-feedback slot uses QPSK modulation on the 24 data sub-carriers it contains, and can carry a data payload of 3 bits. Table xxx defines the mapping between the payload bit sequences and the subcarriers modulation.

**Table xxx—3bit-MIMO Fast-feedback channel subcarrier modulation**

| 3 bit payload | Fast Feedback vector indices per Tile<br>Even = {Tile(0), Tile(2),Tile(4)} or<br>Odd = {Tile(1), Tile(3),Tile(5)} |
|---|---|
| 0b000 | 0,0,0 |
| 0b001 | 1,1,1 |

| | |
|---|---|
| 0b010 | 2,2,2 |
| 0b011 | 3,3,3 |
| 0b100 | 4,4,4 |
| 0b101 | 5,5,5 |
| 0b110 | 6,6,6 |
| 0b111 | 7,7,7 |

Each enhanced Fast-feedback slot consists of 1 OFDMA slots mapped in a manner similar to the mapping of normal uplink data. An enhanced Fast-feedback slot uses QPSK modulation on the 48 data sub-carriers it contains, and can carry a data payload of 6 bits. Table 296a defines the mapping between the payload bit sequences and the subcarriers modulation.

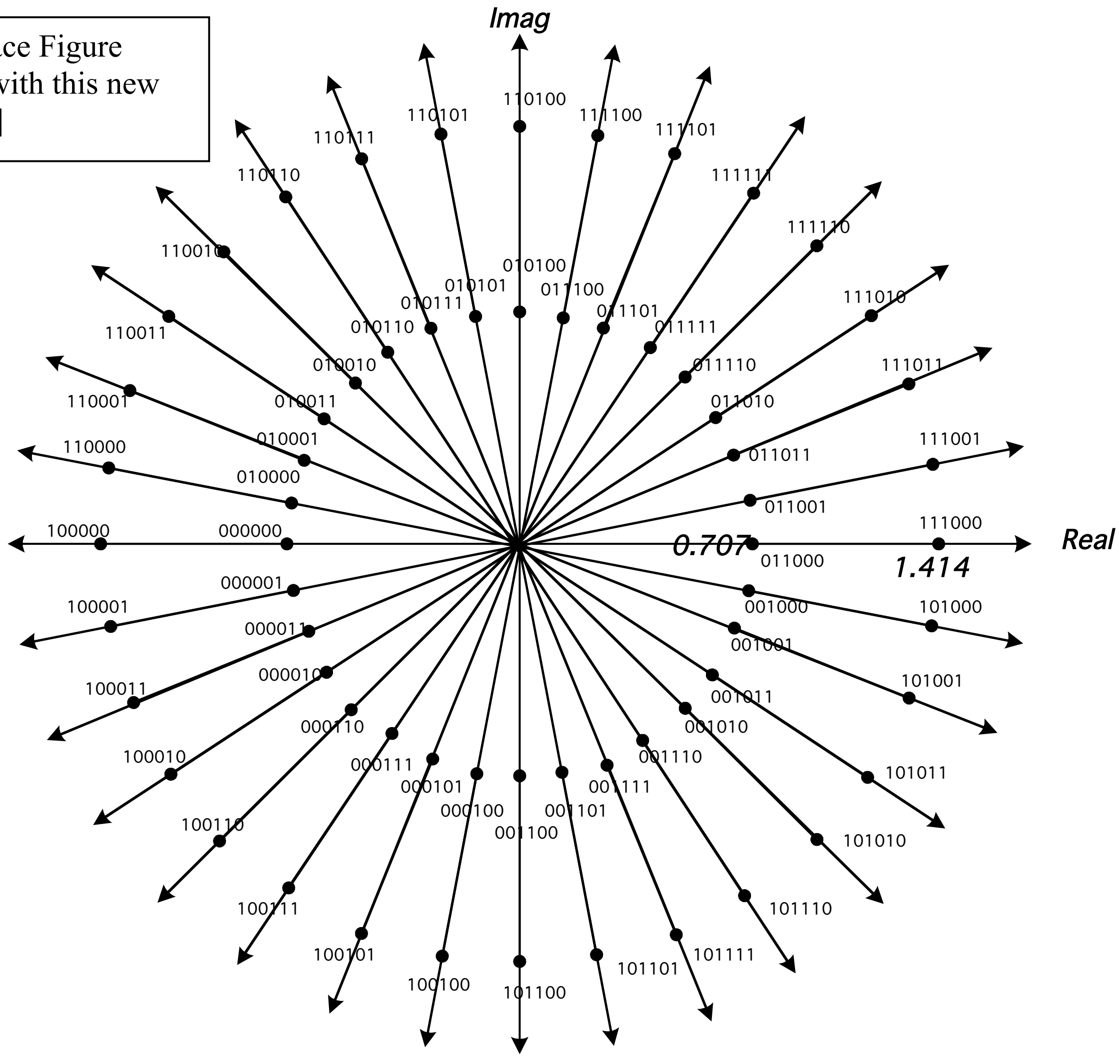
***[Modify Section 8.4.5.4.10.6 as suggested in the following]***

**8.4.5.4.10.6 Fast MIMO Feedback of Quantized Precoding Weight for Enhanced FAST_FEEDBACK Channel**

When the FAST_FEEDBACK subheader Feedback Type field is '01' or '10', or the CQI Feedback Type field in the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7) is 011, or the CQI Feedback Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.15) is 011, the MSS shall report the MIMO coefficient the BS should use for best DL reception. The mapping for the complex weights is shown in Figure 231c, and the SS shall construct the 6 CQI bits with 0 as the MSB and the mapped code as the remaining LSBs. For this type of feedback, if *N* is the number of BS transmit antennas, then *(N-1)* CQICH shall be allocated to the SS and SS shall report the desired antenna weights of antenna 1 through *N-1* based on antenna 0.

**Figure 231c - Mapping of MIMO coefficients for quantized precoding weight for enhanced fast MIMO feedback payload bits**

[Replace Figure 231c with this new figure]




***[Replace Section 8.4.5.4.10.7 with the following]***

### 8.4.5.4.10.7 MIMO Mode Feedback for Enhanced FAST_FEEDBACK channel

When the enhanced FAST FEEDBACK channel is employed, the SS may report the MIMO mode feedback on the assigned CQICH when the FAST_FEEDBACK subheader Feedback Type field is '00', or the CQI Feedback Type field in the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7) is 000, 001, or 010, or the CQI Feedback Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.15) is 000, 001, or 010. The encoding of payload bits is shown in Table 296d.

**Table 296d —Encoding of payload bits for MIMO Mode Feedback with Enhanced FAST FEEDBACK Channel**

| Value | Description |
|---|---|
| 0b101000 | STTD and PUSC/FUSC permutation |
| 0b101001 | STTD and adjacent-subcarrier permutation |
| 0b101010 | SM and PUSC/FUSC permutation |
| 0b101011 | SM and adjacent-subcarrier permutation |
| 0b101100 | Hybrid and PUSC/FUSC permutation |

| | |
|---|---|
| 0b101101 | Hybrid and adjacent-subcarrier permutation |
| 0b101110-0b110110 | Interpretation according to table 296e, 296f or 296g, depending on if antenna grouping, antenna selection or a reduced precoding matrix code book is used. |
| 0b110111 | Closed loop precoding with 1 stream. |
| 0b111000 | Closed loop precoding with 2 streams. |
| 0b111001 | Closed loop precoding with 3 streams. |
| 0b111010 | Closed loop precoding with 4 streams. |
| 0b111011 - 0b111111 | Reserved |

Clarification of streams concept:
The number of streams is the number of outputs from the space-time code.

**Table 296e —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using antenna grouping**

| Value | Description |
|---|---|
| 0b101110 | Antenna Group A1 for rate 1<br>For 3-antenna BS, See 8.4.8.3.4<br>For 4-antenna BS, See 8.4.8.3.5 |
| 0b101111 | Antenna Group A2 for rate 1 |
| 0b110000 | Antenna Group A3 for rate 1 |
| 0b110001 | Antenna Group B1 for rate 2<br>For 3-antenna BS, See 8.4.8.3.4<br>For 4-antenna BS, See 8.4.8.3.5 |
| 0b110010 | Antenna Group B2 for rate 2 |
| 0b110011 | Antenna Group B3 for rate 2 |
| 0b110100 | Antenna Group B4 for rate 2 (only for 4-antenna BS) |
| 0b110101 | Antenna Group B5 for rate 2 (only for 4-antenna BS) |
| 0b110110 | Antenna Group B6 for rate 2 (only for 4-antenna BS) |

**Table 296f —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using antenna selection**

| Value | Description |
|---|---|
| 0b101110 | Antenna selection option 0 |
| 0b101111 | Antenna selection option 1 |
| 0b110000 | Antenna selection option 2 |
| 0b110001 | Antenna selection option 3 |
| 0b110010 | Antenna selection option 4 |
| 0b110011 | Antenna selection option 5 |
| 0b110100 | Antenna selection option 6 |

| | |
|---|---|
| 0b110101 | Antenna selection option 7 |
| 0b110110 | Reserved |

**Table 296g —Interpretation of code words 0b101110-0b110110 in Table 296d in the case of using reduced precoding matrix code book**

| Value | Description |
|---|---|
| 0b101110 | Reduced Precoding matrix code book entry 0 |
| 0b101111 | Reduced Precoding matrix code book entry 1 |
| 0b110000 | Reduced Precoding matrix code book entry 2 |
| 0b110001 | Reduced Precoding matrix code book entry 3 |
| 0b110010 | Reduced Precoding matrix code book entry 4 |
| 0b110011 | Reduced Precoding matrix code book entry 5 |
| 0b110100 | Reduced Precoding matrix code book entry 6 |
| 0b110101 | Reduced Precoding matrix code book entry 7 |
| 0b110110 | Reserved |

***[End of "Replace Section 8.4.5.4.10.7 with the following"]***

***[Added at the end (i.e., line 49) in section 8.4.5.4.10.12 on page 270 of [1] as follows]***

***{The codebooks will also be tabulated}.***

## 8.4.5.4.10.12 MIMO feedback for transmit beamforming

Codebooks are defined for the feedback of MIMO transmit beamforming, whose codeword may be employed as the beamforming matrix in MIMO precoding in 8.4.8.3.6. The vector codebooks for 2x1, 3x1, and 4x1 with 3 bit feedback index are listed in **Table 1**~~Table 1~~, **Table 2**~~Table 2~~, and **Table 3**~~Table 3~~. The notation $V(N_t, L)$ denotes the vector codebook, which consists of $2^L$ complex, unit vectors of a dimension $N_t$. The integer $L$ is the number of bits required for the index that can indicate any vector in the codebook.

Table 1 $V(2,3)$

| Vector index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $v_1$ | 1 | 0.7940 | 0.7940 | 0.7941 | 0.7941 | 0.3289 | 0.5112 | 0.3289 |
| $v_2$ | 0 | -0.5801 + j0.1818 | 0.0576 + j0.6051 | -0.2978 - j0.5298 | 0.6038 + j0.0689 | 0.6614 + j0.6740 | 0.4754 - j0.7160 | -0.8779 - j0.3481 |

Table 2~~32~~ $V(3,3)$

| Vector index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $v_1$ | 1 | 0.500 | 0.500 | 0.500 | 0.500 | 0.4954 | 0.500 | 0.500 |
| $v_2$ | 0 | -0.7201 - j0.3126 | -0.0659 + j0.1371 | -0.0063 + j0.6527 | 0.7171 + j0.3202 | 0.4819 - j0.4517 | 0.0686 - j0.1386 | -0.0054 - j0.6540 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| $v_3$ | 0 | 0.2483 - j0.2684 | -0.6283 - j0.5763 | 0.4621 - j0.3321 | -0.2533 + j0.2626 | 0.2963 - j0.4801 | 0.6200 + j0.5845 | -0.4566 + j0.3374 |

Table 3~~53~~ $V(4,3)$

| Vector index | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| $v_1$ | 1 | 0.3780 | 0.3780 | 0.3780 | 0.3780 | 0.3780 | 0.3780 | 0.3780 |
| $v_2$ | 0 | -0.2698 - j0.5668 | -0.7103 + j0.1326 | 0.2830 – j0.0940 | -0.0841 + j0.6478 | 0.5247 + j0.3532 | 0.2058 - j0.1369 | 0.0618 – j0.3332 |
| $v_3$ | 0 | 0.5957 + j0.1578 | -0.2350 – j0.1467 | 0.0702 – j0.8261 | 0.0184 + j0.0490 | 0.4115 + j0.1825 | -0.5211 + j0.0833 | -0.3456 + j0.5029 |
| $v_4$ | 0 | 0.1587 - j0.2411 | 0.1371 + j0.4893 | -0.2801 + j0.0491 | -0.3272 - j0.5662 | 0.2639 + j0.4299 | 0.6136 - j0.3755 | -0.5704 + j0.2113 |

An operation, $\mathrm{H}(\mathbf{v})$, is defined. It generates a unitary $N$ by $N$ matrix $\mathrm{H}(\mathbf{v})$ using a $N$ vector $\mathbf{v}$ as

$$\mathrm{H}(\mathbf{v}) = \begin{cases} \mathbf{I}, & \mathbf{v} = \mathbf{e}_1 \\ \mathbf{I} - p\mathbf{w}\mathbf{w}^H, & \text{otherwise} \end{cases}, \qquad (1)$$

where $\mathbf{w} = \mathbf{v} - \mathbf{e}_1$ and $\mathbf{e}_1 = [1 \quad 0 \quad \cdots \quad 0]^T$; $p = \frac{2}{\|\mathbf{w}^H\mathbf{w}\|}$; $\mathbf{I}$ is the $N$ by $N$ identity matrix; $^H$ denotes the conjugate transpose operation. Vector codebooks $V(3,6)$ and $V(4,6)$ are generated as follows. All the vector codewords $\mathbf{v}_i$, $i = 2,\cdots,2^L$, are derived from the first codeword $\mathbf{v}_1$ as

$$\tilde{\mathbf{v}}_i = \mathrm{H}(\mathbf{s})Q^i(\mathbf{u})\mathrm{H}^H(\mathbf{s})\mathbf{v}_1, \text{ for } i = 2,\cdots,2^L \qquad (2)$$

$$\mathbf{v}_i = \tilde{\mathbf{v}}_i e^{-j\phi_i}, \text{ for } i = 2,\cdots,2^L \qquad (2)$$

where $Q^i(\mathbf{u}) = \mathrm{diag}\left(e^{j\frac{2\pi}{L}u_1 i}, \cdots, e^{j\frac{2\pi}{L}u_{N_t} i}\right)$ is a diagonal matrix; $\mathbf{u} = [u_1 \quad \cdots \quad u_{N_t}]$ is an integer vector;

; $\phi_i$ is the phase of the first entry of $\tilde{\mathbf{v}}_i$. The parameters for the generation of $V(3,6)$ and $V(4,6)$ are listed in **Table 4**~~**Table 4**~~.

Table 4~~74~~ Generating parameters for $V(3,6)$ and $V(4,6)$

| $N_t$ | $L$ | $\mathbf{u}$ in $Q^i(\mathbf{u})$ | $\mathbf{s}$ in $\mathrm{H}(\mathbf{s})$ |
|---|---|---|---|
| 3 | 6 | $[1 \quad 26 \quad 57]$ | $[1.2518 - j0.6409,\ -0.4570 - j0.4974,\ 0.1177 + j0.2360]^T$ |
| 4 | 6 | $[1 \quad 45 \quad 22 \quad 49]$ | $[1.3954 - j0.0738,\ 0.0206 + j0.4326,\ -0.1658 - j0.5445,\ 0.5487 - j0.1599]^T$ |

The matrix codebooks for multiple stream transmission are constructed from the vector codebooks using three operations. The first operation is $\mathrm{H}(\mathbf{v})$. The second denoted as $\mathrm{HC}(\mathbf{v}_N, \mathbf{A}_{(N-1)\times M})$ generates a $N$ by $M+1$ unitary matrix from a unit $N$ vector and a unitary $N-1$ by $M$ matrix as

$$\mathrm{HC}\left(\mathbf{v}_N, \mathbf{A}_{(N-1)\times M}\right) = \mathrm{H}\left(\mathbf{v}_N\right)\begin{bmatrix} 1 & 0 & \cdots & 0 \\ 0 & & & \\ \vdots & & \mathbf{A}_{(N-1)\times M} & \\ 0 & & & \end{bmatrix}, \qquad (3)$$

where $N-1 \geq M$; the $N-1$ by $M$ matrix unitary matrix has property $\mathbf{A}^H\mathbf{A} = \mathbf{I}$. The third operation denoted as $\mathrm{HE}\left(\mathbf{v}_N, M\right)$ generates a $N$ by $M$ matrix from a unit $N$ vector, $\mathbf{v}_N$, by taking the last $M$ columns of $\mathrm{H}\left(\mathbf{v}_N\right)$ as

$$\mathrm{HE}\left(\mathbf{v}_N, M\right) = \mathrm{H}\left(\mathbf{v}_N\right)_{:,N-M+1:N}. \qquad (4)$$

The three operations jointly generate matrix codebooks as listed in Table 5~~Table 5~~.

Table 5 Generating operations for $N_t$ by $N_s$ codebooks with 3, 6, and 9 bit indexes.

| $N_s$ / $N_t$, $L$ | 2 | 3 | 4 |
|---|---|---|---|
| 2 antennas, 3 bit | $\mathrm{H}(V(2,3))$ | | |
| 3 antennas, 3 bit | $\mathrm{HE}(V(3,3),2)$ | $\mathrm{H}(V(3,3))$ | |
| 4 antennas, 3 bit | $\mathrm{HE}(V(4,3),2)$ | $\mathrm{HE}(V(4,3),3)$ | $\mathrm{H}(V(4,3))$ |
| 3 antennas, 6 bit | $\mathrm{HC}(V(3,3),V(2,3))$ | $\mathrm{HC}(V(3,3),\mathrm{H}(V(2,3)))$ | |
| 4 antennas, 6 bit | $\mathrm{HC}(V(4,3),V(3,3))$ | $\mathrm{HE}(V(4,6),3)$ | $\mathrm{H}(V(4,6))$ |

The set notation $V(N_t, L)$ in the input arguments of the operations (i.e. H, HC, and HE) denotes that each vector in the codebook $V(N_t, L)$ is sequentially taken as an input to the operations. The output of the operation with one or more codebooks as input arguments is a codebook. For example, in $\mathrm{HC}(V(3,6),\mathrm{H}(V(2,3)))$, HC has two codebooks as input. The first is $V(3,6)$ with 64 vectors and the second is $\mathrm{H}(V(2,3))$ with 8 2 by 2 matrixes, which are computed from $V(2,3)$. The feedback index is constructed by sequentially concatenating all the indexes of the input argument vector codebooks in binary format. For example, the feedback index of $\mathrm{HC}(V(3,6),\mathrm{H}(V(2,3)))$ is constructed as $i_2 j_2$, where $i_2$ and $j_2$ are the indexes of the vectors in codebooks $V(3,6)$ and $V(2,3)$ in binary format respectively; $_2$ denotes binary format for the indexes.

***[Modify the following section as indicated]***

### 8.4.5.4.15 CQICH Enhanced Allocation IE Format

CQICH_Enhanced_Alloc_IE(), is introduced to dynamically allocate or de-allocate a CQICH to a SS. This IE shall only be used with enhanced FAST FEEDBACK channel in 8.4.5.4.10.4. Once allocated, the SS transmit feedback information of the specified type on the assigned CQICH with the determined period, until the SS receives a CQICH_Enhanced_Alloc_IE() to de-allocate the assigned CQICH.

**Table 298a. CQICH Enhanced allocation IE format**

| **Syntax** | **Size (bits)** | **Notes** |
|---|---|---|
| CQICH_Enhanced_Alloc_IE() { | | |
| Extended U~~D~~IUC | 4 | 0x09 |

| | | |
|---|---|---|
| Length | 4 | Length in bytes of following fields |
| CQICH_ID | variable | Index to uniquely identify the CQICH resource assigned to the MSS |
| Period (=p) | ~~2~~4 | A CQI feedback is transmitted on the CQICH every 2^p frames |
| Frame offset | 3 | The MSS starts reporting at the frame of which the number has the same 3 LSB as the specified frame offset. If the current frame is specified, the MSS should start reporting in 8 frames |
| Duration (=d) | 3 | A CQI feedback is transmitted on the CQI channels indexed by the CQICH_ID for 10 x 2^d frames. If d==0, the CQICH is de-allocated. If d == 111, the MSS should report until the BS command for the MSS to stop. |
| CQICH_Num | 4 | Number of CQICHs assigned to this CQICH_ID is (CQICH_Num +1) |
| for (i=0;i<CQICH_Num+1;i++)<br>{ | | |
| Feedback_type | 3 | 000 = Fast DL measurement/Default Feedback with antenna grouping<br>001 = Fast DL measurement/Default Feedback with antenna selection<br>010 = Fast DL measurement/Default Feedback with reduced code book<br>011 = Quantized precoding weight feedback<br>100 = Index to precoding matrix in code book<br>101 = Channel Matrix Information<br>101 = Per stream power control<br>110 = Adaptive bit loading<br>111 = Reserved |
| Codebook quantization size | 2 | 00 = 3-bit codebook<br>01 = 6-bit codebook<br>10, 11 = reserved |
| Allocation index | 6 | Index to the fast feedback channel region marked by UIUC=0 |
| CQICH Type | 2 | 00 = 6 bit CQI,<br>01 = DIUC-CQI,<br>10 = 3 bit CQI (even),<br>11 = 3 bit CQI(odd) |
| } | | |
| Band_AMC_Precoding_Mode | 1 | 0 = One common precoder for all bands.<br>1 = Distinct precoders for the bands with the highest S/N values, up to the number of short term precoders fed back as specified by Nr_Precoders_feedback |
| If (Band_AMC_Precoding_Mode =1) {<br><br>Nr_Precoders_feedback (=N)<br><br>} | 3 | Nr of precoders feedback = 2^N. |
| Padding | variable | The padding bits are used to ensure the IE size is integer number of bytes. |
| } | | |

**Feedback Type**

For feedback types 000-010 it instructs the SS to transmit the feedback of the specified type using the 5 LSBs on its assigned CQICH as in Table 296d. In this case the MSB is set to 0. In addition, for feedback types 000-010, the SS may transmit, on its assigned CQICH, the feedback information specified in 8.4.5.4.10.7.

**8.4.5.4.10.8 Fast MIMO Feedback of Adaptive bit loading for Enhanced FAST_FEEDBACK Channel**

When the CQI Feedback Type field in the MIMO Compact DL-MAP IE() (see 6.3.2.3.43.6.7) is 110, or the CQI Feedback Type field in CQICH_Enhanced_Alloc_IE() (see 8.4.5.4.15~~12.1~~) is 110, the MSS shall report the preferred MCS (coding modulation scheme) per layer back to the BS, according to table aaa

**Table aaa Bit loading options**

| ID# | Stream Count | Stream ID vs. Modulation | | | |
|---|---|---|---|---|---|
| | | stream 1 | stream 2 | Stream 3 | stream 4 |
| 1 | 1 | QPSK | | | |
| 2 | 1 | 16QAM | | | |
| 3 | 1 | 64QAM | | | |
| 4 | 2 | QPSK | QPSK | | |
| 5 | 2 | 16QAM | 16QAM | | |
| 6 | 2 | 64QAM | 64QAM | | |
| 7 | 3 | QPSK | QPSK | QPSK | |
| 8 | 3 | 16QAM | 16QAM | 16QAM | |
| 9 | 3 | 64QAM | 64QAM | 64QAM | |
| 10 | 4 | QPSK | QPSK | QPSK | QPSK |
| 11 | 4 | 16QAM | 16QAM | 16QAM | 16QAM |
| 12 | 4 | 64QAM | 64QAM | 64QAM | 64QAM |
| 13 | 2 | 16QAM | QPSK | | |
| 14 | 2 | 64QAM | QPSK | | |
| 15 | 2 | 64QAM | 16QAM | | |
| 16 | 3 | 16QAM | QPSK | QPSK | |
| 17 | 3 | 16QAM | 16QAM | QPSK | |
| 18 | 3 | 64QAM | 16QAM | 16QAM | |
| 19 | 3 | 64QAM | 64QAM | QPSK | |
| 20 | 3 | 64QAM | 64QAM | 16QAM | |
| 21 | 4 | 16QAM | 16QAM | QPSK | QPSK |
| 22 | 4 | 16QAM | 16QAM | 16QAM | QPSK |
| 23 | 4 | 64QAM | 16QAM | 16QAM | QPSK |
| 24 | 4 | 64QAM | 64QAM | 16QAM | QPSK |
| 25 | 4 | 64QAM | 64QAM | 64QAM | QPSK |

# 4. MIMO Precoding

***[Add section 6.3.2.3.59]***

**6.3.2.3.59 MIMO precoding setup/tear-down**

The BS can setup longterm precoding with feedback from a particular SS by sending the MAC-manage message PRC-LT-CTRL to the SS. The BS can also use the same MAC-management message to tear-down the longterm precoding with feedback.
The precoding feedback delay of the base station, in number of frames, should be signaled from the BS to the SS in the PRC-LT-CTRL MAC-management message.

**Table 108a – Setup/Tear-down of long term MIMO precoding (PRC-LT-CTRL) message format**

| Syntax | Size | Notes |
|---|---|---|
| PRC-LT-CTRLformat(){ | | |
| Management message type = 64 | 8 bits | |
| Setup/Tear-down long term precoding with feedback | 1 bit | 1=Turn on<br>0=Turn off |
| BS precoding application delay | 2 bits | k, delay in number of frames beyond the minimal delay of 1 frame for when precoding information fed back from the SS to the BS can or will be applied. |
| } | | |

***[End of adding text]***

***[Modify Section 6.3.2.3 MAC Management messages]***

***[Add row to Table 14a, MAC Management messages according to the Table below:]***

**[Row to be added to Table 14a—MAC Management messages]**

| Type | Message description | Connection |
|---|---|---|
| 64 | Setup/Tear-down of long term MIMO precoding | Basic |

***[End of Modification to Section 6.3.2.3 MAC Management messages]***

***[Modify the following table at the end of section 6.3.2.1.4.1]***

**Table 7b. Feedback Type and feedback content.**

| Feedback Type | Feedback contents | Description |
|---|---|---|
| 0b0000 | Set as described in table 296d. | MIMO mode and permutation. Feedback |
| 0b0001 | DL average CQI (5bits) | 5 bits CQI feedback |
| 0b0010 | Number of index, L (2 bits) + L occurrences of Antenna index (2 bits) + MIMO coefficients (5 bits, 8.4.5.4.10.6) | MIMO coefficients feedback |
| 0b0011 | Preferred-DIUC (4 bits) | Preferred DL channel DIUC feedback |
| 0b0100 | UL-TX-Power (7 bits) (see table 7a) | UL transmission power |
| 0b0101 | Preferred DIUC(4 bits) + UL-TX-Power(7 bits) + UL-headroom (6 bits) (see Table 7a) | PHY channel feedback |
| 0b0110 | Number of bands, N (2 bits) + N occurrences of 'band index (6 bits) + CQI (5 bits)' | CQIs of multiple AMC bands |
| 0b0111 | Number of feedback types, O (2 bits) + O occurrences of 'feedback type (4bits) + feedback content (variable)' | Multiple types of feedback |
| 0b01000 | Feedback of index to long term precoding matrix in code book (6 bits), rank of precoding code book (2 bits) and FEC and QAM feedback (6 bits) according to Table Z. | Long term precoding feedback |
| 0b01001 | Life span of short term precoding feedback (4 bits) according to Table Z2. | The recommended number of frames the short term precoding feedback can be used for. |
| 0b1001-0b1111 | Reserved for future use | |

***[End of "Modify the following table at the end of section 6.3.2.1.4.1"]***

***[Modify the following section as indicated]***

**8.4.8.3.6 MIMO Precoding**

The space time coding output can be weighted by a matrix before mapping onto transmit antennas:

,

where x is a vector with the output from the space-time coding (per-subcarrier), is the number of streams at the output of the space-time coding scheme. The matrix W is an weighting matrix where the quantity is the number of actual transmit antennas. The vector contains the signals after weighting for the different actual antennas. The labeling of the elements in the weighting matrix is performed in accordance with the example of given below for the case of 4 actual antennas and 2 space-time coding output streams:

$$W = \begin{bmatrix} w_{11} & w_{12} \\ w_{21} & w_{22} \\ w_{31} & w_{32} \\ w_{41} & w_{42} \end{bmatrix}$$

**Short term closed loop precoding:**

When Mt=1, then single stream precoding or beamforming shall be applied with the vector W of dimension $N_t \times 1$. The transmission scheme before the precoder is the regular single antenna transmission. When Mt=2, 3 or 4, then the two, three or four STC output streams shall be transmitted with the 2, 3 or 4 Tx pure spatial multiplexing transmission scheme with a precoding matrix of dimension , or .

**Long term closed loop precoding**

The rank of the precoding matrix is indicated in the long term precoding feedback from the SS. The number of columns in the precoding matrix equals its rank. The STC scheme used, Matrix A, B or C, is selected from the set of STC schemes associated with the number of transmit antennas equaling the rank of the long term precoding matrix used. For example, if the rank of the long term precoding matrix is 2 and the spatial rate used is 1 then the Matrix A scheme for 2 Tx antennas is used.

When the long term closed loop precoding is turned on, the life span of short term precoding information, the rank of the long term precoding code book used and the index to the precoding matrix in the specified long term precoding code book is fed back with MAC-header feedback messages 0b0000 and 0b0001. If a short term precoding matrix is available, the BS shall use this short term matrix. If not, the BS shall use the fed back long term precoding matrix, if available.

**Feeding back multiple precoder for band AMC operation**

For band AMC the BS has the choice to request a common precoding matrix for all bands or can request a programmable number, N (see Table 298a), of precoding matrices to be fed back for the N best bands selected in an ordered fashion. In the latter case, the precoding matrices are associated with the bands with the highest S/N values. As a secondary selection criteria, in case the ordering according to highest S/N is not unique, the bands with the lowest band index are chosen first. The index for each precoder is mapped to a CQICH channel of the corresponding size. The precoders for the different bands, in the order described above, is signaled in the corresponding CQICH channels.

**Table Z – Feedback for long term precoding in MAC feedback header message**

| MAC-header feedback type bit indication | Feedback element | Number of bits | Description |
|---|---|---|---|
| 0b01000 | Feedback of index to long term precoding matrix in code book | 6 | Index to long term precoding matrix element in code book |
| 0b01000 | Rank of precoding code book | 2 | k, Rank of precoding code book = k+1 |
| 0b01000 | FEC and QAM feedback | 6 | FEC and QAM specification |

**Table Z2 – Feedback for life span of short term precoding in MAC feedback header message 0b01001**

| Bit field (N) | Life span in number of frames |
|---|---|
| 0000-1111 | 0.125*2^(N+1) |

**Precoding state feedforward and precoding application delay**

If the precoding state is not fed forward in the DL burst allocation IE, then the BS shall apply precoding according to the precoding feedback from the SS (antenna grouping, antenna selection or code book based) with a predetermined number of frames delay.

***[End of modification of the following section as indicated]***

## 5. MIMO Precoding Operation for H-ARQ MAP

Some clarification is made on burst mapping for H-ARQ when multiple MIMO layers are transmitted on the same physical resource. The multiple layer transmission is enabled when spatial multiplexing (SM) schemes are employed with multiple modulation and coding blocks implemented for each spatial layer. We call it horizontal encoding (HE) and this mode enables adaptive rate control for each spatial layer. The other class of spatial multiplexing schemes is called vertical encoding (VE) and it features a common modulation and coding block. Transmit diversity (TD) can be also regarded as single layer technique. Figure 2~~Figure 2~~ shows an example of 2x2 VE MIMO system, whereas Figure 3~~Figure 3~~ illustrates that of 2x2 HE MIMO system. In both figures, L equals the number of layers, Mt the number of STC output streams, Nt the number of BS transmit antennas, and W denotes the precoding matrix. Their relations according to the current standard are tabulized in Table 5~~Table 5~~.

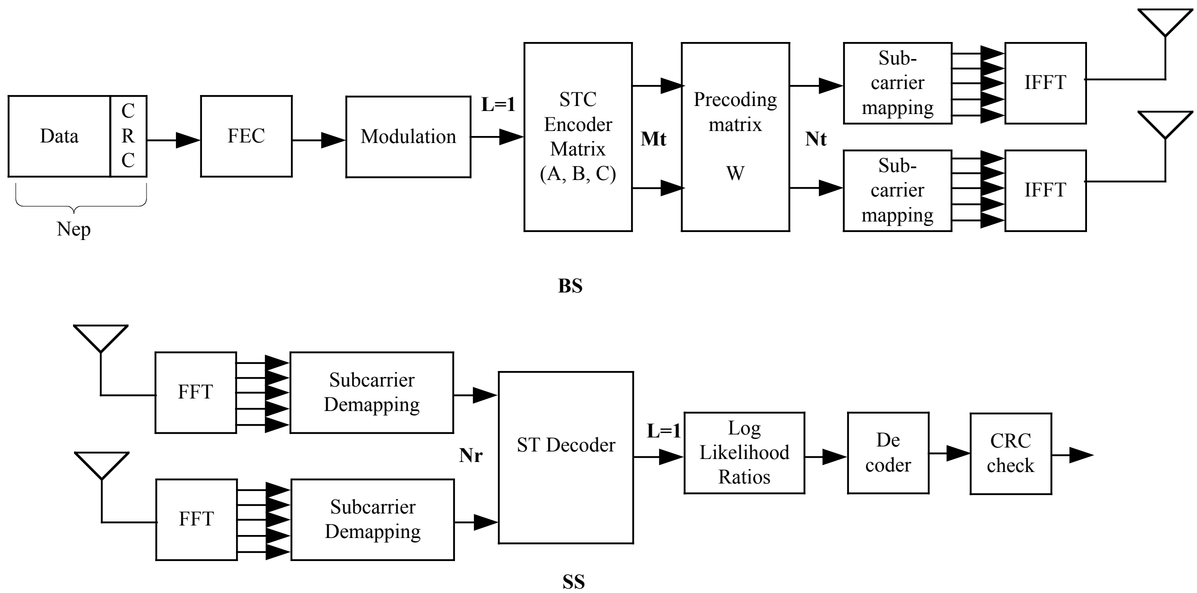



**Figure 2 H-ARQ Enabled Vertically Encoded 2x2 MIMO System**

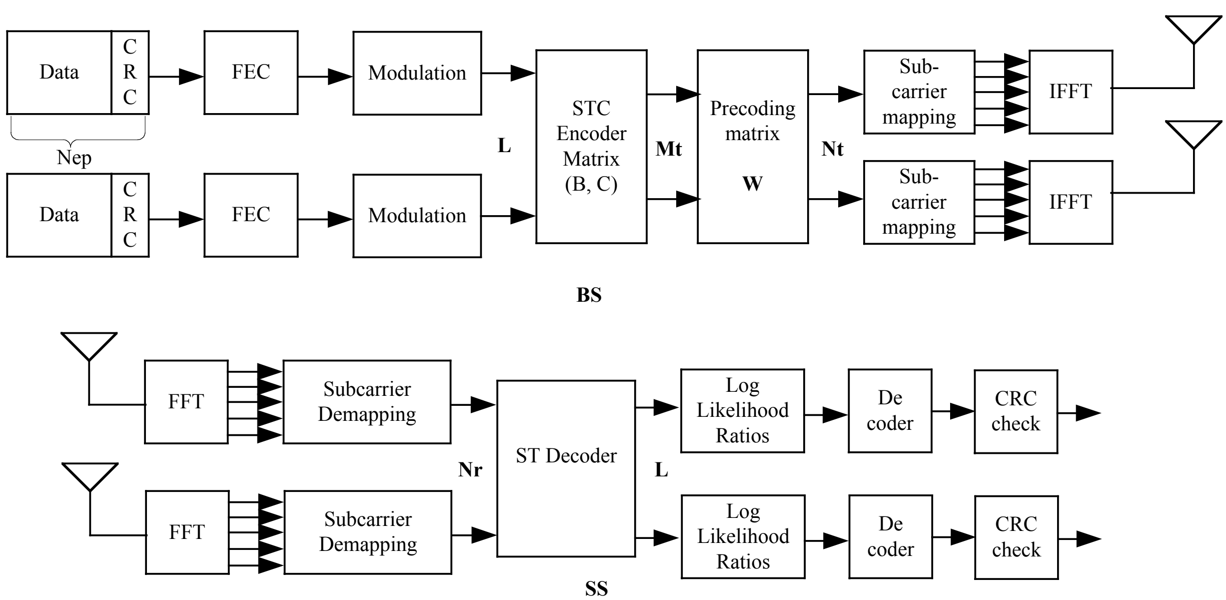



**Figure 3~~43~~ H-ARQ Enabled Horizontally Encoded 2x2 MIMO System**

| Layer = 1 (TD or VE only) | | | | L = 2 (HE only) | | | L = 3 (HE only) | | L = 4 (HE only) |
|---|---|---|---|---|---|---|---|---|---|
| **Mt=1** | **2** | **3** | **4** | **Mt=2** | **3** | **4** | **Mt=3** | **4** | **Mt=4** |
| AAS | A (TD) | A (TD)$^1$ | A (TD)$^1$ | | | | | | |
| | | B (VE)$^1$ | B (VE)$^1$ | | B (HE)$^1$ | B (HE)$^1$ | | | |
| | C (VE) | C (VE) | C (VE) | C (HE) | | | C (HE) | | C (HE) |

**Table 5~~95~~ Clarification on Layer, Mt and Matrix**

In both Figure 1 and Figure 2, when there is no precoding matrix at Tx, Mt becomes the number of transmit antennas. In Table 1, the existing open-loop matrices (A, B, or C) are noted and the superscript $^1$ indicates the applicability of the antenna grouping technique.

***[Replace the following table in Section 6.3.2.3.43.6.7 as follows]***

### 6.3.2.3.43.6.7 MIMO Compact DL MAP IE format

**Table 99a—MIMO Compact DL-MAP IE format**

| Syntax | Size (bits) | Notes |
|---|---|---|
| MIMO_Compact_DL-MAP_IE() { | | |
| Compact DL-MAP Type | 3 | Type = 7 |
| DL-MAP Sub-type | 5 | MIMO = 0x01 |
| Length | 4 | Length of the IE in Bytes |
| Mode Change | 1 bit | Indicates change of MIMO mode<br>0 = No change from previous allocation<br>1 = Change of MIMO mode |
| Antenna Grouping/Selection | 1 bit | Application of antenna grouping/selection to the burst<br>0 = Not applied<br>1 = AG/AS applied |
| Codebook based Precoding | 1 bit | Application of codebook based precoding to the burst<br>0 = Not applied<br>1 = Codebook based precoding applied |
| N_layer | 2 | Number of multiple coding/modulation layers<br>00 – 1 layer<br>01 – 2 layers<br>10 – 3 layers<br>11 – 4 layers |
| if( Mode Change == 1){ | | |
| Matrix | 2 bits | Indicates transmission matrix (See 8.4.8)<br>00 = Matrix A (Transmit Diversity)<br>01 = Matrix B (Hybrid Scheme)<br>10 = Matrix C (Spatial Multiplexing)<br>11 = Reserved |
| Mt | 2 bits | Indicates number of STC output streams<br>00 = 1 stream |

| | | |
|---|---|---|
| | | 01 = 2 streams<br>10 = 3 streams<br>11 = 4 streams |
| if (Antenna Grouping/Selection == 1) { | | |
| Antenna Grouping/Selection Index } | 4 bits | Indicates the index of antenna grouping/selection<br>See 8.4.8.3.4 and 8.4.8.3.5 |
| if (Codebook based precoding == 1) { | | |
| Codebook based precoding Index } | 6 bits | Indicates the index of precoding matrix W in the codebook<br>See 8.4.8.3.6 |
| } | | |
| for (j=1;j<N_layer+1; j++) { | | This loop specifies the Nep/DIUC for layers 2 and above when required for STC.<br>The same Nsch and RCID applied for each layer |
| if (H-ARQ Mode =CTC Incremental Redundancy) {<br>Nep }<br>elseif (H-ARQ Mode = Generic Chase) {<br>DIUC<br>} | 4 bits | H-ARQ Mode is specified in the H-ARQ Compact_DL-MAP IE format for Switch H-ARQ Mode. |
| if (CQICH indicator == 1) { | | CQICH indicator comes from the preceding Compact DL-MAP IE |
| Allocation Index[1]} | 6 | Index to CQICH assigned to this layer. |
| } | | |
| if (CQICH indicator == 1) { | 2 | The number of additional CQICHs allocated to this SS. (0 – 3) |
| CQICH_Num | 2 | The number of additional CQICHs allocated to this SS. (0 – 3) |
| for (i=0; i<CQICH_Num; i++) { | | |
| Feedback_type | 3 | Type of contents on the additional CQICH |
| Allocation index | 6 | |
| CQICH Usage | 2 | Indicates the usage of this CQICH<br>00 = 6 bit CQI (default)<br>01 = DIUC-CQI<br>10 = 3 bit CQI (even)<br>11 = 3 bit CQI(odd) |
| } | | |
| } | | |
| Padding | variable | Padding to byte; shall be set to 0 |
| } | | |

**Matrix Indicator**
This field indicates MIMO matrix for the burst.
~~For 2-antenna BS, 00 = Matrix A; 01 = Matrix B; 10-11 = Reserved.~~
~~For 3-antenna BS, 00 = Matrix A; 01 = Matrix B; 10 = Matrix C; 11 = Reserved.~~
~~For 4-antenna BS, 00 = Matrix A; 01 = Matrix B; 10 = Matrix C; 11 = Reserved.~~
if (Num_layer=1) {
  if (Mt = 1) {
    SISO or AAS mode}
  elseif (Mt = 2) {
    00 = A (TD); 01 = C (VE); 10 – 11 = Reserved}
  elseif (Mt = 3) {
    00 = A (TD); 01 = B (VE); 10 = C (VE); 11 = Reserved}
  elseif (Mt = 4) {

00 = A (TD); 01 = B (VE); 10 = C (VE); 11 = Reserved}
}
elseif (Num_layer = 2) {
if (Mt = 2) {
00 = C (HE); 01 – 11 = Reserved}
elseif (Mt = 3) {
00 = B (HE); 01 – 11 = Reserved}
elseif (Mt = 4) {
00 = B (HE); 01 – 11 = Reserved}
}
elseif (Num_layer = 3) {
if (Mt = 3) {
00 = C (HE); 01 – 11 = Reserved}
}
elseif (Num_layer = 4) {
if (Mt = 4) {
00 = C (HE); 01 – 11 = Reserved}
}
TD means transmit diversity;
VE means vertical encoding (see 8.4.8.3)
HE means horizontal encoding (see 8.4.8.3)

~~**CQI Feedback Type**~~
~~For 4-bit or 5-bit CQI payload, the type dependent feedback in 16 or 32 levels shall be feedback, respectively. For 6-bit CQI payload, however, the MSB of 6-bit payload from a SS is the indicator of the usage for the remaining 5 bits. When the MSB is set to '0' with 6-bit payload, the following 5-bit payload shall be used for the type dependent feedback, and '1' indicates the following 5-bit payload shall be used for type independent feedback in Table 294d.~~

~~**Allocation Index**~~
~~It indicates its position from the start of the CQICH region.~~

**Antenna Grouping/Selection Index**
This field indicates antenna grouping/selection index for the current burst. For the actual description of the following matrices, see 8.4.8.3.4 and 8.4.8.3.5.
if (Num_layer=1) {
if (Mt = 3) {
0000 = A1; 0001 = A2; 0010 = A3;
0011 = B1 (VE); 0100 = B2 (VE); 0101 = B3 (VE);
0110-1111 = Reserved}
elseif (Mt = 4) {
0000 = A1; 0001 = A2; 0010 = A3;
0011 = B1 (VE); 0100 = B2 (VE); 0101 = B3 (VE); 0110 = B4 (VE); 0111 = B5 (VE); 1000 = B6 (VE);
1001-1111 = Reserved}
}
elseif (Num_layer = 2) {
if (Mt = 3) {
0000 = B1 (HE); 0001 = B2 (HE); 0010 = B3 (HE);
0011-1111 = Reserved}
elseif (Mt = 4) {
0000 = B1 (HE); 0001 = B2 (HE); 0010 = B3 (HE); 0011 = B4 (HE); 0100 = B5 (HE); 0101 = B6 (HE);
0110-1111 = Reserved}}

**Allocation Index**[1]
Indicates position from the start of the CQICH region.
The Feedback type of this CQICH shall be one of the three default types (type 000, 001, 010) according to the following rule:
Feedback type = 000 if ((Antenna Grouping/Selection == 1) & (matrix == A or B))
Feedback type = 001 if ((Antenna Grouping/Selection == 1) & (matrix == C))

Feedback type = 010 if ((Codebook based precoding == 1))
**Feedback Type**
Indicates the type of feedback content on the allocated CQICH from SS. Its mapping shall be
000 = Fast DL measurement/Default Feedback with antenna grouping
001 = Fast DL measurement/Default Feedback with antenna selection
010 = Fast DL measurement/Default Feedback with reduced code book
011 = Quantized precoding weight feedback
100 = Index to precoding matrix in code book
101 = Index to MCS table
110-111 = Reserved
When the feedback type is either 000, 001, or 010, the SS shall transmit either the regular S/N measurement using the formula in 8.4.5.4.10.5 in its lower 32 codewords in 8.4.5.4.10.4, or the MIMO mode feedback of the specified type in its upper 32 codewords according to Table 296d in 8.4.5.4.10.7.

For each layer, a codeword shall be constructed according to 8.4.9.2.3.5 with the Nep and Nsch combination and mapped onto the corresponding layer. Multiple codewords from multiple layers shall be interpreted as one H-ARQ channel whose parameters are given in the preceding Compact DL-MAP IE.
At the receiver, an ACK shall be transmitted only when there is no CRC error detected on every layer. Otherwise, a NACK shall be transmitted.

# 6. CL MIMO Enhanced IE

[Insert Section 8.4.5.3.19 Close-loop MIMO DL Enhanced IE format]

8.4.5.3.19 Close-loop MIMO DL enhanced IE format

This IE is used by BS to assign resource to close loop MIMO enabled MSSs.

| Syntax | Size | Notes |
|---|---|---|
| CL_MIMO_DL_Enhanced_IE () { | | |
| Extended DIUC | 4 bits | 0x?? |
| Length | 4 bits | Length in bytes |
| Num_Region | 4 bits | |
| for ( i = 0; i< Num_Region; i++) { | | |
| OFDMA Symbol offset | 10 bits | |
| Subchannel offset | 5 bits | |
| Boosting | 3 bits | |
| No. OFDMA Symbols | 9 bits | |
| No. subchannels | 5 bits | |
| Matrix_indicator | 1 bits | Indicates transmission matrix (See 8.4.8)<br>00 = Matrix A (Transmission deversity)<br>01 = Matrix B (Hybrid Scheme)<br>10 = Matrix C ( Spatial Multiplexing)<br>11 = Codebook |
| If (Matrix indicator == 01) | | |
| Antenna Grouping Index | 3 bits | Indicating the index of the antenna grouping index |
| Elseif (Matrix indicator == 10) | | |
| Antenna Selection Index | 3 bits | Indicating the index of the selected antenna |
| Elseif (Matrix == 11) | | |
| Codebook Precoding Index | 6 bits | Indicate the index of the precoding matrix in the codebook |
| Num_stream | 2 bits | |
| for (j = 0; j< Num_stream; j++) { | | |
| if (INC_CID == 1) { | | |
| CQICH_ID | *variable* | Index to uniquely identify the CQICH resource assigned to the MSS<br><br>The size of this field is dependent on system parameter defined in DCD. |
| } | | |
| stream_index | 2 bits | |
| DIUC | 4 bits | 0-11 burst profiles |
| } | | |
| } | | |

*[Add the following text below the table]*

**Num_Region**

This field indicates the number of the regions defined by OFDMA_Symbol_offset, Subchannel_offset, Boosting, No._OFDMA_Symbols and No._subchannels in this IE.

**Matrix_indicator**

The values of these two bits indicate the STC matrix (see 8.4.8).

**Antenna Grouping Index**

This field is used to indicatethe index of the antenna grouping index

**Antenna Selection Index**

This field is used to indicate the index of the selected antenna

**Codebook Precoding Index**

This field is used to indicate the index of the precoding matrix in the codebook

**Num_stream**

The value of these 2 bits plus one indicate the number of MIMO transmission streams.

**Stream_index**

This field specifies the stream index.

## 6. Direct Channel Coefficient Feedback

Direct channel coefficient feedback provides an enhancement to the uplink sounding that is already in the standard. With the direct channel coefficient feedback, FDD operation is enabled for the uplink sounding. This section provides the signaling framework for the direct channel coefficient feedback.

---------------------- Beginning of Text Changes -------------------------------------

[ In Section 8.4.6.2.7, modify Table 311 as follows:]

Table 311: UL_Sounding_Command_IE()

| Syntax | Size | Notes |
|---|---|---|
| UL_Sounding_Command_IE(){ | | |
| **Extended UIUC** | 4 bits | 0x09 |
| Length | 4 bits | Variable |
| Sounding_Type | 1 bit | 0 = Type A<br>1 = Type B |
| Send Sounding Report Flag | 1 bit | |
| Include additional feedback | 2 bits | 00 = No additional feedback<br>01 = include channel coefficients (See Section 8.4.6.2.7.3)<br>10 = include received pilot coefficients<br>11 = include feedback message |
| | | |
| If (Sounding_Type == 0) { | | |
| Num_Sounding_symbols | 3 bits | Total number of sounding symbols being allocated, from 1 (“000”) to $2^3$=8 (“111”) |
| Separability Type | 1 bit | 0: occupy all subcarriers in the assigned bands;<br>1: occupy decimated subcarriers |
| if (Separability type==0) { | | (using cyclic shift separability) |
| Max Cyclic Shift Index P | 3 bits | 000: P=4;<br>001: P=8;<br>010: P=16,<br>011: P=32<br>100: P=9;<br>101: P=18;<br>110-111: reserved, |
| } Else { | | (using decimation separability) |
| Decimation Value D | 3 bits | Sound every $D^{th}$ subcarrier within the sounding allocation. Decimation value D is 2 to the power of (2 plus this value), hence 4,8,… up to maximum of 64. |

| | | |
|---|---|---|
| Decimation offset randomization | 1 bit | 0= no randomization of decimation offset<br>1= decimation offset pseudo-randomly determined |
| } | | |
| For (i=0;i<Num_Sounding_symbols;i++){ | | |
| Sounding symbol index | 3 bits | Symbol index within the Sounding Zone, from 1 (bits "000") to $2^3$=8 (bits "111") |
| Number of CIDs | 6 bits | Number of CIDs sharing this sounding allocation |
| For (j = 0; j<Num. of CIDs; j++) { | | |
| Shorted basic CID | 12 bits | 12 LS bits of the MSS basic CID value |
| Starting Frequency Band | 7 bits | Out of 96 bands at most (FFT size dependent) |
| Number of frequency bands | 7 bits | Contiguous bands used for sounding |
| Power Assignment Method | 2 bits | 0b00 = equal power;<br>0b01 = reserved;<br>0b10 = Interference dependent. Per subcarrier power limit;<br>0b11 = Interference dependent. Total power limit |
| Power boost | 1 bit | 0 = no power boost<br>1= power boost |
| Multi-Antenna Flag | 1 bit | 0=MSS sounds first antenna only<br>1=MSS sounds all antennas |
| if (Separability type==0) { | | |
| Cyclic time shift index m | 5 bits | Cyclically shifts the time domain symbol by multiples (from 0 to P –1) of N/P where N=FFT size, and P=Max Cyclic Shift Index. |
| } Else { | | |
| Decimation Offset d | 6 bits | Relative starting offset position for the first sounding occupied subcarrier in the sounding allocation |
| } | | |
| Periodicity | 3 bits | 000 = single command, not periodic, or terminate periodicity. Otherwise, repeat sounding once per r frames, where r = 2^(n-1), where n is the decimal equivalent of the periodicity field |
| } | | |
| } | | |
| } else { | | |
| Permutation | 2 bits | 0b00 = PUSC perm.<br>0b01 = FUSC perm.<br>0b10 = Optional FUSC perm.<br>0b11 = Adjacent subcarrier perm. |
| IDcell | 6 bits | |
| Num_Sounding_symbols | 3 bits | |
| for (i=0;i<Num_Sounding_symbols;i++){ | | |
| Number of CIDs | 7 bits | |
| For (j=0; j<Number of CIDs; j++) { | | |
| Shortend basic CID | 12 bits | 12 LS bits of the MSS basic CID value |
| Subchannel offset | 7 bits | The lowest index subchannel used for carrying the burst, starting from subchannel 0 |
| Number of subchannels | 3 bits | The number subchannels with subsequent indexes, used to carry the burst. |
| Periodicity | 3 bits | |

| | | |
|---|---|---|
| | | 000 = single command, not periodic, or terminate periodicity. Otherwise, repeat sounding once per r frames, where r = 2^(n-1), where n is the decimal equivalent of the periodicity field |
| Power Assignment Method | 2 bits | 0b00 = equal power;<br>0b01 = reserved;<br>0b10 = Interference dependent. Per subcarrier power limit;<br>0b11 = Interference dependent. Total power limit |
| Power boost | 1 bit | 0 = no power boost<br>1= power boost |
| } | | |
| } | | |
| } | | |
| Padding | Variable | Pad IE to octet boundary. Bits shall be set to 0 |
| } | | |

If the field "Include Channel Coefficients" is enabled, then the UL Sounding Command IE() enables the MSS to perform the direct transmission of DL channel coefficients to the BS along with the UL sounding waveform. For the description of the direct channel coefficient encoding method, see Section 8.4.6.2.7.3.

## References:

[1] IEEE P802.16-REVd/D5-2004 Draft IEEE Standards for local and metropolitan area networks part 16: Air interface for fixed broadband wireless access systems

[2] IEEE P802.16e/D5a 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

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