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Abstract	This document represents detailed assumptions underlying the self-evaluation report and compliance templates in the IMT-Advanced proposal document L802.16-09/0104. This is an extract of P802.16/D1, as modified by resolutions developed at addressed at IEEE 802.16 Session #63 to comments submitted in IEEE 802.16 Working Group Letter Ballot #30.
Purpose	This document details the conditions of the evaluation, particularly for use by others wishing to repeat the studies. It is not intended as a description of the RIT.

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1. Definitions

1.1 subframe: A structured data sequence of predefined duration used by the Advanced Air Interface specification.

1.2 superframe: A structured data sequence of fixed duration used by the Advanced Air Interface specifications. A superframe is comprised of four frames.

1.3 multi-carrier transmission: More than 1 carrier is used to exchange data between ABS and AMSs.

1.4 primary carrier: An OFDMA carrier on which ABS and the AMS exchange traffic and full PHY/MAC control information defined in the Advanced Air Interface specification. Further, the primary carrier is used for control functions for proper AMS operation, such as network entry. Each AMS shall have only one carrier it considers to be its primary carrier in a cell.

1.5 secondary carrier: An OFDMA carrier that AMS may use for traffic, only per BS's specific allocation commands and rules, typically received from the primary carrier. The secondary carrier may also include control signaling to support multi-carrier operation.

1.6 fully configured carrier: A carrier for which all control channels including synchronization, broadcast, multicast and unicast control signaling are configured. Further, information and parameters regarding multi-carrier operation and the other carriers can also be included in the control channels.

1.7 partially configured carrier: A carrier with only downlink transmission in TDD or a downlink carrier without paired UL carrier in FDD mode and configured with all control channels to support downlink transmission.

1.8 physical resource unit (PRU): The basic resource allocation unit that consists of 18 adjacent carriers in consecutive symbols in same subframe.

1.9 distributed resource unit (DRU): The resource allocation unit of the same size as the PRU that has undergone the subband partitioning and miniband permutation, assigned to distributed allocation and will be submitted to the subcarrier permutation in DL and tile permutation in UL.

1.10 contiguous resource unit (CRU): The resource allocation unit of the same size as the PRU that has undergone the subband partitioning and miniband permutation, assigned to contiguous allocation and will bypass subcarrier permutation in DL and tile permutation in UL. Also known as a localized resource unit.

1.11 logical resource unit (LRU): the generic name of logical units for distributed and localized resource allocations. LRU is of same size as PRU.

1.12 transmission time interval (TTI): The duration of the transmission of the physical layer encoded packet over the radio air interface and is equal to an integer number of subframes. The default TTI is 1 subframe.

1.13 layer: An information path fed to the MIMO encoder as an input

1.14 stream: Each information path encoded by the MIMO encoder that is passed to the precoder

1.15 rank: For the spatial multiplexing modes in SU-MIMO, the number of streams to be used for the user allocated to the Resource Unit (RU)

1.16 rate: The number of QAM symbols signaled per array channel use.

1 **1.17 horizontal encoding:** Indicates transmitting multiple separately FEC-encoded layers over multiple
2 antennas. The number of encoded layers may be more than 1
3

4 **1.18 vertical encoding:** Indicates transmitting a single FEC-encoded layer over multiple antennas. The
5 number of encoded layers is always 1.
6

7
8 **1.19 resource unit:** A granular unit in frequency and time, described by the number of OFDMA subcarriers
9 and OFDMA symbols
10

11
12 **1.20 single user MIMO:** A MIMO transmission scheme in which a single MS is scheduled in one RU
13

14 **1.21 multi-user MIMO:** A MIMO transmission scheme in which multiple MSs are scheduled in one RU,
15 by virtue of spatial separation of the transmitted signals
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2. Abbreviations and acronyms

AAI	advanced air interface
A-MAP	advanced MAP
A-Preamble	advanced preamble
CAS	CRU allocation size
CL	closed-loop
CMI	codebook matrix index
CRU	contiguous resource unit
CoRe	constellation re-arrangement
CSG	closed subscriber group
CSM	collaborative spatial multiplexing
DL	downlink
DLUR	distributed LRU
DRU	distributed resource unit
FP	frequency partition
FMT	UL feedback mini-tile
FPC	frequency partition configuration
FPCT	frequency partition count
FPS	frequency partition size
FPSC	frequency partition subband count
GRA	group resource allocation
HARQ	hybrid ARQ
HE	horizontal encoding
HMT	UL HARQ mini-tiles
IE	information element
IR	incremental redundancy
LRU	logical resource unit

1	MCS	modulation and coding scheme
2		
3	MLRU	minimum A-MAP logical resource unit
4		
5		
6	MU	multi-user
7		
8	NLRU	miniband LRU
9		
10		
11	OL	open-loop
12		
13	PA	persistent allocation
14		
15	PA-Preamble	primary advanced preamble
16		
17		
18	PFBCH	UL primary fast feedback channel
19		
20		
21	PMI	preferred matrix index
22		
23	PRU	physical resource unit
24		
25	P-SFH	primary superframe header
26		
27		
28	RCP	ranging cyclic prefix
29		
30	RFMT	Reordered UL feedback mini-tile
31		
32		
33	RHMT	Reordered UL HARQ mini-tile
34		
35		
36	RP	ranging preamble
37		
38	RU	resource unit
39		
40	S-ABS	serving ABS
41		
42		
43	SAC	subband allocation count
44		
45	SA-Preamble	secondary advanced preamble
46		
47		
48	SFBC	space-frequency block code
49		
50	SFBCH	UL secondary fast feedback channel
51		
52		
53	SFH	superframe header
54		
55	SLRU	subband LRU
56		
57	SPID	subpacket ID
58		
59		
60	S-SFH	secondary superframe header
61		
62	STC	space-time coding
63		
64		
65	SU	single-user

1	T-ABS	target ABS
2		
3	UCAS	uplink CRU allocation size
4		
5	UFPC	uplink frequency partition configuration
6		
7		
8	UL	uplink
9		
10	USAC	uplink subband allocation count
11		
12		
13	VE	vertical encoding
14		
15	CSG	Closed Subscriber Group
16		
17	OSG	Open Subscriber Group
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19		
20	SOHO	Small Office Home Office
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3. Advanced Air Interface

3.1 Introduction

This document represents detailed assumptions underlying the self-evaluation report and compliance templates in the IMT-Advanced proposal document L802.16-09/0104. This is an extract of P802.16/D1, as modified by resolutions developed at addressed at IEEE 802.16 Session #63 to comments submitted in IEEE 802.16 Working Group Letter Ballot #30.

This document details the conditions of the evaluation, particularly for use by others wishing to repeat the studies. It is not intended as a description of the RIT.

3.2 Medium access control

3.2.1 Persistent Scheduling in the Advanced Air Interface

Persistent allocation is a technique used to reduce assignment overhead for connections with periodic traffic pattern and with relatively fixed payload size. To allocate resources persistently to a single connection, the ABS shall transmit the DL Individual Persistent Allocation A-MAP IE for DL allocations and the UL Individual Persistent Allocation A-MAP IE for UL allocations. To allocate resources persistently to multiple connections, the ABS shall transmit the DL Composite Persistent Allocation A-MAP IE for DL allocations and the UL Composite Persistent Allocation A-MAP IE for UL allocations. The persistently allocated resource size, position and the MCS shall be maintained by the ABS and AMS until the persistent assignment is de-allocated, changed, or an error event occurs. Persistent scheduling does not include special arrangements for HARQ retransmission of data initially transmitted using persistently allocated resources. Resources for retransmissions can be allocated one at a time as needed using a DL Basic Assignment A-MAP IE or a DL Basic Assignment A-MAP IE.

3.2.1.1 Allocation Mechanism

3.2.1.1.1 Allocation Mechanism for an Individual Connection

For individual persistent allocation in the DL/UL, the ABS shall transmit the DL/UL Individual Persistent A-MAP IE. Allocation of the persistently assigned resource begins in the DL/UL subframe that is referenced by the DL/UL Individual Persistent A-MAP IE and repeats after an allocation period that is specified in the DL/UL Individual Persistent A-MAP IE. The attributes of the persistently allocated resource including size, location, MIMO encoder format and MCS are maintained as per the DL/UL Individual Persistent A-MAP IE. The values of ACID field and N_ACID field in the DL/UL Individual Persistent A-MAP IE are used together to specify an implicit cycling of HARQ channel identifiers. The allocation period and number of ACIDs required for persistent operation are configured in the DL/UL Individual Persistent A-MAP IE.

In order to facilitate link adaptation and avoid resource holes, the attributes of a persistently allocated resource can be changed. To change an individual persistent assignment, the ABS shall transmit the DL Individual Persistent A-MAP IE for DL reallocation and the UL Individual Persistent A-MAP IE for UL reallocation respectively. If an AMS has an existing individual persistent allocation in a particular subframe and receives a new individual persistent allocation in the same subframe, the new individual persistent allocation replaces the original allocation (i.e., the original persistent allocation is de-allocated).

When the BS sends a PA A-MAP IE to reallocate a persistently assigned resource, a different HARQ feedback channel must be assigned in the PA A-MAP IE used for reallocation. Reception of an ACK/NACK in the newly assigned HARQ feedback channel for the persistently assigned resource with the changed attributes will ensure that the reallocation A-MAP IE was received correctly.

3.2.1.1.2 Allocation Mechanism for Multiple Connections

For multiple persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Composite Persistent A-MAP IE. Allocation of the persistently assigned resource for each connection begins in the DL/UL subframe that is referenced by the DL/UL Composite Persistent A-MAP IE and repeats after an allocation periods that are specified in the DL/UL Composite Persistent A-MAP IE. The attributes of the persistently allocated resource for each connection including size, location, MIMO encoder format and MCS are maintained as per the DL/UL Composite Persistent A-MAP IE. The values of ACID field and N_ACID field in the DL/UL Composite Persistent A-MAP IE are used together to specify an implicit cycling of HARQ channel identifiers. The allocation period and number of ACIDs required for persistent operation are configured in the DL/UL Composite Persistent A-MAP IE.

In order to facilitate link adaptation and avoid resource holes, the attributes of a persistently allocated resource can be changed. To change persistent assignments for multiple connections, the ABS shall transmit a DL Composite Persistent A-MAP IE for DL reallocation and the UL Composite Persistent A-MAP IE for UL reallocation respectively. If an AMS has an existing persistent allocation in a particular subframe and receives a new persistent allocation in the same subframe, the new persistent allocation replaces the original allocation (i.e., the original persistent allocation is de-allocated).

When the BS sends a PA A-MAP IE to reallocate a persistently assigned resource, a different HARQ feedback channel must be assigned in the PA A-MAP IE used for reallocation. Reception of an ACK/NACK in the newly assigned HARQ feedback channel for the persistently assigned resource with the changed attributes will ensure that the reallocation A-MAP IE was received correctly.

3.2.1.2 Deallocation Mechanism

3.2.1.2.1 Deallocation Mechanism for an Individual Connection

For deallocation of individual persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Individual Persistent A-MAP IE. When the Allocation Period is set to 0b00 in the DL/UL Individual Persistent A-MAP IE, the assigned persistent resource in DL/UL Individual Persistent A-MAP IE is deallocated in referenced DL/UL subframe and the ABS and AMS terminate the persistent allocation.

When the BS sends a PA A-MAP IE to deallocate a persistently assigned resource, a different HARQ feedback channel must be assigned in the PA A-MAP IE used for deallocation. Reception of an ACK/NACK in the newly assigned HARQ feedback channel for deallocating a persistently assigned resource will ensure that the deallocation PA A-MAP IE was received correctly.

3.2.1.2.2 Deallocation Mechanism for Multiple Connections

For deallocation of multiple persistent allocations in the DL/UL, the ABS shall transmit the DL/UL Composite Persistent A-MAP IE. When the Allocation Period is set to 0b00 for each connection that is being deallocated in the DL/UL Composite Persistent A-MAP IE, the assigned persistent resource in DL/UL Composite Persistent A-MAP IE is deallocated in referenced DL/UL subframe and the ABS and AMS terminate the persistent allocation.

When the BS sends a PA A-MAP IE to deallocate a persistently assigned resource, a different HARQ feedback channel must be assigned in the PA A-MAP IE used for deallocation. Reception of an ACK/NACK in the newly assigned HARQ feedback channel for deallocating a persistently assigned resource will ensure that the deallocation PA A-MAP IE was received correctly.

3.2.1.3 HARQ Retransmissions

Asynchronous HARQ retransmission is used for downlink individual and composite persistent allocations. The DL Basic Assignment A-MAP IE shall be transmitted to signal control information for HARQ retransmission. Synchronous HARQ retransmission is used for uplink individual and composite persistent allocations. The UL Basic Assignment A-MAP IE may be transmitted to signal control information for HARQ retransmission.

3.2.1.4 Error Handling Procedure

3.2.1.4.1 Error Handling Procedure for an Individual Connection

For transmissions with HARQ enabled, an ACK is transmitted to acknowledge the successful decoding of a data burst, or a NACK is transmitted to notify failure in decoding a burst transmitted on the DL/UL. If an ACK or a NACK for the data burst identified by the DL Individual Persistent A-MAP IE is detected in the assigned HARQ Feedback channel, the ABS shall assume that the DL Individual Persistent A-MAP IE is correctly received by AMS. If the UL data burst identified by the UL Individual Persistent A-MAP IE is detected, the ABS shall assume that the UL Individual Persistent A-MAP IE is correctly received by AMS.

When NULL detection is used, in the absence of an ACK or a NACK in the HARQ feedback channel assigned in the DL Individual Persistent A-MAP IE for the data burst, the ABS shall assume that the AMS has not received the DL Individual Persistent A-MAP IE and the same DL Persistent A-MAP IE can be transmitted again.

In the case of deallocation of individual persistent allocations in the DL/UL, the ABS shall transmit a HARQ Feedback Allocation in the DL/UL Individual Persistent A-MAP IE. This allocation is used to identify the HARQ channel in which the ACK for the DL/UL Individual Persistent A-MAP IE signaling the deallocation is transmitted. In the absence (NULL detection) of an ACK, the ABS shall assume that the AMS has not received the DL/UL Individual Persistent A-MAP IE, and the same DL/UL Persistent A-MAP IE that signaled the deallocation can be transmitted again.

3.2.1.4.2 Error Handling Procedure for Multiple Connections

For transmissions with HARQ enabled, an ACK is transmitted to acknowledge the successful decoding of a data burst, or a NACK is transmitted to notify failure in decoding a burst transmitted on the DL/UL. If an ACK or a NACK for the data burst identified by the DL Composite Persistent A-MAP IE is detected in the assigned HARQ Feedback channel, the ABS shall assume that the DL Composite Persistent A-MAP IE is correctly received by AMS. If the UL data burst identified by the UL Composite Persistent A-MAP IE is detected, the ABS shall assume that the UL Composite Persistent A-MAP IE is correctly received by AMS.

When NULL detection is used, in the absence of an ACK or a NACK in the HARQ feedback channel assigned to one or more connections in the DL Composite Persistent A-MAP IE for data burst, the ABS shall assume that the corresponding AMSs have not received the DL Composite Persistent A-MAP IE and the DL Composite A-MAP IE can be transmitted again for these connections. If the persistent allocation needs to be transmitted to only one connection the DL Individual A-MAP IE can be transmitted again for this connection.

In the case of deallocation of multiple persistent allocations in the DL/UL, the ABS shall transmit HARQ Feedback Allocations in the DL/UL Composite Persistent A-MAP IE. These allocations are used to identify the HARQ channels in which the ACK for the DL/UL Composite Persistent A-MAP IE signaling the deallocations are transmitted. In the absence (NULL detection) of an ACK from one or more connections, the ABS shall assume that the corresponding AMSs have not received the DL/UL Composite Persistent A-MAP IE, and the same DL/UL Composite A-MAP IE that signaled the deallocation may be transmitted again. If the

deallocation needs to be transmitted to only one connection the DL/UL Individual A-MAP IE can be transmitted again for this connection.

3.3 Physical Structure

3.3.1 Downlink physical structure

Each downlink subframe is divided into 4 or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR) or multicast and broadcast services (MBS). Figure 1 illustrates the downlink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where Sc stands for subcarrier.

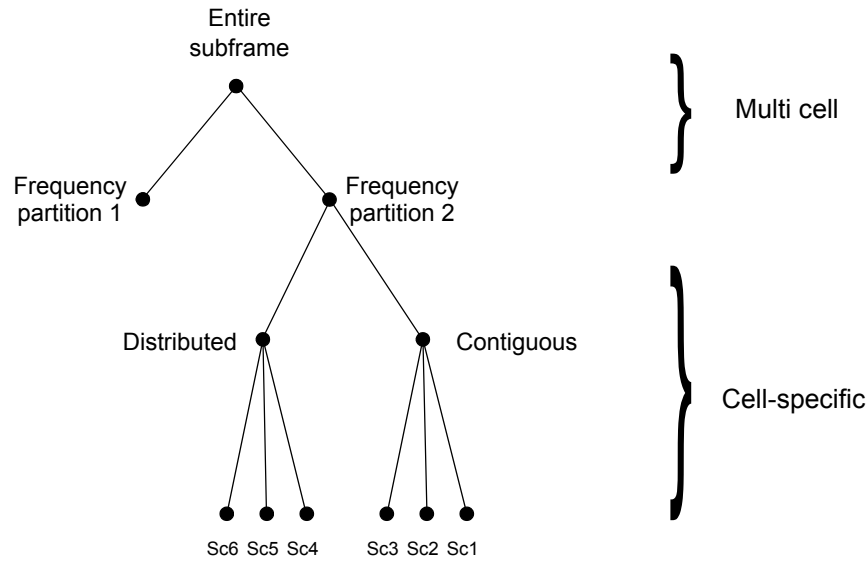


Figure 1—Example of downlink physical structure

3.3.1.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 subcarriers and N_{sym} is 6, 7, and 5 OFDMA symbols for type-1, type-2, and type-3 subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. An LRU is $P_{sc} \cdot N_{sym}$ subcarriers for type-1 subframes, type-2 subframes, and type-3 subframes. The effective number of subcarriers in an LRU depends on the number of allocated pilots.

3.3.1.1.1 Distributed logical resource unit

The distributed logical resource unit (DLRU) contains a group of subcarriers that are spread across the distributed resource allocations within a frequency partition. The size of the DRU equals the size of PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DLRU is equal to a pair of

subcarriers, called tone-pair, as defined in Clause 3.3.1.3.2. The DLRUs are obtained by subcarrier permuting the distributed resource units (DRUs).

3.3.1.1.2 Contiguous logical resource unit

The localized logical resource unit, also known as contiguous logical resource unit (CLRU) contains a group of subcarriers that are contiguous across the localized resource allocations. The size of the CLRU equals the size of the PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The CLRUs are obtained from direct mapping of contiguous resource units (CRUs). Two types of CLRUs are supported according to the two types of CRUs, i.e. subband and miniband based CRUs.

3.3.1.2 Multi-cell resource mapping

3.3.1.2.1 Subband partitioning

The PRUs are first subdivided into subbands and minibands where a subband comprises of N_1 adjacent PRUs and a miniband comprises of N_2 adjacent PRUs, where $N_1 = 4$ and $N_2 = 1$. Subbands are suitable for frequency selective allocations as they provide a contiguous allocation of PRUs in frequency. Minibands are suitable for frequency diverse allocation and are permuted in frequency.

The number of subbands is denoted by K_{SB} . The number of PRUs allocated to subbands is denoted by L_{SB} , where $L_{SB} = N_1 \cdot K_{SB}$. A 5, 4 or 3-bit field called Downlink Subband Allocation Count (DSAC) determines the value of K_{SB} depending on system bandwidth. The DSAC is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB} . The number of PRUs allocated to minibands is denoted by L_{MB} , where $L_{MB} = N_2 \cdot K_{MB}$. The total number of PRUs is denoted as N_{PRU} where $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = \lfloor N_{PRU} / N_1 \rfloor$.

Table 1 through Table 3 show the mapping between DSAC and K_{SB} for the 20 MHz, 10 MHz, and 5 MHz bands, respectively.

Table 1—Mapping between DSAC and K_{SB} for 20MHz

DSAC	# of subbands allocated (K_{SB})	DSAC	# of subbands allocated (K_{SB})
0	0	16	16
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	N.A.
7	7	23	N.A.
8	8	24	N.A.
9	9	25	N.A.

Table 1—Mapping between DSAC and K_{SB} for 20MHz

DSAC	# of subbands allocated (K_{SB})	DSAC	# of subbands allocated (K_{SB})
10	10	26	N.A.
11	11	27	N.A.
12	12	28	N.A.
13	13	29	N.A.
14	14	30	N.A.
15	15	31	N.A.

Table 2—Mapping between DSAC and K_{SB} for 10 MHz

DSAC	# of subbands allocated (K_{SB})	DSAC	# of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	N.A.
4	4	12	N.A.
5	5	13	N.A.
6	6	14	N.A.
7	7	15	N.A.

Table 3—Mapping between DSAC and K_{SB} for 5 MHz

DSAC	# of subbands allocated (K_{SB})	DSAC	# of subbands allocated (K_{SB})
0	0	4	4
1	1	5	N.A.
2	2	6	N.A.
3	3	7	N.A.

PRUs are partitioned and reordered into two groups: subband PRUs and miniband PRUs, denoted by PRU_{SB} and PRU_{MB} , respectively. The set of PRU_{SB} is numbered from 0 to $(L_{SB} - 1)$. The set of PRU_{MB} are numbered from 0 to $(L_{MB} - 1)$. Equation (1) defines the mapping of PRUs to PRU_{SB} s. Equation (2) defines the

mapping of PRUs to PRU_{MB} s. Figure 2 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB} for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; j = 0, 1, \dots, L_{SB} - 1 \quad (1)$$

where:

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j}{N_1} \right\rfloor + \left\lfloor \frac{j}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{j\} \cdot \bmod \{N_1\} \quad (2)$$

where $\{x\} \bmod \{y\}$ is modulus when dividing x by y , and $GCD(x, y)$ is the greatest common divisor of x and y .

$$PRU_{MB}[k] = PRU[i]; k = 0, 1, \dots, L_{MB} - 1 \quad (3)$$

where:

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k+L_{SB}}{N_1} \right\rfloor + \left\lfloor \frac{k+L_{SB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{k+L_{SB}\} \cdot \bmod \{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases} \quad (4)$$

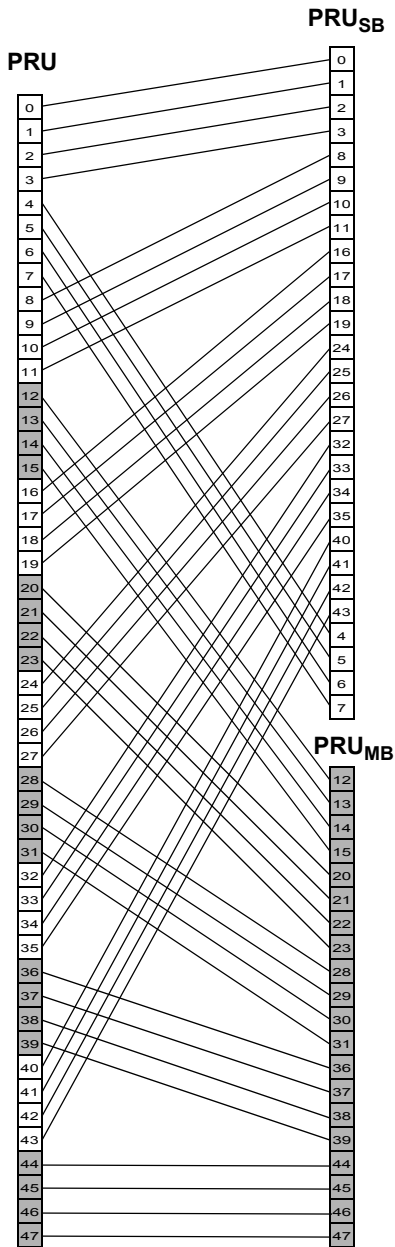


Figure 2—PRU to PRU_{SB} and PRU_{MB} mapping for BW=10 MHz, K_{SB}=7

3.3.1.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB} s to Permuted PRU_{MB} s ($PPRU_{MB}$ s) to insure frequency diverse PRUs are allocated to each frequency partition. Equation (5) describes the mapping from PRU_{MB} to $PPRU_{MB}$ s:

$$PPRU_{MB}[j] = PRU_{MB}[i]; j = 0, 1, \dots, L_{MB} - 1 \quad (5)$$

where:

$$i = (q(j) \bmod(D)) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor \quad (6)$$

$$P = \min(K_{MB}, N_1/N_2) \quad (7)$$

$$r(j) = \max(j - (K_{MB} \bmod(P) \cdot D), 0) \quad (8)$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor, D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor \quad (9)$$

Figure 37 depicts the mapping from PRUs to PRU_{SB} and $PPRU_{MB}$.

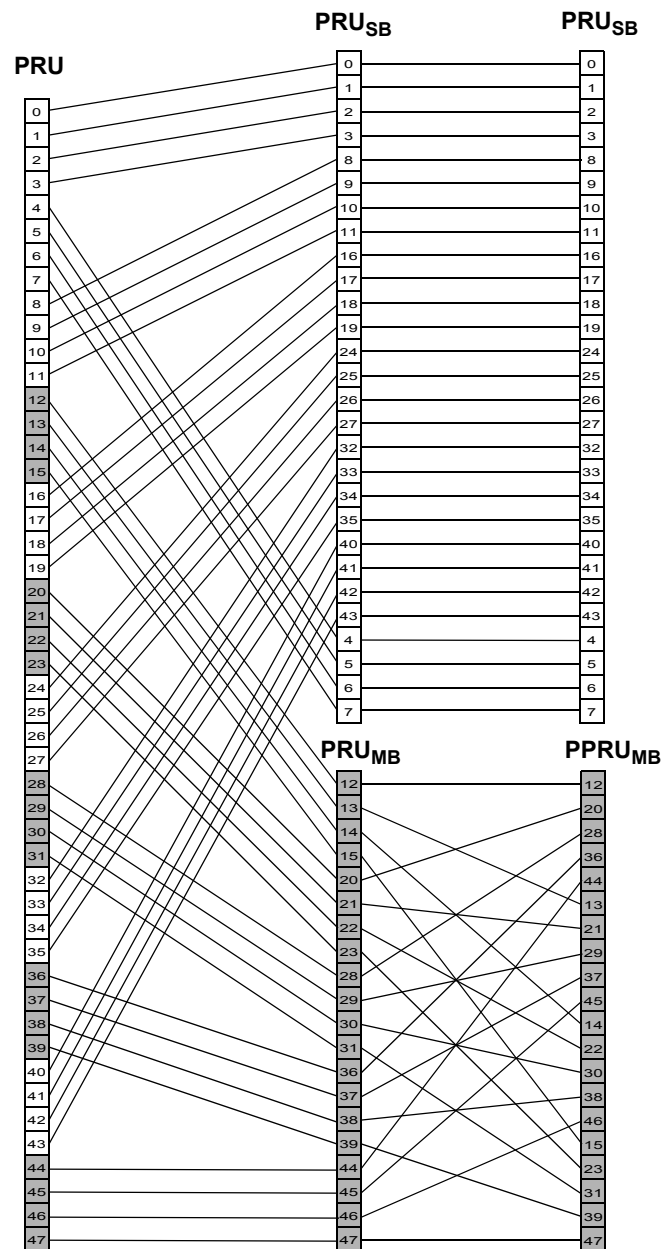


Figure 3—Mapping from PRUs to PRU_{SB} and $PPRU_{MB}$ mapping for BW=10 MHz, $K_{SB}=7$

3.3.1.2.3 Frequency partitioning

The PRU_{SB} s and $PPRU_{MB}$ s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is trans-

mitted in the SFH in a 4 or 3-bit field called the Downlink Frequency Partition Configuration (DFPC) depending on system bandwidth. The Frequency Partition Count (FPCT) defines the number of frequency partitions. The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to FP_i . FPCT and FPS_i are determined from DFPC as shown in Table 4 through Table 6. A 3, 2, or 1-bit field called the Downlink Frequency Partition Subband Count (DFPSC) defines the number of subbands allocated to FP_i , $i > 0$.

Table 4—Mapping between DFPC and frequency partitioning for 20 MHz

DFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	FPCT	FPS_0	FPS_i ($i>0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU} * 1/3$
2	1 : 1 : 1 : 1	4	$N_{PRU} * 1/4$	$N_{PRU} * 1/4$
3	3 : 1 : 1 : 1	4	$N_{PRU} * 1/2$	$N_{PRU} * 1/6$
4	5 : 1 : 1 : 1	4	$N_{PRU} * 5/8$	$N_{PRU} * 1/8$
5	9 : 1 : 1 : 1	4	$N_{PRU} * 9/12$	$N_{PRU} * 1/12$
6	9 : 5 : 5 : 5	4	$N_{PRU} * 3/8$	$N_{PRU} * 5/24$
7-15	<i>Reserved</i>			

Table 5—Mapping between DFPC and frequency partitioning for 10 MHz

DFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	FPCT	FPS_0	FPS_i ($i>0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU} * 1/3$
2	1 : 1 : 1 : 1	4	$N_{PRU} * 1/4$	$N_{PRU} * 1/4$
3	3 : 1 : 1 : 1	4	$N_{PRU} * 1/2$	$N_{PRU} * 1/6$
4	5 : 1 : 1 : 1	4	$N_{PRU} * 5/8$	$N_{PRU} * 1/8$
5	9 : 5 : 5 : 5	4	$N_{PRU} * 3/8$	$N_{PRU} * 5/24$
6-7	<i>Reserved</i>			

Table 6—Mapping between DFPC and frequency partitioning for 5 MHz

DFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	FPCT	FPS_0	FPS_i ($i>0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU} * 1/3$

Table 6—Mapping between DFPC and frequency partitioning for 5 Mhz

DFPC	Freq. Partitioning (FP ₀ :FP ₁ :FP ₂ :FP ₃)	FPCT	FPS ₀	FPS _i (i>0)
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4	9 : 5 : 5 : 5	4	N _{PRU} * 3/8	N _{PRU} * 5/24
5-7	Reserved			

The number of subbands in i^{th} frequency partition is denoted by K_{SB,FP_i} . The number of minibands is denoted by K_{MB,FP_i} , which is determined by the FPS_i and DFPC fields. When DFPC = 0, DFPC must be equal to 0. The number of subband PRUs in each frequency partition is denoted by L_{SB,FP_i} , which is given by $L_{SB,FP_i} = N_1 \cdot K_{SB,FP_i}$. The number of miniband PRUs in each frequency partition is denoted by L_{MB,FP_i} , which is given by $L_{MB,FP_i} = N_2 \cdot K_{MB,FP_i}$. The number of subbands for each frequency partition is given by Equation (10).

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT - 1) \cdot DFPSC & i = 0, FPCT = 4 \\ DFPSC & i > 0, FPCT = 3 \quad \text{or} \quad 4 \\ K_{SB} & i = 0, FPCT = 1 \end{cases} \quad (10)$$

The number of minibands for each frequency partition is given by Equation (11).

$$K_{MB,FP_i} = (FPS_i - K_{SB,FP_i} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (11)$$

When DFPC = 1 and FPCT = 3, the number of subbands in FP_i (for $i > 0$) is given by $K_{SB,FP_i} = DFPSC$. The number of minibands for each frequency partition is given by Equation (12).

$$K_{MB,FP_i} = (FPS_i - K_{SB,FP_i} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (12)$$

The mapping of subband PRUs and miniband PRUs to the frequency partition i is given by Equation (13):

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & \text{for } 0 \leq j < L_{SB,FP_i} \\ PPRU_{MB}(k_2) & \text{for } L_{SB,FP_i} \leq j < (L_{SB,FP_i} + L_{MB,FP_i}) \end{cases} \quad (13)$$

where

$$k_1 = \sum_{m=0}^{i-1} L_{SB,FP_m} + j$$

and

$$k_2 = \sum_{m=0}^{i-1} L_{MB,FP_m} + j - L_{SB,FP_i}$$

Figure 34 depicts the frequency partitioning for BW = 10 MHz, $K_{SB} = 7$, FPCT = 4, $FPS_0 = FPS_i = 12$, and DFPSC = 2.

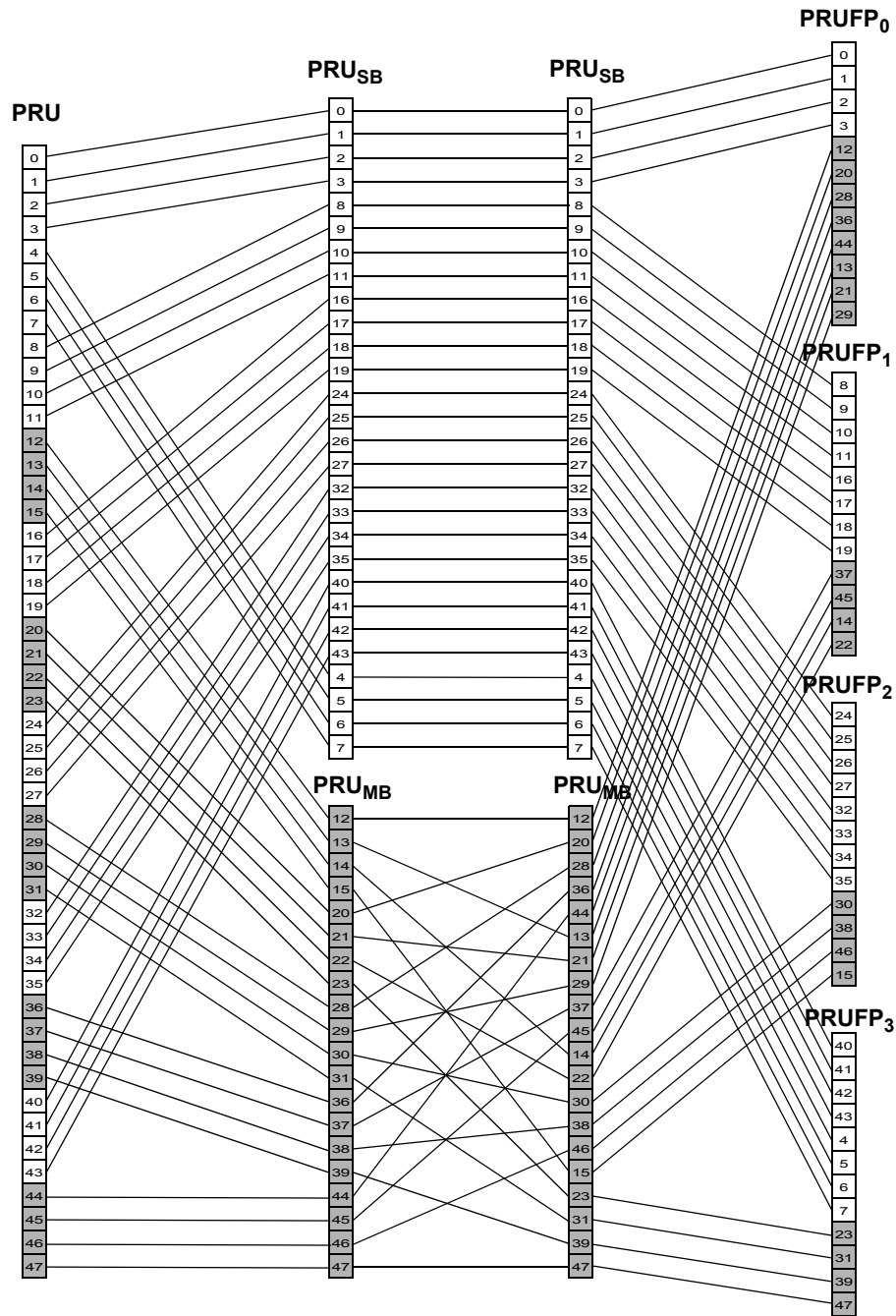


Figure 4—Frequency partition for BW=10 MHz, $K_{SB}=7$, $FPCT=4$, $FPS_0=FPS_i=12$, $DFPSC=2$

3.3.1.3 Cell-specific resource mapping

PRU_{FPi} s are mapped to LRUs. All further PRU and subcarrier permutation are constrained to the PRUs of a frequency partition.

3.3.1.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. Let L_{SB-CRU,FP_i} and L_{MB-CRU,FP_i} denote the number of allocated subband CRUs and miniband CRUs for FP_i ($i > 0$). The number of total allocated subband and miniband CRUs, in units of a subband (i.e. N_1 PRUs), for FP_i ($i > 0$) is given by the downlink CRU allocation size, $DCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $DCAS_{SB,0}$ and $DCAS_{MB,0}$, in units of a subband and miniband, respectively. When DFPC = 0, $DCAS_i$ must be equal to 0.

For FP_0 , the value of $DCAS_{SB,0}$ is explicitly signaled in the SFH as a 5, 4 or 3-bit field to indicate the number of subbands in unsigned-binary format. A 5, 4 or 3-bit Downlink miniband-based CRU allocation size ($DCAS_{MB,0}$) is sent in the SFH only for partition FP_0 , depending on system bandwidth. The number of subband-based CRUs for FP_0 is given by the Equation (14).

$$L_{SB-CRU,FP_0} = N_1 \cdot DCAS_{SB,0} \quad (14)$$

The mapping between $DCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in the Table 90 through Table 92 for system bandwidths of 20 MHz, 10 MHz, and 5 MHz respectively.

Table 7—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 20 MHz

$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. L_{MB-CRU,FP_0})	$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. L_{MB-CRU,FP_0})
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 8—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 10 MHz

$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. $L_{MB,FP0}$)	$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. $L_{MB,FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 9—Mapping between $DCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 5 MHz

$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. $L_{MB,FP0}$)	$DCAS_{MB,0}$	# of miniband-based CRU for FP_0 (i.e. $L_{MB,FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For FP_i ($i > 0$), only one value for $DCAS_i$ is explicitly signaled for all $i > 0$, in the SFH as a 3, 2 or 1-bit field to signal the same numbers of allocated CRUs for FP_i ($i > 0$).

For FP_i ($i > 0$), the number of subband CRUs ($L_{SB-CRU,FPi}$) and miniband CRUs ($L_{MB-CRU,FPi}$) are derived using Equation (15) and Equation (16) respectively.

$$L_{SB-CRU,FPi} = N_1 \cdot \min\{DCAS_i, K_{SB,FPi}\} \quad (15)$$

$$L_{MB-CRU,FPi} = \begin{cases} 0, & DCAS_i \leq K_{SB,FPi} \\ (DCAS_i - K_{SB,FPi}) \cdot N_1 & DCAS_i > K_{SB,FPi} \end{cases} \quad (16)$$

The total number of CRUs in frequency partition FP_i , for $0 \leq i < FPCT$, is denoted by $L_{CRU,FPi}$, where

$$L_{CRU,FPi} = L_{SB-CRU,FPi} + L_{MB,FPi} \quad (17)$$

The number of DRUs in each frequency partition is denoted by $L_{DRU,FPi}$, where

$$L_{DRU,FPi} = FPS_i - L_{CRU,FPi} \quad \text{for } 0 \leq i < FPCT \quad (18)$$

and FPS_i is the number of PRUs allocated to FP_i .

The mapping from PRU_{FPi} to CRU_{FPi} (for $0 \leq i < FPCT$) is given by:

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \leq j < L_{SB-CRU,FPi} \\ PRU_{FPi}[k + L_{SB-CRU,FPi}], & L_{SB-CRU,FPi} \leq j < L_{CRU,FPi} \end{cases} \quad (19)$$

where $k = s[j] - L_{SB-CRU,FPi}$.

$s[j]$ is the CRU/DRU allocation sequence defined in Equation (20) and $0 \leq s[j] < FPS_i - L_{SB-CRU,FPi}$.

$$s[j] = \{ \text{PermSeq}(j) + \text{DL_PermBase} \} \bmod (FPS_i - L_{SB-CRU,FPi}) \quad (20)$$

In Equation (20), $\text{PermSeq}()$ is the permutation sequence of length $(FPS_i - L_{SB-CRU,FPi})$ and is determined by $SEED = \{ID_{cell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 3.3.1.3.3. DL_PermBase is set to preamble ID_{cell} .

The mapping of PRU_{FPi} to DRU_{FPi} is given by:

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB-CRU,FPi}], \quad 0 \leq j < L_{DRU,FPi} \quad (21)$$

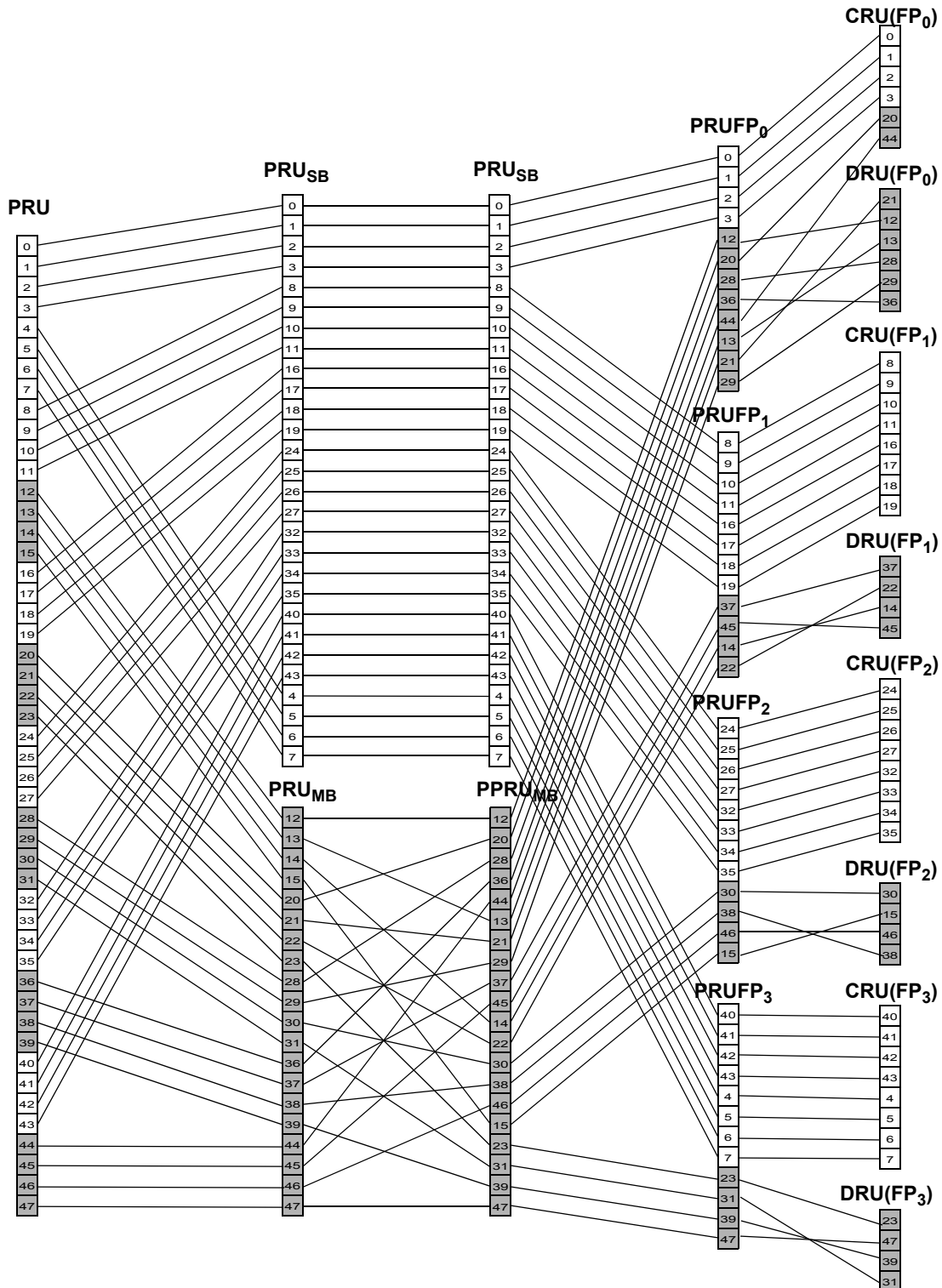
where $k = s[j] + L_{CRU,FPi} - L_{SB-CRU,FPi}$.

Figure 5 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and CRU/DRU allocation for the case of 10 MHz system bandwidth. For this example, $K_{SB} = \text{DSAC} = 7$, $FPCT = 4$, $FPS_i = 12$ (for $i \geq 0$), $\text{DFPSC} = 2$, $\text{DCAS}_{SB,0} = 1$, $\text{DCAS}_{MB,0} = 2$, and $\text{DCAS}_i = 2$.

Table 10 presents a summary of the parameters used to configure the DL PHY structure.

Table 10—DL PHY Structure - Summary of parameters

	Operation Procedure	Related Signaling Field (BW20/10/5MHz)	Channel for Signaling	Parameters Calculated from Signaled Fields	Definition	Units
Sector Common	Sub-band Partitioning	DSAC (5/4/3) bits	SFH - SP2	K_{SB}	Number of Subbands	Subbands
	Mini-band Partitioning			$L_{SB} = N_1 * K_{SB}$	Number of PRUs assigned to Subbands	PRUs
				L_{MB}	Number of PRUs assigned to minibands	PRUs
	Frequency Partitioning	DFPC (4/3/3 bit)		FPCT	Number of Frequency Partitions	Frequency Partitions
				FPS_i	Number of PRUs in FP_i	PRUs
		DFPSC (3/2/1 bit)		K_{SB, FP_i}	Number of SBs assigned to FP_i	Subbands
				K_{MB, FP_i}	Number of MiniBands assigned to FP_i	Subbands (Groups of N_1 PRUs)
				$L_{SB, FP_i} = N_1 * K_{SB, FP_i}$	Number of MiniBands assigned to FP_i	PRUs
				$L_{MB, FP_i} = N_2 * K_{MB, FP_i}$	Number of PRUs assigned to be Subbands in FP_i	PRUs
Sector Specific	CRU/DRU Allocation	$DCAS_{SB,0}$ (5/4/3 bit) $DCAS_{MB,0}$ (5/4/3 bit) $DCAS_i$ (3/2/1) bit	SFH - SP1	L_{SB-CRU, FP_i}	Number of Subband-based CRUs in FP_i	CRUs
				L_{MB-CRU, FP_i}	Number of Miniband-based CRUs in FP_i	CRUs
				$L_{CRU_FP_i} = L_{SB-CRU, FP_i} + L_{MB-CRU, FP_i}$	Number of CRUs in FP_i	CRUs
				$L_{DRU_FP_i} = FPS_i - L_{CRU_FP_i}$	Number of DRUs in FP_i	DRUs
		Tone Permutation		Obtained from SA-Pre-amble		



$K_{SB}=7$, $FPCT=4$, $FPS_0=FPS_1=12$, $DFPSC=2$,
 $DCAS_{SB,0} = 1$, $DCAS_{MB,0} = 2$, $DCAS_i=2$, and $IDCell=2$.

Figure 5—Frequency partition for BW=10 MHz

3.3.1.3.2 Subcarrier permutation

The downlink DRUs are used to form 2-stream DLRUs by subcarrier permutation. The subcarrier permutation defined for the DL distributed resource allocations within a frequency partition spreads the subcarriers of the DRU across the whole distributed resource allocations. The granularity of the subcarrier permutation is equal to a pair of subcarriers.

After mapping all pilots, the remaining used subcarriers are used to define the distributed LRUs. To allocate the LRUs, the remaining subcarriers are paired into contiguous tone-pairs. Each LRU consists of a group of tone-pairs.

Let $L_{SC,l}$ denote the number of data subcarriers in l^{th} OFDMA symbol within a PRU, i.e., $L_{SC,l} = P_{sc} - n_l$, where n_l denotes the number of pilot subcarriers in the l^{th} OFDMA symbol within a PRU. Let $L_{SP,l}$ denote the number of data subcarrier-pairs in the l^{th} OFDMA symbol within a PRU and is equal to $L_{SC,l} / 2$. The permutation sequence $PermSeq()$ is defined in Clause 3.3.1.3.3. The DL subcarrier permutation is performed as follows:

For each l^{th} OFDMA symbol in the subframe:

- 1) Allocate the n_l pilots within each DRU as described in Clause 3.3.1.4. Denote the data subcarriers of $DRU_{FPi}[j]$ in the l^{th} OFDMA symbol as $SC_{DRUj,l}^{FPi}[k]$, for $0 \leq j < L_{DRU,FPi}$ and $0 \leq k < L_{SC,l}$.
- 2) Renumber the $L_{DRU,FPi} \cdot L_{SC,l}$ data subcarriers of the DRUs in order, from 0 to $L_{DRU,FPi} \cdot L_{SC,l} - 1$. Group these contiguous and logically renumbered subcarriers into $L_{DRU,FPi} \cdot L_{SP,l}$ pairs and renumber them from 0 to $L_{DRU,FPi} \cdot L_{SP,l} - 1$. The renumbered subcarrier pairs in the l^{th} OFDMA symbol are denoted by $RSP_{FPi,l}$.

$$RSP_{FPi,l}[u] = \{ SC_{DRUj,l}^{FPi}[2v], SC_{DRUj,l}^{FPi}[2v+1] \}, \quad 0 \leq u < L_{DRU,FPi} L_{SP,l}$$

where $j = \lfloor u / L_{SP,l} \rfloor$ and $v = \{u\} \bmod (L_{SP,l})$.

- 3) Apply the subcarrier permutation formula Equation (22) to map $RSP_{FPi,l}$ into the s^{th} distributed LRUs $s = 0, 1, \dots, L_{DRU,FPi} - 1$. The subcarrier permutation formula is given by

$$SP_{LRUs,l}^{FPi}[m] = RSP_{FPi,l}[k] \quad 0 \leq m < L_{SP,l} \quad (22)$$

where

$$k = L_{DRU,FPi} \cdot f(m, s) + g(PermSeq(), s, m, l)$$

- $SP_{LRUs,l}^{FPi}[m]$ is the m^{th} subcarrier pair in the l^{th} OFDMA symbol in the s^{th} distributed LRU of the l^{th} subframe.
- m is the subcarrier pair index, 0 to $L_{SP,l} - 1$.
- l is the OFDMA symbol index, 0 to $N_{sym} - 1$.
- s is the distributed LRU index, 0 to $L_{DRU,FPi} - 1$.
- $PermSeq()$ is the permutation sequence of length $L_{DRU,FPi}$ and is determined by $SEED = \{ID_{cell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in Clause 3.3.1.3.3.
- $g(PermSeq(), s, m, l)$ is a function with value from the set $[0, L_{DRU,FPi} - 1]$, which is defined according to Equation (23).
- $f(m, s) = (m + 13 * s) \bmod L_{SP,l}$.

$$g(\text{PermSeq}(), s, m, l) = \{\text{PermSeq}[\{f(m, s) + s + l\} \bmod L_{DRU, FPI}] + DL_PermBase\} \bmod L_{DRU, FPI} \quad (23)$$

3.3.1.3.3 Random sequence generation

The permutation sequence generation algorithm with 10-bit *SEED* ($S_{n-10}, S_{n-9}, \dots, S_{n-1}$) generates a permutation sequence of size M as described below:

- 1) Initialization
 - a) Initialize the variables of the first order polynomial equation with the 10-bit seed, *SEED*. Set $d_1 = \text{floor}(SEED/2^5) + 619$ and $d_2 = SEED \bmod 2^5$.
 - b) Initialize an array A with size M with the numbers $0, 1, \dots, M-1$ (i.e. $A[0]=0, A[1]=1, \dots, A[M-1]=M-1$).
 - c) Initialize the counter i to $M-1$.
 - d) Initialize x to -1 .
- 2) Repeat the following steps if $i > 0$
 - a) Increment x by i .
 - b) Calculate the output variable of $y = \{(d_1 * x + d_2) \bmod 1031\} \bmod M$.
 - c) If $y \geq i$, set $y = y \bmod (i + 1)$.
 - d) Swap $A[i]$ and $A[y]$.
 - e) Decrement i by 1.
- 3) $\text{PermSeq}[i] = A[i]$, where $0 \leq i < M$.

3.3.1.3.4 Formation of MLRU

To form MLRUs for the assignment A-MAP,

- 1) Renumber all tone pairs in the distributed LRUs in the A-MAP region in a time first manner. Assuming that each LRU has L_{SP} tone-pairs per symbol, the renumbered A-MAP tone-pairs are denoted by $\text{RMP}[u]$, where u ranges from 0 to $L_{AMAP} \cdot N_{sym} \cdot L_{SP} - 1$.

L_{AMAP} is the number of LRU allocated to the A-MAP.

- 2) A distributed tone-pair, $SP_{LRUs, l}^{FPI}[m]$, is mapped to $\text{RMP}[u]$, where $u = s \cdot N_{sym} \cdot L_{SP} + m \cdot N_{sym} + 1$. $u = s \cdot N_{sym} \cdot L_{SP} + m \cdot N_{sym} + l$. $SP_{LRUs, l}^{FPI}[m]$ is the tone-pair index of the m^{th} tone-pair in the l^{th} OFDMA symbol in the s^{th} distributed LRU of frequency partition i as defined in Clause 3.3.1.3.2.

- 3) Suppose $\text{RMP}[v]$ is the first tone-pair for Assignment A-MAP. The k^{th} MLRU is formed by tone-pairs from $\text{RMP}[v + k \cdot N_{MLRU} / 2]$ to $\text{RMP}[v + (k+1) \cdot N_{MLRU} / 2 - 1]$, where N_{MLRU} is the size of an MLRU.

3.3.1.3.5 Logical Resource Unit Mapping

Both contiguous and distributed LRUs are supported in the downlink. The CRUs are directly mapped into contiguous LRUs, including subband LRUs and miniband LRUs. The DRUs are permuted as described in Clause 3.3.1.3.2 to form distributed LRUs

3.3.1.4 Pilot structure

The transmission of pilot subcarriers in the downlink is necessary for enabling channel estimation, measurements of channel quality indicators such as the SINR, frequency offset estimation, etc. To optimize the system performance in different propagation environments and applications, IEEE 802.16m supports both common and dedicated pilot structures. The categorization in common and dedicated pilots is done with respect to their usage. The common pilots can be used by all MSs. Dedicated pilots can be used with both

localized and distributed allocations. The dedicated pilots are associated with a specific resource allocation, can be only used by the MSs allocated to said specific resource allocation, and therefore can be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to eight transmission (Tx) streams and there is a unified pilot pattern design for common and dedicated pilots. There is equal pilot density per Tx stream, while there is not necessarily equal pilot density per OFDMA symbol of the downlink subframe. Further, within the same subframe there is equal number of pilots for each PRU of a data burst assigned to one MS.

3.3.1.4.1 Pilot patterns

Pilot patterns are specified within a PRU.

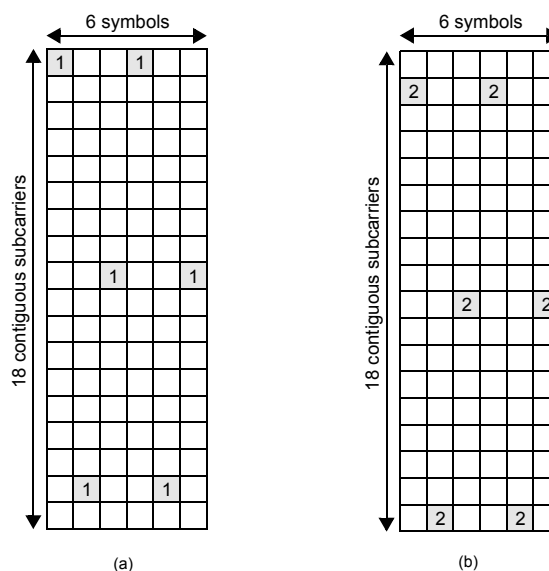


Figure 6—Pilot patterns used for 1 DL data stream

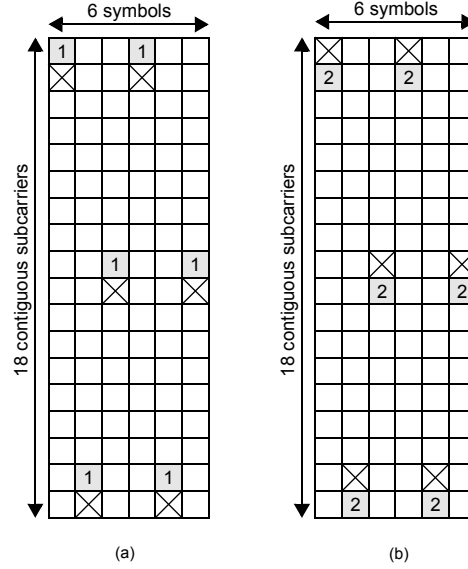


Figure 7—Pilot patterns used for 2 DL data streams

Base pilot patterns used for DL data transmission with one data stream in dedicated and common pilot scenarios are shown in Figure 6, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) and Subfigure (b) in Figure 6 show the pilot locations for pilot stream 1 and pilot stream 2, respectively.

The selection method of pilot stream is TBD.

Base pilot patterns used for two DL data streams in dedicated and common pilot scenarios are shown in Figure 7, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) and Subfigure (b) in Figure 7 shows the pilot location for pilot stream 1 and pilot stream 2 in a PRU, respectively. The number on a pilot subcarrier indicates the pilot stream the pilot subcarrier corresponds to. The subcarriers marked as 'X' are null sub-carriers, on which no pilot or data is transmitted.

The interlaced pilot patterns are generated by cyclic shifting the base pilot patterns. The interlaced pilot patterns are used by different BSs for one and two streams. Interlaced pilot patterns for one stream is shown in Figure 8 and interlaced pilot patterns on stream 1 and stream 2 for two streams are shown in Figure 9 and Figure 10, respectively. Each BS chooses one of the three pilot pattern sets (pilot pattern set 0, 1, and 2) as shown in Figure 8 and Figure 9. The index of the pilot pattern set used by a particular BS with Cell_ID = k is denoted by p_k . The index of the pilot pattern set is determined by the Cell_ID according to the following equation:

$$p_k = \text{mod}(k, 3)$$

For the subframe consisting of 5 symbols, the last OFDM symbol in each pilot pattern set shown in Figure 7 is deleted. For the subframe consisting of 7 symbols, the first OFDM symbol in each pilot pattern set shown in Figure 7 is added as 7th symbol.

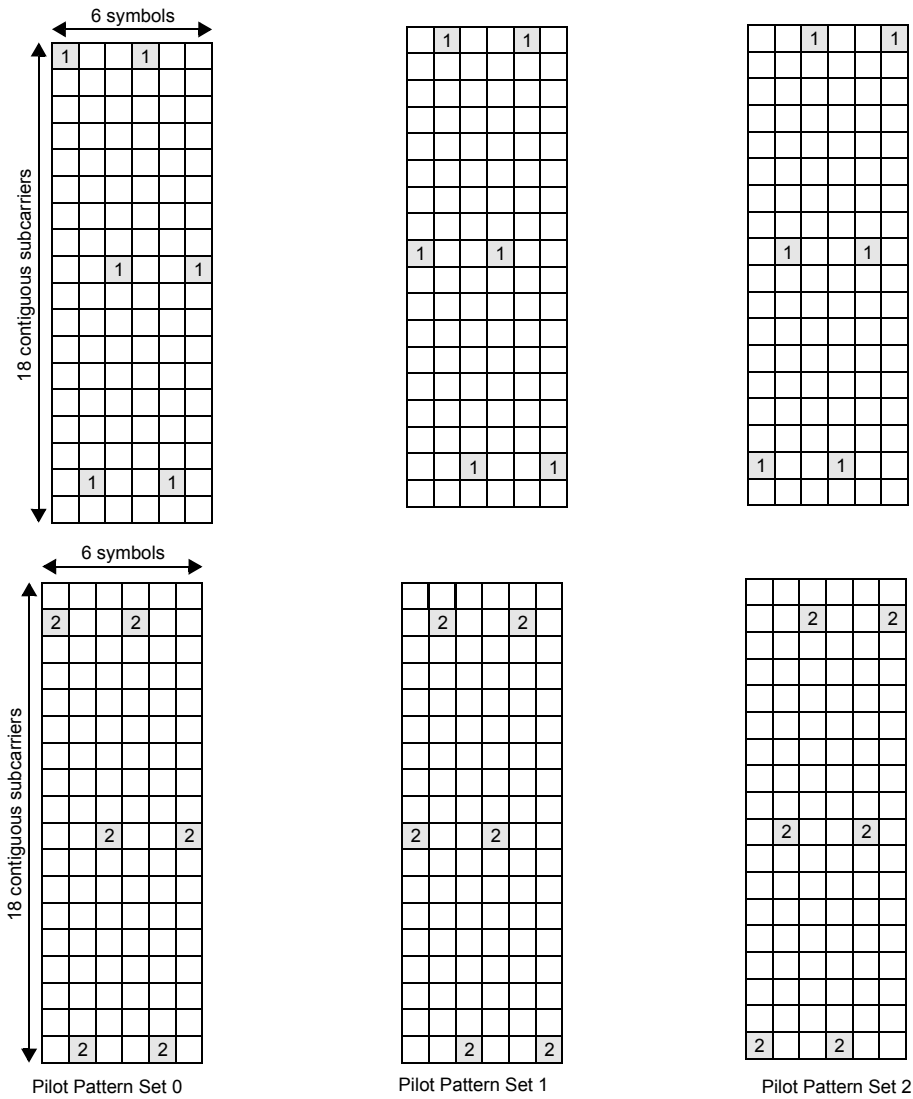


Figure 8—Interlaced pilot patterns for 1 pilot stream

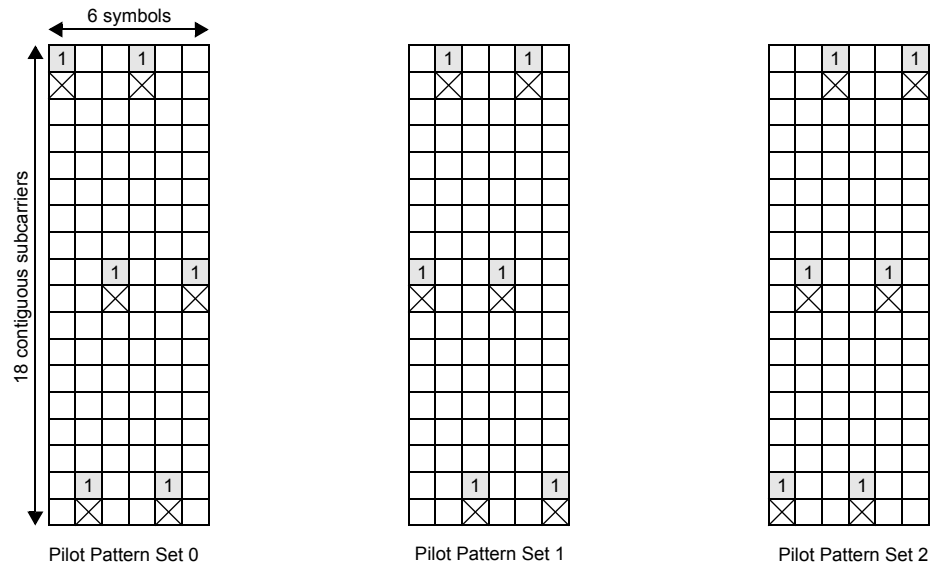


Figure 9—Interlaced pilot patterns on stream 0 for 2 data streams

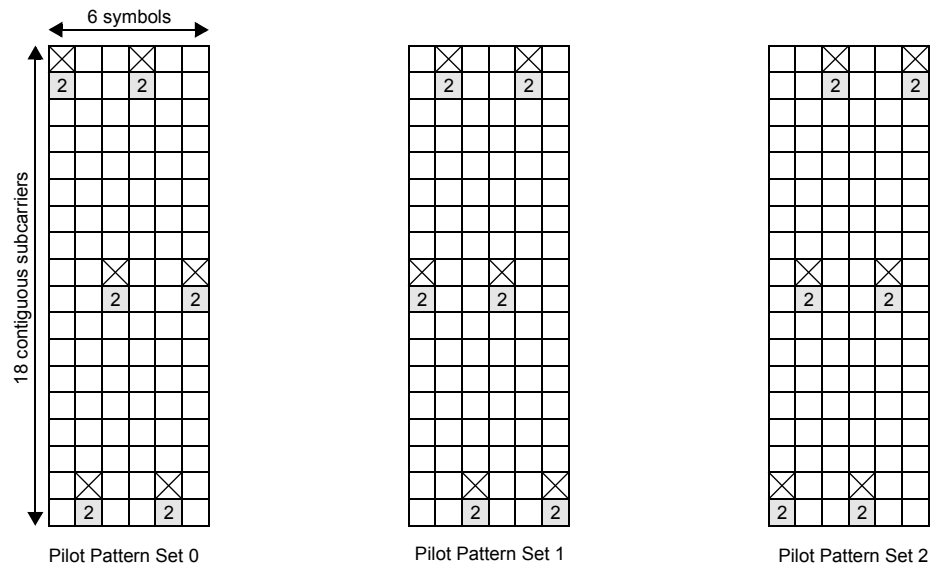


Figure 10—Interlaced pilot patterns on stream 1 for 2 data streams

The pilot patterns on stream 0 - stream 3 for four pilot streams are shown in Figure 11 through Figure 14 respectively, with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 11 through Figure 14 show the pilot pattern for four pilot streams in subframe with six OFDM symbols; Subfigure (b) in Figure 11 through Figure 14 show the pilot pattern for four pilot streams in subframe with five OFDM symbols; Subfigure (c) in Figure 11 through Figure 14 show the pilot pattern for four pilot streams in subframe with seven OFDM symbols.

For 3 streams MIMO transmissions, the first three of the four pilot streams will be used and the unused pilot stream is allocated for data transmission.

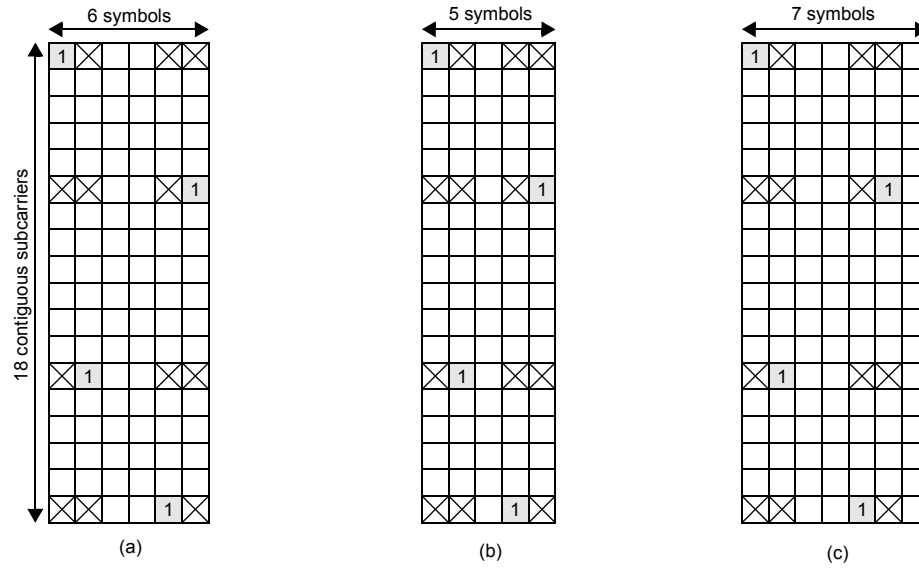


Figure 11—Pilot patterns on stream 0 for 4 data streams

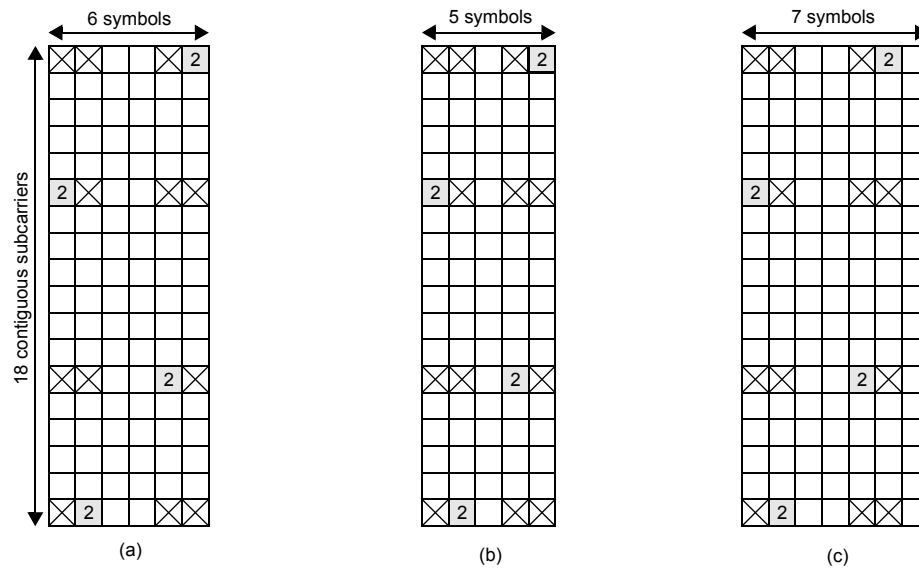


Figure 12—Pilot patterns on stream 1 for 4 data streams

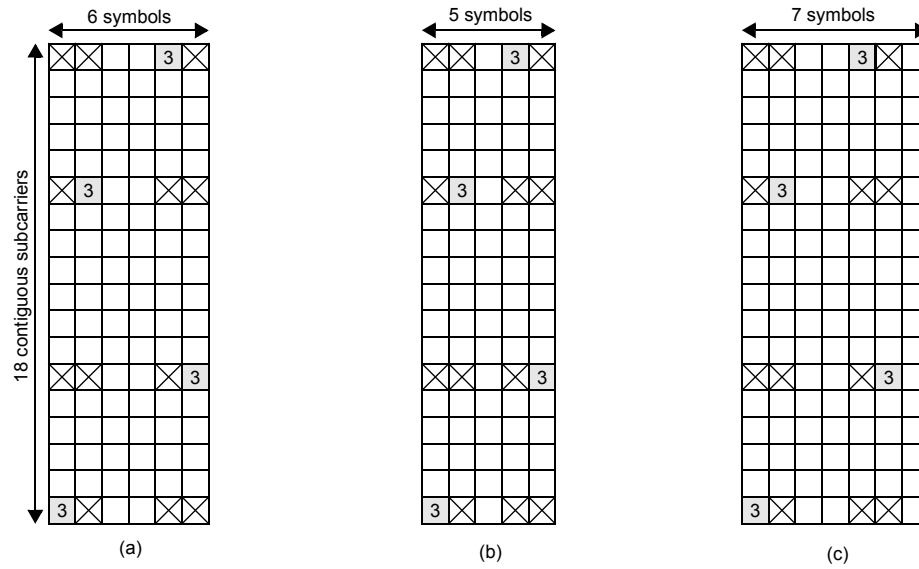


Figure 13—Pilot patterns on stream 2 for 4 data streams

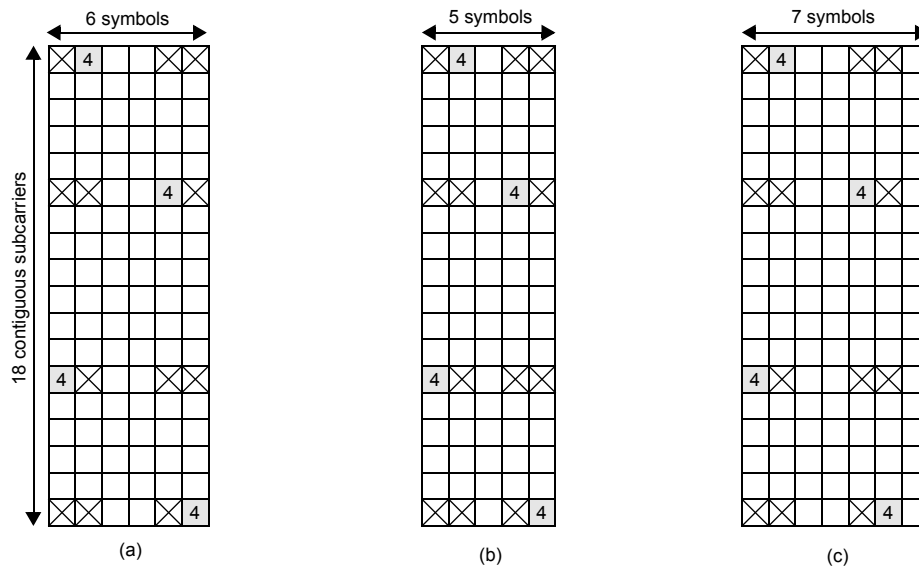


Figure 14—Pilot patterns on stream 3 for 4 data streams

The pilot patterns for eight pilot streams are shown in Figure 15 with the subcarrier index increasing from top to bottom and the OFDM symbol index increasing from left to right. Subfigure (a) in Figure 15 shows the pilot pattern for eight pilot streams in subframe with six OFDM symbols; Subfigure (b) in Figure 15 shows the pilot pattern for eight pilot streams in subframe with five OFDM symbols; Subfigure (c) in Figure 15 shows the pilot pattern for eight pilot streams in subframe with seven OFDM symbols.

For 5, 6 and 7 streams MIMO transmissions, the first five, six and seven of the eight pilot streams will be, respectively. The unused pilot stream is allocated for data transmission.

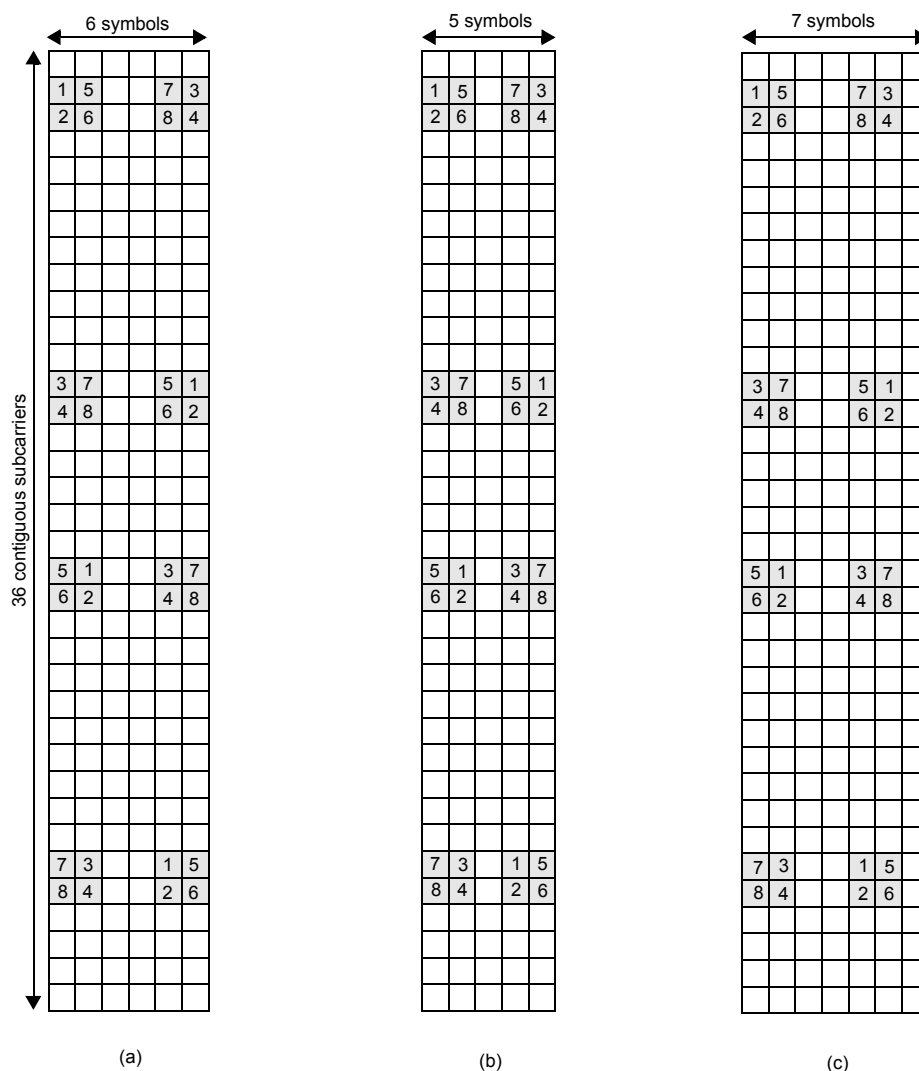


Figure 15—Pilot patterns for 8 data streams

3.3.1.4.2 MIMO midamble

MIMO midamble is used for PMI selection in closed loop MIMO. For OL MIMO, midamble can be used to calculate CQI. MIMO midamble shall be transmitted every frame on the second last DL subframe. The midamble signal occupies the first OFDMA symbol in a DL type-1 or type-2 sub-frame. For the type-1 sub-frame case, the remaining 5 consecutive symbols form a type-3 subframe. For the type-2 subframe case, the remaining 6 consecutive symbols form a type-1 subframe.

The MIMO midamble signal transmitted by the ABS antenna is defined by Equation (24):

$$s(t) = \text{Re} \left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi \left(k - \frac{N_{used}-1}{2}\right) \Delta f (t - T_g)} \right\} \quad (24)$$

where b_k is a complex coefficients modulating subcarriers in the midamble symbol defined by Equation (25):

$$b_k = \begin{cases} 1 - 2 \cdot G([k + u + \text{offset}(fft)] \bmod fft), k \neq \frac{N_{used}-1}{2}, k \bmod (3 \times N_t) = \left(g + \left\lfloor \frac{k-s}{N_1 \times N_{SC}} \right\rfloor\right) \bmod N_t + N_t \times (BSID \cdot \bmod 3) \\ 0, \text{otherwise} \end{cases} \quad (25)$$

where k is the subcarrier index ($0 \leq k \leq N_{used} - 1$), N_{used} is the number of used subcarriers, N_t is a number of transmit antennas, $G(x)$ is the Golay sequence defined in Table 11 ($0 \leq x \leq 2047$), fft is the FFT size used, u is a shift value ($0 \leq u \leq 127$), where the actual value of u is derived from $u = \bmod(BSID, 128)$, $\text{offset}_D(fft)$ is an FFT size specific offset as defined in Table 12, g is a ABS transmit antenna index, N_t is number of ABS transmit antennas, parameter $s = 0$, for $k \leq (N_{used} - 1)/2$ and $s = 1$, for $k > (N_{used} - 1)/2$.

Example of physical structure of MIMO midamble is shown in Figure 40 for 4TX antenna and BSID = 0.

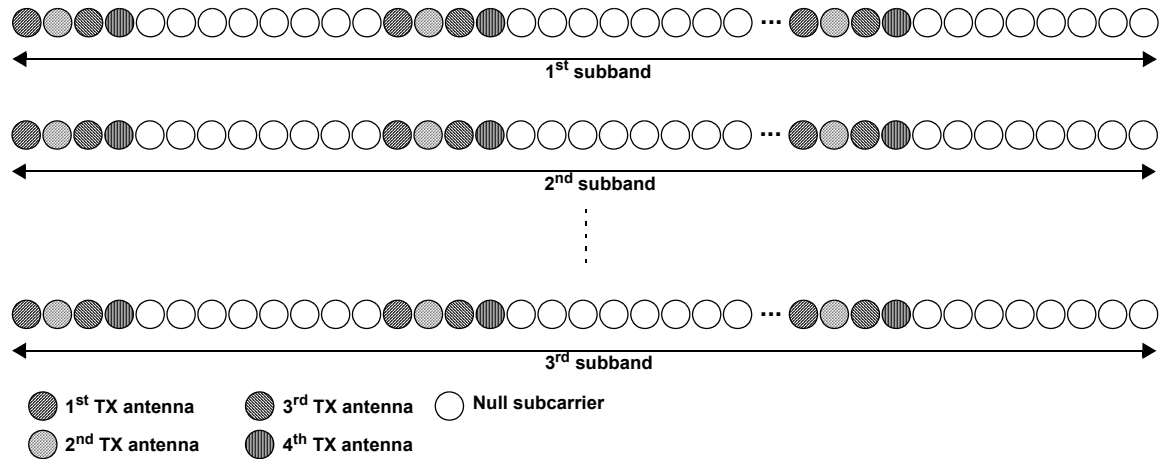


Figure 16—MIMO midamble physical structure for 4TX antennas and BSID=0

MIMO midamble shall be transmitted with boosting of 2dB.

Table 11—Golay sequence of length 2048 bits

0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2
0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D

Table 11—Golay sequence of length 2048 bits

0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0xEDE2	0xED1D	0xEDE2	0x12E2	0x121D	0x12E2	0xEDE2	0x12E2	0xEDE2	0xED1D	0xEDE2	0x12E2
0xEDE2	0xED1D	0x121D	0xED1D	0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0x121D	0x12E2	0xEDE2	0x12E2	0x121D	0x12E2	0x121D	0xED1D
0xEDE2	0xED1D	0x121D	0xED1D	0xEDE2	0xED1D	0xEDE2	0x12E2	0xEDE2	0xED1D	0x121D	0xED1D
0x121D	0x12E2	0x121D	0xED1D	0xEDE2	0xED1D	0x121D	0xED1D				

Table 12—Offsets in the Golay sequence

FFT Size	Offset
2048	30
1024	60
512	40

3.3.1.5 Downlink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 3.3.1.1 and 3.3.1.4. The guard PRUs are used as miniband CRUs at partition FP0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth.

3.3.2 Downlink control structure

3.3.2.1 Advanced Preamble

There are two types of Advanced Preamble (A-Preamble): primary advanced preamble (PA-Preamble) and secondary advanced preamble (SA-Preamble). One PA-Preamble symbol and three SA-Preamble symbols exist within the superframe. The location of the A-Preamble symbol is specified as the first symbol of frame. PA-Preamble is located at the first symbol of second frame in a superframe while SA-Preamble is located at the first symbol of remaining three frames. Figure 17 depicts the location of A-Preamble symbols.

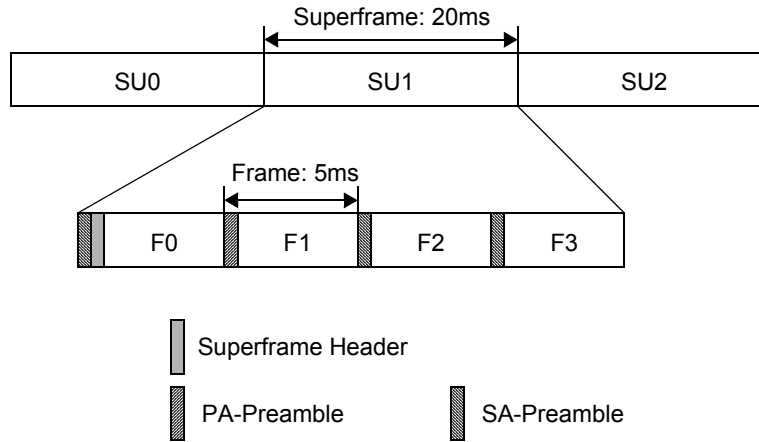


Figure 17—Location of the A-Preamble

3.3.2.1.1 Primary advanced preamble (PA-Preamble)

The length of sequence for PA-Preamble is 216 regardless of the FFT size. PA-Preamble carries the information of system bandwidth and carrier configuration. When the subcarrier index 256 is reserved for DC, the allocation of subcarriers is accomplished by Equation (26):

$$PAPreambleCarrierSet = 2 \cdot k + 41 \quad (26)$$

where

$PAPreambleCarrierSet$ specifies all subcarriers allocated to the PA-Preamble, and

k is a running index 0 to 215.

Figure 18 depicts the symbol structure of the PA-Preamble in the frequency domain.

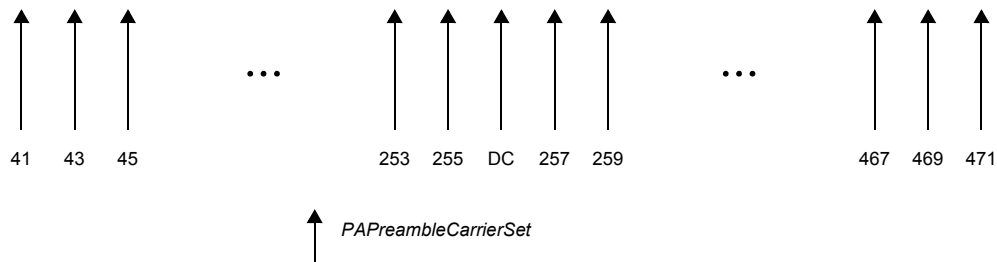


Figure 18—PA-Preamble symbol structure

In Table 13 the sequence of the PA-Preamble is defined in a hexadecimal format. The defined series is mapped onto subcarriers in ascending order. The value of the series is obtained by converting the series to a binary series and starting the series from the MSB up to 216 bits (0 mapped to +1 and 1 mapped to -1).

Table 13—PA-Preamble series

Index	Carrier	BW	Series to modulate
0	Fully configured	5 MHz	6DB4F3B16BCE59166C9CEF7C3C8C A5EDFC16A9D1DC01F2AE6AA08F
1		7, 8.75 and 10 MHz	1799628F3B9F8F3B22C1BA19EAF94 FEC4D37DEE97E027750D298AC
2		20 MHz	92161C7C19BB2FC0ADE5CEF3543A C1B6CE6BE1C8DCABDDDD319EAF7
3		<i>Reserved</i>	6DE116E665C395ADC70A8971690862 0868A60340BF35ED547F8281
4		<i>Reserved</i>	BCFDF60DFAD6B027E4C39DB20D78 3C9F467155179CBA31115E2D04
5		<i>Reserved</i>	7EF1379553F9641EE6ECDBF5F14428 7E329606C616292A3C77F928
6		<i>Reserved</i>	8A9CA262B8B3D37E3158A3B17BFA 4C9FCFF4D396D2A93DE65A0E7C
7		<i>Reserved</i>	DA8CE648727E4282780384AB53CEE BD1CBF79E0C5DA7BA85DD3749
8		<i>Reserved</i>	3A65D1E6042E8B8AADC701E210B5 B4B650B6AB31F7A918893FB04A
9		<i>Reserved</i>	D46CF86FE51B56B2CAA84F26F6F20 4428C1BD23F3D888737A0851C
10	Partially configured	N/A	640267A0C0DF11E475066F1610954B5 AE55E189EA7E72EFD57240F

The magnitude boosting levels for different FFT size are shown in Table 14.

Table 14—PA-Preamble boosting levels

512	1k	2k
2.3999	3.4143	5.1320

For 512-FFT, the boosted PA-Preamble at k^{th} subcarrier can be written as

$$c_k = 2.3999 \cdot b_k$$

where b_k represents the PA-Preamble before boosting (+1 or -1).

In the case where advanced air interface supports the WirelessMAN-OFDMA MSs in mixed mode, the PA-Preamble symbol with a different time domain waveform from the WirelessMAN-OFDMA preamble should be transmitted by offset of an integer number of subframes, T_{OFFSET} as shown in Figure 19

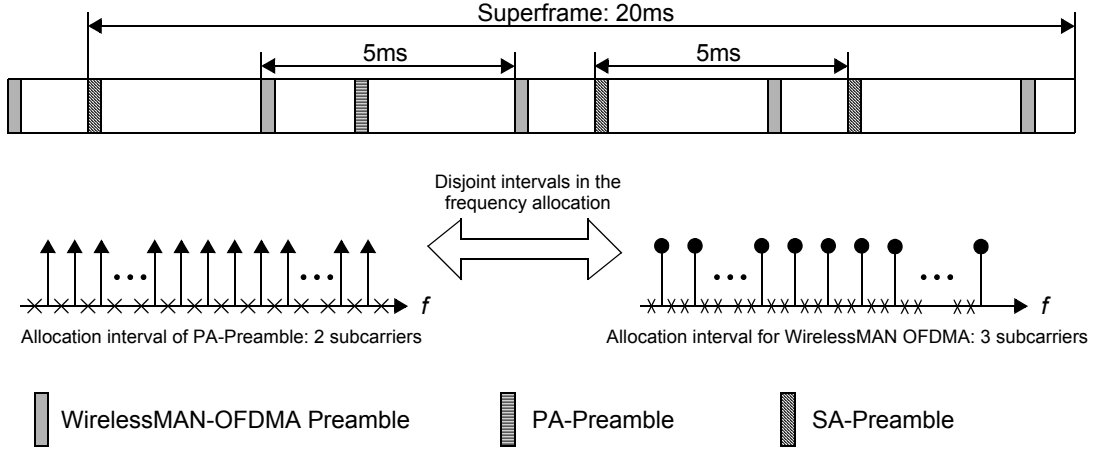


Figure 19—A-Preamble transmission structure supporting WirelessMAN-OFDMA

3.3.2.1.2 Secondary advanced preamble (SA-Preamble)

The N_{SAP} , the lengths of sequences for SA-Preamble are 144, 288, and 576 for 512-FFT, 1024-FFT, and 2048-FFT, respectively. The allocation of subcarriers is accomplished by Equation (27), when the subcarrier indexes 256, 512, and 1024 are reserved for DC for 512-FFT, 1024-FFT, and 2024-FFT, respectively.

$$SAPreambleCarrierSet_n = n + 3 \cdot k + 40 \cdot \frac{N_{SAP}}{144} + \left\lfloor \frac{2 \cdot k}{N_{SAP}} \right\rfloor \quad (27)$$

where

$SAPreambleCarrierSet_n$ specifies all subcarriers allocated to the specific SA-Preamble,

n is the index of the SA-Preamble carrier-set 0, 1 and 2 representing segment ID,

k is a running index 0 to $N_{SAP} - 1$ for each FFT sizes.

No circular shift which will be defined later is assumed.

Each segment uses an SA-Preamble composed of a carrier-set out of the three available carrier-sets in the following manner:

Segment 0 uses SA-Preamble carrier-set 0.

Segment 1 uses SA-Preamble carrier-set 1.

Segment 2 uses SA-Preamble carrier-set 2.

Each cell ID has an integer value ID_{cell} from 0 to 767. The ID_{cell} is defined by segment index and an index per segment as follows:

$$ID_{cell} = 256n + Idx$$

where

n is the index of the SA-Preamble carrier-set 0, 1 and 2 representing segment ID,

$$Idx = 2 \bmod(q, 128) + \lfloor q/128 \rfloor, q \text{ is a running index 0 to 255.}$$

SA-Preamble sequences are partitioned and each partition is dedicated to specific base station type like macrocell ABS, Macro Hotzone ABS, Femto ABS. The base station types are categorized into macro ABS and non-macro ABS cells by hard partition with [TBD] sequences dedicated for macro ABS. The non-macro ABS information is broadcasted in a hierarchical structure, which composes of S-SFH SP3 and AAI_SCD message. In S-SFH SP3, non-macro ABS cell type is partitioned as public and CSG femto base stations. The AAI_SCD message provides finer partition information. The non-macro ABS base stations can be further categorized different types, such as: hotzone, relay, OSG and etc. The CSG femto base stations can be further categorized, such as: CSG-closed and CSG-open.

For the support of femtocell deployment, a Femto ABS should self-configure the segment or subcarrier set for SA-Preamble transmission based on the segment information of the overlay macrocell BS for minimized interference to macrocell if the Femto ABS is synchronized to macrocell BSs. The segment information of the overlay macrocell BS may be obtained by communications with macrocell BS through backbone network or active scanning of SA-Preamble transmitted by macrocell BS.

For 512-FFT size, the 144-bit SA-Preamble sequence is divided into 8 main sub-blocks, namely, A, B, C, D, E, F, G, and H. The length of each sub-block is 18 bits. Each segment ID has different sequence sub-blocks. Table 17 to Table 19 depict the 8 sub-blocks of each segment ID where LSB 36 bits are used to represent the QPSK sequence $\{+1, +j, -1, -j\}$ of each sub-block. The sequences for each sub-block for each segment are represented by QPSK manner. Table 17, Table 18, and Table 19 include 128 sequences indexed by q from 0 to 127 in a hexadecimal format for segment0, segment1, and segment2, respectively. The modulation sequence is obtained by converting a hexadecimal $X_i^{(q)}$ of a sub-block into two QPSK symbols $v_{2i}^{(q)}$ and $v_{2i+1}^{(q)}$, where $i = 0, 1, \dots, 7$. The converting equations are as follows:

$$v_{2i}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,0}^{(q)} + b_{i,1}^{(q)})\right)$$

$$v_{2i+1}^{(q)} = \exp\left(j\frac{\pi}{2}(2 \cdot b_{i,2}^{(q)} + b_{i,3}^{(q)})\right)$$

where $X_i^{(q)} = 2^3 \cdot b_{i,0}^{(q)} + 2^2 \cdot b_{i,1}^{(q)} + 2^1 \cdot b_{i,2}^{(q)} + 2^0 \cdot b_{i,3}^{(q)}$

The other 128 sequences indexed by q from 128 to 255 can be obtained by the following equations: $v_k^{(q)} = (v_k^{(q-128)})^*$, where $q = 128, 129, \dots, 254, 255$

For 512-FFT size, A, B, C, D, E, F, G, and H are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID, as shown in Figure 20. For higher FFT sizes, the basic sub-blocks (A,B,C,D, E, F, G, H) are repeated in the same order. For instance in 1024-FFT size, E, F, G, H, A, B, C, D, E, F, G, H, A, B, C, D are modulated and mapped sequentially in ascending order onto the circular-shifted SA-Preamble subcarrier-set corresponding to segment ID.

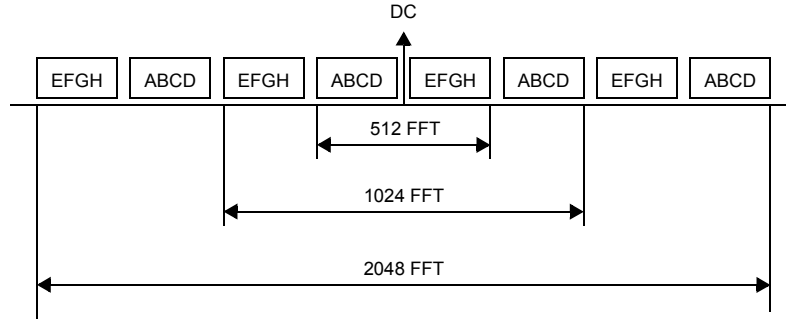


Figure 20—Allocation of sequence sub-blocks for each FFT

A circular shift is applied to over 3 consecutive sub-carriers after applying subcarrier mapping based on Equation (27). Each subblock has common offset. The circular shift pattern for each subblock is:

$$[2, 1, 0, \dots, 2, 1, 0, \dots, 2, 1, 0, 2, 1, 0, \text{DC}, 1, 0, 2, 1, 0, 2, \dots, 1, 0, 2, \dots, 1, 0, 2],$$

where the shift is circularly right shift.

For 512-FFT size, the sub-blocks (A, B, C, D, E, F, G, H) experience the following right circular shift (0, 2, 1, 0, 1, 0, 2, 1) respectively. Figure 21 depicts the symbol structure of SA-Preamble in the frequency domain for 512-FFT.

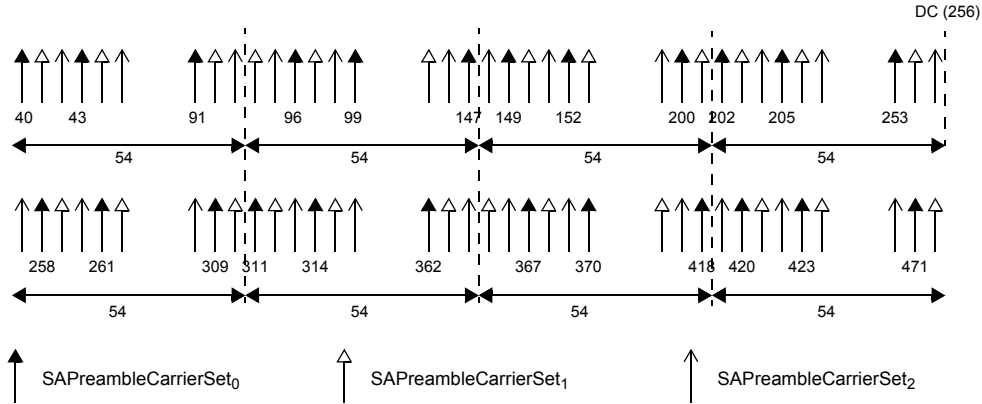
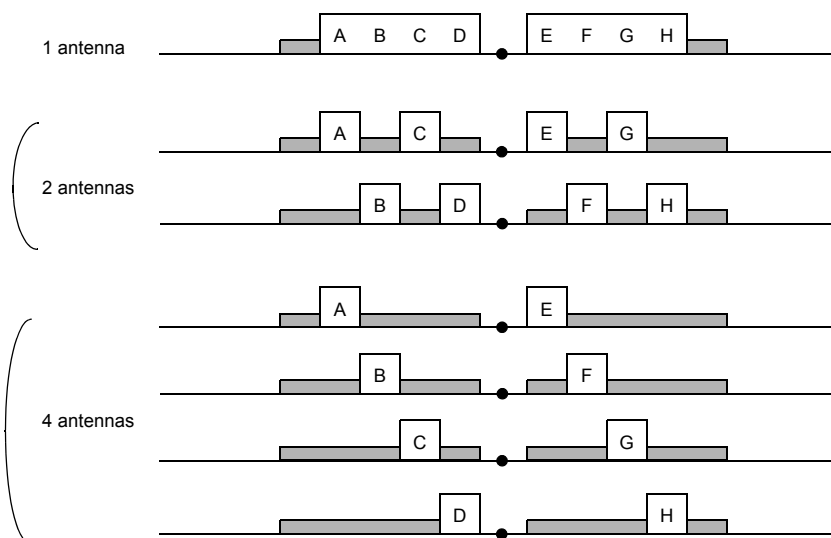


Figure 21—SA-Preamble symbol structure for 512-FFT

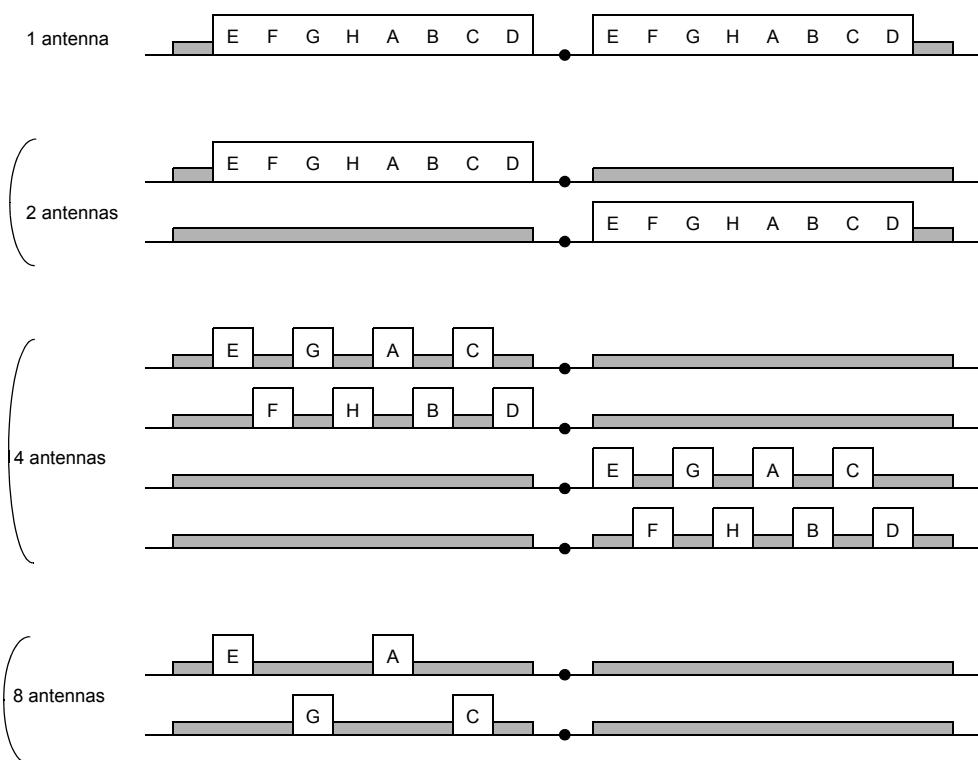
For multiple antenna systems, the SA-Preamble blocks or sub-blocks are interleaved on the number of antennas as follows. For 512-FFT size, Figure 22 depicts the SA-Preamble allocation for 1, 2, 4 and 8 antennas.



8 antennas: Each antenna sends one sub-block {A,B,C,D,E,F,G,H}

Figure 22—Multi antenna example for 512-FFT

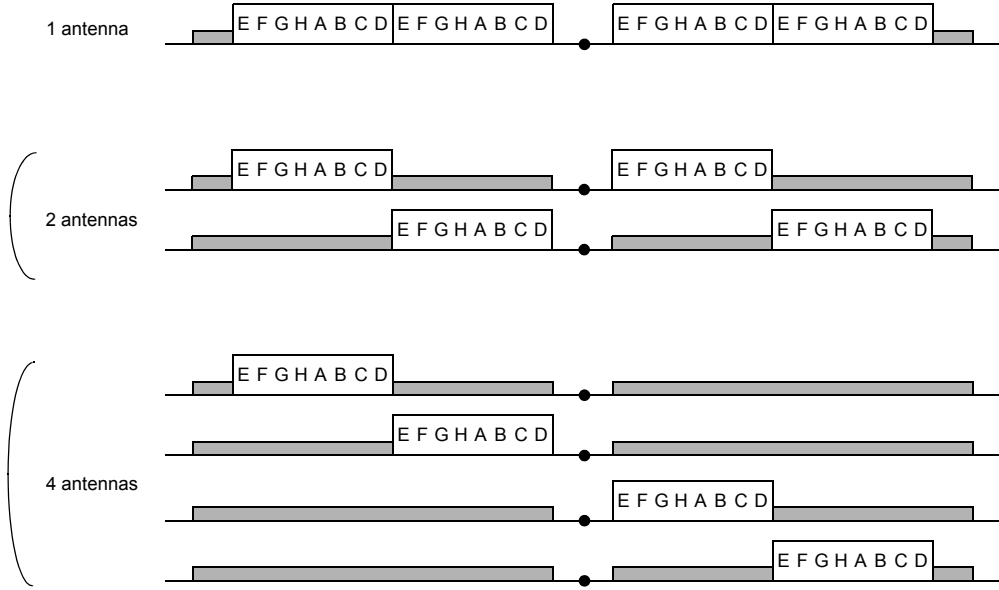
For 1024-FFT size, Figure 23 depicts the SA-Preamble allocation for 1, 2, 4, and 8 antennas.



Similarly, each four blocks of the 4-antenna case is transmitted using two antennas in the 8-antenna case using interleaved structure

Figure 23—Multi-antenna example for 1024-FFT

For the 2048-FFT, Figure 24 depicts the SA-Preamble allocation for 1, 2, and 4 antennas.



8 antennas: Each block {E,F,G,H,A,B,C,D} in the above 4-antenna scenario is interleaved across two antennas where [E,0,G,0,A,0,C,0] is transmitted via the first antenna and [0,F,0,H,0,B,0,D] is transmitted via the second antenna.

Figure 24—Multi-antenna example for 2048-FFT

Let “block” denote 8 consecutive sub-blocks {E, F, G, H, A, B, C, D}. The algorithm to assign the preamble blocks to multiple transmit antennas where the number of antennas is power of 2 can be described as follows. Let:

- N_t : number of transmit antennas,
- N_b : total number of blocks,
- N_s : total number of sub-blocks; $N_s = 8 * N_b$,
- N_{bt} : number of blocks per antenna; $N_{bt} = N_b / N_t$, and
- N_{st} : number of sub-blocks per antenna; $N_{st} = N_s / N_t$

If ($N_{bt} \geq 1$)

Distribute consecutive blocks across the N_t antennas

For a given antenna, a block is repeated with period N_t

Block position of the antenna $t = t + p * N_t$, where $t = 0, 1, \dots, N_t - 1$, $p = 0, 1, \dots, N_{bt} - 1$

Else

If ($N_{st} = 4$)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 2 consecutive antennas

Block [E,0,G,0,A,0,C,0] is sent from antenna i at block position: $\text{floor}(i/2)$

Block [0,F,0,H,0,B,0,D] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/2)$, where $i = 0$ for 512-FFT. $i = 0, 2$ for 1024-FFT, and $i = 0, 2, 4, 6$ for 2048-FFT

Else If ($N_{st} = 2$)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 4 consecutive antennas
 Block [E,0,0,0,A,0,0,0] is sent from antenna i at block position: $\text{floor}(i/4)$
 Block [0,0,G,0,0,0,C,0] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/4)$
 Block [0,F,0,0,0,B,0,0] is sent from antenna $i+2$ at block position: $\text{floor}((i+2)/4)$
 Block [0,0,0,H,0,0,0,D] is sent from antenna $i+3$ at block position: $\text{floor}((i+3)/4)$, where
 $i = 0$ for 512-FFT and $i = 0,2$ for 1024-FFT

Else If ($N_{st} = 1$)

Interleave the 8 sub-blocks {E,F,G,H,A,B,C,D} across each 8 consecutive antennas, i.e.,
 send 1 sub-block per antenna
 Block [E,0,0,0,0,0,0,0] is sent from antenna i at block position: $\text{floor}(i/8)$
 Block [0,F,0,0,0,0,0,0] is sent from antenna $i+1$ at block position: $\text{floor}((i+1)/8)$
 Block [0,0,G,0,0,0,0,0] is sent from antenna $i+2$ at block position: $\text{floor}((i+2)/8)$
 Block [0,0,0,H,0,0,0,0] is sent from antenna $i+3$ at block position: $\text{floor}((i+3)/8)$
 Block [0,0,0,0,A,0,0,0] is sent from antenna $i+4$ at block position: $\text{floor}((i+4)/8)$
 Block [0,0,0,0,0,B,0,0] is sent from antenna $i+5$ at block position: $\text{floor}((i+5)/8)$
 Block [0,0,0,0,0,0,C,0] is sent from antenna $i+6$ at block position: $\text{floor}((i+6)/8)$
 Block [0,0,0,0,0,0,0,D] is sent from antenna $i+7$ at block position: $\text{floor}((i+7)/8)$, where
 $i = 0$ for 512-FFT.

Each time frame, the transmitted structures are rotated across the transmit antennas. For example, we consider the 512-FFT system with 4 transmit antennas. At the j^{th} frame, the preamble structure [A,0,0,0,E,0,0,0] is sent via the first antenna, and structure [0,0,0,D,0,0,0,H] is sent via the fourth antenna. Hence, at the $(j+1)^{\text{th}}$ frame, structure [0,0,0,D,0,0,0,H] is sent via the first antenna, while structure [A,0,0,0,E,0,0,0] is sent via the second antenna.

The magnitude boosting levels for different FFT size and number of antennas are shown in Table 15.

Table 15—SA-Preamble boosting levels

Ant\FFT	512	1k	2k
1	1.87	1.75	1.73
2	2.51	2.33	2.43
4	4.38	3.56	3.98
8	8.67	6.25	5.13

For single-antenna case, the SA-Preamble is transmitted with a magnitude boost of 1.87. The boosted SA-Preamble at k -th subcarrier can be written as:

$$c_k = 1.87 \cdot b_k$$

where b_k represents SA-Preamble before the boosting (+1, -1, +j or -j). The block cover sequence shall be applied to each sub-block. Each bit {0, 1} of block cover sequence shown in Table 16 as a hexadecimal format is mapped to real number {+1, -1}, and then multiplied to all the sub-carriers in the corresponding sub-block in the structure depicted in Figure 20.

Table 16—SA-Preamble block cover sequence

(FFT,number of antennas)\Segment ID	0	1	2
(512,1)	00	00	00
(512,2)	22	22	37
(512,4)	09	01	07
(512,8)	00	00	00
(1024,1)	0FFF	555A	000F
(1024,2)	7373	3030	0000
(1024,4)	3333	2D2D	2727
(1024,8)	0F0F	0404	0606
(2048,1)	08691485	1E862658	4D901481
(2048,2)	7F55AA42	4216CC47	3A5A26D9
(2048,4)	6F73730E	1F30305A	77000013
(2048,8)	2F333319	0B2D2D03	0127271F

Table 17—SA Preamble for $n = 0$ (Segment 0)

Idx\blk	A	B	C	D	E	F	G	H
0	314C8648F	18BC23543	06361E654	27C552A2D	3A7C69A77	011B29374	277D31A46	14B032757
1	281E84559	1A0CDDF7E	2473A5D5B	2C6439AB8	1CA9304C1	0AC3BECDD	34122C7F5	25362F596
2	00538AC77	38F9CBBC6	04DBCCB40	33CDC6E42	181114BE4	0766079FA	2DD2F5450	13E0508B2
3	3BE4056D1	2C7953467	0E5F0DE66	03C9B2E7D	1857FD2E3	15A276D4F	210F282AF	27CE61310
4	3DBAAE31E	254AE8A85	168B63A64	05FDF74FB	3948B6856	33656C528	1799C9BA1	004E0B673
5	177CE8FBC	21CEE7F09	397CD6551	01D4A1A10	1730F9049	067D89EA9	3AC141077	3D7AD6888
6	3B78215A1	17F921D66	385006FDC	011432C9D	24ED16EA6	0A54922F1	02067E65D	0FEC2128D
7	01FF4E172	2A704C742	3A58705E1	3F3F66CD2	07CA4C462	1854C8AA3	03F576092	06A989824
8	1A5B7278E	1630D0D82	3001EF613	34CCF51A1	2120C250A	06893FA2D	156073692	07178CFA7
9	032E31906	2DD318EAA	1DE55B14D	0EF4B6FB3	27DED0610	1BC8440D3	0ED86BF8D	14FAFDE2C
10	174725FFD	0D2FB1732	124470F56	292D9912B	1571408A7	227197AE9	2430BC576	0B67304E0
11	1F1DCD669	293DD1701	0C34F1B84	28496EE51	3DC41327F	071C06523	28E1657B6	02588EFDA
12	22E4AA041	3810362F1	1955F1DE7	0D6D2F8BE	11F31358E	3EB27BB12	1F4E60111	119BDA927
13	14300B522	152E6D482	168DF6E43	0740B7AE0	14FE7DCDD	0FA092626	23697615A	1F1331EB8

Table 17—SA Preamble for $n = 0$ (Segment 0)

14	12C65ED00	317643CD7	2C637A415	15E3E185	0F5CBB9E0	23290B156	26F37EFE8	1AA174793
15	1DD6453F0	032C4BD39	082659BD5	320C5E691	224E555B2	3A9615A8D	1BED03424	28E6A9CED
16	068AE7EE9	16F724910	3803DD9BD	2A31A2FFB	010BF5237	33CB067E6	0280C28B7	184417B94
17	1D651280A	2C7BCF443	17324EFB0	236E5C411	381215183	2F076E64E	0A6F2EE74	3DA4196B7
18	27341650F	1B520099C	09AC91114	000A5F48B	30AB4B9B6	2D0DB0DE6	1CF57978A	2D424406B
19	3A01E2FB2	0DF5B257B	019D1C63A	0EA7DCDD8	242D96605	2DA675F15	1DEC54193	3B6341C16
20	2DDFAEB05	21D0A1700	0FA09BB78	17DA7F8BB	06E883B3F	02E6B929B	2C1C413B4	030E46DD1
21	1B625E3F9	0F708F756	00CD97B18	3F036B4DF	2CF08C3E5	213A5A681	14A298D91	3D2ED63BC
22	2DA48D5A9	0C085BD17	01903428A	3DF2A30D9	29061309A	16F7DC40E	2AF88A583	27C1DA5E9
23	30DBAC784	20C3B4C56	0F1538CB7	0DDE7E1BE	2C312903B	0FF21E6C2	032C15DE3	26C9A6BA4
24	3188E8100	385FEFE2D	3967B56C7	3F62D246B	1826A755E	2CDA895EA	2FAB77825	1B525FF88
25	339467175	2DE49506B	27B7282A9	0254470A3	3374310AF	2DF20FD64	3848A6806	11C183E49
26	02AFA38DC	0F2AFDDF4	1A05650E2	061439F88	11C275BE0	30C41DEC9	119E070E9	1E76542C1
27	1B364E155	086FF808C	29F1BA9DC	0A830C788	2E70D0B3A	34EA776B1	3D13615C0	15FC708D4
28	38ECFC198	07034E9B3	2340F86B3	07562464C	22823E455	1F68D29E9	257BB66C6	1083992F1
29	375C4F5AB	3C0F5A212	0EA21BC30	13E8A26F2	17C039773	283AD6662	1F63AB833	2DE933CAF
30	2B773E3C5	3849BBE6C	1CAD2E5AB	0405FA1DE	1B27B4269	3B3BF258F	300E77286	39599C4B1
31	1E878F0BE	0AE5267EC	376F42154	1CD517CC2	302781C47	123FEC7E0	16664D3D8	24B871A55
32	20E200C0A	1C94D2FF1	213F8F01B	369A536E0	161588399	29389C7FC	259855CAC	06025DCE2
33	28D2E001C	3C51C3727	106F37D0E	1FB0EFDD1	2CD9D33C3	1EA190527	0BB5A6F9E	074867D50
34	08EFC44B5	1B484EABE	05FEB2DE2	211AF91B5	0CF52B1E1	002B5C978	11D6E5138	0D402BDD2
35	337C618F4	0A4C31DDA	1D93003D6	006D7D088	348043A6D	325E05758	2C53EEEB8	15ED8E614
36	38375C2FF	18C78FD02	30C11EF53	3916581DD	1B75263FF	2D8DFD6A9	00C4E8482	1D201F96A
37	2E10B0D05	2EF203893	2491D95F1	34D995B51	32214BDF5	3E45674B1	3E74AC66E	1B813A999
38	153E7269D	2391C7BFC	1ADD3A595	0EFD3086E	00AD88A8E	0D8B007CA	0F22C5F9D	010E86385
39	3B58C7BFF	0BA76496E	3AD0B7BBF	1D6D10FB3	3A607BEFC	28F122A95	057950727	179449CB7
40	37AC5194A	390BD9C00	3A48C0461	12FBCE4C6	2A8DD4171	10E9F1E34	251F5D167	1124E96B1
41	0FEF20C67	31EC9EA3F	275B31143	22DA4F02B	352C0F648	21FF5B9F3	3E5BC2372	0A1AE08FE
42	080EDC49B	17AD7F7BA	390775B3C	1380B00DA	2477FF17C	2E6D9E5AF	05381F2DD	26143CC17
43	2DB485795	1B3252799	39AD0211C	3AAE31B76	30532A187	1C8EA5F5A	2EA6E4D6B	30570A2E4
44	11BB4F78A	12CCE1428	2C67EEF99	20E3F841A	20CFCD5F2	1618A7B94	111FF6092	2ED034E06
45	1C66335E5	0CA9B9BD2	3213028AE	15542DD28	290F7DAE2	2137F02D5	17DF9445D	24F162FFB
46	360FB966B	17D878955	1C1D67093	065B84F3A	1A1D955E3	24C73C11E	270EA9EB2	114DCA02C
47	002CE84DD	0616DD253	3EB188345	1FF852926	37E160F00	040DF51EC	1857A33BA	230FD8A0D
48	233C0A71F	22E428104	0325F8170	39566B188	32DA16A4A	039FDF1DC	27A3E946C	0D69F26D9
49	0583F9F73	378380CB6	059D8A960	3E3442C7F	026138ADB	25F370F1E	09D3EB2CC	2D37D50C0
50	08DF9CC66	2C2E7AA8F	3CB241ED2	03216B4D2	39736B451	25F6F113F	08FD2AC3C	1974574FD
51	3D1FF6041	2CE2AB97F	01A734F3B	1DCF9F3C5	268D595CA	1FBD2A8B8	0F1449F86	370C352FD
52	123218E40	3AA057589	20F73A16F	26E3BCA5F	3A7330DC6	12C659384	39D99FF1B	276DFC540

Table 17—SA Preamble for $n = 0$ (Segment 0)

53	185AEDEA4	0418B3643	382F7700A	3FC35ED60	07BA2F838	1BC840C93	2469A41EC	0CE7B4CB0
54	2E194E2BF	3302A0B28	1836001EE	154A4738A	36A3BBD72	23CCD0EB1	044B3A13B	2B50C8057
55	0B76405D3	231AAA728	0EE05E9B6	0093A21F2	2065A01D0	1F2B810D4	1082F3A73	1DAFEA492
56	07AD23A3A	2091957F1	3B9D8CBF0	21E4160BE	1BFB25224	3D9085D16	03076DD39	1DBCFFD03
57	226D70EBF	3ED15246C	364130C46	22F6D4AA3	3FCC9A71B	3B9283111	0484F0E58	14574BD47
58	3F49B0987	305231FA6	0CF4F6788	3B9296AED	2346190C5	3365711F4	078900D4A	352686E95
59	1D62AC9A4	104EDD1F5	1B0E77300	1CED8E7F0	388E8002C	1FE6199F4	02239CB15	1FE5D49A2
60	21314C269	28600D12A	22E4F1BAA	044E211B1	0DECFE1B4	3E5B208CC	1CFC91293	21E7A906B
61	02C029E33	1BA88BE4D	3742AE82F	21EF0810F	17D23F465	240446FB5	17CCE51D9	2C0B0E252
62	16F9D2976	10185ECE6	2821673FD	02674271C	3A8A75B7C	226D4BF0F	2216004E5	0E8605674
63	06E4CB337	32A31755D	062BE7F99	1417A922D	2271C07E5	24D6111FA	3F2639C75	0CE2BB3A0
64	18D139446	2426B2EA8	352F18410	1133C335E	10CC1A28F	1A8B54749	22A54A6F4	2F1920F40
65	22443017D	2265A18F5	14E1DAE70	11AC6EA79	31A740502	3B14311E7	3AA31686D	26A3A961C
66	2018F4CA9	3A0129A26	39BDA332E	1941B7B49	03BBCE0D8	20E65BD62	2E4A6EE6C	3B095CCB3
67	0CC97E07D	11371E5FF	31DFF2F50	17D46E889	352B75BEA	1F1529893	21E6F4950	1BD034D98
68	275B00B72	125F0FE20	0FB6DE016	0C2E8C780	3026E5719	119910F5F	3B647515B	1D49FED6F
69	250616E04	0882F53BF	11518A028	3E9C4149D	09F72A7FB	0CC6F4F74	2838C3FD1	08E87689B
70	212957CC2	03DD3475B	044836A0B	2463B52C0	0342FB4B0	34AD95E9B	2936E2045	3B0592D99
71	2922BD856	22E06C30C	390070AED	09D6DC54F	3485FA515	064D60376	07E8288B3	3DD3141BF
72	29CB07995	007EE4B8B	16E787603	07C219E93	1031B93DD	23DEFF60B	30F1D7F67	0EFE0E2882
73	11F3A0A2F	38C598A57	3FE72D35B	1F655E0D1	0B3AC0D92	3430DDDB1A	3BAADBF42	02D6124C0
74	05FC8085D	345A5C470	07DAAE1E9	0D7150B88	25D2A5B10	16F8E5021	3240EFC71	0F0F5922D
75	399F32F6E	2EEB17A8E	0D61665D0	2138EE96F	3F8119063	01B5048F7	27075153D	265DF8280
76	3962CC581	2337D2983	286FD7BBA	185126E0E	1F95AD927	0F7EBC374	1E3A4B6FF	20CA9B9BD
77	1C85C13AF	290C37167	1FDD26E8F	0C38736B8	0174DB972	0A921E3CC	097557C9D	09452C1E6
78	2D48D6C00	2D9BC8DFE	10FF1E128	25C96BA85	0FB071B8E	0F09B3C9C	1A3E11441	38EDDA03D
79	396B88B2F	0029F4BDB	30D098CAD	0D54D12CB	1D0823F55	2DC53B9AA	11BCF7438	33F6EC091
80	21E03CD65	1A2FE5B92	2851F8445	0251E386C	1468950D8	1A8B39748	001B42236	26CD82DA5
81	2CEA1E6BB	006C97E74	00C2B887D	23461AF95	0E9CB2BD2	0B0EA3022	1FB56A7A3	25A7FA625
82	208FC2A1F	381C5733A	03F11D7E3	07ED6A7B7	1FEC85E09	3D61E0440	356F4B1C3	3756E5042
83	2061E47F0	22EAA0AD3	24796BB65	03C59B4D8	32A75E105	22155381B	23E5F041C	155D2D7F9
84	381AFFB73	212B5E400	1F1FE108E	04BF2C90D	3C1A949D9	2854A9B45	001B09322	3A9372CC1
85	058B23433	0904C6684	158CADB9E	11BA4B978	1854368F4	1919ECEA7	147F1FD34	2E228AA3C
86	34857F3DB	2CB44F7BF	111A065D3	1BEAB392E	27F081ED8	3E67D1186	0F6265AC5	27716FAF9
87	38EBB8BF1	32ED6E78F	2B0BA4966	2188282AA	00D49B758	1765BA752	2B50AFDCC	068C82450
88	234F0B406	02FB239CD	15AD61139	2250A5A05	1CD8117E0	0D849163F	268C7A5A6	22A802020
89	2D0FE8D16	0C14E3771	07DE5320C	0640C2762	1CBD9FF4E	37A91986D	2024DA401	164D4A84C
90	3225B4D60	3013B75F2	2A77AE5C5	2C25377EE	03C8DF835	346E80FCB	116B79FA5	356D2B604
91	0D55231FD	247907F31	0CFA0B049	36D069A95	10D4CDE71	1A32544D7	38336885F	173ECC08D

Table 17—SA Preamble for $n = 0$ (Segment 0)

92	207420EAC	26FCFE182	3FE7B31C6	15B320E13	187AA34A8	1B52253BF	1FA16669D	3725A81A5
93	3C9C7404A	092B77FEB	3B9865B46	349456F61	39B7C6A66	3075EC990	01BE637DF	330897B17
94	1CA4C048D	2B4D50621	2BF917627	3EA2CC5E1	33EC0A1E3	05FE0F747	349553D72	396077301
95	04CEC1C82	1F828DD00	30122C790	1AD8A7895	1CE0912C0	298382F37	2D4D33F06	001364B36
96	37F8BB035	2F0897994	333F5F096	0F28AB363	20036829F	338017E2D	3A5A05D76	0CC02E5E0
97	02FD351E6	03E316288	2FCAEB4F8	1C5A80CE3	3D3AC3FDD	3E456746D	119A5381F	1581C894E
98	1623B3D0F	103224DB0	0FB936BC8	2EED7F082	26C91513A	2F12E4C31	290F3AEF2	392CBFF67
99	02F75DE8F	2E61A834D	02A692866	1F21044A3	2D7881A95	18651EE05	11FE3D308	39EED56DA
100	3A858659E	2F7A87BE0	135FD561D	27B3B651A	05E131CB9	0D5865123	2CD6991E5	3EE6DF705
101	3F3B247E1	32D02B245	16B98A593	1E4CCFF18	0C4A9D285	06D519FE2	023A336CD	1B20E999E
102	3A9E8B49B	239656AD1	3396D1C51	06F4DCF40	15D819D3F	2A3061144	20BD2A33E	2FFB139CD
103	38622F3AF	24BF9BB7F	1D2729010	15877B93A	00376B0E7	0FF064887	3505CFD9B	354C366B6
104	2A0AB7033	1AFA65DE1	1198D0AD6	38E80C86A	27693D541	3BB26F3D4	39154881C	0E7DD6B6B
105	1B0DE4333	27FE0F6D1	0F00B2888	0BDA322FF	2759B5A4F	0543A2D27	0C36DD1E5	04E9A262D
106	1C7E636BF	000E9C271	2B44F4F30	28255BF77	1CC4D69CE	03F4C57B2	3E926D59B	00AA39BDB
107	1FDE98AE0	0CD076B07	171124FB5	33F098288	1E0B3043E	39731D117	3E7ABC2C8	19CC50279
108	28EE855ED	2A704C371	03288F4B0	3C83E26C2	0A905148B	18C66BB94	1BCC32537	10D71AB44
109	26238A065	0FBD7BCDD	02507CF76	059F69484	3FE0D6F77	2466A50DB	3C07A75B2	2DC0F099E
110	3CDCD6CBE	1446783DA	1626C83F9	2FD4C4DF3	13A59A2D1	2C903D2A3	0FD37F076	0B1039EDD
111	043B07DD7	28D9C2155	2CCE57A8	34254C1B7	09B933B2F	1FA410127	10BD5E9E6	010EC6389
112	345E8FCAC	226BD7EFA	27341A51C	23854F031	04C297212	044DED8E8	319B3BFB8	37DBBBF57
113	16FBFA72	1B5EF9484	2DEE7A5BF	097695C12	08AEAD5E8	3DA7C1327	2B81F3E2D	31AFBED32
114	3484086B1	2DFA56B9E	226E8AFE5	285F45484	3E69AC8E1	1CB33645F	2DE53BC30	2F6ED567E
115	1117B5E7D	122A4D471	1AC936544	267010D71	10428CA47	24B72A000	2E27FE185	1E62C1403
116	0B3161E37	038C3DC98	100793647	1A95D8D36	399668787	06C0D4922	25F48AA58	2DFFF1789
117	04FEF7231	381910B63	298783078	30CE5EC1C	29F6F299D	3C34CA770	37BAAB139	3D2069B65
118	18F644052	2051880EC	23ADB9F49	04237280A	18304E663	287364EFF	314698D78	149A21E51
119	39E14BBCB	1DBDA9EF4	3ECCAD8D3	1BA3EF99D	26D85CEBF	270547292	0FB3C7826	0131E73D6
120	2DD6F3F93	0FC282088	14A143DDD	0AB840813	0B973037C	29535C9AB	0DF8DA2AC	271CBC095
121	1C1D063F9	3F4EF6DCC	00128D932	145E31F97	0B21590D1	38F1602D8	3AC2EBB74	2320957C5
122	3383C846F	12128F29B	19985CE7D	2834CBBF2	1E1513B3D	364DB5800	33EE3F46C	01A865277
123	0129D260B	238A85BA0	2D81AA924	3917048B6	36F857692	1D2F813C3	0505FB48B	3DC438BC5
124	05E0F8BDC	3D978C1F1	266F83FCA	0E89D715A	01821DEA4	12D9AE517	22F8EAC2C	3C098DA58
125	1575D1CE9	26F291851	3A7BB6D2C	12CC21A3A	2975589B0	39CF607FF	388ABF183	3D3BAAB0B
126	101E5EC7A	0B75BCF3B	13ED25A86	35FC032B6	2F6209FF0	13C7B2041	1F2791466	3A759A6C2
127	1EF89091A	11A653D2C	223FC1F42	2F7B97B31	2CA4EE011	00F68767D	10FE34682	018339212

Table 18—SA Preamble for $n = 1$ (Segment 1)

Idx\blk	A	B	C	D	E	F	G	H
0	20A601017	10D0A84DE	0A8C74995	07B9C4C42	23DB99BF9	12114A3F5	25341EDB0	362D37C00
1	1364F32EC	0C4648173	08C12DA0C	19BD8D33A	3F5F0DDA6	24F99C596	026976120	3B40418C7
2	1C6548078	0A0D98F3C	0AC496588	38CBF2572	22D7DA300	1CCEAF135	356CA0CCF	093983370
3	03A8E3621	2D2042AF5	2AB5CC93B	05A0B2E2E	0B603C09E	117AC5C94	2D9DEA5A0	0BDF0D89
4	07C4F8A63	3E6F78118	32CCD25F2	1792A7B61	0A8659788	1F9708C04	086AF6E64	040B9CD78
5	2D7EE485A	2C3347A25	3B98E86AF	242706DC3	1CEF639AF	2E1B0D6A9	3E9F78BC1	0FB31275F
6	0307936D0	21CE15F03	392655B2D	17BE2DE53	3718F9AB8	01A986D24	077BDA4EB	1D670A3A6
7	05A10F7B7	31900ACE0	28DCA8010	2D927ABE5	370B33E05	31E57BCBE	030DC5FE1	093FDB77B
8	092C4FED1	268BF6E42	24576811F	09F2DAA7F	24EFC8B1	21C205A90	1E7A58A84	048C453EB
9	29F162A99	1F739A8BF	09F684599	1BEC37264	38ED51986	286325300	344FC460A	3907B1161
10	0E4616304	0FABDCD08	0F6D6BE23	1B0E7FEDD	0047DE6C2	36742C0C6	2D7ABB967	10D5481DF
11	32DD51790	237D6ACFA	2F691197A	16724EA58	149143636	3810C6EE1	3A78B3FC6	1B1259333
12	1BB0FD4D3	235F10A55	1C7302A27	1148B18E5	04F25FBC8	2A0A8830C	3646DBE59	2F25F8C30
13	0FB38C45B	069DF29E9	00F93771B	3AA35746D	2CAF48FD0	0A42CDD55	19A23CE8F	26318A30F
14	365FBEDAC	27710945F	2AA367D61	05A484318	2563F27D9	2D37D5C00	287D18FBB	3ADB44805
15	3038BC77D	2A45D29EC	156173792	03EC7679E	07577E1A4	1B6A94A74	1D26E5A94	0FD878D5A
16	1F22158E4	3F02A1D37	2767EC03F	1C8CD535A	23DA2E5AB	2D5F25A59	0971AA889	3E78C1846
17	16521E709	12C2DB8FE	3A596C221	1562D5C27	1D9E1F39A	345B96872	301C7894E	2797F032D
18	2EC951A24	1ED768F3F	11217930A	39DB44855	36E41B3FC	0F6E48C44	36254C517	14493C673
19	3EA159E72	24ADE96FE	3458C73A6	30674E1FB	242109AF2	24DAF32B6	24B1EDFFE	291CB9D15
20	2AD0E6696	04F4077D9	1BB279A53	38957605B	379B7A6A0	0BAD35616	1285EAE51	37425C7FF
21	083637980	34F2ED66F	282846A88	19D5E40A6	21205942C	27AC551E9	0F3F4C262	0505FB522
22	3E7D64856	1DB0E599E	159120A4B	1FC788139	235C454FB	3CE5B67C8	339EADB32	0F9F7DDC1
23	3956371B8	1D67BE6E5	1EFCF7D53	041A5C363	2E281EB3F	00AF8A1ED	2DE24A56F	1332C0793
24	0818C47A9	1F945634B	1C5ED3403	1043B5BF4	149702D22	024CBB687	34B01FA8B	1E9F5992F
25	3A6618167	3A0007886	3EDB5756B	2F2FA6FCD	21A5252B8	396FFAD9D	05347B60C	2E0ECA200
26	0D45F89A1	3F9C2C26E	1CBFCF809E	3CBE5FCD0	3D2DCF245	14F351A1E	224F5B3FF	2AA6ED34B
27	3BA85ADF8	282005732	3AD7C0223	2E73D1800	23DEA3F46	2275280F6	1586270F9	0CEF4287B
28	07DFE662E	314B74F2F	397BDDC4C	223A8071F	1F5BE3BB4	093BB1F33	0FCA2D129	21B3526A9
29	39FEADC12	0ECE1CD67	206228FAA	38FCCA606	0C5EEE08F	1C1BBDD4E	1459E42ED	11FD64ADF
30	2735FFB20	2AE9B244A	1A5AED974	38FCFD5CB	20310DB81	1C5FC3E24	19FB3BA17	3785BE865
31	24FF6B7EC	01C682673	19CB14113	2C8CD3C2A	066725853	02CD0A23B	279B54315	0CD571063
32	015E28584	30B497250	127E9B2E1	2C675E959	05F442DEE	394AEF6E2	079E5C840	12703D619
33	3CE4B1266	35270B10F	03549C4B3	3B3E6C375	1DBEF270E	0042C9737	049522EC6	24961653E
34	34176CD90	2B5E9EAE1	1C95E3C2B	1EF541D4D	26D1450E6	3B9D895AB	1B0C84349	104B6B428
35	07A813421	2B39EAADC	33553571C	0F8046CDF	2CF6A7F23	0AE3BE8C8	308BFF531	2DBC0F9E3

Table 18—SA Preamble for $n = 1$ (Segment 1)

36	168276972	2CF41744F	3CF2512E0	0F8B68ABC	2E609F6AF	04E03AC8C	0F9B66F49	3AFE28736
37	03456021F	1982574F3	0BB2B3F49	15A4A1CDE	15487D58E	2907C9ABB	15C0D2D73	28D8CFEC3
38	3D3FD677C	33AF2628F	3D217FDCF	30027E85F	0A463F23B	2F2AE8324	1D1E945E0	2EB355D28
39	3BCAF9076	3A7D2FF70	3C541F38B	249BD8A94	287BC4833	141391EB7	05B6443D0	2FEACC5E7
40	275F118FA	3A96B346D	0C713CDE5	02F394A28	3EBB1D18D	1BE7A9FDD	223C53CA1	2BF040F77
41	1161DE4F5	0544F9DB7	230847E45	322AF4E17	26944A0B4	3299F1420	1C9405B8E	2DBABD4CE
42	33165C531	268FE9B9B	081A914B4	39100772B	27DBF03E9	3E3A18AB0	13F2D2B83	2CEEE5FF4
43	275F97006	0A578F2EF	16CEE7EC8	38A5B0084	00DC9A1F5	1B88CFA3D	0D8B0B8EF	29FC4CCF2
44	04BBE4F2C	1546C3988	237105A43	339042B36	3A5DEBE2B	1BD09449D	38EFF588B	1CDD3A6C0
45	002E32D38	1E85D3125	3F51120D7	00420ED63	3384713AF	1D941BD34	2B39EA9CF	05B6D9E94
46	2B3100F7B	335EDB2E6	1AC8C8EE4	337FF7139	0672D7995	38A54856E	0124753F2	3A3560851
47	046207CE9	0FE1BC312	09BA5B289	39376EF2B	33F826C2C	2F6531496	3933B8616	23125B50F
48	3E5849C45	01EEDB390	141D9A024	2DE07E565	1813D12BB	36DB8D404	0E8A272AB	3A66B71AD
49	1A2A88A4C	3F0C9B4DB	266CFBDF9	163420CA5	281ABBE99	34771C295	3AC051848	3C53CB875
50	16F795184	3466F1FFA	1F433B456	1DDF13810	25F58CF69	1DD6CFE4E	10A236FDF	12AE697ED
51	1C8D17F4F	07C43B7D1	1C8DAD395	28F6C112E	3A336ADB3	0EB6889AB	2783A6A1F	2CDA40458
52	16044624E	252AA04B2	11484E85C	07F5024B7	286E3A67F	2EE6BACE4	277F1F864	22F3CF57D
53	2D1A3F4CF	0EEB6DEC1	30CD76F42	20403D1AC	3A72EF9D6	1DAAF2A39	03AB76CE0	0A2856267
54	0FA2A786B	38273EDF2	228A45016	0309DF52D	093BDAEDC	1B11E9300	1DA9C5324	03365EB1E
55	24DCFD0C6	11CF909D6	2FF693F4C	366338F1F	22E641569	0ACA60D55	32D1B009E	035472E09
56	17F5D6662	062FCF913	35B211035	21ACE73FB	3B4148706	2D0CD106F	2CAB457A4	103E1E49B
57	21859E8DA	2F1E3B3D9	1F1014BE2	062A3DEB5	354C0C786	05A8982D4	35A758943	346EBA72A
58	00CB49E5F	211B1034A	3A5D2DAF1	21D3F3EB0	24B2D1150	1097C3685	2AA3671CE	0E5DC1308
59	24C8401BE	217B1F994	1FB9664A8	3D5057708	05A506088	1314842B9	3C8657064	14B1FA77F
60	2AD698E2E	3C129D1F6	2C744FF4E	1C1C052F8	18C38A9FE	252168A10	2EB68D098	3A001CBD2
61	2AF71324C	2BF41D408	0FC498E18	149A1A407	0FDC2C4A3	19D00C4A1	0F6B0DD29	268CF8E86
62	19F4D82A5	342C73FD5	0F5AEDEE7	21A2A8953	15ADB7A94	11DBE038D	0A5B6634A	0FA382B77
63	0A5985778	35AC3032D	35691C85D	2829D55EE	04A3FBD8C	2C85BFA8E	0F459B864	3E878F0BC
64	10C785EB0	054D4CE18	1BF657A8E	101DC64EF	0B4E3032A	24ECFD9C2	00C98BE0A	2A1F82444
65	300E8B09C	31A079FB3	0C41DEC5F	216CCFE4D	226C5A693	3C31A41DD	3A019974C	23B64EAFD
66	249BDC80F	0316ED79E	1E42B5567	0CFF04A4B	310678543	34D986980	1E3195429	280966E65
67	359A72B64	186A3999D	065825DDF	2D28E6000	10964C1E1	1468C970E	34C8B606A	33CC94DB1
68	370B29C05	12841A9E8	2147E7160	1835345EE	06DB43F37	33854A725	065E6614C	151E2D7B1
69	0EAADDB27	004EC6DDD	30AA39B8B	2AEB34AD4	2A13D6649	00EC67B83	1176417CE	0E3683151
70	0832BA87B	3B67515B9	0FD34BC87	1688F83CB	370B52AD5	3A2CD6F3F	3343BF461	37BD48546
71	16EA2751C	1799D9C42	24055CEC9	226A907D4	133C68F80	22CA03BF0	05F723395	2D35008AF
72	122A5C67D	3E46230BC	09F475BA9	15B4B6754	11DE75C50	28C17544F	1D85FAB8D	0D5AD9537
73	1C5497CD9	3D405F487	05535D737	06952087B	1C4744AF4	3E0EF881C	3CED3D1BB	1D91157CE
74	1D276153D	14604EA77	1661FB979	3BAC5E9FB	089F41406	283154122	2AFDCE892	1FD5E0810

Table 18—SA Preamble for $n = 1$ (Segment 1)

75	2A620F4C2	0DE484180	2D05E6458	3E6D15A27	0A92FF0B7	2CBF7BF53	25A2F28FA	19A10CE02
76	3A77B1FBE	2B262F810	2BEEA0F46	39706BBA2	09257163F	1026D5D74	2E2483EBF	1D6527C1E
77	0DC1EBA02	383C59C77	28C7ED115	06FED31D4	16F610DC3	000890B82	2FAD16A3A	35C9AD95F
78	3E5C1EBE2	3C65A7691	2394005B6	251B1BB49	1F42BFA23	0E8608C07	24666F55C	11A5214DF
79	323E882C5	2DBFF5E13	3638BC43F	38CC5CBB5	1DBF783FB	0499418C7	2285E5A40	1A61D17E7
80	1E508F19D	0CF345F97	0E5648601	0A0951DF3	1194EE717	0A6C0B374	03C4E19EC	06F725799
81	0B54F4AEF	186A12343	04C4A60C6	27C2CC0E9	3973075A1	392C5EEB7	3933C99B1	005F98CB2
82	021B6635A	3764D0696	20942B266	0155C4EDD	3FDBF7497	37356D442	374F3DB06	2718357FE
83	120DF6F80	0E41F376A	03544C7B2	2D6795EFD	29E8811F1	1B3EFD388	01CA4C48D	2067E8033
84	07703D649	35221AB50	22141A0D7	268061A59	2D9192B05	3834711FF	3A07258C0	36253B5AA
85	1C4A564C1	26804247A	16A4DB29D	0BEF93C88	37A3EAB6C	25547B136	3FC935878	250E3BF1C
86	17049BB43	0D6426761	2BF3A471E	1665820E9	14412A13D	30D5744B0	2ECE5CAE6	01395189C
87	29615B890	0A2C5A664	216DA64F4	3D4AA9D2C	07B98342C	2603F0D76	0574BDEA8	3F9B35D5D
88	3A0414B22	0A8BE885E	155C220E4	2D3B17AA6	3017E1B48	26508C6C8	3FF25EC63	240EFF072
89	2ACD81CE3	0468D7943	2A4108121	1F2E8E67F	3AB446179	33325CA24	3006DD3A5	1A33F3A2C
90	2B038BAF7	070660C4E	30953C7B7	3E7375D04	1D6A39944	001BE5C8D	199A89253	0A82087BB
91	03BF7C836	2CBF9FC48	38EAB1C98	11C303993	3D748807F	1EBD41D17	351085EF2	1C55B94D3
92	116E0BE61	17BC8C403	31BD1EAA2	1CF87C049	2A41CC04D	3883EFEC1	3971BBBE2	190CAE3B7
93	172799BB5	3301DB193	2480B569B	34DBEFE9C	003287827	38DAEA1CB	0B0E25BB4	1972B37E3
94	3EF1F9EF4	189D8C3E0	1941998D3	259838BC9	28E545988	33BFC60D8	3572B10F3	197913B6B
95	24CF96D66	285347801	22BC70E5E	394231BCC	077583F4E	0364420AF	278FBF5CB	3850AFC8B
96	1B38C4A50	04439E0B5	3A7BEB18B	3003A36CD	329D5A2B6	1BB123AFA	049C2CC94	0F604D1DC
97	28D47EF33	24CF66B6B	24B716FA9	34ED7F6BB	186AE44B4	1380D0726	1CC51324E	16BA74F62
98	04422E60A	3424BA16C	3FF1B39DD	1A1E658F7	33457317D	14E822151	3EC02F279	28593D11D
99	0F2DF0912	21BBFA838	32D634EBF	2061148FD	09A565B74	2BCE430B7	34DAAD9FA	228ADAFE5
100	2D7EE0544	25D57B7CA	0FADAF20D	19B4F6444	3A75DF1C1	0AD3EDD56	0A4D61EEA	28C1262A5
101	1B6AEE253	0BFE02772	24AB19547	186A377A5	03089B4E8	128955F60	3A8DA9AC8	2931648B3
102	21BE0200F	00F34B4F5	34FF3261B	1A0E27AED	0A821AEFB	21B0BA404	1C6A644A4	1734EBB33
103	201FBFD73	0592E9D86	053D87C9D	3CAFC7479	22F1BA3FA	3DB25DD15	31D468990	22FF2B539
104	06C77404E	18AE64252	3963D899A	37179C03C	0FD2E3D04	191E64DBB	380B841FB	368E1DEAA
105	3A561759B	156243DE8	04325D217	33993D0B0	0CEAC2109	002242D1B	33C1D9F5E	1EC4195D3
106	17D7A9B74	1F44ABA75	17B572FE3	096008B9B	1F1E00AAE	05489F7A1	17A4C131D	1C018E923
107	0A4ACCEC8	1F294A30D	19CAEE64E	002787A1B	03EB3238D	27C10F626	1C9E656A0	3F73609F0
108	1E0E3C802	1B52D12AA	2F4E003B7	23BA7A6F1	3CAA0998A	32E96C916	168EFA1EE	28147EE33
109	1CEC9799E	215D9302B	176BB6639	003D5E371	12FE4ADB3	3106B64E2	001D9C28E	0F39059DC
110	31570792D	2260D7FEF	1AC830374	118FE7C78	08F982159	23BB2B13A	2C7944305	376396F3C
111	2D340540B	272E94D06	097C70995	0E70DDADA	1DBD644E5	341A72A58	01CBF5334	2C7999AF9
112	3FF17764D	0701DFAD3	146BDBB97	229D2D7F0	03C5DA21D	3A5916EC7	2390AC01D	197D64233
113	3E9759D5A	00B237425	0B7E646B9	190CB4D16	2646AA1D4	1A373103D	337E5EFB1	0199DE4A1

Table 18—SA Preamble for $n = 1$ (Segment 1)

114	3FD5ADE8A	26B843860	0A2D0AA7B	3C351E07F	1B25376AE	05C553CDD	1DBC3F38D	019823A2A
115	30FF187B4	112F9D7A1	1AE977517	3760AF555	004F86368	3700975C2	0518029DE	032427D9B
116	3A86D49BB	057E649D8	2FDE33D7E	31254217C	30E05CE12	10BCC1CD7	1889C5139	38A163ECF
117	2610F5174	02A7ACB27	208B84FF0	14609CA80	0F3526318	38EBC7384	287C57BAA	279661A9C
118	014F6D77B	1036B3D2C	294F1999A	33A059187	26CCE0507	180DF3129	00A6CAE22	2AC0F23A2
119	347C62997	1912A710D	2260C531F	2F54BBEBB	0A2D90305	1BBEE20E4	0AF79997E	2376F3D0F
120	04484EB82	181977944	1C1CC2693	227ECAB0F	23F32982B	19E2F290C	1BA2300F8	0EFB06247
121	0EC048AD8	3B2168495	34FC02DA1	2C0CDEF52	0553CA222	25DFA4581	29CF66B6B	0AB9C21CD
122	2AF502148	3B00632F9	387CDC4BF	3F8B9F716	19084CD65	0354918C7	39D1FD9AA	0F5ABDB77
123	2C6E2557A	3E8A19D6B	3E6756A28	237E6E5BF	24CA57004	1D52401AD	0237F1D80	0FB2B335D
124	228F4B540	07532BF5D	101F67F52	29D8598EE	0421A0E23	2D89C2AFF	0963D2F3B	24C472A63
125	0CF3598E8	196A40BD2	00E63B26D	088A0BFCA	1C78E9016	03835236C	33071A836	3949DC586
126	3E815D747	1588D4E96	073C8D44A	303281AE4	095D31EC8	1F10F69DC	200F057D8	1F270128F
127	34F9ACB6B	384870FF1	257A863DE	34B36BA0F	3FA3D216B	27425041B	0E0DD0BAD	2E95AD35D

Table 19—SA Preamble for $n = 2$ (Segment 2)

Idx\blk	A	B	C	D	E	F	G	H
0	13F99E8EC	3CF776C2A	3300A482C	0B2BF4791	17BECDFE8	35998C6D4	05F8CB75C	259B90F0B
1	116913829	05188F2A4	2DB0A8D00	2F770FE4A	185BE5E33	0F039A076	212F3F82C	116635F29
2	004EE1EC6	18EF4FDD9	26C80900E	1A63FB8A7	1DAA917D4	0E6716114	02690646D	0CC94AD36
3	06D4FF377	2716E8A54	16A1720C8	08750246F	393045CCB	1DBCCDE43	114A0CAD6	181690377
4	3DC4EF347	1F53452FC	01584B5D3	11D96034F	1FA62568E	11974FACA	191BE154D	397C9D440
5	05A1B6650	29835ADAD	2F6DDABE4	0976A607B	11BA92926	2456B1943	3E3FD608B	095E7584B
6	00CC66282	0560BE767	21EBAA7C6	2D8E9ACE3	198A9E285	05F3E73DD	13DA751A2	176B75E43
7	03D08ADC1	2254606FC	3C695D892	1DA9E0280	2CD4FF589	19B78A5A4	0CE67A7C6	12535A61C
8	0984647CF	0822BA46B	3EB2BC076	212596F54	11CC2E64E	120BADF9F	0DA72CEDE	30D0E106F
9	083CE5726	1F05DA925	169D93EF6	1FCADF3D3	08A5CF0BC	317C8508F	19BDCCE7	0FACE3631
10	27583A466	1CB1634D5	03C7849F7	38C6CED00	1161C173A	15A645D3E	281A7ED92	076ADA797
11	33BA1AE8F	187F578EE	32473D69A	2458B703B	267E59071	0F317883B	3E7DEDBF1	3B9859BA7
12	0322609A3	20C4C957C	3FD638746	3FB716D79	36BD0CF1C	333B11B8F	0027ED1F2	3E7471BF3
13	3529922B1	0ECECEBE04	1980B9B9E	38D60363F	18904BCED	108E3E5F1	34B95C446	338F51DAC
14	21FD50527	0EA2F7A31	1E294A159	114734A02	120B90BF3	3F3617C92	0129071E2	106640936
15	2B59354BB	275BF9761	39C6FF332	2004B3902	053F9DCB0	19D79A902	2B3125038	20649B43E
16	03A8A7A2B	091AE6721	18651FD9E	1F5415ECD	1B38EA62E	07FB0F422	3EB58896B	077FE4C7C

Table 19—SA Preamble for $n = 2$ (Segment 2)

17	06A13CB38	340099B18	2AE6D6385	1669631F9	28E51A676	19A023391	261855F39	3E518F0BC
18	2A88F831B	09D295831	294C468DF	1477F0A13	37725C6EB	00E7DB222	27D610157	349A8FAB6
19	163E1C44D	3F98B6F4A	1805538DD	01EE3DB4A	22AA1797E	27568753E	16090F219	2C9838C01
20	34B0543DC	121B8EA82	00873B4A0	220FE7C05	2EDBEAE34	1104BDB93	0711E8C0E	0E1C107BD
21	226183AFF	15643DE71	04A4CDECB	2E67FDF8A	26D2A6D40	25E7695F1	1A99778F5	20FE0C1A3
22	0F7EAC09D	12BB72B2A	182E44301	2962EB85A	3477C1B69	3E3CF56F7	29C9D00C6	39788600C
23	31084BEB5	1DC90E345	391736CC1	3C8292AE1	38A0D515C	3977012F6	25D1F6055	36A7D3F8B
24	229D3ABAC	1044BA05F	0C391B88A	0636A90A6	0B14322AB	21ADC33E4	2DC1A3BFE	0D7FF6D1F
25	33C85B393	37BFA31B6	134F872F0	0C5EA36E1	286956ED1	1632092FA	382B4BB10	23DC3EF14
26	38E8B9BF6	0A0CE666B	207D98054	23FF360AD	121BFDA4E	347D442FD	242922C07	23C6E4115
27	263EA8516	36138BD6A	0ED9C55E7	3F0937876	03232BC24	18E5FFF26	3530CF206	3981B7414
28	1D9AC2E79	051B220E9	3F3B09EC8	0D3F6C366	0201A7CB9	3D5477092	22185FF9F	1C5AA5348
29	208D85694	22104E7C5	14BCFD3DD	3592DF665	1F4EC3265	24358076A	2D20A8000	017F2D489
30	36B3A9A2C	3F8E0F162	13ACDCCF2	16951F727	271E73555	1B3EDCDE7	162B45352	1CAFA635A
31	2D30FE705	3EC9BFC8D	1B10F8349	34F973F31	1CA96A349	1A28B4543	1C5367CE6	2DFAB0AE7
32	21D93EB5A	0E49D6211	3C6FCF774	09F44CACF	2D8CD2BEA	037DDAD3D	3BBD06D1D	39CBB996F
33	159B1F948	0183E8DCD	3A484866C	21F8DF1A5	219A58193	2D1B3C399	2275F19BA	0EFF4C612
34	22EB93A82	15047E272	15428D77B	38FFC612E	20609BE54	3226C8254	3E5568DB2	159284EED
35	34529707C	2E84585F4	20DFFB4C5	28288AA00	10EFC1E07	3C4D211FC	379087C3F	25716A7DD
36	20106354F	22AEB9FD7	3A6BAC67D	3126294C6	0FBC874AC	2DFE5675A	391B1DDAA	06BAA74D8
37	348F831C5	2E44BF3C2	3D9F6F454	20746A30E	08D183029	35C6BFEA7	2729B552B	263BB2EBD
38	202D7F08F	0DBE1C144	132F4EC09	184CD9B93	2596F5884	2A55B8217	2BEAE02D8	235A19A43
39	2DDE3FF5F	23932555C	001ED92D7	22FCD3D60	2C0737593	0B27E62FF	0693CFBDC	284D5B33F
40	1DB9AB8E9	2995EE0A1	1ACFE9892	0D41BCB9D	2E3806507	25CCD5D60	3536DF04C	0BB0A5E3B
41	3FFD4DD82	3E69CC1C1	2BC30FB74	3462F70FC	164FAE762	09B83F8AD	1DF593F3C	2DB478034
42	16E24E9B6	0A9FCFBD2	3A018544C	1ED8E2855	0037681E4	05950E1F8	1107DA097	377A25C65
43	03C9318B8	0C70A7749	0D58708C2	0CA2808C4	219E02554	39315B2F2	2E089B00F	302E135C7
44	04DC211E8	1DD20A505	21A50649F	2CA438C04	39CAD66AE	2E1BD969F	002748760	069924211
45	2E84BCF09	226F5D43C	37BE7EB10	07CDC854A	06FB50D48	08966435B	01BA5E5D2	1D34057FA
46	2D8DFD565	0A30D633F	33F93B7C6	0B330E9D2	0E659B262	130669024	19A9D5F64	38059132D
47	17E4777AE	1308F9046	2F7C0483E	1859E0943	0982C9101	05453D92C	001F53877	388A571AB
48	00D29CC63	0A6D3BDED	1CA44D2AF	388C002CA	2A3D70EF7	2DD3F5A6F	39FEAF0B6	11DFE385F
49	3E3A6CEC4	122F5E8BE	360B96301	0632CF244	2E8985A9F	0FD256C87	0449C29D4	26B713C90
50	238150687	3D96F7F7B	0091E6D18	21802352A	02F7A466E	0A5BB6648	350DA85DB	1C97F4544
51	306BA76DE	379A88697	3F0DA31E1	0EBF48C71	27F8A46EB	3F75A19F6	277002F97	275B43715
52	24D946CC1	38DF102DC	3EFE1F5B3	3C316E148	2735B20CF	0688E430F	0316DC923	24919BEA1
53	0EEAF72D2	3C7248573	1087A7BD6	08EDA9BF6	2B5D97BF4	26733DC60	1190D275B	2EC7ABD30
54	37C6AB63E	2FFC9C790	02CAA37A7	1B34A3F84	0022CD5F6	3ECF891BF	193D545E2	0172C674E
55	0848A41C3	1D8150EE7	3D8A8549A	2595F707B	00640B276	2D44EBDAE	1CAF37453	377EF590A

Table 19—SA Preamble for $n = 2$ (Segment 2)

56	16B7A5F7D	1F5AA7998	382300A8B	218916E53	19D00E728	1EDA11790	0BBDEF9C4	1DEB15796
57	3EFB3368D	392AA88AD	29CF3CADC	03F59ED8A	1042098CA	1721B8F3A	2B5DE9312	0CB5E6F23
58	1A8B0FB9E	3FBC09C8B	3D7F3E248	034C9BCB5	1BDD89300	3392476C0	0C10AED4B	23BECA42A
59	0EBC749B6	33453C7F6	304735F5C	334628143	1DAF6E7A9	11BB9C393	226C5E4FF	170372039
60	3F9262CBC	0693308C8	21B563415	09BDCC403	0112C79D4	2DA9F1134	36AA1CD7D	3A1608BFC
61	218AC590E	0FACC734D	02132C9A3	27087557E	076B3ECE7	2EA16BA3D	0E1D452F1	3F70B027A
62	004F9DC68	25BE3AD9C	2CBD3C07B	3F9DECD71	3E771E15A	11FF2F24D	2AEA5DF67	1E838955D
63	3A04BC376	1D19254F1	00F92DD2B	3C57484F3	181D0973E	319F9CEEA	053ADEEDB	1A3C22150
64	0F78BA6BC	2DFE0E681	3035BD77D	0A0FFD148	275F50C66	2246E9053	27B2BF3E9	1741894F8
65	1ACCD0F79	22F0AEA4F	32796ADB5	134A4A876	183D989E3	204C4BF97	22300E86F	3F18744A3
66	3EB6E19EF	1B24EAB88	2E318F810	3F07B618E	26B4C0C87	31CC10EA8	169E1B650	017DF88ED
67	2BD9E8FED	0AB104122	30C9D81A0	09EA73C7F	141357B1D	000A7DB48	1DD06FD41	0AFA8EF72
68	19CA5678F	28A89AA43	1DB945917	262AF69C3	3145A4473	3742CBFF5	1BCD965E9	1B0E7FC84
69	077838B25	2BF7032F8	23DC2E014	028544277	37B411B5F	392FF6CDC	1D66F2BE9	011372DA0
70	39596216C	05A651F63	183A6AE26	0D1FCA203	0FF6F0D22	2FEB8364B	05A438ED8	32D045F13
71	3711AD513	290B237FF	20E2A9B26	0C72A0234	2F1ABBE93	19B505378	354ED915D	0C359F272
72	1D7786BA4	1CCDF053A	36828B333	0ED27AFB6	241326FC4	1A9C37F8B	0A9C3C372	05937E898
73	1053B9CDB	040B97B1D	0D4FF481D	23AD465A8	2906EBDE2	0C4F6C09D	2189C5FEA	2D90D305A
74	39073122B	35FEAA236	1B38B7A90	2E02AB9F7	219FEEA0A	36B3B2EF8	39A3F4C8B	15A42C9DD
75	2C6326A9E	33F7536C1	2A120C75F	37030CAA0	3A011882C	098C8504E	3B92D756B	175811CF9
76	38A0F736B	2BD9E9C32	3B989715A	2A646ADF4	2D02FE38C	11AC7E9E6	3F5464862	0F382B0D8
77	26897D80C	145B21D3E	143F5E320	30549707E	28126710C	122CA92BE	3AF47270C	0B544128F
78	00E931208	2E1E75EAA	374C36E5F	21724DFC5	1DFCD2028	1B3FF774E	3A826A68B	1781CDCA4
79	0C3D7268D	0B7A26BF9	1587CE5CD	1D04E1E60	36240C07D	1AC403449	0417F9622	02B9F8BED
80	1B569F488	08A3F3A46	377F03A18	2DE416045	1ED96E381	33F4F16DC	2C8DAAE4F	33E384AC7
81	13F709786	02A4E32CB	14C7F849E	09EA16987	06C849EA4	219E4B995	243CB7F07	253513BC6
82	09B83FDF2	119D60439	278290BFF	2483E6F2C	0EDEC175D	242A669C1	3EB639EF0	31EBB4CA0
83	22CAEF0E4	0B2FCDED0	19BA79607	343F81C7B	289AA213E	358AC9FFA	23956ADA1	00BC725E7
84	1186F95E3	2F95F4048	3CFBF41E2	1D1E4BE96	26B38BA65	2F715E590	2235C0029	2C89AF93F
85	33437ED6C	12F14DB69	2E70F5611	183752704	142BC8B34	3B90ECD86	1C11EB493	1022D4782
86	248457F60	05B9A28A5	0A2A5DD56	16002D9E7	34C87FB16	2E32BAE0C	21065BD64	1CCE92BB0
87	1DCE3941A	1D940ACE3	30D331B98	3D5A3BAB6	119791607	10FB0D788	2C78E9015	100B598E4
88	39C0BC811	1B886594E	27AF50C73	2DCEA05E6	0805EDCA9	3A5989B08	18AD24255	1683B7CF2
89	186A3D233	09E8B95DA	1ED9F3DBE	1B19A74F8	356CA7443	316C9FBE9	3F8A3162A	3A0BC11CC
90	02F039B63	2F02D3E75	0F5B5E89E	3D062255C	222C6AA4E	25DEA06FB	39488C071	139318BFB
91	27B5B6EE8	22154E0BD	3FF7729F1	1052B1947	3D477BF2B	3EDB6745A	1B30CF849	030F84AF4
92	27B2D40BC	01EE5E9B6	24B0ACF84	3370F65E0	067D8DFA9	1C01B9327	26FF8FDB5	3809C0CA6
93	11F581193	07B9B7A7D	1CA56B4A3	3D088CC6C	11D52C38A	344760F0A	3D3AA336D	0118CBD93
94	096990784	2960D1672	3BFD7D847	2BC297EEE	32168CF28	3912FFF6C	08ED9BAB1	34452C6E5

Table 19—SA Preamble for $n = 2$ (Segment 2)

95	02CD48DC2	186403849	24C6EE1EA	12ED5268A	2718C00E9	27E8F18CF	145913E2D	0B09009BB
96	06B97DD08	2880C9B96	37EB87E03	14C4ED01D	17041E5DC	347A412CB	088CE591B	0BE926B22
97	116250DF7	1745B4329	1102B7093	1CA549C5A	25244AB6C	374E0F19B	274F76015	0FB738F16
98	12841B9E9	1F9C4AEEB	1445F0C98	39FFB6307	02AB688E7	0FD8B499E	28D533072	138F162EA
99	22BD9525E	2030E58C6	25F2CD033	157D93437	1442E92D2	3D6EE9DF3	3CA5B469D	0588A0FAE
100	0FDEC177D	2606157BE	2224E556C	0C6F33897	0F830DE1B	3C3F9C1D8	2AF576923	0D4173E27
101	376EF82C2	30E3C582E	0A82DE29A	1B8D454D9	079ACE6D9	2579984C6	392F28400	24CEAEDF1
102	1CD4AA9D2	1DD6F4DA5	3485B7150	105DE02F9	22168E0FA	24F48AA6C	003771A39	306890843
103	1F8303786	2C981AAE4	0819F22E9	0A1D88D55	3B4C012FD	0214CDF52	19DF3BE8F	02364E19A
104	1364A15C0	16E9F9961	17E598810	2654E5A2C	09B43C7C8	3A5E2AF45	14FC71E26	2B4BA69F4
105	12E128BEF	19166342E	04A1404B7	283D17B66	014836F64	13BE0B4B5	2F8583C08	2B19A7FB4
106	19F83FDE2	361D25170	36354011B	3FF4EC74B	1B2128FF9	0C849EB1B	096B991D8	1CA7A74AA
107	32E0BEF35	11A61714D	34C56D40B	0742C52FE	00ED2F1C4	3997FC7B7	06E414374	180DCD64F
108	18399ED59	224E6C2FF	3450F1BB7	27A1CA959	21B5E00F8	13B67DAE8	0B14C022E	0E41BBEE2
109	318D94D05	2EBB53B17	331C3E6F4	0FBCE71ED	380FF18B8	3E3C75B26	0E0088A18	17553D2A2
110	37AC7E5D5	27C9EADFA	3FC47B5E4	38699BB57	1564F8B27	3579C7FEB	13401BD88	0DB519DE0
111	0FF4D6F22	3C84242F3	2DEAE40AD	305F320A5	244CB97B0	0892DA905	3F09D5CB5	332E7DB02
112	31479E580	1B6AD13E0	16A1CF9E2	33A0A119A	1AC8388E9	3D4105F37	226501835	27AF1310F
113	1CBDAFE39	3E5A30C1C	236E9A029	063430D97	0CD91A825	02F335D7E	1989FE0BE	13C4E2A20
114	10B393370	33CB79316	2CEB44FC0	236019420	248F95ACB	35034B6F0	365691771	34A8FBCB6
115	25463FC5F	082FC0ED2	038ACE1CC	3E959B49D	21B8C04F5	08633F3A0	3A5D18159	12B3EC4C7
116	167B32C3E	06FF88387	34C3F468B	3239005B2	121C913AF	21C90CE16	28B54D557	3811CB0A9
117	221BD0503	0AF619499	21F8D40C1	1B3DA7AEE	3FA2E3B05	348466C50	10F12A28D	0E70B26AB
118	1D79A57C5	315D2460F	1402B8222	28DC66FEA	1BCF748F9	2AD5D4227	0094D2CAD	25EA22A58
119	062B39CFB	310E8818D	0F2D0A235	3F6468866	33F86F342	39CAB5BBC	2E7D6A8BF	3E9218162
120	2FCDEA0E0	1BDD766A4	2827B99BB	0B5F04CC9	1C9E02A9A	1A6675ED4	033497A06	07D4ADD44
121	3CD46CD9D	311A64A85	24DDFE6FF	3411C6FE5	0D0613CDA	0E9276056	178ACC4F8	23DEA3CB0
122	2762D6A40	306FE3843	1402589C8	382B07654	160BA3DEA	3815B54C8	273960105	2076A15E5
123	1C593A744	1562487F6	0C38617B4	2CA68266A	071C4BF93	2593F0BDC	1562436E5	199BEEA49
124	35B8C7503	278F57EAA	34A804061	19C657A74	385734710	3FAC27628	0707BED4E	32F20F45E
125	34994C46C	1C6B99499	1AF24D850	11AD795D3	19288BFE9	1360C1B96	3B5D8DBC0	2554E72D6
126	22D7095A4	34B70502A	3F0CB27D2	04FC214E6	24C0B80C5	03D6F4DC8	1432A099E	26300D70E
127	21C33416F	18B894695	3AC062614	3537CF601	00A20A8B8	1CD10BAF5	394DF1DC0	0925851ED

3.3.2.2 DL Control Channels

DL control channels convey information essential for system operation. Information on DL control channels is transmitted hierarchically over different time scales from the superframe level to the subframe level.

In mixed mode operation (WirelessMAN-OFDMA/Advanced Air Interface), an AMS can access the system without decoding WirelessMAN-OFDMA FCH and MAP messages.

3.3.2.2.1 Superframe Header

The Superframe Header (SFH) carries essential system parameters and system configuration information. The SFH is located in the first subframe within a superframe. The SFH uses the last 5 OFDM symbols within the first subframe.

The PHY structure for resource allocation of the SFH is described in 3.3.1. The subframe where SFH is located has one frequency partition.

All PRUs in the first subframe of a superframe have the 2 stream pilot pattern defined in 3.3.1 and are permuted to generate distributed LRUs. SHF occupies the first N_{SFH} distributed LRUs in the subframe where N_{SFH} is no more than 24. The remaining distributed LRUs in the subframe are used for other control and data transmission.

The permutation and frequency partition of the SFH subframe can be described by DSAC = 0 (all miniband without subband), DFPC = 0 (reuse 1 only), DCAS_{SB0} = 0 (no subband CRU allocated), and DCAS_{MB0} = 0 (no miniband CRU allocated). Definitions of these parameters are given in 3.3.1.

The SFH is divided into two parts: Primary Superframe Header (P-SFH) and Secondary Superframe Header (S-SFH).

Table 20 includes the parameters and values for resource allocation of the SFH.

Table 20—Parameters and values for resource allocation of SFH

Parameters	Description	Value
N_{SFH}	The number of distributed LRUs which are occupied by SFH. Note that $N_{SFH} = N_{P-SFH} + N_{S-SFH}$	TBD(<= 24)
N_{P-SFH}	The number of distributed LRUs which are occupied by P-SFH	Fixed (value is TBD)
N_{S-SFH}	The number of distributed LRUs which are occupied by S-SFH	Variable according to the type of S-SFH SP

3.3.2.2.1.1 Primary Superframe Header

The Primary Superframe Header (P-SFH) shall be transmitted in every superframe.

The first N_{P-SFH} distributed LRUs of the first subframe are allocated for P-SFH transmission. N_{P-SFH} is a fixed value.

3.3.2.2.1.2 Secondary Superframe Header

The Secondary Superframe Header (S-SFH) may be transmitted in every superframe

If the S-SFH is present, the S-SFH shall be mapped to the N_{S-SFH} distributed LRUs following the N_{P-SFH} distributed LRUs. The value of N_{S-SFH} is indicated in P-SFH IE.

The S-SFH can be repeated over two consecutive superframes.

The information transmitted in S-SFH is divided into three sub-packets.

3.3.2.2.2 Advanced MAP (A-MAP)

The Advanced MAP (A-MAP) carries unicast service control information. Unicast service control information consists of user-specific control information and non-user-specific control information. User-specific control information is further divided into assignment information, HARQ feedback information, and power control information, and they are transmitted in the assignment A-MAP, HARQ feedback A-MAP, and power control A-MAP, respectively. All the A-MAPs share a region of physical resources called A-MAP region.

A-MAP regions shall be present in all DL subframes. When default TTI is used, DL data allocations corresponding to an A-MAP region occupy resources in the subframe where the A-MAP region is located

Figure 25 illustrates the location of A-MAP region in the TDD mode.

A-MAP	A-MAP	A-MAP	A-MAP				
DL SF0	DL SF1	DL SF2	DL SF3	UL SF4	UL SF5	UL SF6	UL SF7

TDD system with a 4:4 subframe DL:UL split

Figure 25—Example of locations of A-MAP location regions

If FFR is used in a DL subframe, both the reuse 1 partition and the highest-power reuse 3 partition may contain an A-MAP region. In a DL subframe, non-user specific, HARQ feedback, and power control A-MAPs are located in a frequency partition called the primary frequency partition. The primary frequency partition can be either the reuse 1 partition or the highest-power reuse 3 partition, which is indicated by ABS through SFH. Assignment A-MAP can be in the reuse 1 partition or the highest-power reuse 3 partition or both. The number of assignment A-MAPs in each frequency partition is signaled through non-user specific A-MAP.

The structure of an A-MAP region is illustrated in the example in Figure 26. The resource occupied by each A-MAP may vary depending on the system configuration and scheduler operation.

In DL subframes other than the first subframe of a superframe, an A-MAP region consists of the first N_{A-MAP} distributed LRUs in a frequency partition and the LRUs are formed from PRUs with N_{sym} symbols. In the first DL subframe of a superframe, the A-MAP region consists of the first N_{A-MAP} distributed LRUs after N_{SFH} distributed LRUs occupied by SFH.

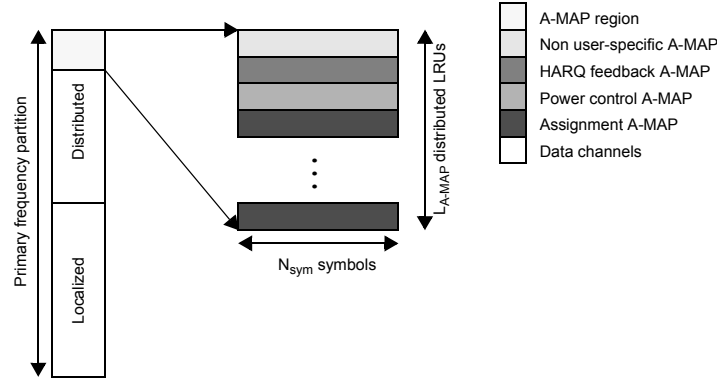


Figure 26—Structure of an A-MAP region

3.3.2.2.1 Non-user Specific A-MAP

Non-user-specific A-MAP consists of information that is not dedicated to a specific user or a specific group of users. The AMS should firstly decode the non-user-specific A-MAP in the primary frequency partition to obtain the information needed for decoding assignment A-MAPs and HF A-MAPS.

The resource occupied by non-user specific information is of fixed size.

3.3.2.2.2 Assignment A-MAP

Assignment A-MAP contains resource assignment information which is categorized into multiple types of assignment A-MAP IEs. Each assignment A-MAP IE is coded separately and carries information for one or a group of AMSs.

The minimum logical resource unit in the assignment A-MAP is called MLRU, consisting of $N_{MLRU} = 56$ data tones.

The assignment A-MAP IE shall be transmitted with one MLRU or multiple concatenated MLRUs in the A-MAP region. The number of logically contiguous MLRUs is determined based on the assignment A-MAP IE size and channel coding rate, where channel coding rate is selected based on AMS' link condition.

Assignment A-MAP IEs are grouped together based on channel coding rate and A-MAP IE sizes. Assignment A-MAP IEs in the same group are transmitted in the same frequency partition with the same channel coding rate and contain the same A-MAP IE size. Each assignment A-MAP group contains several logically contiguous MLRUs. The number of assignment A-MAP IEs in each assignment A-MAP group is signaled through non-user specific A-MAP in the same subframe.

All the multicast assignment A-MAP IEs, i.e., all the assignment A-MAP IEs intended for more than a single AMS, present in any assignment A-MAP group, shall occupy a contiguous set of MLRUs starting from the beginning the assignment A-MAP group. The DL/UL Group Resource Allocation A-MAP IE, and the DL/UL Composite Persistent A-MAP IE are examples of multicast assignment A-MAP IEs.

All the unicast assignment A-MAP IEs intended for a particular AMS shall be transmitted in the same assignment A-MAP group. The DL/UL Basic Assignment A-MAP IEs are an example of unicast assignment A-MAP IEs.

3.3.2.2.3 HARQ Feedback A-MAP

HARQ feedback A-MAP carries HARQ ACK/NACK information for uplink data transmission.

3.3.2.2.4 Power Control A-MAP

Power Control A-MAP carries fast power control command to AMS.

3.3.2.3 Resource Mapping of DL Control Channels

3.3.2.3.1 Superframe Header

3.3.2.3.1.1 Primary Superframe Header

Figure 27 shows the physical processing block diagram for the P-SFH.

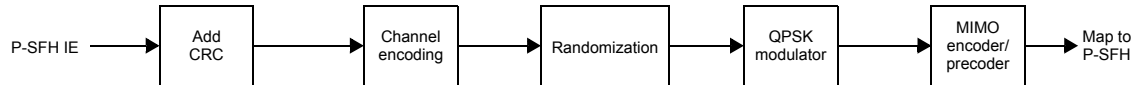


Figure 27—Physical processing block diagram for the P-SFH

The P-SFH IE shall be appended with $N_{\text{CRC,P-SFH}}$ bits CRC followed by scrambling with a cell-specific sequence. The cell-specific sequence is determined from the A-Preamble.

The resulting sequence of bits shall be encoded by the TBCC described in << 15.3.12.2>> with parameter $M = N_{\text{Rep,P-SFH}} K_{\text{bufsize}}$ and $K_{\text{bufsize}} = 4L$, where L is the number of information bits and $N_{\text{Rep,P-SFH}}$ is the number of repetition for effective code rate of $[1/16]$ or $1/24$.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC for two antennas. The two streams using SFBC may be precoded and mapped to more than two antennas described in section <<15.3.7.1.1>>.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in section <<15.3.6.2.1.1>>.

3.3.2.3.1.2 Secondary Superframe Header

Figure 28 shows the physical processing block diagram for the S-SFH.

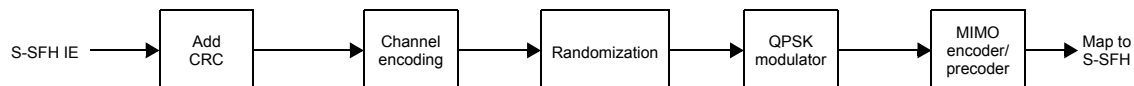


Figure 28—Physical processing block diagram for the S-SFH

The S-SFH IE shall be appended with a 16-bit CRC followed by scrambling with a cell-specific sequence. The cell-specific sequence is determined from the A-Preamble.

The resulting sequence of bits shall be encoded by the TBCC described in << 15.3.12.2>> with parameter $M = N_{Rep, S-SFH} K_{bufsize}$ and $K_{bufsize} = 4L$, where L is the number of information bits.

The value of $N_{Rep, S-SFH}$ is indicated in P-SFH.

The encoded bit sequences shall be modulated using QPSK.

The modulated symbols shall be mapped to two transmission streams using SFBC for two antennas. The two streams using SFBC may be precoded and mapped to more than two antennas.

Antenna specific symbols at the output of the MIMO encoder/precoder shall be mapped to the resource elements described in section <<15.3.6.2.1>>.

3.3.2.3.2 Advanced MAP (A-MAP)

SFBC with precoding shall be used for the A-MAP region.

3.3.2.3.2.1 Non-user Specific A-MAP

The coding chain for non-user-specific A-MAP-IE to A-A-MAP symbols is shown in Figure 29.

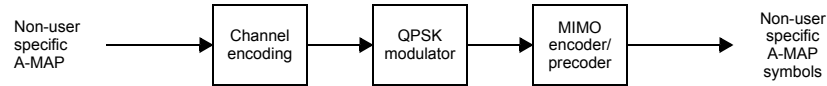


Figure 29—Chain of non-user specific A-MAP-IE to A-A-MAP symbols

The non-user specific A-MAP IE is encoded by TBCC with parameter $M = 3K_{bufsize}$ and $K_{bufsize} = 4L$ for 1/12 code, where L is the number of information bits. In FFR configurations, the non-user specific A-MAP is also encoded with a code rate of 1/12 when it is in the frequency reuse 1 partition. When the non-user specific A-MAP is in the power boosted frequency reuse 3 partition, it should be encoded with parameter $M = K_{bufsize} = 4L$ for 1/4 code rate. The encoded sequence is modulated using QPSK.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{NUS}[0]$ to $S_{NUS}[L_{NUS}-1]$, are mapped to tone-pairs from RMP[0] to RMP[$L_{NUS}/2-1$], where RMP is the renumbered A-MAP tone-pairs described in 3.3.1.3.4 and L_{NUS} is the number of tones required to transmit the non-user specific A-MAP IE.

3.3.2.3.2.2 Assignment A-MAP

The Assignment A-MAP (A-A-MAP) shall include one or multiple A-A-MAP-IEs and each A-A-MAP-IE is encoded separately. Figure 30 describes the procedure for constructing A-A-MAP symbols.



Figure 30—Chain of A-A-MAP-IE to A-A-MAP symbols

A 16-bit CRC is generated based on the contents of the A-MAP IE excluding the station ID. The CRC is then masked by the Station ID. Following randomization, the resulting sequence of bits shall be encoded by the TBCC described in <<15.3.12. 2. >>

Coded bits can be repeated to improve the robustness of an A-A-MAP channel based on the link condition of a particular AMS.

For a given system configuration, assignment A-MAP IEs can be encoded with two different effective code rates. The set of code rates is (1/2, 1/4) or (1/2, 1/8) and is explicitly signaled in the S-SFH.

In case of FFR, two code rates, either (1/2, 1/4) or (1/2, 1/8), can be used in the reuse 1 partition. Only 1/2 code rate is used in the highest-power reuse 3 partition.

The parameters for TBCC are $M = K_{bufsize} = 2L$ for 1/2 code rate, $M = K_{bufsize} = 4L$ for 1/4 code rate, and $M = 2K_{bufsize}$ and $K_{bufsize} = 4L$ for 1/8 code rate where L is the number of information bits. The encoded bit sequences shall be modulated using QPSK

3.3.2.3.2.3 HARQ Feedback A-MAP

HARQ feedback A-MAP (HF-A-MAP) contains HARQ-feedback-IEs for ACK/NACK feedback information to uplink data transmission.

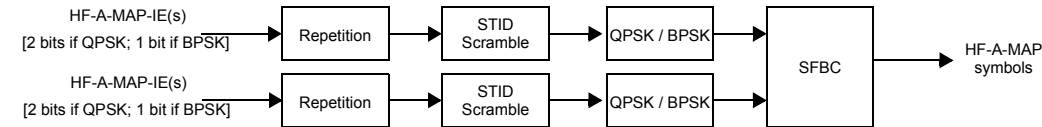


Figure 31—Chain of HF-A-MAP IE to HF-A-MAP symbols

Figure 31 shows the construction procedure of HF-A-MAP symbols from HF-A-MAP-IE.

Each HF-A-MAP IE carries 1 bit information. Depending on the channel conditions, the modulation can be QPSK or BPSK. If QPSK is used, 2 HF-A-MAP IEs are mapped to a point in the signal constellation. If BPSK is used, each HF-A-MAP IE is mapped to a point in the signal constellation. The repetition number, $N_{Rep, HF-A-MAP}$, is 8. Repeated HF-A-MAP IE bits are scrambled by the $N_{Rep, HF-A-MAP}$ LSBs of the STID of the associated AMS.

Figure 31 shows a cluster of HF-A-MAP channels, which consists of 4 HF-A-MAP channels numbered as $4c$, $4c+1$, $4c+2$, $4c+3$ where c is the HF-A-MAP cluster index in a HF-A-MAP region. Channel $4c$ in the cluster occupies the real part of the first symbol in each tone pair before the SFBC encoder. Channel $4c+1$ in the cluster occupies the imaginary part of the first symbol in each tone pair before the SFBC encoder. Channel $4c+2$ in the cluster occupies the real part of the second symbol in each tone pair before the SFBC

encoder. Channel $4c+3$ in the cluster occupies the imaginary part of the second symbol in each tone pair before the SFBC encoder.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{HF}[0]$ to $S_{HF}[L_{HF}-1]$, are mapped to tone-pairs from $RMP[L_{NUS}/2]$ to $RMP[(L_{NUS}+L_{HF})/2-1]$, where RMP is the renumbered A-MAP tone-pairs described in 3.3.1.3.4 and L_{HF} is the number of tones required to support all HF-A-MAP channels in an A-MAP region. Clusters of HF-A-MAP are indexed sequentially from index 0 within a HF-A-MAP region in the mapping process.

For persistent allocation, HF-A-MAP resource index is specified in HFA of UL Individual Persistent A-MAP IE or UL Composite Persistent A-MAP IE.

For group resource allocation, HF-A-MAP resource index for the l -th AMS in GRA allocation is $(i_{start} + \lfloor l \cdot N_{HF-A-MAP} / N_{GRA} \rfloor) \bmod N_{HF-A-MAP}$, where i_{start} is the ACK Channel Offset in UL group resource allocation A-MAP IE, $N_{HF-A-MAP}$ is the total number of HF-A-MAP configured, and N_{GRA} is the Use Bit Map Size in UL group resource allocation A-MAP IE.

For resource allocation using UL basic assignment A-MAP, HF-A-MAP resource index is $(M(j) + n) \bmod N_{HF-A-MAP}$, where j is HF-A-MAP Index Parameter in Non-user specific A-MAP IE, n is HFA in UL basic assignment A-MAP IE, $M(j)$ is STID when $j=0$ and $M(j)$ is lowest LRU index of corresponding UL transmission when $j=1$.

3.3.2.3.2.4 Power Control A-MAP

Power Control A-MAP (PC-A-MAP) contains PC-A-MAP-IEs for closed-loop power control of the uplink transmission. The ABS shall transmit PC-A-MAP-IE to every AMS which operates in closed-loop power control mode.

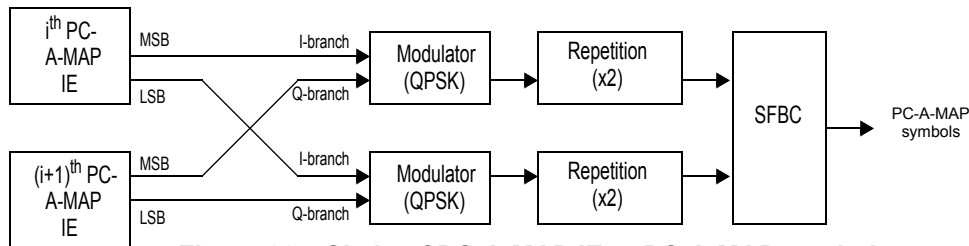


Figure 32—Chain of PC-A-MAP IE to PC-A-MAP symbols

Figure 32 shows the construction procedure of PC-A-MAP symbols from PC-A-MAP-IE.

The i^{th} PC-A-MAP-IE shall have the size of 2 bits according to power correction value.

The i^{th} and $(i+1)^{\text{th}}$ PC-A-MAP IEs shall be mapped to two QPSK symbols as depicted in Figure 32. Only the i^{th} PC-A-MAP may also be mapped to two QPSK symbols for transmitting to the corresponding MS with poor channel quality.

Power scaling by $\sqrt{P_i}$ ($0 \leq i < N_{PC-A-MAP-IE}$) shall be applied to the i^{th} PC-A-MAP-IE where $N_{PC-A-MAP-IE}$ is the number of PC-A-MAP-IEs and $\sqrt{P_i}$ is the value determined by the management entity to satisfy the link performance.

The QPSK symbols are repeated $N_{\text{rep,PC-A-MAP-IE}}$ times, where $N_{\text{rep,PC-A-MAP-IE}}$ equals two.

Figure 32 shows a cluster of PC-A-MAP channels, which consists of 2 PC-A-MAP channels numbered as $2c$ and $2c+1$ where c is the PC-A-MAP cluster index in the A-MAP region. Channel $2c$ in the cluster occupies the real part of both symbols in each tone pair before the SFBC encoder. Channel $2c+1$ occupies the imaginary part of both symbols in each tone pair before the SFBC encoder.

For each Tx antenna, symbols at the output of MIMO encoder, denoted by $S_{\text{PC}}[0]$ to $S_{\text{PC}}[L_{\text{PC}}-1]$, are mapped to tone-pairs from $\text{RMP}[(L_{\text{NUS}}+L_{\text{HF}})/2]$ to $\text{RMP}[(L_{\text{NUS}}+L_{\text{HF}}+L_{\text{PC}})/2-1]$, where RMP is the renumbered A-MAP tone-pairs described in 3.3.1.3.4 and L_{PC} is the number of tones required to support all HF-A-MAP channels in an A-MAP region. Clusters of PC-A-MAP are indexed sequentially in the mapping process.

3.3.2.4 Downlink power control

The ABS should be capable of controlling the transmit power per subframe and per user.

An ABS can exchange necessary information with neighbor ABS through backbone network to support downlink power control.

3.3.2.4.1 Power Control for A-MAP

Downlink transmit power density of A-MAP transmission for an AMS may be set in order to satisfy target error rate for the given MCS level which is used for the A-MAP transmission. Detail algorithm is left to vendor-specific implementations.

3.3.2.5 DL Control Information Elements

3.3.2.5.1 DL Sub-band Assignment A-MAP IE

The DL Sub-band Assignment A-MAP IE shall have an identical structure to the DL Basic Assignment A-MAP IE defined in Section 15.3.6.5.2.2. With the exception of the “IE Type” and the “Resource Allocation” field, all of the other fields shall be interpreted in the same manner as defined for the DL Basic Assignment A-MAP IE.

The “IE Type” field shall be set to the value 0b0010.

For all bandwidths, the “Resource Allocation” field shall be 11 bits long

The structure and interpretation of the RA field for the DL Sub-band Assignment A-MAP IE shall be as defined below, for the cases of 5, 10 & 20 MHz.

In all cases, the ABS/AMS shall perform the following pre-processing steps to define some terms that are used in the indexing and in the interpretation of the RA field. The notation and terms in these steps, related to sub-channelization, are defined in Section 15.3.5.

3.3.2.5.1.1 Pre-Processing

The mapping between the LRU indices and the physical PRU indices (and vice-versa) may be derived as described in Section 15.3.6.5.2.2 (“DL Basic Assignment A-MAP IE”).

Derivation of the mapping between the sub-band-CRU index and the physical PRU index shall be done as follows. The total number of sub-bands over all partitions may be calculated as

$$Y = \sum_{m=0}^3 \text{DCAS}_{\text{SB},m}$$

For each frequency partition i , the total number of sub-band-CRUs up-to and including that partition may be calculated as

$$X_i = \sum_{m=0}^i N_1 \text{DCAS}_{\text{SB},m}, 0 \leq i < 3$$

Then, the sub-band CRUs are indexed as

$$\text{SBCRU}[k] = \text{CRU}_{\text{FP}_i}[k - X_{i-1}], \text{for } X_{i-1} \leq k < (N_1 \text{DCAS}_{\text{SB},i} + X_{i-1}) \text{ with } 0 \leq i < 3, \text{ with } 0 \leq k < N_1 Y$$

The mapping from the to the physical PRU_{FP_i} indices (and vice-versa) is as specified in Section 15.3.5.

The LRU & SBCRU indices indicated by the RA field refer to the $\text{LRU}[]$ and the $\text{SBCRU}[]$ defined above.

3.3.2.5.1.2 Nominal Channel Bandwidth = 5 MHz

For a 5 MHz system:

- 1) A single instance of a resource allocation shall be made using a single IE.
- 2) The AMS shall interpret the RA field as defined by Table 21.

Table 21—Interpretation of the RA Field in a 5 MHz system

Total # of sub-bands over all frequency partitions, Y	RA Field Interpretation	
Y = 6	<p>The 2 MSB bits of the RA field are denoted as the “Indication Type field” (ITF). The 6 LSB bits of the RA field are denoted as the “Resource Indexing Field” (RIF). Denote $RIF[j]$ as the j^{th} bit position in the RIF, $0 \leq j < 6$, with $j = 0$ being the LSB.</p>	
	ITF == 00	<p>Each of the $RIF[j]$, $0 \leq j < 6$, indicates the allocation or non-allocation of all $N_1 (= 4)$ CRUs within a particular sub-band.</p> <p>$RIF[j] = 1 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have not been allocated.</p>
	ITF == 01	<p>Each of the $RIF[j]$, $0 \leq j < 6$, indicates the allocation or non-allocation of the 1st 2 CRUs within a particular sub-band.</p> <p>$RIF[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j$ have not been allocated.</p>
	ITF == 10	<p>Each of the $RIF[j]$, $0 \leq j < 6$, indicates the allocation or non-allocation of the last 2 CRUs within a particular sub-band.</p> <p>$RIF[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j + 1$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j + 1$ have not been allocated.</p>
Y <= 5	<p>Each of the j bit-positions in the RA field, $0 \leq j < 11$, indicates the allocation or non-allocation of 2 CRUs within a particular sub-band.</p> <p>Position j in RA corresponds to the 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$.</p> <p>Denoting $RA[j]$ as the j^{th} position in RA field, $0 \leq j < 11$, with $j = 0$ the LSB,</p> <p>$RA[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$ have been allocated.</p> <p>$RA[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$ have not been allocated.</p>	

3.3.2.5.1.3 Nominal Channel Bandwidth = 10 MHz

1 For a 10 MHz system a single instance of a resource allocation shall be made using a single IE. Furthermore
2 when Y (the total number of sub-bands over all frequency partitions) ≤ 11 , the AMS shall interpret the bits
3 in the Resource Allocation field as indicated by Table 22 (the row corresponding to the particular value of Y
4 in that table). In the case that Y = 12, the RA field shall be interpreted as in the first row of Table 22.
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Table 22—Interpretation of the RA Field in a 10 MHz or a 20 MHz system, when $Y \leq 11$ (Y is the total number of sub-bands over all frequency partition)

Total # of sub-bands over all frequency partitions, Y	RA Field Interpretation	
$Y = 10$ or 11	<p>Each of the j bit-positions in the RA field, $0 \leq j < 11$, indicates the allocation or non-allocation of all $N_1 (= 4)$ CRUs within a particular sub-band.</p> <p>Denote $RA[j]$ as the j^{th} bit position in the RA Field, $0 \leq j < 11$, with $j = 0$ being the LSB.</p> <p>$RA[j]$ corresponds to the sub-band, i.e., the 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$</p> <p>Depending on the value of Y, not all j may be relevant.</p> <p>$RIF[j] = 1 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have not been allocated.</p>	
$Y = 6, 7, 8$ or 9	<p>The 2 MSB bits of the RA field are denoted as the “Indication Type field” (ITF).</p> <p>The Y LSB bits of the RA field are denoted as the “Resource Indexing Field” (RIF).</p> <p>Denote $RIF[j]$ as the j^{th} bit position in the RIF, $0 \leq j < Y$, with $j = 0$ being the LSB.</p>	
	ITF == 00	<p>Each of the $RIF[j]$, $0 \leq j < Y$, indicates the allocation or non-allocation of all $N_1 (= 4)$ CRUs within a particular sub-band (out of the Y sub-bands).</p> <p>$RIF[j] = 1 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have not been allocated.</p>
	ITF == 01	<p>Each of the $RIF[j]$, $0 \leq j < Y$, indicates the allocation or non-allocation of the 1st 2 CRUs within a particular sub-band.</p> <p>$RIF[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j$ have not been allocated.</p>
	ITF == 10	<p>Each of the $RIF[j]$, $0 \leq j < Y$, indicates the allocation or non-allocation of the last 2 CRUs within a particular sub-band.</p> <p>$RIF[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j + 1$ have been allocated.</p> <p>$RIF[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = 2j + 1$ have not been allocated.</p>

Table 22—Interpretation of the RA Field in a 10 MHz or a 20 MHz system, when $Y \leq 11$ (Y is the total number of sub-bands over all frequency partition)

$Y \leq 5$	<p>Each of the j bit-positions in the RA field, $0 \leq j < 11$, indicates the allocation or non-allocation of 2 CRUs within a particular sub-band.</p> <p>Denote $RA[j]$ as the j^{th} bit position in the RA Field, $0 \leq j < 11$, with $j = 0$ being the LSB.</p> <p>$RA[j]$ corresponds to the 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$</p> <p>Depending on the value of Y, not all j may be relevant.</p> <p>$RA[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$ have been allocated.</p> <p>$RA[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1/2} \right\rfloor = j$ have not been allocated.</p>
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3.3.2.5.1.4 Nominal Channel Bandwidth = 20 MHz

For a 20 MHz system the following procedure shall be followed:

- 1) When Y (total number of sub-bands over all frequency partitions) ≤ 11 , a single instance of a resource allocation shall be made using a single IE. In this case, the AMS shall interpret the bits in the Resource Allocation field as indicated by Table 22 (the row corresponding to the particular value of Y in that table).
- 2) When Y (total number of sub-bands over all frequency partitions) > 11 , a single instance of a resource allocation may be made using a single or two IEs.
 - a) When an allocation is made using 2 IEs, the RA fields of the two IEs shall be concatenated to form a 22-bit field, referred to as the Concatenated-RA field (C-RA field). The LSB of the RA field of the IE occurring last in the A-AMAP region shall be interpreted as the LSB of the C-RA field. The AMS shall interpret the bits in the C-RA field as indicated by Table 23 (the row corresponding to the particular value of Y in that table). The AMS may infer that two IEs refer to the same instance of a resource allocation from the values of the ACID and SPID fields.
 - b) When an allocation is made using a single IE, the RA field shall be interpreted as in Table 24 & Table TBD. These tables map the value of the RA field to the indices of 2 non-contiguous sub-bands, and 3 non-contiguous sub-bands, respectively.

Table 23— Interpretation of the C-RA Field in a 20 MHz system

Total # of sub-bands over all frequency partitions, Y	C-RA Field Interpretation
$Y = 21, 22, 23$ or 24	<p>Each of the j bit-positions in the C-RA field, $0 \leq j < 22$, indicates the allocation or non-allocation of all $N_1 (= 4)$ CRUs within a particular sub-band.</p> <p>Denote $RA[j]$ as the j^{th} bit position in the C-RA Field, $0 \leq j < 22$, with $j = 0$ being the LSB.</p> <p>$RA[j]$ corresponds to the sub-band, i.e., the the 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$</p> <p>Depending on the value of Y, not all j may be relevant.</p> <p>$RA[j] = 1 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have been allocated.</p> <p>$RA[j] = 0 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{SBCRU[k]}{N_1} \right\rfloor = j$ have not been allocated.</p>

Table 23— Interpretation of the C-RA Field in a 20 MHz system

20 <= Y <= 12	The 2 MSB bits of the C-RA field are denoted as the “Indication Type field” (ITF). The Y LSB bits of the C-RA field are denoted as the “Resource Indexing Field” (RIF). Denote RIF[j] as the j^{th} bit position in the RIF, $0 \leq j < Y$, with $j = 0$ being the LSB.
ITF == 00	Each of the RIF[j], $0 \leq j < Y$, indicates the allocation or non-allocation of all $N_1 (= 4)$ CRUs within a particular sub-band (out of the Y sub-bands). $\text{RIF}[j] = 1 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1} \right\rfloor = j$ have been allocated. $\text{RIF}[j] = 0 \Rightarrow$ The 4 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1} \right\rfloor = j$ have not been allocated.
ITF == 01	Each of the RIF[j], $0 \leq j < Y$, indicates the allocation or non-allocation of the 1 st 2 CRUs within a particular sub-band. $\text{RIF}[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1/2} \right\rfloor = 2j$ have been allocated. $\text{RIF}[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1/2} \right\rfloor = 2j$ have not been allocated.
ITF == 10	Each of the RIF[j], $0 \leq j < Y$, indicates the allocation or non-allocation of the last 2 CRUs within a particular sub-band. $\text{RIF}[j] = 1 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1/2} \right\rfloor = 2j + 1$ have been allocated. $\text{RIF}[j] = 0 \Rightarrow$ The 2 CRUs with indices k such that $\left\lfloor \frac{\text{SBCRU}[k]}{N_1/2} \right\rfloor = 2j + 1$ have not been allocated.

Table 24 maps the value of the 11-bit RA to a pair of non-contiguous sub-band indices.

Table 24—Mapping of decimal values of the 11-bit RA (for $0 \leq \text{RA value} < 254$) to a pair of non-contiguous sub-band indices, for a 10 MHz system

1 st SBI 2 nd SBI	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	0									9												21
1		22																				42
2			43																			62
3				63																		81
4					82																	99
5						100																116
6							117															132
7								133														147
8									148													161
9										162												174
10											175											186
11												187										197
12													198									207
13														208								216
14															217							224
15																225						231
16																	232					237
17																		238				242
18																			243			246
19																				247		249
20																					250	251
21																						252

In Table 24, the decimal value of the RA field increase from left to right, and then from top to bottom; values at the beginning and end of each row are shown in the table. The shaded cells are not used to make interpretations. For a given value of the RA, the mapping using that value is given by the indices of the two sub-bands as indicated in the “1st sub-band index” row and the “2nd sub-band index” column. As an example, RA = 00001001 (Decimal value 9) maps to the pair of sub-bands indices {0, 11}. Then, the allocation is the set of LRUs with index k such that $\left\lfloor \frac{\text{LRU}[k]}{N_1} \right\rfloor = 0 \text{ or } 11$.

Table TBD translates values of the 11-bit RA from 253 to 2047 to triplets of non-contiguous sub-band indices. This table is TBD.

3.3.2.5.2 UL Sub-band Assignment A-MAP IE

The UL Sub-band Assignment A-MAP IE shall have an identical structure to the UL Basic Assignment A-MAP IE defined in Section 15.3.6.5.2.3. With the exception of the “IE Type” and the “Resource Allocation” field, all of the other fields shall be interpreted in the same manner as defined for the DL Basic Assignment A-MAP IE.

The “IE Type” field shall be set to the value 0b0010.

For all bandwidths, the “Resource Allocation” field shall be 11 bits long.

The structure and interpretation of the RA field for the UL Sub-band Assignment A-MAP IE shall be the same as that for the RA field for the DL Sub-band Assignment A-MAP IE, with all DL parameters/terms replaced by their UL equivalents.

3.3.2.5.3 Broadcast Control Information Elements

3.3.2.5.3.1 P-SFH IE

The P-SFH IE contains essential system information and it is mapped to the P-SFH. The format of the P-SFH IE is shown in Table 25.

Table 25—P-SFH IE format

Syntax	Size (bit)	Notes
P-SFH IE format () {		
LSB of Superframe number	4	Part of superframe number
S-SFH change count	4	Describes the S-SFH SPx IE that apply to this superframe.
S-SFH Size	4	The units of LRU
S-SFH Number of Repetitions	2	Indicate the transmission format (repetition) used for S-SFH.

Table 25—P-SFH IE format

Syntax	Size (bit)	Notes
S-SFH Scheduling information bit-mat	3	0b000: no S-SFH If 1 st bit = 1, S-SFH includes SP1 otherwise no SP1 If 2 nd bit = 1, S-SFH includes SP2 otherwise no SP2 If 3 rd bit = 1, S-SFH includes SP3 otherwise no SP3
S-SFH SP change bitmap	3	Indicate the change of S-SFH SPx IE. The bit #0 to bit #2 is mapped to S-SFH SP 1 IE to S-SFH SP3 IE, respectively.
Reserved	4	The reserved bits are for future extension.
}		

S-SFH Count

Incremented by one (modulo TBD) by the ABS whenever any of the values (except MSBs of superframe number in S-SFH SP1) of the S-SFH IEs changes. If the value of this count in a subsequent P-SFH IE remains the same, the AMS can quickly decide that the S-SFH IEs have not changed and may be able to disregard the S-SFH IEs.

S-SFH SP change bitmap

Toggled change bit of S-SFH SP IEs. If any field of S-SFH SP IE is changed (except MSBs of superframe number in S-SFH SP1), the corresponding bit is toggled.

3.3.2.5.3.2 S-SFH IE

The S-SFH IE is mapped to the S-SFH. Essential system parameters and system configuration information belonging to the S-SFH are categorized into three S-SFH subpacket IEs such as SP1, SP2 and SP3. These SPs are transmitted in different timing and periodicity. The periodicity of SP (T_{SP}) is determined with $T_{SP1} < T_{SP2} < T_{SP3}$. The S-SFH IE format are shown in Table 26.

Each S-SFH subpacket IE is of a fixed size.

Table 26—S-SFH IE format

Syntax	Size (bit)	Notes
S-SFH IE format () {		
If (1 st bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP1 IE ()		

Table 26—S-SFH IE format

Syntax	Size (bit)	Notes
}		
if (2 nd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP2 IE ()		
}		
if (3 rd bit of S-SFH Scheduling information bitmap == 1) {		
S-SFH SP3 IE ()		
}		
}		

S-SFH SP1 IE contains information for network re-entry, see Table 27.

Table 27—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
S-SFH SP1 IE format () {		
Start superframe offset where new SP1 information is used	2	
MSB of superframe number	8	Remaining bit of SFN except LSB of SFN in P-SFH
LSB of 48 bit ABS MAC ID	12	Specifies the 12 least bit of ABS ID
Number of UL ACK/NACK channels per HARQ feedback region	2	Channel numbers represented by the two bits (0, 1, 2, 3) are as follows. For 5 MHz band, 6, 12, 18, 24 For 10 MHz band, 6, 12, 24, 30 For 20 MHz band, 12, 24, 48, 60
Number of UL ACK/NACK channels per HF-A-MAP egion	2	Channel numbers represented by the two bits (0, 1, 2, 3) are as follows. For 5 MHz band, 4, 8, 12, 16 For 10 MHz band, 8, 16, 24, 32 For 20 MHz band, 16, 32, 48, 64
Power control channel resource size indicator	2	
Non-user specific A-MAP location	1	Reuse 1 or reuse 3
A-A-MAPMCS selction	1	
DL permutation configuration (CRU, DRU partitioning and signaling related to that)	13	For 20 MHz, DL_CAS_SB0 (4 bits), DL_CAS_MB0 (6 bits), DL_CAS_SBi (3 bits)

Table 27—S-SFH SP1 IE format

Syntax	Size (bit)	Notes
UL permutation configuration (CRU, DRU partitioning and signaling related to that)	13	For 20 MHz, UL_CAS_SB0 (4 bits), UL_CAS_MB0 (6 bits), UL_CAS_SBi (3 bits)
Unsync ranging allocation interval channel information (ranging region periodicity)	3	
Unsync ranging location in the frame (time and frequency)	2	
RNG codes information	8	
Ranging code subset/ partition configuration	3	
ABS EIRP	7	Signed in units of 1 dBm
Cell bar information	1	If Cell Bar bit = 1, this cell is not allowed for any new initial entry
Reserved	TBD	
}		

S-SFH SP2 IE contains information for initial network entry and network discovery, see Table 28.

Table 28—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
S-SFH SP2 IE format () {		
Start superframe offset where new SP2 information is used	2	
Frame configuration index	6	The mapping between value of this index and frame configuration is listed in Table X, X+1, and X+2
If (Duplexing mode == FDD) {		
UL carrier frequency	6	
UL bandwidth	3	
}		
MSB bytes of 48 bit ABS MAC ID	36	Specifies 36 MBS of BS ID
MAC protocol revision	4	version number of IEEE 802.16m supported on this channel

Table 28—S-SFH SP2 IE format

Syntax	Size (bit)	Notes
FFR partitioning info for DL region	12	For 20 MHz, DL_SAC(5 bits), DL_FPSC(3 bits), DL_FPC(4 bits) For 5 MHz, DL_SAC(3 bits), DL_FPSC(1 bit), DL_FPC(3 bits)
FFR partitioning info for UL region	12	For 20 MHz, UL_SAC(5 bits), UL_FPSC(3 bits), UL_FPC(4 bits) For 5 MHz, UL_SAC(3 bits), UL_FPSC(1 bit), UL_FPC(3 bits)
AMS Transmit Power Limitation Level	5	Unsigned 5-bit integer. Specifies the maximum allowed AMS transmit power. Values indicate power levels in 1 dB steps starting from 0 dBm
EIRP _{IR,min}	5	
reserved		
}		

S-SFH SP3 IE contains remaining essential system information, see Table 29.

Table 29—S-SFH SP3 IE format

Syntax	Size (bit)	Notes
S-SFH SP3 IE format () {		
Start superframe offset where new SP3 information is used	2	
Rate of change of SP (1-3) info	4	
SA-sequence soft partitioning information	4	
FFR partition resource metrics	TBD	
MIMO rank 1 OL region signaling	TBD	
MIMO rank 1 OL region	TBD	
N1 information for UL power control	TBD	
UL Fast FB Size	4	Specifies the size of UL feedback channel per a UL subframe
# Tx antenna	2	0b00: 2 antennas 0b01: 4 antennas 0b10: 8 antennas 0b11: reserved
Default RSSI and CINR averaging parameter	3	
SP scheduling periodicity information	TBD	

Table 29—S-SFH SP3 IE format

Syntax	Size (bit)	Notes
HO Ranging backoff start	4	Initial backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0)
HO Ranging backoff end	4	Final backoff window size for MS performing initial ranging during HO process, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff start	4	Initial backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
Initial ranging backoff end	4	Final backoff window size for initial ranging contention, expressed as a power of 2. Values of n range 0-15
UL BW REQ channel information	3	
Bandwidth request backoff start	4	Initial backoff window size for contention BRs, expressed as a power of 2. Values of n range 0-15 (the highest order bits shall be unused and set to 0)
Bandwidth request backoff end	4	Final backoff window size for contention BRs, expressed as a power of 2. Values of n range 0-15
Uplink subframe bitmap for sounding	8	
Sounding multiplexing type (SMT) for sounding	1	
Decimation value D/ Max Cyclic Shift Index P for sounding	3	
Reserved	TBD	
}		

3.3.2.5.4 Unicast Control Information Elements

A-MAP IE is defined as the basic element of unicast service control.

3.3.2.5.4.1 Non-user-specific A-MAP IE

Non-user-specific A-MAP IE consists of information that is not dedicated to a specific user or a specific group of users. It includes information required to decode assignment A-MAP IE. The number of assignment A-MAPs in each assignment A-MAP group is indicated in the Non-user-specific A-MAP IE. A-MAP IE also includes HF-A-MAP Index Parameter and HFBCH Index Parameter, which are used to indicate which transmission parameter is used to calculate HF-A-MAP index and HFBCH index respectively. The detailed information included in non-user specific information is TBD. The non-user specific A-MAP IE is shown in Table 30. Non-user specific A-MAP IE has [12] bits in total.

Table 30—Non-user specific A-MAP IE

Syntax	Size [bits]	Notes
Assignment A-MAP size	TBD	Indicate the number of assignment A-MAPs in each assignment A-MAP group as shown in <<Table 667.>>
HF-A-MAP Index Parameter	1	Indicate which transmission parameter is used to calculate HF-A-MAP index.
HFBCCH Index Parameter	1	Indicate which transmission parameter is used to calculate HFBCCH index.
Non-user specific A-MAP extension flag	1	If non-user specific A-MAP extension flag is set, it indicates that non-user specific A-MAP is extended. The extended non-user specific part uses the same PHY structure as the non-user specific A-MAP
Reserved	TBD	Reserved bits

Table 31 [Detailed entry is TBD] shows the number of the assignment A-MAPs in each assignment A-MAP group.

Table 31—The number of assignment A-MAPs in each assignment A-MAP group

Index	Assignment A-MAP group-1	Assignment A-MAP group-2	...
...	

The resource allocation for Broadcast messages (e.g., PGID Info, AAI-TRF-IND, AAI-PAG-ADV, and other broadcast) is based on A-MAP_IE or non-user specific A-MAP extension.

If the non-user specific A-MAP extension flag in the non-user specific A-MAP is set, the non-user specific A-MAP extension may be used to specify the information used to decode the PGID Info, AAI-TRF-IND, AAI-PAG-ADV, and other broadcast messages. The PHY structure for this extension is the same as the non-user specific A-MAP.

Table 32 describes Assignment A-MAP IE Types.

Table 32—Assignment A-MAP IE types

A-MAP IE Type	Usage
0b0000	DL Basic Assignment A-MAP IE
0b0001	UL Basic Assignment A-MAP IE
0b0010	DL Subband Assignment A-MAP IE
0b0011	UL Subband Assignment A-MAP IE
0b0100	Feedback Allocation A-MAP IE
0b0101	UL Sounding Command A-MAP IE

A-MAP IE Type	Usage
0b0110	CDMA Allocation A-MAP IE
0b0111	DL Persistent A-MAP IE
0b1000	UL Persistent A-MAP IE
0b1001	DL Group Configuration A-MAP IE
0b1010	UL Group Configuration A-MAP IE
0b1011	DL Group Resource Allocation A-MAP IE
0b1100	UL Group Resource Allocation A-MAP IE
0b1101	Reserved
0b1110	Reserved
0b1111	Reserved

3.3.2.5.4.2 DL basic assignment A-MAP IE

3.3.2.5.4.3

Table 33 describes the fields in a DL Basic Assignment A-MAP IE used for resource assignment in the DL.

Definitions of the fields in the DL Basic Assignment A-MAP IE are listed following Table 33.

Table 33—DL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
DL-MAP() {		
A-MAP IE Type	4	DL Basic Assignment A-MAP IE
$I_{\text{SizeOffset}}$	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: CDR
if (MEF == 0b01){		Parameters for vertical encoding
if($N_t = 2$){		
Mt	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams
}else if($N_t = 4$){		

Table 33—DL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
Mt	2	Number of streams in transmission for $N_t = 4$ ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
}else if($N_t == 8$) {		
Mt	3	Number of streams in transmission for $N_t = 8$ ($M_t \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
} else if(MEF == 0b10) {		Parameters for horizontal encoding
If($N_t == 2$) {		
PSI	1	Allocated pilot stream index for $N_t = 2$ 0b0: #1 stream 0b1: #2 stream
Mp	2	Modulation constellation of the paired user 0b00: QPSK 0b01: 16 QAM 0b10: 64 QAM 0b11: other modulation information not available.
} else {		

Table 33—DL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
Si	4	Index used when Nt= 4 or 8, to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO , and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI=stream1 and other modulation =QPSK 0b0001: 2 streams with PSI=stream1 and other modulation =16QAM 0b0010: 2 streams with PSI=stream1 and other modulation =64QAM 0b0011: 2 streams with PSI=stream1 and other modulation information not available 0b0100: 2 streams with PSI=stream2 and other modulation =QPSK 0b0101: 2 streams with PSI=stream2 and other modulation =16QAM 0b0110: 2 streams with PSI=stream2 and other modulation =64QAM 0b0111: 2 streams with PSI=stream2 and other modulation information not available 0b1000: 3 streams with PSI=stream1 0b1001: 3 streams with PSI=stream2 0b1010: 3 streams with PSI=stream3 0b1011: 4 streams with PSI=stream1 0b1100: 4 stream with PSI=stream2 0b1101: 4 streams with PSI=stream3 0b1110: 4 streams with PSI=stream4 0b1111: n/a
}		
}		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size.
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	[4]	TBD HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	4	HARQ channel identifier
SPID/CoRe Version	[3]	HARQ subpacket identifier for IR and Constellation Rearrangement version
Reserved	TBD	Reserved bits
Padding	variable	Padding to reach byte boundary
}		

* A 16 bit CRC is generated based on the contents of the DL Basic Assignment A-MAP IE. The CRC is masked by the Station ID.

A-MAP IE Type: Defines the structure of the A-MAP IE for the bits in the A-MAP IE following the A-MAP IE type field. A-MAP IE Type distinguishes between UL/DL, basic/extended IE. Additional IE types are reserved for future use.

MEF: MIMO Encoder Format.

PSI: Allocated pilot stream index for horizontal encoding.

Mt: Number of streams in transmission. The DL pilot pattern with Mt streams shall be used in the allocated resource..

Mp: Modulation constellation of the paired user for 2 stream MU-MIMO operation with Nt = 2

Si: Index used when Nt= 4 or 8, to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO , and the modulation constellation of paired user in the case of 2 stream transmission

RA: Resource Allocation information is used to signal the type of resource unit allocated (DRU/CRU), the location (start/end) and allocation size.

Long TTI Indication: Indicator to signal allocations span multiple subframes in time.

HFA: TBD allocation for HARQ feedback.

SPID/CoRe Version: Signaling for HARQ IR including HARQ subpacket identifier for IR and Constellation Rearrangement version.

RI: Resource Index with location and size of one instance of a resource allocation.

Resource Indexing in the DL Basic Assignment A-MAP IE

The resource index RI for an allocation of contiguous LRUs in a DL/UL subframe includes the size (S) of the allocated resource in number of contiguous LRUs and index (L) of the LRU from where the scheduled allocation begins.

Derivation of the mapping between LRU index and physical PRU index:

For each frequency partition i, the total number of CRUs & DRUs up-to and including that partition is calculated as

$$S_i = \sum_{m=0}^{m=i} FPS_m, 0 \leq i < 3 \quad (28)$$

$$LRU[k] = \left\{ \begin{array}{l} CRU_{FP_i}[k - S_{i-1}], \text{ for } S_{i-1} \leq k \leq (L_{CRU, FP_i} + S_{i-1}) \\ DRU_{FP_i}[k - (L_{CRU, FP_i} + S_{i-1})], \text{ for } (L_{CRU, FP_i} + S_{i-1}) \leq k \leq S_i \end{array} \right\}, \text{ for } 0 \leq i \leq 3 \quad (29)$$

with $0 \leq k < \sum_{m=0} FPS_m$

The mapping from CRU_{FP_i} and DRU_{FP_i} to the physical PRU indices (and vice-versa) is as specified in Section 15.3.5.

The LRU index, L obtained from the RI field refers to the LRU[] defined above.

Determining the Resource Index for the Scheduled Resource at the ABS

For a given system bandwidth with $N_{max} = S_3$ LRUs across all frequency partitions, the ABS maintains a vector I_a of length N_{max} in which the non-zero entries contain the starting index for each of the assignable resource sizes.

The i th element of I_a , $1 \leq i \leq 96$ for 11 bit resource indexing in a DL/UL subframe for a 20 MHz system

bandwidth is defined as in <<equation>>:

$$I_a(i) = \begin{cases} 0 & i = 1 \\ I_a(i-1) + (96 - (i-1) + 1) & 2 \leq i \leq 12 \\ I_a(i-2) + (96 - (i-2) + 1) & i = 2k, 7 \leq k \leq 12 \\ I_a(i-4) + (96 - (i-4) + 1) & i = 4k, 7 \leq k \leq 12 \\ I_a(i-8) + (96 - (i-8) + 1) & i = 8k, 7 \leq k \leq 11 \\ 96 \\ 2048 - \sum_{k=i}^{96} 96 - k + 1 & 92 \leq i \leq 96 \\ 0 & otherwise \end{cases} \quad (30)$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = \begin{cases} I_a(S) + L & \text{if } I_a(S) > 0 \\ \text{not assignable} & \text{if } I_a(S) = 0 \text{ and } S > 1 \end{cases}$$

where $1 \leq S \leq 96$ and $0 \leq L \leq 95$

The ABS first determines if the required resource size is assignable by checking if the S^{th} element in I_a has a non-zero value or $S = 1$. If the size S is assignable, then the 11 bit resource index is then determined by simply adding L to the value of the S^{th} element in I_a . If the required resource is not assignable, the next higher or lower non-zero element in I_a is selected based on the link adaptation scheme employed.

The i th element of I_a , for 11 bit resource indexing in a DL/UL subframe for a 10 MHz system bandwidth is defined as:

$$I_a(i) = \begin{cases} 0 & i = 1 \\ I_a(i-1) + (48 - (i-1) + 1) & 2 \leq i \leq 48 \end{cases}$$

$$RI = I_a(S) + L, 1 \leq S \leq 48 \text{ and } 0 \leq L \leq 47$$

The i^{th} element of I_a , $1 \leq i \leq 24$ for 9 bit resource indexing in a DL/UL subframe for a 5 MHz system bandwidth is defined as:

$$I_a(i) = \begin{cases} 0 & i = 1 \\ I_a(i-1) + (24 - (i-1) + 1) & 2 \leq i \leq 24 \end{cases}$$

The resource index RI for an allocation of size S LRUs beginning at LRU L is computed as

$$RI = I_a(S) + L, 1 \leq S \leq 24 \text{ and } 0 \leq L \leq 23$$

Determining the Scheduled Resource from the Resource Index at the Receiver

At the receiver the 11 bit index, RI in the A-MAP is decoded as follows. The value of element S in I_a with the smallest value equal to or less than the index is used to determine the assigned resource size S . Let this value be $I_a(i)$.

The starting LRU for the allocation is determined by subtracting the value of the S^{th} element in I_a from the index in the A-MAP, i.e.,

$$L = RI - I_a(i)$$

Table 34 describes Assignment A-MAP IE Types.

Table 34—Assignment A-MAP IE types

A-MAP IE Type	Usage
0b0000	DL Basic Assignment A-MAP IE
0b0001	UL Basic Assignment A-MAP IE
0b0010	DL Subband Assignment A-MAP IE
0b0011	UL Subband Assignment A-MAP IE
0b0100	Feedback Allocation A-MAP IE
0b0101	UL Sounding Command A-MAP IE
0b0110	CDMA Allocation A-MAP IE
0b0111	DL Persistent A-MAP IE
0b1000	UL Persistent A-MAP IE
0b1001	DL Group Configuration A-MAP IE
0b1010	UL Group Configuration A-MAP IE
0b1011	DL Group Resource Allocation A-MAP IE
0b1100	UL Group Resource Allocation A-MAP IE
0b1101	Reserved
0b1110	Reserved
0b1111	Reserved

3.3.2.5.4.4 UL basic assignment A-MAP IE

Table 35 describes the fields in a UL Basic Assignment A-MAP IE used for resource assignment in the UL.

Table 35—UL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
UL-MAP_IE() {		
A-MAP IE Type	4	UL Basic Assignment A-MAP IE
$I_{SizeOffset}$	5	Offset used to compute burst size index
CSM PMI Indicator	1	Flag to indicate if both CSM and PMI are signaled 0b0: SU-MIMO with or without PMI indication , or CSM without PMI indication 0b1: CSM with PMI indication
If(CSM-PMI Indicator == 0b0){		
M_t	2	Number of streams in transmission ($M_t \leq N_t$), up to 4 streams per AMS supported 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
SU-PMI Indicator	1	Flag to indicate if both SU-MIMO and PMI are signaled 0b0: SU MIMO without PMI indication, or CSM without PMI indication 0b1: SU MIMO with PMI indication
If(SU-PMI Indicator == 0b0){		
CSM	1	Flag to indicate CSM 0b0: SU-MIMO 0b1: CSM
if(CSM == 0b0){		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding Non-adaptive precoding shall be used at the AMS with SFBC
if(MEF == 0b1){		
PF	1	Precoding flag for SU-MIMO when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive codebook precoding using the precoder of rank M_t of MS's choice
}		
} else if(CSM == 0b1){		Parameters for CSM
PF	1	Precoding flag for CSM when PMI is not signaled 0b0: Non-adaptive precoding 0b1: Adaptive codebook precoding using the precoder of rank M_t of MS's choice

Table 35—UL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
if(TNS == 2){		
SI	1	First pilot index for CSM with TNS = 2
} else{		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		
}else if (SU-PMI Indicator == 0b1){		Parameters for SU-MIMO with PMI (adaptive precoding)
if(N_t == 2){		
PMI	4	3 bits PMI for N_t = 2
}else if(N_t == 4){		
PMI	6	6 bits PMI for N_t = 4
}		
}else if(CSM-PMI Indicator == 0b1){		Parameters for CSM with PMI (adaptive precoding)
CSM Format	4	For non CSM, modes, TNS = M_t . For CSM modes the following combinations apply for upto 4 streams 0b0000: TNS = 2, M_t =1, SI=1 0b0001: TNS = 2, M_t =1, SI=2 0b0010: TNS = 3, M_t =1, SI=1 0b0011: TNS = 3, M_t =1, SI=2 0b0100: TNS = 3, M_t =1, SI=3 0b0101: TNS = 3, M_t =2, SI=1 0b0110: TNS = 3, M_t =2, SI=2 0b0111: TNS = 4, M_t =1, SI=1 0b1000: TNS = 4, M_t =1, SI=2 0b1001: TNS = 4, M_t =1, SI=3 0b1010: TNS = 4, M_t =1, SI=4 0b1011: TNS = 4, M_t =2, SI=1 0b1100: TNS = 4, M_t =2, SI=2 0b1101: TNS = 4, M_t =2, SI=3 0b1110: TNS = 4, M_t =3, SI=1 0b1111: TNS = 4, M_t =3, SI=2
if(N_t == 2){		
PMI	3	3 bits PMI for N_t = 2
}else if(N_t == 4){		
PMI	6	6 bits PMI for N_t = 4

Table 35—UL basic assignment A-MAP IE*

Syntax	Size in bits	Description/Notes
}		
}		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 UL subframes for FDD or all UL subframes for TDD If number of DL subframes, D, is less than number of UL subframes, U, Long TTI Indicator= 0b1
HFA	[4]	TBD HARQ Feedback Allocation
AI_SN	1	HARQ identifier sequence number
ACID	3	HARQ channel identifier
Reserved	TBD	Reserved bits
Padding	variable	Padding to reach byte boundary
}		

*A 16 bit CRC is generated based on the contents of the UL Basic Assignment A-MAP IE. The CRC is masked by the Station ID

TNS: Total number of streams in the LRU for CSM

SI: First pilot index for CSM.

PF: Precoding flag to indicate adaptive or non-adaptive precoding.

PMI: Precoding matrix index .

CSM-PMI Indicator: Flag to indicate if both CSM and PMI are signaled

SU-PMI Indicator: Flag to indicate if both SU-MIMO and PMI are signaled

CSM: Flag to indicate if CSM is signaled

The Resource Index field in the UL Basic Assignment A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE, with 'DL' specific terminology replaced by 'UL' equivalents.

3.3.2.5.4.5 Group resource allocation A-MAP IE

Group control information is used to allocate resources and/or configure resources to one or multiple AMSs within a user group. The group resource allocation A-MAP IE is shown in Table 36.

Group scheduling requires two operations

- 1) Assignment of an AMS to a group. In order to add a AMS to a group in the DL or UL, the ABS shall transmit a Group Configuration A-MAP IE.
- 2) Allocation of resources to AMSs within a group. In order to assign resources to one or more AMSs in a group, the ABS shall transmit the DL/UL Group Resource Allocation A-MAP IE. The DL/UL Group Resource Allocation A-MAP IE is included in user-specific resource assignment in an A-MAP region. The GRA A-MAP IE contains bitmaps to indicate scheduled AMSs and signal nominal , MCS, MIMO mode and resource size.

Table 36—DL group resource allocation A-MAP IE*

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	DL Group Resource Allocation A-MAP IE
Long TTI Length	1	Defines number of subframes spanned by the allocated resource. 0: 1 subframe (default) 1: 4 DL/UL subframes for FDD or all DL/UL subframe for TDD
Resource Offset	[6]	Indicates starting LRU for resource assignment to this group
ACK Channel Offset	TBD	Indicates the start of ACK index used for scheduled allocations and de-allocations at this subframe in the group. The ACK channels for scheduled allocations occur first, in the order of user bitmap, followed by the ACK channel for de-allocations, followed by the ACK channels for shifted AMSs.
User Bitmap Size	[2][5]	Indicates the length of User Bitmap
User Bitmap	<i>Variable</i>	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size. 0: AMS not allocated in this subframe 1: AMS allocated in this frame
N_deallocated_AMS	2	Number of deallocated AMSs
For(i=0; i<N_deallocated_AMS; i++){		
De-allocated AMS index	<i>Variable</i>	Signals the indices of de-allocated AMS among the inactive AMSs in the user bitmap. The length of De-allocated AMS Index field determined as $\text{Ceil}\{\log_2(\text{Number of Inactive AMSs in User Bitmap})\}$.
}		
Re-arrange Indicator	1	Signals whether the re-arrange bitmap is present in this GRA IE
If (Re-arrange Indicator == 1) {		
Re-arrange Bitmap	<i>Variable</i>	This bitmap signals the occupied bits in the user bitmap. The size of the bitmap is equal to the number of 0's in the user bitmap
}		
If(Group MIMO mode set ==0b01 or 0b11){		
MIMO Bitmap	<i>Variable</i>	Bitmap to indicate MIMO mode for the scheduled AMSs.

Table 36—DL group resource allocation A-MAP IE*

Syntax	Size in bits *	Description/Notes
}		
If(Group MIMO mode set == 0b11){		
PSI Bitmap	<i>Variable</i>	Bitmap to indicate PSI for MU-MIMO
Pairing Bitmap	<i>Variable</i>	Bitmap to indicate AMS pair sharing same resource for MU-MIMO
}		
Resource Assignment Bitmap	<i>Variable</i>	Bitmap to indicate burst size/resource size for each scheduled AMS
Padding	<i>Variable</i>	Padding to reach byte boundary

* A 16 bit CRC is generated based on the contents of the DL Group Resource Allocation A-MAP IE. The CRC is masked by the Group ID for the DL Group Resource Allocation A-MAP IE.

Table 37—UL group resource allocation A-MAP IE*

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	UL Group Resource Allocation A-MAP IE
Long TTI Length	1	Defines number of subframes spanned by the allocated resource. 0: 1 subframe (default) 1: 4 DL/UL subframes for FDD or all DL/UL subframe for TDD
Resource Offset	[6]	Indicates starting LRU for resource assignment to this group
ACK Channel Offset	TBD	Indicates the start of ACK index used for scheduled allocations at this subframe in the group
User Bitmap Size	[2][5]	Size of the user bitmap; may not be needed if user bitmap size is included in configuration message/A-MAP IE
User Bitmap	<i>Variable</i>	Bitmap to indicate scheduled AMSs in a group. The size of the bitmap is equal to the User Bitmap Size
N_deallocated_AMS	2	Indicates the number of deleted AMSs in the group.
For(i=0;i<N_deallocated_AMS ; i++) {		
De-allocated AMS index	<i>Variable</i>	Signals the indices of de-allocated AMS among the inactive AMSs in the user bitmap. The length of De-allocated AMS Index field determined as $\text{Ceil}\{\log_2(\text{Number of Inactive AMSs in User Bitmap})\}$.
}		
Re-arrange Indicator	1	Signals whether the re-arrange bitmap is present in this GRA IE
If (Re-arrange Indicator == 1) {		

Table 37—UL group resource allocation A-MAP IE*

Syntax	Size in bits *	Description/Notes
Re-arrange Bitmap	<i>Variable</i>	This bitmap signals the occupied bits in the user bitmap. The size of the bitmap is equal to the number of 0's in the user bitmap
}		
If (N_deallocated_AMS != 0b00 or Re-arrange Indicator == 1) {		
HF Index	<i>TBD</i>	Starting HF Index for deallocated AMSs and re-arranged AMSs, if present
}		
If(Group MIMO mode set == 0b01){		
MIMO Bitmap	<i>Variable</i>	Bitmap to indicate MIMO mode for the scheduled AMSs.
}		
If(Group MIMO mode set == 0b10){		
PSI Bitmap	<i>Variable</i>	Bitmap to indicate PSI for MU-MIMO
Pairing Bitmap	<i>Variable</i>	Bitmap to indicate AMS pair sharing same resource for MU-MIMO
}		
Resource Assignment Bitmap	<i>Variable</i>	Bitmap to indicate burst size/resource size for each scheduled user
Padding	<i>Variable</i>	Padding to reach byte boundary

*A 16 bit CRC is generated based on the contents of the UL Group Resource Allocation A-MAP IE. The CRC is masked by the Group ID for the UL Group Resource Allocation A-MAP IE

3.3.2.5.4.6 Group Configuration A-MAP IE

The unicast group configuration A-MAP IE is used to assign an AMS to a group

Table 38—DL Group Configuration A-MAP IE*

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	DL Group Configuration A-MAP IE
Group ID	5	Indicates group identifier.
Lowest MCS in group	4	The index of the lowest MCS that shall be allowed in this group from the list of nominal MCSs defined in Table 744.
Highest MCS in group	4	The index of the highest MCS that shall be allowed in this group from the list of nominal MCSs defined in Table 744

Table 38—DL Group Configuration A-MAP IE*

Syntax	Size in bits *	Description/Notes
HARQ Burst Size Set ID	[2]	Indicates HARQ data burst size set supported in the group that is selected from the configured HARQ data burst size set candidates in additional broadcast message.
GRA Periodicity	[2]	Indicate the period of transmitting GRA A-MAP IE 0b00: 1 frame 0b01: 2 frame 0b10: 4 frame 0b11: 8 frame
Group MIMO Mode	2	Indicate Group MIMO mode set supported in the group. 0b00: SFBC 0b01: SFBC and Vertical encoding 0b10: CL SU-MIMO 0b11: CL SU-MIMO and CL MU-MIMO
User Bitmap Index	[5]	Indicates User Bitmap index to the AMS. An AMS may have multiple User Bitmap Indexes in a group.
Initial ACID	[4]	Indicates the start of ACID used for group resource allocation.
N_ACID	[3]	Indicates the number of ACIDs used for group resource allocation.
Padding	<i>Variable</i>	Padding to reach byte boundary

* A 16 bit CRC is generated based on the contents of the DL Group Configuration A-MAP IE. The CRC is masked by the Station ID for the DL Group Configuration A-MAP IE

Table 39—UL Group Configuration A-MAP IE*

Syntax	Size in bits *	Description/Notes
A-MAP IE Type	4	UL Group Configuration A-MAP IE
Group ID	5	Indicates group index.
Lowest MCS in group	4	The index of the lowest MCS that shall be allowed in this group from the list of nominal MCSs defined in Table 744.
Highest MCS in group	4	The index of the highest MCS that shall be allowed in this group from the list of nominal MCSs defined in Table 744
HARQ Burst Size Set ID	[2]	Indicates HARQ data burst size set supported in the group that is selected from the configured HARQ data burst size set candidates in additional broadcast message.
GRA Periodicity	[2]	Indicate the period of transmitting GRA A-MAP IE 0b00: 1 frame 0b01: 2 frame 0b10: 4 frame 0b11: 8 frame
Group MIMO Mode	2	Indicate Group MIMO mode set supported in the group. 0b00: SFBC 0b01: SFBC and Vertical encoding 0b10: OL MU-MIMO 0b11: <i>reserved</i>

Table 39—UL Group Configuration A-MAP IE*

Syntax	Size in bits *	Description/Notes
if ($N_{\text{subframe, A-MAP}} = 2$) {		
If (DL:UL != 3:5) {		
Allocation Rel- evance	1	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) 0b0: Allocation in the first DL subframe relevant to an A-MAP region 0b1: Allocation in the second DL subframe relevant to an A-MAP region
} else if (DL:UL != 3:5) {		
Allocation Rel- evance	2	Subframe index when an A-MAP region occurs every 2 subframes ($N_{\text{subframe, A-MAP}} = 2$) and DL:UL subframe ratio is 8:0, 6:2, 4:4 or 5:3 0b0: Allocation in the first UL subframe relevant to an A-MAP region 0b1: Allocation in the second UL subframe relevant to an A-MAP region
}		
}		
User Bitmap Index	[5]	Indicates User Bitmap index to the AMS. An AMS may have multiple User Bitmap Indexes in a group.
Initial ACID	[4]	Indicates the start of ACID used for group resource allocation.
N_ACID	[3]	Indicates the number of ACIDs used for group resource allocation.
Padding	<i>Variable</i>	Padding to reach byte boundary

* A 16 bit CRC is generated based on the contents of the UL Group Configuration A-MAP IE. The CRC is masked by the Station ID for the UL Group Configuration A-MAP IE.

3.3.2.5.4.7 DL PA A-MAP IE

The DL persistent A-MAP IE is specified in Table 40.

Table 40—DL persistent A-MAP IE*

Syntax	Size in bits	Description/Notes
DL Persistent A-MAP_IE() {	--	--
A-MAP IE Type	4	DL Persistent A-MAP IE
if (MCRC is masked with Station ID) {		
DL Individual Persistent A-MAP_IE()		Refer to Table 41
} else if (MCRC is masked with Composite ID) {		
DL Composite Persistent A-MAP_IE()		Refer to Table 42

Table 40—DL persistent A-MAP IE*

Syntax	Size in bits	Description/Notes
}		
}		

* A 16 bit CRC is generated based on the contents of the DL Individual or Composite Persistent A-MAP IE and the CRC is masked by Station ID or the Composite ID (well-known ID specified in the system, TBD) respectively

DL Individual PA A-MAP IE

The DL individual persistent A-MAP IE is specified in Table 41.

Table 41—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
DL Persistent A-MAP_IE() {	-	-
Allocation Period	2	Period of persistent allocation If (Allocation Period==0b00), it indicates the deallocation of a persistently allocated resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
If (Allocation Period==0b00){		
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
<i>Reserved</i>	TBD	
} else if (Allocation Period != 0b00){		
$I_{SizeOffset}$	5	Offset used to compute burst size index
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a

Table 41—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
if (MEF == 0b01){		Parameters for vertical encoding
Mt	3	Number of streams in transmission for $N_t = 8$ ($M_t \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
<i>Reserved</i>	1	
} else if (MEF == 0b10){		Parameters for horizontal encoding
Si	4	Index to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO, and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI=stream1 and other modulation =QPSK 0b0001: 2 streams with PSI=stream1 and other modulation =16QAM 0b0010: 2 streams with PSI=stream1 and other modulation =64QAM 0b0011: 2 streams with PSI=stream1 and other modulation information not available 0b0100: 2 streams with PSI=stream2 and other modulation =QPSK 0b0101: 2 streams with PSI=stream2 and other modulation =16QAM 0b0110: 2 streams with PSI=stream2 and other modulation =64QAM 0b0111: 2 streams with PSI=stream2 and other modulation information not available 0b1000: 3 streams with PSI=stream1 0b1001: 3 streams with PSI=stream2 0b1010: 3 streams with PSI=stream3 0b1011: 4 streams with PSI=stream1 0b1100: 4 stream with PSI=stream2 0b1101: 4 streams with PSI=stream3 0b1110: 4 streams with PSI=stream4 0b1111: n/a
}		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size

Table 41—DL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit index for HARQ Feedback Allocation
ACID	4	HARQ channel identifier. The ACID field shall be set to the initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers. N_ACIDs: Number of ACIDs for implicit cycling of HARQ channel identifier N_ACID=Floor{ PA_Max_ReTx_Delay/ (Allocation Period*Frame_length) }+1
}		
Reserved	TBD	Reserved bits
Padding	Variable	Padding to reach byte boundary
}	-	-

The Resource Index field in the DL Individual Persistent A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE.

The maximum HARQ retransmission delay for persistent allocation, $PA_Max_ReTx_Delay$ can be computed from N_Max_ReTx , the maximum number of retransmission and $PA_ReTx_Interval$, the allowable delay between consecutive retransmission of persistent allocation as follows.

$$PA_Max_ReTx_Delay = N_Max_ReTx * PA_ReTx_Interval$$

where $PA_ReTx_Interval$ is determined from $Long_TTI_Indicator$, T_{proc} , the data burst processing time, and $Frame_length$, the frame length as follows.

If $T_{proc} \leq 3$ and $Long_TTI_Indicator = 0$, $PA_ReTx_Interval = Frame_length$, otherwise, $PA_ReTx_Interval = 2 * Frame_length$.

DL Composite PA A-MAP IE

The DL composite persistent A-MAP IE is specified in Table 42.

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
DL Composite Persistent A-MAP_IE() {	-	-
Number of allocations	5	Number of allocation specified

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
RCID Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3
For (j=0;j<Number of allocations; j++) {		For loop where each loop element specifies information for one allocation.
Persistent Flag	1	0 = non-persistent 1 = persistent
RCID	variable	Specifies the station ID 16-bit composite ID with 12-bit station ID in MSB and 4-bit FID in LSB in RCID format, type defined by RCID Type
if (Persistent Flag == 1) {		
Allocation Period	2	Period of persistent allocation If (Allocation Period == 0b00), it indicates the deallocation of a persistently allocated resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
Allocation Period and ACID Indicator	1	If Allocation Period and ACID Indicator is 1, it indicates that allocation information (allocation period, Number of ACID (ACID) is explicitly assigned for this allocation. Otherwise, this allocation will use the same allocation period as the previous allocation. If j is 0 then this indicator shall be 1.
if (Allocation Period and ACID Indicator == 1) {	-	-
Allocation Periodicity (AP)	5	Period of the persistent allocation is this field value plus 1 (unit is sub-frame/frame TBD)
}		
ACID	4	HARQ channel identifier. The ACID field shall be set to the initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers. N_ACIDs: Number of ACIDs for implicit cycling of HARQ channel identifier N_ACID = Floor{ PA_Max_ReTx_Delay / (Allocation Period * Frame_length) } + 1
if (Persistent Flag == 1 & Allocation Period == 0b00) {		

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
}else{		
Allocation MCS indicator	1	If Allocation MCS Indicator is 1, it indicates that $I_{SizeOffset}$ is explicitly assigned for this allocation. Otherwise, this allocation will use the same $I_{SizeOffset}$ as the previous subburst. If j is 0 then this indicator shall be 1.
if (Allocation MCS indicator == 1) {		
$I_{SizeOffset}$	5	Offset used to compute burst size index
}		
MEF	2	MIMO encoder format 0b00: SFBC 0b01: Vertical encoding 0b10: Horizontal encoding 0b11: n/a
if (MEF == 0b01){		Parameters for vertical encoding
if($N_t == 2$){		
Mt	1	Number of streams in transmission for $N_t = 2$ ($M_t \leq N_t$) 0b0: 1 stream 0b1: 2 streams
}else if($N_t == 4$){		
Mt	2	Number of streams in transmission for $N_t = 4$ ($M_t \leq N_t$) 0b00: 1 stream 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
}else if($N_t == 8$){		

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Mt	3	Number of streams in transmission for $N_t = 8$ ($M_t \leq N_t$) 0b000: 1 stream 0b001: 2 streams 0b010: 3 streams 0b011: 4 streams 0b100: 5 streams 0b101: 6 streams 0b110: 7 streams 0b111: 8 streams
}		
} else if(MEF == 0b10){		Parameters for horizontal encoding
if($N_t == 2$){		
PSI	1	Allocated pilot stream index for $N_t = 2$ 0b0: #1 stream 0b1: #2 stream
Mp	2	Modulation constellation of the paired user 0b00: QPSK 0b01: 16 QAM 0b10: 64 QAM 0b11: n/a
} else{		

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Si	4	Index used to identify the combination of the number of streams and the allocated pilot stream index in a transmission with MU-MIMO , and the modulation constellation of paired user in the case of 2 stream transmission 0b0000: 2 streams with PSI=stream1 and other modulation =QPSK 0b0001: 2 streams with PSI=stream1 and other modulation =16QAM 0b0010: 2 streams with PSI=stream1 and other modulation =64QAM 0b0011: 2 streams with PSI=stream1 and other modulation information not available 0b0100: 2 streams with PSI=stream2 and other modulation =QPSK 0b0101: 2 streams with PSI=stream2 and other modulation =16QAM 0b0110: 2 streams with PSI=stream2 and other modulation =64QAM 0b0111: 2 streams with PSI=stream2 and other modulation information not available 0b1000: 3 streams with PSI=stream1 0b1001: 3 streams with PSI=stream2 0b1010: 3 streams with PSI=stream3 0b1011: 4 streams with PSI=stream1 0b1100: 4 stream with PSI=stream2 0b1101: 4 streams with PSI=stream3 0b1110: 4 streams with PSI=stream4 0b1111: n/a
}		
}		
RAI	2	Resource Allocation Indicator (RAI) 0b00: It indicates that resource allocation information is explicitly assigned for this subburst. 0b01: It indicates that resource offset is explicitly assigned for this subburst and this subburst will use the same duration as the previous subburst. 0b10: It indicates that this subburst will use the same duration as the previous subburst and follow the previous subburst. 0b11: Rsvd If j is 0 then this indicator shall be 0b00.
if (RAI == 0b00) {		
Resource index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
}		
else if (RAI == 0b01) {		

Table 42—DL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Resource offset	7	It indicates the start position of resource region for this subburst
}		
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit Index for HARQ Feedback Allocation
}		
}		
}		

The Resource Index field in the DL Composite Persistent A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE.

3.3.2.5.4.8 UL PA A-MAP IE

The UL persistent A-MAP IE is specified in Table 43.

Table 43—UL Persistent A-MAP IE*

Syntax	Size in bits	Description/Notes
UL Persistent A-MAP_IE() {	--	--
A-MAP IE Type	4	UL Persistent A-MAP IE
if MCRC is masked with Station ID {		
UL Individual Persistent A-MAP_IE()		Refer to Table 44
} else if MCRC is masked with Composite ID {		
UL Composite Persistent A-MAP_IE()		Refer to Table 45
}		
}		

* A 16 bit CRC is generated based on the contents of the UL Individual or Composite Persistent A-MAP IE and the CRC is masked by Station ID or the Composite ID (well-known ID specified in the system, TBD) respectively

UL Individual PA A-MAP IE

The UL individual persistent A-MAP IE is specified in Table 44.

Table 44—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
UL Persistent A-MAP_IE() {	-	-
Allocation Period	2	Period of persistent allocation If (Allocation Period==0b00), it indicates the deallocation of persistent resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
If (Allocation Period==0b00){		
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
} else if (Allocation Period != 0b00){		
$I_{SizeOffset}$	5	Offset used to compute burst size index
Mt	1	Number of streams in transmission ($Mt \leq Nt$), up to 2 streams per AMS supported 0b0: 1 stream 0b1: 2 streams
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams
If(TNS > Mt){		Parameters for CSM
if(TNS == 2) {		
SI	1	First pilot index for CSM with TNS = 2

Table 44—UL Individual Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
}		
else {		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		
else if (TNS == Mt) {		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
}		
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive codebook precoding using the precoder of rank Mt of MS's choice
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 UL subframes for FDD or all UL subframes for TDD If number of DL subframes, D is less than number of UL subframes, U, Long TTI Indicator= 0b1
HFA	5	Explicit Index for HARQ Feedback Allocation
ACID	3	HARQ channel identifier N_ACIDs: Number of ACIDs for implicit cycling of HARQ channel identifier N_ACID=Floor{ PA_Max_ReTx_Delay/ (Allocation Period*Frame_length) }+1
}		
Reserved	TBD	Reserved bits
Padding	Variable	Padding to reach byte boundary
}	-	-

The Resource Index field in the UL Individual Persistent A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE.

UL Composite PA A-MAP IE

The UL composite persistent A-MAP IE is specified in Table 45.

Table 45—UL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
UL Composite Persistent A-MAP_IE() {	-	-
Number of allocations	5	Number of allocation specified
RCID Type	2	0b00: Normal CID 0b01: RCID11 0b10: RCID7 0b11: RCID3
For (j=0;j<Number of allocations; j++) {		For loop where each loop element specifies information for one allocation.
Persistent Flag	1	0 = non-persistent 1 = persistent
RCID	variable	Specifies the station ID 16-bit composite ID with 12-bit station ID in MSB and 4-bit FID in LSB in RCID format, type defined by RCID Type
if (Persistent Flag == 1) {		
Allocation Period	2	Period of persistent allocation If (Allocation Period == 0b00), it indicates the deallocation of a persistently allocated resource. 0b00: deallocation 0b01: 2 frames 0b10: 4 frames 0b11: 8 frames
Allocation Period and ACID Indicator	1	If Allocation Period and ACID Indicator is 1, it indicates that allocation information (allocation period, Number of ACID (ACID)) is explicitly assigned for this allocation. Otherwise, this allocation will use the same allocation period as the previous allocation. If j is 0 then this indicator shall be 1.
if (Allocation Period and ACID Indicator == 1) {	-	-
Allocation Periodicity (AP)	5	Period of the persistent allocation is this field value plus 1 (unit is sub-frame/frame TBD)
}		

Table 45—UL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
ACID	4	HARQ channel identifier. The ACID field shall be set to the initial value of HARQ channel identifier for implicit cycling of HARQ channel identifiers. N_ACIDs: Number of ACIDs for implicit cycling of HARQ channel identifier N_ACID=Floor{ PA_Max_ReTx_Delay/ (Allocation Period*Frame_length) }+1
if (Persistent Flag ==1 && Allocation Period==0b00){		
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD
HFA	5	Explicit Index for HARQ Feedback Allocation to acknowledge receipt of deallocation A-MAP IE
}		
else{		
Allocation MCS indicator	1	If Allocation MCS Indicator is 1, it indicates that MCS is explicitly assigned for this allocation. Otherwise, this allocation will use the same MCS as the previous subburst. If j is 0 then this indicator shall be 1.
if (Allocation MCS indicator == 1) {		
$I_{SizeOffset}$	5	Offset used to compute burst size index
}		
Mt	1	Number of streams in transmission (Mt <= Nt), up to 2 streams per AMS supported 0b0: 1 stream 0b1: 2 streams
TNS	2	Total number of streams in the LRU for CSM 0b00: reserved 0b01: 2 streams 0b10: 3 streams 0b11: 4 streams

Table 45—UL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
if (TNS > Mt){		Parameters for CSM
if(TNS == 2){		
SI	1	First pilot index for CSM with TNS = 2
} else{		
SI	2	First pilot index for CSM with TNS = 3,4
}		
}		
else if (TNS == Mt) {		Parameters without CSM
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding
}		
PF	1	Precoding Flag 0b0: non adaptive precoding 0b1: adaptive codebook precoding using the precoder of rank Mt of MS's choice
RAI	2	Resource Allocation Indicator (RAI) 0b00: It indicates that resource allocation information is explicitly assigned for this sub-burst. 0b01: It indicates that resource offset is explicitly assigned for this subburst and this subburst will use the same duration as the previous sub-burst. 0b10: It indicates that this subburst will use the same duration as the previous subburst and follow the previous subburst. 0b11: Rsvd If j is 0 then this indicator shall be 0b00.
if (RAI == 0b00) {		
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
} else if (RAI == 0b01) {		
Resource offset	7	It indicates the start position of resource region for this subburst
}		

Table 45—UL Composite Persistent A-MAP IE

Syntax	Size in bits	Description/Notes
Long TTI Indicator	1	Indicates number of subframes spanned by the allocated resource. 0b0: 1 subframe (default) 0b1: 4 DL subframes for FDD or all DL subframes for TDD f number of DL subframes, D is less than number of UL subframes, U, Long TTI Indicator= 0b1
HFA	5	Explicit Index for HARQ Feedback Allocation
}		
}		
}		

The Resource Index field in the UL Composite Persistent A-MAP IE is interpreted as in the DL Basic Assignment A-MAP IE.

3.3.2.5.4.9 HARQ Feedback A-MAP IE

HARQ Feedback A-MAP IE includes one bit and corresponding value for HARQ ACK/NACK information is shown in Table 46. If HF-A-MAP IE has the 0b0 or 0b1, it shall be interpreted as ACK information or NACK information, respectively.

Table 46—HF-A-MAP-IE

Syntax	Size (bit)	Notes
HF-A-MAP IE format {		
HF-A-MAP IE value	1	0b0 : ACK feedback info. 0b1 : NACK feedback info.
}		

3.3.2.5.4.10 Feedback Allocation A-MAP IE

Table 47 describes the fields in a Feedback Allocation A-MAP IE used for dynamically allocating or de-allocating UL fast feedback control channels (including both PFBCH and SFBCH) to an AMS. If an AMS has an existing fast feedback control channel and receives a new feedback channel allocation, the original fast feedback channel is de-allocated automatically.

Definitions of the fields in the Feedback Allocation A-MAP IE are listed below in Table 47.

Table 47—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
Feedback-Allocation-MAP_IE() {	-	-
A-MAP IE Type	[4]	Feedback Allocation A-MAP IE = 0b0010
Channel Index	<i>Variable</i>	Feedback channel index within the UL fast feedback control resource region (Dependent on L_{FB,FP_i} defined in 3.3.4.3.3.2)
Short-term feedback period (p)	[3]	A feedback is transmitted on the FBCH every 2^p frames
Long-term feedback Period (q)	[2]	A long-term feedback is transmitted on the FBCH every 2^q short-term feedback opportunities. If $q = 0b00$, long-term feedback is not used.
Frame offset	[3]	The AMS 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 AMS should start reporting in eight frames.
Allocation Duration(d)	[3]	An FBCH is transmitted on the FBCH channels indexed by Channel Index for 8×2^d frames. If $d = 0b000$, the FBCH is deallocated. If $d = 0b111$, the AMS should report until the ABS command for the AMS to stop.
ACK allocation flag	[1]	Indicated if one ACK channel is allocated
If (ACK allocation flag == 0b1) {		
HFA	[3]	HARQ feedback channel allocation for Feedback Channel De-allocation confirmation
}		

Table 47—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
MaxMt	Variable [1-2]	Variable number of bits - depends on number of transmit antenna N_t If $N_t=2$: (SU-MIMO and MU-MIMO) 0b0: 1 0b1: 2 If $N_t=4$: (SU-MIMO and MU-MIMO) 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If $N_t=8$ (SU-MIMO) 0b000: 1 0b001: 2 0b011: 4 0b111: 8 If $N_t=8$: (MU-MIMO) 0b00: 1 0b01: 2 0b10: 3 0b11: 4
MFM	[3]	MIMO Feedback Mode as defined in Table 671
If (MFM = 2,3,5,6) {		
Feedback Format	[2]	
}		
If (MFM = 0,1,4,7) {		
FPI	[2]	Frequency partition indication: ABS indicate AMS to send wideband CQI and STC rate of the frequency partition and reuse factor in the future: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3
}		
If (MFM = 0,1 & long term feedback period != 0b00 {		

Table 47—Feedback Allocation A-MAP IE

Syntax	Size (bit)	Notes
Long term FPI	[2]	Frequency partition indication: ABS indicate AMS to send wideband CQI and STC rate for the second frequency partition using long term feedback: 0b00: Frequency partition index 0 0b01: Frequency partition index 1 0b10: Frequency partition index 2 0b11: Frequency partition index 3
}		
If (MFM == 3,4,6,7) {		CL SU and MU MIMO
CM	[2]	Codebook Feedback Mode and Codebook Coordination Enable 0b00: standard with CCE disabled 0b01: transformation with CCE disabled 0b10: differential with CCE disabled 0b11: standard with CCE enabled
CS	[1]	Codebook subset
}		
If (MFM == 0,1,2,5) {		
Measurement Method Indication	[1]	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with MaxMt streams for CQI measurements
}		
Padding	<i>Variable</i>	Padding to reach byte boundary
MCRC	[16]	16 bit CRC masked by Station ID
}	-	-

Channel Index: Uniquely identifies a fast feedback channel on which an AMS can transmit fast feedback information. With this allocation, a one-to-one relationship is established between **Channel Index** and the AMS.

ACK Allocation Flag: BS may set ACK Allocation Flag to 0b1 if Allocation Duration equals 0b00. BS may set ACK Allocation Flag to 0b1 if Allocation Duration doesn't equal 0b00 and the channel index of the newly allocated FBCH is the same as the channel index of the deallocated FBCH.

Short-term Feedback Period (p): A short-term feedback is transmitted on the FBCH every 2^p frames

Long-term Feedback Period (q): A long-term feedback is transmitted on the FBCH every 2^q short-term feedback opportunity. If $q = 0b00$, long-term feedback is not used.

Allocation duration (d): A FBCH is transmitted on the FBCH channels indexed by Channel Index for 8×2^d frames. If $d = 0b000$, the FBCH is deallocated. If $d = 0b111$, the AMS shall report until the ABS command for the AMS to stop.

MFM: MIMO feedback mode, defined in Table 58.

Feedback Format: This field specifies the feedback format index when reporting fast feedback information in FBCH. Feedback format definitions for different MIMO feedback modes are described in 3.3.5.3.1.4.

FPI: The frequency partition over which the short term period report shall be measured by the AMS.

Long term FPI: The frequency partition over which the long term period report shall be measured by the AMS.

MaxMt: This field specifies the maximum rank to be fed back by the AMS if MFM=0,1,2,3,4 (which indicates a SU MIMO feedback mode for SM), or it specifies the maximum number of users scheduled on each RU at the ABS if MFM=5,6,7 (which indicates a MU MIMO feedback mode)

CCE: Codebook Coordination Enable. When CCE is enabled, AMS finds PMI within whole broadcasted codebook type entry; when the CMI field is set to 0b11, it means AMS finds rate-1 PMI within broadcasted codebook entries indicated by BC_SI and codebook subset indication CS.

CM: this field specifies codebook feedback mode, which is needed only for MFM 3 and 6.

Measurement Method Indication: This field indicates the use of midamble or pilots for CQI measurement.

3.3.2.5.4.11 Power Control A-MAP IE

The PC-A-MAP IE includes two bits and corresponding values for power correction is shown in Table 48, e.g., if the power correction value is 0b00, it shall be interpreted as tone power (power density) should be reduced by 0.5dB

Table 48—PC-A-MAP IE format

Syntax	Size (bit)	Notes
PC-A-MAP IE format {		
Power correction value	2	0b00 = -0.5 dB 0b01 = 0.0 dB 0b10 = 0.5 dB 0b11 = 1.0 dB
}		

3.3.2.5.4.12 UL Sounding Command A-MAP IE

Table 49—UL Sounding Command A-MAP IE

Syntax	Size (bit)	Notes
UL Sounding Command IE format() {	-	-
A-MAP IE type	4	
Sounding subframe	3	Indicates the sounding subframe
Sounding subband bitmap	<i>variable</i> max. 12	FFT size dependant
If (Multiplexing type == 0) {		
Decimation offset d	5	Unique decimation offset
} else {		
Cyclic time shift m	5	Unique cyclic shift
}		
Periodicity (p)	3	0b000 = Single command, not periodic, or terminate the periodicity. Otherwise, repeat sounding once per $2^{(p-1)}$ frames, where p is decimal value of the periodicity field
Antenna switching	1	0b0: Antenna switching 0b1: No antenna switching
If (Antenna switching == 1) {		
Transmit antenna bitmap	4	Indicates an active set of transmit antennas
}		
Padding	<i>variable</i>	Padding
}		

d: Sounding channel index indicates unique decimation offset

n: Sounding channel index indicates unique cyclic time shift.

*A 16-bit CRC is generated based on the contents of the UL Sounding Channel Command A-MAP IE. The CRC is masked by the Station ID.

Table 49 specifies the fields of UL Sounding Command A-MAP IE used by the ABS to request sounding transmission by the AMS. Decimal equivalent of the sounding subframe indicates the subframe number with sounding symbol (the first subframe in frame is indexed 0). The sounding subband bitmap field is used to indicate the sounding subbands used in the sounding allocation. For that purpose, the N_{used} contiguous subcarriers are divided into sounding subbands, where each sounding subband compromises $N_1 * N_{sc}$ adjacent subcarriers with $N_{sc} = 18$ for $N_{FFT} = 512, 1024$ and $N_{sc} = 36$ for $N_{FFT} = 2048$. The MSB of the Sounding subband bitmap field corresponds to the sounding subband with lowest subcarrier indexes. The three periodicity bits are used to indicate the MS to periodically repeat the sounding transmission. Setting periodicity

bits to 0b000 indicates a single sounding command or terminates the sounding if periodic sounding command is being performed.

If the antenna switching flag equals 0, the AMS sounds with antenna switching, while if the antenna switching flag equals 1, the AMS sounds all active transmit antennas. If the antenna switching field equals 1 then the i^{th} active antenna of the AMS corresponds to the actual decimation offset $g = d + i - 1$ for multiplexing type 0 or to the actual cyclic shift index $n = m + i - 1$ for multiplexing type 1. To indicate a set of active antennas Transmit antenna bitmap field is used, where MSB bit of the field corresponds to the first antenna of AMS. Before assignment of the actual decimation offset value g or cyclic shift index n to the transmit antenna, the active antennas of AMS shall be renumbered starting from one.

3.3.2.5.4.13 Feedback Polling A-MAP IE

The information element shown in Table 50 is used by the ABS to schedule MMO feedback transmission by the AMS. The AMS sends the MIMO feedback using a MAC control message or an extended header, depending on the requested feedback content.

If the feedback includes only the quantized transmit correlation matrix when the ABS is equipped with 2 or 4 transmit antennas, or only the wideband information for MIMO feedback modes 0, 1, 4 and 7, or only the subband information for 1 subband for MIMO feedback modes 2, 3, 5 and 6, then the MS shall use an extended header. In other cases, for the feedback of the quantized transmit correlation matrix when the ABS is equipped with 8 transmit antennas, or for the feedback of subband information for more than one subband for MIMO feedback modes 2, 3, 5 and 6, or for multi-BS feedback, the MS shall use a MAC control message. In case of feedback for MIMO feedback modes 0, 1, 4 or 7, the MS shall feedback the CQI for FP0 if FPCT equals 1 or 4, or for FPk if FPCT is not equal to 1 or 4, where FPk is determined by $k = \text{floor}(\text{IDCell}/255)$.

If MIMO_feedback_IE_type = 0b1, the AMS shall transmit using MIMO mode 0 if it has multiple transmit antennas, or using MIMO mode 1 with Mt=1 stream if it has a single transmit antenna. If MIMO_feedback_IE_type = 0b0, the AMS shall follow the MEF instruction in the IE.

Table 50—Feedback Polling A-MAP IE

Syntax	Size (bits)	Notes
A-MAP IE Type{	[4]	Feedback_Polling_IE
Allocation Duration (d)	3	The allocation is valid for $2^{(d-1)}$ superframes starting from the superframe defined by allocation relevance. If $d == 0b000$, the pre-scheduled feedback header transmission is released. If $d == 0b111$, the pre-scheduled feedback header transmission shall be valid until the ABS commands to release it.
If (d == 0b00){		

Table 50—Feedback Polling A-MAP IE

Syntax	Size (bits)	Notes
Resource Index	11	Confirmation of the resource index for a previously assigned persistent resource that has been deallocated 5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
HFA	3	HARQ feedback channel allocation for Feedback Channel De-allocation confirmation
} else if (d != 0b00){		
Dedicated UL allocation	1	0b0: No dedicated UL resource is allocated. ABS shall provide UL allocation for the MIMO feedback IE transmission through UL A-MAP IE at each designated transmitting frame defined by this IE. 0b1: Dedicated UL resource is included in this IE
If (Dedicated UL allocation == 0b1){		
I _{SizeOffset}	5	Offset used to compute burst size index
Resource Index	11	5 MHz: 0 in first 2 MSB bits + 9 bits for resource index 10 MHz: 11 bits for resource index 20 MHz: 11 bits for resource index Resource index includes location and allocation size
}		
Period (p)	3	Transmit feedback header every 4 ^p frame
MIMO_feedback_IE_type	1	0b0: feedback for single-BS MIMO operation 0b1: feedback for multi-BS MIMO operation
If (MIMO_feedback_IE_type == 0b0){		Single-BS MIMO feedback request
If (Dedicated UL allocation == 0b1){		
MEF	1	MIMO encoder format 0b0: SFBC 0b1: Vertical encoding with M _t = 2 if N _t =2 or 4, or M _t = 1 if N _t =1 Non-adaptive precoding shall be used at the AMS. N _t is the number of transmit antennas at the AMS.
}		

Table 50—Feedback Polling A-MAP IE

Syntax	Size (bits)	Notes
Transmit_Correlation_Matrix	1	0b0: feedback of the transmit correlation matrix is indicated by CM 0b1: feedback of the quantized ABS transmit correlation matrix only Transmit correlation matrix shall be feedback if CM = 0b1
If (Transmit_Correlation_Matrix == 0b0){		ABS requests AMS to feedback CQI And CSI for a specific MFM.
MaxMt	Variable 1 or 2	Variable number of bits - depends on number of transmit antenna Nt If Nt=2 (SU-MIMO and MU-MIMO): 0b0: 1 0b1: 2 If Nt=4 (SU-MIMO and MU-MIMO): 0b00: 1 0b01: 2 0b10: 3 0b11: 4 If Nt=8 (SU-MIMO): 0b000: 1 0b001: 2 0b011: 4 0b111: 8 If Nt=8: (MU-MIMO): 0b00: 1 0b01: 2 0b10: 3 0b11: 4
MFM	3	MIMO Feedback Mode for which the AMS shall feedback CQI and CSI to the ABS
If (MFM = 2, 3, 5, 6) {		Feedback of CQI and CSI for localized resource units
Num_best_subbands	3	0b000: report all subbands 0b001~0b111: Number of best subbands to report $1 < \text{Num_best_subbands} \leq N_{\text{sub}}$
}		
If (MFM == 3,4,6,7) {		CL SU and MU MIMO
CM	[TBD]	[TBD]
CS	1	0b0: report PMI from the base codebook 0b1: report PMI from the codebook subset

Table 50—Feedback Polling A-MAP IE

Syntax	Size (bits)	Notes
}		
if((MFM=0, 1, 2, 5){		
Measurement Method Indication	1	0b0: Use the midamble for CQI measurements 0b1: Use pilots in OL region with MaxMt streams for CQI measurements
}		
}		
}		
else{		Multi-BS MIMO feedback request
TRU	2	Target RU indicating which RUs or which type of RU to work on for feedback 0b00: Latest best subbands reported for single BS MIMO 0b01: Whole bandwidth 0b10: FFR partition 0 0b11: boosted FFR partition
ICT	2	0b00: PMI restriction for single-BS precoding; 0b01: PMI recommendation for single-BS precoding; 0b10: CL-MD for multi-BS precoding; 0b11: Co-MIMO for multi-BS precoding;
CS	1	0b0: report PMI from the base codebook 0b1: report PMI from the codebook subset
<i>N_multiBS_reports</i>	3	<i>N_multiBS_reports</i> indicates the number of reports.
If (ICT = 0b10 or 0b11) {		
CPI	1	Concatenating PMI Feedback indication; 0b0: feedback CPMI for <i>N_multiBS_reports</i> -1 diversity set members; 0b1: no feedback CPMI
If (ICT = 0b11) {		
MaxUser	2	Maximum number of users supported in Co-MIMO in the same resource. 0b00: 2 users 0b01: 3 users 0b10: 4 users 0b11: reserved
}		
}		
}		

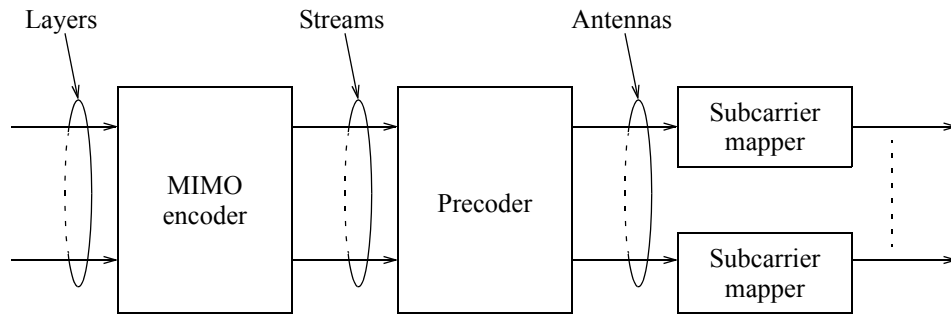
Table 50—Feedback Polling A-MAP IE

Syntax	Size (bits)	Notes
}		
Reserved	1	
Padding	<i>variable</i>	Padding to reach byte boundary
MCRC	16	16 bit CRC masked by Station ID

3.3.3 Downlink MIMO

3.3.3.1 Downlink MIMO architecture and data processing

The architecture of downlink MIMO at the transmitter side is shown in Figure 33.

**Figure 33—DL MIMO architecture**

The MIMO encoder block maps L layers ($L \geq 1$) onto M_t streams ($M_t \geq L$), which are fed to the Precoder block. A layer is defined as a coding and modulation path fed to the MIMO encoder as an input. A stream is defined as an output of the MIMO encoder which is passed to the precoder.

For SU-MIMO, only one user is scheduled in one Resource Unit (RU), and only one FEC block exists at the input of the MIMO encoder (vertical MIMO encoding at transmit side).

For MU-MIMO, multiple users can be scheduled in one RU, and multiple FEC blocks exist at the input of the MIMO encoder (horizontal MIMO encoding at transmit side).

The Precoder block maps stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol

3.3.3.1.1 Layer to stream mapping

Layer to stream mapping is performed by the MIMO encoder. The MIMO encoder is a batch processor that operates on M input symbols at a time.

The input to the MIMO encoder is represented by an $M \times 1$ vector as specified in Equation (31)

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \quad (31)$$

Where s_i is the i -th input symbol within a batch.

Layer to stream mapping of the input symbols is done in the space dimension first. The output of the MIMO encoder is an $M_t \times N_F$ MIMO STC matrix as given in Equation (32), which serves as the input to the pre-coder.

$$\mathbf{x} = S(\mathbf{s}) \quad (32)$$

Where,

M_t is the number of streams

N_F is the number of subcarriers occupied by one MIMO block

\mathbf{x} is the output of the MIMO encoder

\mathbf{s} is the input layer vector

$S()$ is a function that maps an input layer vector to an STC matrix

$S(\mathbf{s})$ is an STC matrix

The STC matrix \mathbf{x} can be expressed as in Equation (33):

$$\mathbf{x} = \begin{bmatrix} x_{1,1} & x_{1,2} & \dots & x_{1,N_F} \\ x_{2,1} & x_{2,2} & \dots & x_{2,N_F} \\ \dots & \dots & \dots & \dots \\ x_{M_t,1} & x_{M_t,2} & \dots & x_{M_t,N_F} \end{bmatrix} \quad (33)$$

The four MIMO encoder formats (MEF) are SFBC, vertical encoding (VE), horizontal encoding (HE), and CDR. For SU-MIMO transmissions, the STC rate is defined as in Equation (34)

$$R = \frac{M}{N_F} \quad (34)$$

For MU-MIMO transmissions, the STC rate per user (R) is equal to 1.

3.3.3.1.1.1 SFBC encoding

The input to the MIMO encoder is represented by a 2×1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \quad (35)$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{x} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \quad (36)$$

Where \mathbf{x} is a 2x2 matrix.

The SFBC matrix, \mathbf{x} , occupies two consecutive subcarriers.

3.3.3.1.1.2 Vertical encoding

The input and the output of MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \quad (37)$$

Where s_i is the i -th input symbol within a batch.

For vertical encoding, $s_1 \dots s_M$ belong to the same layer. The encoder is an identity operation.

3.3.3.1.1.3 Horizontal encoding

The input and output of the MIMO encoder is represented by an $M \times 1$ vector.

$$\mathbf{x} = \mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \\ \dots \\ s_M \end{bmatrix} \quad (38)$$

Where s_i is the i -th input symbol within a batch.

For horizontal encoding, $s_1 \dots s_M$ belong to different layers.

Horizontal encoding is only used for MU-MIMO mode. The encoder is an identity operation.

3.3.3.1.1.4 CDR encoding

The input to the MIMO encoder is represented by a 1×1 vector.

$$s = s_1 \quad (39)$$

The MIMO encoder generates the CDR matrix.

$$\mathbf{X} = \begin{bmatrix} s_1 & s_1^* \end{bmatrix} \quad (40)$$

The CDR matrix, \mathbf{x} , occupies two consecutive subcarriers.

3.3.3.1.2 Stream to antenna mapping

Stream to antenna mapping is performed by the precoder. The output of the MIMO encoder is multiplied by an $N_t \times M_t$ precoder, \mathbf{W} . The output of the precoder is denoted by an $N_t \times N_F$ matrix, \mathbf{z} . The mapping can be defined in Equation (41).

(41)

$$\mathbf{z} = \mathbf{W}\mathbf{x} = \begin{bmatrix} z_{1,1} & z_{1,2} & \cdots & z_{1,N_F} \\ z_{2,1} & z_{2,2} & \cdots & z_{2,N_F} \\ \cdots & \cdots & \cdots & \cdots \\ z_{N_t,1} & z_{N_t,2} & \cdots & z_{N_t,N_F} \end{bmatrix}$$

Where N_t is the number of transmit antennas and $z_{j,k}$ is the output symbol to be transmitted via the j -th physical antenna on the k -th subcarrier.

3.3.3.1.2.1 Non-adaptive precoding

With non-adaptive precoding, the precoding matrix is an $N_t \times M_t$ matrix $\mathbf{W}(k)$, where N_t is the number of transmit antennas, M_t is the numbers of streams, and k is the physical index of the subcarrier where $\mathbf{W}(k)$ is applied. The matrix \mathbf{W} is selected from a subset of size N_W precoders of the base codebook for a given rank. \mathbf{W} belongs to one of the subsets of the base codebook specified in <<<15.3.7.2.6.6.2.4.1>>>, according to the type of allocation, MEF, N_t and M_t , as specified in Table 51 and Table 52. The notation $\mathbf{C}_{\text{DL,OL,SU}}(N_t, M_t, N_w)$ denotes a DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t . The base codebook and the codebook subsets are defined in 15.3.7.

Table 51—Codebook subsets used for non-adaptive precoding in DL diversity allocations (DLRU and NLRU)

MEF	RU with M_t pilot streams outside OL region	RU in OL region with $\text{Max}M_t$ streams
SFBC	$\mathbf{C}_{\text{DL,OL,SU}}(N_t, M_t, N_w), M_t = 2$	$\mathbf{C}_{\text{DL,OL,SU}}(N_t, 2, N_w), \text{Max}M_t = 2$
VE	$\mathbf{C}_{\text{DL,OL,SU}}(N_t, M_t, N_w), M_t = 1, \dots, \text{Max}M_t$	$\mathbf{C}_{\text{DL,OL,SU}}(N_t, 2, N_w), \text{Max}M_t = 2$
HE	na	na

Table 52—Codebook subsets used for non-adaptive precoding in DL SLRU

MEF	RU with M_t pilot streams outside OL region	RU in OL region with $\text{Max}M_t$ streams
SFBC	na	na
VE	$N_t=2$: $\mathbf{C}(2, M_t, 3), M_t = 1, \dots, \text{Max}M_t$ $N_t=4$: $\mathbf{C}(4, M_t, 4), M_t = 1, \dots, \text{Max}M_t$ $N_t=8$: $\mathbf{C}(8, M_t, 4), M_t = 1, \dots, \text{Max}M_t$	$N_t=2$: $\mathbf{C}(2, \text{Max}M_t, 3), \text{Max}M_t = 1$ or 2 $N_t=4$: $\mathbf{C}(4, \text{Max}M_t, 4), \text{Max}M_t = 1$ or 2 $N_t=8$: $\mathbf{C}(8, \text{Max}M_t, 4), \text{Max}M_t = 1$ or 2

Table 52—Codebook subsets used for non-adaptive precoding in DL SLRU

HE	$N_t=2$: C(2, $MaxM_t$, 3), $M_t = 1, \dots, MaxM_t$ $N_t=4$: C(4, $MaxM_t$, 4), $M_t = 1, \dots, MaxM_t$ $N_t=8$: C(8, $MaxM_t$, 3), $M_t = 1, \dots, MaxM_t$	$N_t=2$: C(2, 2, 3), $MaxM_t = 2$ $N_t=4$: C(4, 2, 4), $MaxM_t = 2$ $N_t=8$: C(8, 2, 4), $MaxM_t = 2$
----	--	--

Non-adaptive precoding outside the OL region

In a RU allocated outside the OL region, with MEF = 0b00 (SFBC) or 0b01 (VE) and non-adaptive precoding, the matrix \mathbf{W} changes every $N_1 P_{SC}$ contiguous physical subcarriers according to equation (10), and it does not depend on the subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the open-loop codebook subset of rank M_t , where i is given by

$$i = s \bmod N_W, \quad s = 0 \dots N_{sub}-1 \quad (42)$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In a RU allocated outside the OL region, with MEF = 0b10 (HE) and non-adaptive precoding, the matrix \mathbf{W} changes every N_1 PRUs according to Equation (43), and it does not depend on the subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in subband s is selected as any M_t unordered columns of the codeword of index i in the open-loop codebook subset of rank $MaxM_t$, where i is given by Equation (42).

Non-adaptive precoding inside the OL region

In a RU allocated in the $MaxM_t$ -streams OL Region in DLRU or SLRU, the matrix \mathbf{W} changes every N PRUs.

$N = N_1$ in all OL regions except in the OL region of type 1 with NLRU. The $N_t \times MaxM_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical subband s is selected as the codeword of index i in the open-loop codebook subset of rank $MaxM_t$, where i is given by

$$i = s \bmod N_W, \quad s = 0 \dots N_{sub}-1 \quad (43)$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

In the OL region of type 1 with NLRU, $N = N_2$, and the $N_t \times 1$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in PRU s in subframe number t is selected as the codeword of index i in the open-loop codebook subset of rank 1, where i is given by

$$i = (m + (t \bmod 2)) \bmod N_W, \quad s = 0 \dots N_{PRU}-1 \quad (44)$$

where N_{PRU} denotes the number of physical PRUs across the entire system bandwidth.

3.3.3.1.2.2 Adaptive precoding

With adaptive precoding, the precoder \mathbf{W} is derived from the feedback of the AMS.

For codebook-based precoding (codebook feedback), there are 3 feedback modes: Base mode, transformation mode and differential mode, which are described in <<15.3.7.2.6.6.1>>.

For TDD sounding-based precoding, the value of \mathbf{W} is derived from the AMS sounding feedback. The sounding channel is defined in 3.3.3.2.5.7.

3.3.3.1.3 Downlink MIMO modes

There are six MIMO transmission modes for unicast DL MIMO transmission as listed in Table 53.

Table 53—Downlink MIMO modes

Mode index	Description	MIMO encoding format (MEF)	MIMO precoding
Mode 0	OL SU-MIMO (Tx diversity)	SFBC	non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	adaptive
Mode 3	OL MU-MIMO (SM)	HE	non-adaptive
Mode 4	CL MU-MIMO (SM)	HE	adaptive
Mode 5	OL SU-MIMO (Tx diversity)	CDR	non-adaptive

The allowed values of the parameters for each DL MIMO mode are shown in Table 54.

Table 54—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	$Rate$	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1
	8	1	2	2	1

Table 54—DL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	$Rate$	M_t	N_F	L
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
	8	1	1	1	1
	8	2	2	1	1
	8	3	3	1	1
	8	4	4	1	1
	8	5	5	1	1
	8	6	6	1	1
	8	7	7	1	1
	8	8	8	1	1
MIMO mode 3 and MIMO mode 4	2	1	2	1	2
	4	1	2	1	2
	4	1	3	1	3
	4	1	4	1	4
	8	1	2	1	2
	8	1	3	1	3
	8	1	4	1	4
MIMO mode 5	2	1/2	1	2	1
	4	1/2	1	2	1
	8	1/2	1	2	1

M_t refers to the number of streams transmitted to one AMS with MIMO modes 0, 1, and 2.

M_t refers to the total number of streams transmitted to multiple AMS on the same RU with MIMO modes 3 and 4.

3.3.3.2 Transmission schemes for data channels

3.3.3.2.1 Encoding and precoding of SU-MIMO

3.3.3.2.1.1 Encoding of SU-MIMO modes

- MIMO mode 0: SFBC encoding of section 3.3.3.1.1.1 shall be used with MIMO mode 0.
- MIMO mode 1: Vertical encoding of section 3.3.3.1.1.2 shall be used with MIMO mode 1. The number of streams is , $M_t \leq \min(N_r, N_r)$ where N_r is the number of receive antennas and M_t is no more than 8.
- MIMO mode 2: Vertical encoding of section 3.3.3.1.1.2 shall be used with MIMO mode 2. The number of streams is , $M_t \leq \min(N_r, N_r)$ where M_t is no more than 8.
- MIMO mode 5: CDR encoding shall be used with MIMO mode 5.

3.3.3.2.1.2 Precoding of SU-MIMO modes

- MIMO mode 0: Non-adaptive precoding of section 3.3.3.1.2.1 with $M_t=2$ streams shall be used with MIMO mode 0.
- MIMO mode 1: Non-adaptive precoding of section 3.3.3.1.2.1 with M_t streams shall be used with MIMO mode 1.
- MIMO mode 2: Adaptive precoding of section 3.3.3.1.2.2 shall be used with MIMO mode 2.
- MIMO mode 5: Non-adaptive precoding of section 3.3.3.1.2.1 with $M_t = 1$ stream shall be used with MIMO mode 5.

3.3.3.2.2 Encoding and precoding of MU-MIMO

Multi-user MIMO schemes are used to enable a resource allocation to communicate data to two or more AMSs. Multi-user transmission with one stream per user is supported for MU-MIMO.

MU-MIMO includes the MIMO configuration of 2Tx antennas to support up to 2 AMSs, and 4Tx or 8Tx antennas to support up to 4 AMSs, with 1 stream per AMS.

Both OL MU-MIMO (mode 3) and CL MU-MIMO (mode 4) are supported

3.3.3.2.2.1 Encoding of MU-MIMO modes

- MIMO mode 3: Horizontal encoding of section 3.3.3.1.1.3 shall be used with MIMO mode 3.
- MIMO mode 4: Horizontal encoding of section 3.3.3.1.1.3 shall be used with MIMO mode 4

3.3.3.2.2.2 Precoding of MU-MIMO modes

- MIMO mode 3

Non-adaptive precoding of section 15.3.7.1.2.1 shall be used with MIMO mode 3.

With OL MU MIMO inside the OL region, the precoder \mathbf{W} with 2 streams is predefined and fixed over time. With OL MU MIMO outside the OL region, the precoder \mathbf{W} is an $N_r \times M_t$ sub-matrix of a predefined $N_r \times \text{Max}M_t$ matrix.

The precoding matrix \mathbf{W} used by the ABS is represented in Equation (45).

$$\mathbf{W}(k) = [v_1(k) \quad v_2(k) \quad \dots \quad v_{M_t}(k)] \quad (45)$$

Where $v_i(k)$ is the precoding vector for the i -th AMS on the k -th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the i -th pilot stream on the k -th subcarrier.

- MIMO mode 4

Adaptive precoding of 3.3.3.1.2.2 shall be used with MIMO mode 4.

In CL MU MIMO, the precoder \mathbf{W} is an $N_t \times M$ matrix for each subcarrier. It is used to communicate to M AMSs simultaneously. The form and derivation of the precoding matrix does not need to be known at the AMS. The ABS determines the precoding matrix based on the feedback received from the AMS.

The ABS shall construct the precoding matrix \mathbf{W} as represented in Equation (46).

$$\mathbf{W}(k) = \begin{bmatrix} \mathbf{v}_1(k) & \mathbf{v}_2(k) & \dots & \mathbf{v}_{M_t}(k) \end{bmatrix} \quad (46)$$

Where, $\mathbf{v}_i(k)$ is the precoding vector for the i -th AMS on the k -th subcarrier.

$v_i(k)$ shall be used for precoding the pilot symbols on the i -th pilot stream on the k -th subcarrier.

3.3.3.2.3 Mapping of data and pilot subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

3.3.3.2.4 Usage of MIMO modes

Table 55 shows permutations supported for each MIMO mode. The definitions of DRU, mini-band based CRU, and subband based CRU are in subclause [TBD].

Table 55—Supported Permutation for each DL MIMO mode

	DRU	Mini-band based CRU (diversity allocation)	Mini-band and Subband based CRU (localized allocation)
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with $M_t=2$	Yes	Yes
MIMO mode 2	No	Yes, with $M_t=1$	Yes
MIMO mode 3	No	No	Yes
MIMO mode 4	No	Yes	Yes

Mini band based CRU diversity allocation represents a resource allocation composed of non-contiguous minibands.

All pilots are precoded regardless of number of transmit antennas and allocation type.

3.3.3.2.5 Feedback mechanisms and operation

3.3.3.2.5.1 Open-Loop Region

An open-loop region with $MaxMt$ streams is defined as a time-frequency resource using the $MaxMt$ streams pilot pattern and a given open-loop MIMO mode with $Mt = MaxMt$ without rank adaptation. The open-loop region allows base stations to coordinate their open-loop MIMO transmissions, in order to offer a stable interference environment where the precoders and numbers of streams are not time-varying. The resource units used for the open-loop region are indicated in a downlink broadcast message [SFH or ABI is TBD]. These resource units shall be aligned across cells.

Only a limited set of open-loop MIMO modes are allowed for transmission in the open-loop region. There is no limitation to the use of any open-loop MIMO mode outside the open-loop region, as specified in Table 55.

An open-loop region is associated with a specific set of parameters:

- Type (number of streams $MaxMt$, MIMO mode, MIMO feedback mode, type of permutation)
- Resource unit [TBD]

There are three types of open-loop regions, as specified in Table 56.

Table 56—Types of open-loop regions

	MaxMt	MIMO mode	MIMO feedback mode	Supported permutation
OL region type 0	2 streams	MIMO mode 0 MIMO mode 1 ($Mt = 2$ streams)	0	DRU
OL region type 1	1 stream	MIMO mode 5 ($Mt = 1$ stream)	1	Miniband based CRU (diversity allocation)
			2	Subband based CRU (localized allocation)
OL region type 2	2 streams	MIMO mode 2 ($Mt = 2$ streams) MIMO mode 3 ($Mt = 2$ streams)	5	Subband based CRU (localized allocation)

The OL region type 0 is present if OL-Region-ON is indicated in a downlink broadcast message [SFH or ABI is TBD].

All base stations that are coordinated over the same open loop region should use the same number of streams, in order to guarantee low interference fluctuation and thus improve the CQI prediction at the AMS. All pilots are precoded by non-adaptive precoding with $MaxMt$ streams in the open-loop region. CQI measurements should be taken by the AMS on the precoded demodulation pilots rather than on the downlink reference signals.

3.3.3.2.5.2 MIMO mode feedback selection

An AMS may send an unsolicited event-driven report to indicate its preferred MIMO mode to the ABS. Event-driven reports for MIMO feedback mode selection may be sent on the P-FBCH during any allowed

transmission interval for the allocated P-FBCH. The P-FBCH codewords allocated to event-driven reports are specified in 3.3.5.3. The precoded pilots shall be transmitted in all the LRUs in the OL region even if data is not being transmitted by the ABS on some or all of the LRUs

3.3.3.2.5.3 MIMO feedback information

Table 57 specifies the feedback information required for MIMO operation.

Table 57—MIMO feedback information

	Feedback information type	Description
Long period feedback	STC rate	For MIMO modes 0, 1 and 2
	Subband selection	For CRU allocations, indicating which subbands are preferred
	Stream index	For MIMO mode 3, indicating which streams are preferred.
	Quantized Correlation matrix	For transformation codebook feedback mode and long term wideband beamforming
	PMI report for serving cell	For long-term wideband beamforming
	PMI report for neighboring cell	For PMI coordination among multiple ABSs
	CQI	For link adaptation (MCS selection)
Short period feedback	CQI	For link adaptation (MCS selection)
	PMI report for serving cell	For short-term beamforming with MIMO modes 2 and 4
Event-driven feedback	Preferred MIMO feedback mode	For AMS reporting of its preferred MIMO mode in unsolicited manner

3.3.3.2.5.4 MIMO feedback modes

Each MIMO transmission mode can be supported by one or several MIMO feedback modes. When allocating a feedback channel, the MIMO feedback mode shall be indicated to the AMS, and the AMS will feedback information accordingly.

The description of MIMO feedback modes and corresponding supported MIMO transmission modes is shown in Table 58. The detailed description of feedback and AMS processing are in the following subsections.

The feedback of the quantized wideband correlation matrix shall be requested by the ABS for operation with transformation codebook-based feedback mode. The ABS may request the feedback of the quantized wideband correlation matrix independently of the MIMO feedback mode requested in the FBCH_Alloc_IE. The quantized wideband correlation matrix may be used for wideband beamforming.

MIMO feedback mode 0 is used for the OL-SU SFBC and SM adaptation in diversity permutation. The AMS estimates the wideband CQI for both SFBC and SM, and reports the CQI and STC Rate. STC Rate 1 means SFBC with precoding and STC Rate 2 means rank-2 SM with precoding.

Table 58—MIMO feedback modes

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
0	OL SU MIMO SFBC/SM (Diversity: DLRU, NLRU)	1. STC Rate 2. Wideband CQI	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI 2 ≤ STC Rate ≤ 4: SM CQI In DLRU: $M_T=2$ for SM. In Miniband based SLRU: $M_T \geq 2$ for SM	MIMO mode 0 and MIMO mode 1. Flexible adaptation between the two modes STC Rate = 1: SFBC CQI STC Rate = 2: SM CQI In DLRU only.
1	OL SU MIMO SM (Diversity: NLRU)	1. STC Rate 2. Wideband CQI	MIMO mode 1 1 ≤ STC ≤ 4	MIMO mode 5 STC Rate = 1/2
2	OL SU MIMO SM (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband Selection	MIMO mode 1 1 ≤ STC Rate ≤ 8	MIMO mode 5 STC Rate = 1/2
3	CL SU MIMO (localized: SLRU)	1. STC Rate 2. Subband CQI 3. Subband PMI 4. Subband selection 5. Wideband correlation matrix	MIMO mode 2 1 ≤ STC Rate ≤ 8	N/A
4	CL SU MIMO (Diversity: NLRU)	1. Wideband CQI 2. Wideband PMI 3. Wideband correlation matrix	MIMO mode 2 ($M_T=1$)	N/A
5	OL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband Selection 3. Stream indicator	MIMO mode 3	MIMO mode 3
6	CL MU MIMO (localized: SLRU)	1. Subband CQI 2. Subband PMI 3. Subband Selection [4. Wideband PMI] 5. Wideband correlation matrix	MIMO mode 4	N/A

Table 58—MIMO feedback modes

MIMO Feedback Mode	Description and type of RU	Feedback content	Supported MIMO transmission mode outside the OL region (when Measurement Method Indication = 0b0)	Supported MIMO transmission mode inside the OL region (when Measurement Method Indication = 0b1)
7	CL MU MIMO (Diversity: SLRU, NLRU)	1. Wideband CQI 2. Wideband PMI 3. Wideband correlation matrix	MIMO mode 4	N/A

MIMO feedback mode 1 is used for the OL-SU SM with rank adaptation in diversity permutation. The transmission rank is determined by the STC Rate. STC Rate 1 means the rank-1 precoding.

MIMO feedback mode 2 is used for the OL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of streams for SM. The subband CQI shall correspond to the selected rank.

MIMO feedback mode 3 is used for the CL-SU SM in localized permutation for frequency selective scheduling. The STC Rate indicates the preferred number of streams for SM. The subband CQI shall correspond to the selected rank.

The MIMO feedback mode 4 is used for the CL SU MIMO using wideband beamforming with rank 1. In this mode, AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix, or via the feedback of the wideband PMI.

The MIMO feedback mode 5 is used for OL MU MIMO in localized permutation with frequency selective scheduling. In the mode, AMS shall feedback the subband selection, stream indicator and the corresponding CQI.

The MIMO feedback mode 6 is used for CL MU MIMO in localized permutation with frequency selective scheduling. In the mode, AMS shall feedback the subband selection, corresponding CQI and subband PMI. The subband CQI refers to the CQI of the best PMI in the subband. Rank-1 base codebook (or its subset) is used to estimate the PMI in one subband.

The MIMO feedback mode 7 is used for CL MU MIMO in diversity permutation using wideband beamforming MU MIMO. In this mode, AMS shall feedback the wideband CQI. The wideband CQI shall be estimated at the AMS assuming short-term or long-term precoding at the ABS, according to the feedback period. The channel state information may be obtained at the ABS via the feedback of the correlation matrix, or via the feedback of the wideband PMI.

3.3.3.2.5.5 Downlink signaling support of DL-MIMO modes

The BS shall send some parameters necessary for DL MIMO operation in a broadcast message. The broadcast information is carried in the SFH or in the additional broadcast information.

The BS shall send some parameters necessary for DL MIMO operation in a unicast message. The unicast information is carried in the A-MAP IE, in the FBCH_Alloc_IE, or in the Sounding_IE.

Table 692 specifies the DL control parameters required for MIMO operation.

Table 59—DL MIMO control parameters

Parameter	Description	Value	DL Control channel	Notes
Broadcast Information				
Nt	Number of transmit antennas at the BS	2, 4, 8	SFH (system information)	
OL_Region	OL MIMO region, which signaling is used to indicate MS where is the predefined OL MIMO region and number of streams (1 or 2)	OL-Region-ON (1 bit): Signal the existence of OL region. OL-Rank1-Config (3 bit): to signal the combination of sub-band and mini-band in OL region type 1. Refer to Table 56. SB-OL-Region-2-Size (4 bit) : signal the number of sub-bands in OL region type 2.	Additional broadcast information	OL region signaling is SFH-SP3 or ABI (TBD)
BC_SI	Rank-1 base codebook subset indication for interference mitigation with PMI coordination	BitMAP: 8 bits if Nt = 2 16 bits if Nt = 4, 8	Additional broadcast information	Rank-1 codebook element restriction/recommendation information It shall be ignored if CM = 0b00, 0b01 or 0b10
Unicast Information				
MEF	MIMO encoder format	SFBC Vertical encoding Horizontal encoding	A-MAP IE	MIMO encoder format.
Mt	Number of streams in transmission	1 to 8	A-MAP IE	Number of streams in the transmission.
SI	Index of allocated pilot stream	1 to 4	A-MAP IE	SI shall be indicated if MEF is HE
Feedback Allocation IEs				
MFM	MIMO feedback mode	Refer to Table 691		To decide the feedback content and related MS processing
MaxMt	Maximum number of streams	If MFM indicates a SU feedback mode: 1, 2, 4 or 8. If MFM indicates a MU feedback mode: 1, 2, 3, or 4.		If MFM indicates a SU feedback mode: the maximum number of streams scheduled for each user If MFM indicates a MU feedback mode: the maximum number of users scheduled on each RU

Table 59—DL MIMO control parameters

Parameter	Description	Value	DL Control channel	Notes
CS indication	Codebook subset type for CL MIMO modes 2 and 4	Base codebook or codebook subset		Depending on the MFM and CS indication, the MS shall feedback a PMI from the SU or MU base codebook, or from a subset of the SU or MU of the base codebook.
CM	Codebook feedback mode for CL MIMO modes 2 and 4	0b00: standard mode with codebook coordination disabled 0b01: transformation mode with codebook coordination disabled 0b10: differential mode with codebook coordination disabled 0b11: standard mode with codebook coordination enabled		In codebook-based feedback mode: Codebook coordination disabled: MS finds PMI within whole codebook type entry indicated by CS indication Codebook coordination enabled: MS shall find the rate-1 PMI within codebook entries indicated by BC_SI and CS indication

The indication of the type of MIMO feedback for CL MIMO modes 2 and 4 depends on the IE type sent by the BS. Fast feedback channel allocation IE indicates that the MS shall use codebook-based feedback. The sounding commend IE indicates that the MS shall use uplink sounding.

When CS indication indicates the use of a codebook subset and MFM indicates a SU CL MIMO mode, the MS shall use the SU base codebook subset of Table 709 when $N_t=4$. When CS indication indicates the use of a codebook subset and MFM indicates a MU CL MIMO mode, the MS shall use the MU base codebook subset of Table 709 when $N_t=4$.

3.3.3.2.5.6 Quantized MIMO feedback for closed-loop transmit precoding

15.3.7.2.6.6.1 Quantized feedback modes

An AMS feedbacks a Preferred Matrix Index (PMI) to support DL precoding.

There are three types of codebook feedback modes.

The operation of the codebook feedback modes for the PMI is summarized below:

- 1) **The base mode:** the PMI feedback from a AMS shall represent an entry of the base codebook. It shall be sufficient for the ABS to determine a new precoder.
- 2) **The transformation mode:** the PMI feedback from a AMS shall represent an entry of the transformed base codebook according to long term channel information.
- 3) **The differential mode:** the PMI feedback from a AMS shall represent an entry of the differential codebook or an entry of the base codebook at PMI reset times. The feedback from a AMS provides a differential knowledge of the short-term channel information. This feedback represents information that is used along with other feedback information known at the ABS for determining a new precoder.

- 4) Mobile station shall support the base and transformation mode and may support the differential mode.

The transformation and differential feedback modes are applied to the base codebook or to a subset of the base codebook.

15.3.7.2.6.6.2 Base mode for codebook-based feedback

The base codebook is a unitary codebook. A codebook is a unitary codebook if each of its matrices consists of columns of a unitary matrix.

The AMS selects its preferred matrix from the base codebook based on the channel measurements. The AMS sends back the index of the preferred codeword, and the ABS computes the precoder \mathbf{W} according to the index. Both ABS and AMS use the same codebook for correct operation.

For the base mode, the PMI feedback from a mobile station shall represent an entry of the base codebook, where the base codebooks are defined as follows for two, four, and eight transmit antennas at the ABS.

The notation $C(N_t, M_t, NB)$ denotes the codebook, which consists of 2^{NB} complex, matrices of dimension N_t by M_t , and M_t denotes the number of streams.

The notation $C(N_t, M_t, NB, i)$ denotes the i -th codebook entry of $C(N_t, M_t, NB)$.

15.3.7.2.6.6.2.1 Base codebook for two transmit antennas

15.3.7.2.6.6.2.1.1 SU-MIMO base codebook

The base codebook of SU-MIMO with two transmit antennas consist of rank-1 codebook $C(2,1,3)$ and rank-2 codebook $C(2,2,3)$, as illustrated in Table 60 and Table 61, respectively.

Table 60— $C(2,1,3)$

Index	m	$C(2,1,3,m) = [\mathbf{c}_1; \mathbf{c}_2]$	
		\mathbf{c}_1	\mathbf{c}_2
000	0	0.7071	-0.7071
001	1	0.7071	-0.5000 - 0.5000i
010	2	0.7071	-0.7071i
011	3	0.7071	0.5000 - 0.5000i
100	4	0.7071	0.7071
101	5	0.7071	0.5000 + 0.5000i
110	6	0.7071	0.7071i
111	7	0.7071	-0.5000 + 0.5000i

Table 61—C(2,2,3)

Index	m	$C(2, 2, 3, m) = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix}^T$	
		c_{11} c_{21}	c_{12} c_{22}
000	0	0.7071 0.7071	-0.7071 0.7071
001	1	0.7071 0.7071	-0.5000 - 0.5000i 0.5000 + 0.5000i
010	2	0.7071 0.7071	-0.7071 0.7071
011	3	0.7071 0.7071	0.5000 - 0.5000i -0.5000 + 0.5000i
100~111	4~7	-	-

15.3.7.2.6.6.2.1.2 MU-MIMO base codebook

The base codebook for MU-MIMO is the same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.1.1

15.3.7.2.6.6.2.2 Base codebook for four transmit antennas**15.3.7.2.6.6.2.2.1 SU-MIMO base codebook**

The base codebooks of SU-MIMO with four transmit antennas consist of rank-1 codebook C(4,1,6), rank-2 codebook C(4,2,6), rank-3 codebook C(4,3,6) and rank-4 codebook C(4,4,6). Table 62, Table 63, Table 64 and Table 65 are included to illustrate the rank-1,2,3,4 base codebooks.

Table 62—C(4,1,6)

Binary Index	m	$C(4,1,6,m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
000000	0	0.5000	-0.5000	0.5000	-0.5000
000001	1	-0.5000	-0.5000	0.5000	0.5000
000010	2	-0.5000	0.5000	0.5000	-0.5000
000011	3	0.5000	-0.5000i	0.5000	-0.5000i
000100	4	-0.5000	-0.5000i	0.5000	0.5000i
000101	5	-0.5000	0.5000i	0.5000	-0.5000i
000110	6	0.5000	0.5000	0.5000	0.5000

Table 62—C(4,1,6)

Binary Index	m	$C(4,1,6,m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
000111	7	0.5000	0.5000i	0.5000	0.5000i
001000	8	0.5000	0.5000	0.5000	-0.5000
001001	9	0.5000	0.5000i	-0.5000	0.5000i
001010	10	0.5000	-0.5000	0.5000	0.5000
001011	11	0.5000	-0.5000i	-0.5000	-0.5000i
001100	12	0.5000	0.3536 + 0.3536i	0.5000i	-0.3536 + 0.3536i
001101	13	0.5000	-0.3536 + 0.3536i	-0.5000i	0.3536 + 0.3536i
001110	14	0.5000	-0.3536 - 0.3536i	0.5000i	0.3536 - 0.3536i
001111	15	0.5000	0.3536 - 0.3536i	-0.5000i	-0.3536 - 0.3536i
010000	16	0.5000	-0.4619 - 0.1913i	0.3536 + 0.3536i	-0.1913 - 0.4619i
010001	17	0.3117	0.6025 + 0.1995i	-0.4030 - 0.4903i	-0.1122 - 0.2908i
010010	18	0.3117	-0.6025 - 0.1995i	-0.1122 - 0.2908i	0.4030 + 0.4903i
010011	19	0.3058	0.1901 - 0.6052i	0.1195 + 0.2866i	0.4884 - 0.4111i
010100	20	0.5000	-0.1913 + 0.4619i	-0.3536 - 0.3536i	0.4619 - 0.1913i
010101	21	0.5000	0.1913 - 0.4619i	-0.3536 - 0.3536i	-0.4619 + 0.1913i
010110	22	0.5000	0.4619 + 0.1913i	0.3536 + 0.3536i	0.1913 + 0.4619i
010111	23	0.3082	0.0104 + 0.3151i	0.4077 + 0.4887i	-0.4783 + 0.4145i
011000	24	0.3117	0.3573 - 0.2452i	0.6025 - 0.1995i	-0.1578 + 0.5360i
011001	25	0.3117	0.2452 + 0.3573i	-0.6025 + 0.1995i	0.5360 + 0.1578i
011010	26	0.3082	-0.3666 + 0.2426i	0.6092 - 0.1842i	0.1615 - 0.5298i
011011	27	0.3117	-0.2452 - 0.3573i	-0.6025 + 0.1995i	-0.5360 - 0.1578i
011100	28	0.3117	0.4260 + 0.0793i	0.1995 + 0.6025i	0.2674 + 0.4906i
011101	29	0.3117	-0.0793 + 0.4260i	-0.1995 - 0.6025i	0.4906 - 0.2674i
011110	30	0.3117	-0.4260 - 0.0793i	0.1995 + 0.6025i	-0.2674 - 0.4906i
011111	31	0.3117	0.0793 - 0.4260i	-0.1995 - 0.6025i	-0.4906 + 0.2674i
100000	32	0.5636	-0.3332 - 0.2672i	0.1174 + 0.5512i	-0.3308 - 0.2702i
100001	33	0.5587	0.3361 + 0.2735i	-0.3361 - 0.2735i	-0.1135 - 0.5471i
100010	34	0.5587	-0.3361 - 0.2735i	-0.1135 - 0.5471i	0.3361 + 0.2735i
100011	35	0.5587	0.2735 - 0.3361i	0.1135 + 0.5471i	0.2735 - 0.3361i
100100	36	0.3082	-0.4887 + 0.4077i	-0.6092 - 0.1842i	0.2837 - 0.1205i

Table 62—C(4,1,6)

Binary Index	m	$C(4,1,6,m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
100101	37	0.5636	0.2673 - 0.3331i	-0.1222 - 0.5501i	-0.2673 + 0.3331i
100110	38	0.5636	0.3691 + 0.5142i	0.3331 + 0.2673i	0.0862 + 0.3032i
100111	39	0.5587	-0.2990 + 0.0880i	0.3361 + 0.2735i	-0.5216 + 0.3616i
101000	40	0.5587	0.0880 - 0.2990i	0.3361 - 0.2735i	-0.3616 + 0.5216i
101001	41	0.5587	0.2990 + 0.0881i	-0.3362 + 0.2735i	0.5216 + 0.3616i
101010	42	0.5587	-0.0880 + 0.2990i	0.3361 - 0.2735i	0.3616 - 0.5216i
101011	43	0.5587	-0.2990 - 0.0880i	-0.3361 + 0.2735i	-0.5216 - 0.3616i
101100	44	0.5636	0.2741 - 0.1559i	0.2672 + 0.3332i	0.1081 + 0.6236i
101101	45	0.5636	0.1559 + 0.2741i	-0.2672 - 0.3332i	0.6236 - 0.1081i
101110	46	0.5587	-0.2737 + 0.1492i	0.2735 + 0.3361i	-0.1132 - 0.6245i
101111	47	0.5587	-0.1492 - 0.2737i	-0.2735 - 0.3361i	-0.6245 + 0.1132i
110000	48	0.5000	-0.4619 + 0.1913i	0.3536 - 0.3536i	-0.1913 + 0.4619i
110001	49	0.3117	0.4030 + 0.4903i	-0.6025 - 0.1995i	-0.1122 - 0.2908i
110010	50	0.3117	-0.4029 - 0.4904i	-0.1184 - 0.2883i	0.6067 + 0.1865i
110011	51	0.3082	0.4887 - 0.4077i	0.1205 + 0.2837i	0.1842 - 0.6092i
110100	52	0.5000	0.1913 + 0.4619i	-0.3536 + 0.3536i	-0.4619 - 0.1913i
110101	53	0.5000	-0.1913 - 0.4619i	-0.3536 + 0.3536i	0.4619 + 0.1913i
110110	54	0.5000	0.4619 - 0.1913i	0.3536 - 0.3536i	0.1913 - 0.4619i
110111	55	0.3117	-0.2452 + 0.3573i	0.6025 + 0.1995i	-0.5360 + 0.1578i
111000	56	0.3117	0.3117	0.4030 - 0.4903i	-0.4030 + 0.4903i
111001	57	0.3117	0.3117i	-0.4030 + 0.4903i	0.4903 + 0.4030i
111010	58	0.3082	-0.3152 - 0.0036i	0.4076 - 0.4888i	0.4040 - 0.4872i
111011	59	0.3082	0.0036 - 0.3152i	-0.4076 + 0.4888i	-0.4872 - 0.4040i
111100	60	0.3117	0.2204 + 0.2204i	0.4903 + 0.4030i	0.0618 + 0.6317i
111101	61	0.3117	-0.2204 + 0.2204i	-0.4903 - 0.4030i	0.6317 - 0.0618i
111110	62	0.3082	-0.2154 - 0.2302i	0.4887 + 0.4077i	-0.0451 - 0.6313i
111111	63	0.3082	0.2254 - 0.2204i	-0.4888 - 0.4076i	-0.6302 + 0.0588i

Table 63—C(4,2,6)

Index	m	$C(4, 2, 6, m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \end{bmatrix}^T$			
		$\begin{matrix} c_{11} \\ c_{21} \end{matrix}$	$\begin{matrix} c_{12} \\ c_{22} \end{matrix}$	$\begin{matrix} c_{13} \\ c_{23} \end{matrix}$	$\begin{matrix} c_{14} \\ c_{24} \end{matrix}$
000000	0	0.5000 0.5000	0.5000 -0.5000	0.5000 0.5000	0.5000 -0.5000
000001	1	0.5000 -0.5000	0.5000 -0.5000	0.5000 0.5000	0.5000 0.5000
000010	2	0.5000 -0.5000	0.5000 0.5000	0.5000 0.5000	0.5000 -0.5000
000011	3	0.5000 -0.5000	-0.5000 -0.5000	0.5000 0.5000	-0.5000 -0.5000
000100	4	0.5000 -0.5000	-0.5000 0.5000	0.5000 0.5000	-0.5000 -0.5000
000101	5	-0.5000 -0.5000	-0.5000 0.5000	0.5000 0.5000	0.5000 -0.5000
000110	6	0.5000 -0.5000	0.5000i - 0.5000i	0.5000 0.5000	0.5000i 0.5000i
000111	7	0.5000 -0.5000	0.5000i 0.5000i	0.5000 0.5000	0.5000i - 0.5000i
001000	8	0.5000 -0.5000	- 0.5000i - 0.5000i	0.5000 0.5000	- 0.5000i 0.5000i
001001	9	0.5000 -0.5000	- 0.5000i 0.5000i	0.5000 0.5000	- 0.5000i - 0.5000i
001010	10	0.5000 -0.5000	0.5000 - 0.5000i	0.5000 0.5000	0.5000 0.5000i
001011	11	0.5000 -0.5000	0.5000 0.5000i	0.5000 0.5000	0.5000 - 0.5000i
001100	12	0.5000 -0.5000	0.5000i -0.5000	0.5000 0.5000	0.5000i 0.5000
001101	13	0.5000 -0.5000	0.5000i 0.5000	0.5000 0.5000	0.5000i -0.5000
001110	14	0.5000 0.5000	0.5000 -0.5000	0.5000 0.5000	-0.5000 0.5000
001111	15	0.5000 0.5000	-0.3536 + 0.3536i 0.3536 - 0.3536i	- 0.5000i - 0.5000i	0.3536 + 0.3536i -0.3536 - 0.3536i
010000	16	0.5000 -0.5000	-0.5000 - 0.5000i	0.5000 0.5000	-0.5000 0.5000i
010001	17	0.5000 -0.5000	-0.5000 0.5000i	0.5000 0.5000	-0.5000 - 0.5000i

Table 63—C(4,2,6)

010010	18	0.5000 0.5587	-0.5000 0.3361 + 0.2735i	0.5000 -0.3361 - 0.2735i	-0.5000 -0.1135 - 0.5471i
010011	19	-0.5000 0.5000	-0.5000 - 0.5000i	0.5000 0.5000	0.5000 - 0.5000i
010100	20	-0.5000 0.5587	-0.5000 -0.3361 - 0.2735i	0.5000 -0.1135 - 0.5471i	0.5000 0.3361 + 0.2735i
010101	21	-0.5000 0.3117	-0.5000 -0.2452 + 0.3573i	0.5000 0.6025 + 0.1995i	0.5000 -0.5360 + 0.1578i
010110	22	-0.5000 0.5000	0.5000 - 0.5000i	0.5000 0.5000	-0.5000 - 0.5000i
010111	23	0.5000 0.5000	0.5000 0.5000i	0.5000 -0.5000	-0.5000 0.5000i
011000	24	-0.5000 0.5587	0.5000 -0.2990 + 0.0880i	0.5000 0.3361 + 0.2735i	-0.5000 -0.5216 + 0.3616i
011001	25	0.5000 0.5000	0.5000 - 0.5000i	0.5000 -0.5000	-0.5000 - 0.5000i
011010	26	0.5000 0.3117	0.5000 -0.2452 - 0.3573i	0.5000 -0.6025 + 0.1995i	-0.5000 -0.5360 - 0.1578i
011011	27	0.5000 0.5000	0.5000i -0.5000	-0.5000 0.5000	0.5000i 0.5000
011100	28	0.5000 0.5587	0.5000i -0.0880 + 0.2990i	-0.5000 0.3361 - 0.2735i	0.5000i 0.3616 - 0.5216i
011101	29	0.5000 0.5000	-0.5000 - 0.5000i	0.5000 -0.5000	0.5000 - 0.5000i
011110	30	0.5000 0.5587	-0.5000 -0.2990 - 0.0880i	0.5000 -0.3361 + 0.2735i	0.5000 -0.5216 - 0.3616i
011111	31	0.5000 0.5000	0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000i - 0.5000i	-0.3536 + 0.3536i 0.3536 + 0.3536i
100000	32	0.5000 0.5000	0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000i 0.5000i	-0.3536 + 0.3536i 0.3536 - 0.3536i
100001	33	0.5000 0.5000	0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000i - 0.5000i	-0.3536 + 0.3536i -0.3536 - 0.3536i
100010	34	0.5000 0.3117	0.3536 + 0.3536i 0.0793 - 0.4260i	0.5000i -0.1995 - 0.6025i	-0.3536 + 0.3536i -0.4906 + 0.2674i
100011	35	0.5000 0.5000	-0.3536 + 0.3536i -0.3536 - 0.3536i	- 0.5000i 0.5000i	0.3536 + 0.3536i 0.3536 - 0.3536i
100100	36	-0.5000 0.3082	0.5000i 0.0104 + 0.3151i	0.5000 0.4077 + 0.4887i	- 0.5000i -0.4783 + 0.4145i
100101	37	0.5000 0.5000	-0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000i - 0.5000i	0.3536 - 0.3536i -0.3536 - 0.3536i
100110	38	0.5000 0.5587	-0.3536 - 0.3536i -0.1492 - 0.2737i	0.5000i -0.2735 - 0.3361i	0.3536 - 0.3536i -0.6245 + 0.1132i

Table 63—C(4,2,6)

100111	39	0.3117 -0.5000	0.6025 + 0.1995i 0.5000	-0.4030 - 0.4903i 0.5000	-0.1122 - 0.2908i -0.5000
101000	40	0.3117 -0.5000	0.6025 + 0.1995i 0.5000	-0.4030 - 0.4903i 0.5000	-0.1122 - 0.2908i -0.5000
101001	41	0.3117 0.3058	-0.6025 - 0.1995i 0.1901 - 0.6052i	-0.1122 - 0.2908i 0.1195 + 0.2866i	0.4030 + 0.4903i 0.4884 - 0.4111i
101010	42	0.3117 0.5000	-0.6025 - 0.1995i 0.5000	-0.1122 - 0.2908i 0.5000	0.4030 + 0.4903i 0.5000
101011	43	0.3117 0.5000	0.3573 - 0.2452i 0.5000i	0.6025 - 0.1995i -0.5000	-0.1578 + 0.5360i 0.5000i
101100	44	0.3117 0.5000	0.2452 + 0.3573i -0.5000	-0.6025 + 0.1995i 0.5000	0.5360 + 0.1578i 0.5000
101101	45	0.3117 0.5000	0.4260 + 0.0793i -0.3536 + 0.3536i	0.1995 + 0.6025i - 0.5000i	0.2674 + 0.4906i 0.3536 + 0.3536i
101110	46	0.3117 0.5000	-0.0793 + 0.4260i -0.3536 - 0.3536i	-0.1995 - 0.6025i 0.5000i	0.4906 - 0.2674i 0.3536 - 0.3536i
101111	47	0.3117 0.5000	-0.4260 - 0.0793i 0.3536 - 0.3536i	0.1995 + 0.6025i - 0.5000i	-0.2674 - 0.4906i -0.3536 - 0.3536i
110000	48	0.5636 0.5587	-0.3332 - 0.2672i -0.3361 - 0.2735i	0.1174 + 0.5512i -0.1135 - 0.5471i	-0.3308 - 0.2702i 0.3361 + 0.2735i
110001	49	0.5587 0.5587	-0.3361 - 0.2735i 0.2735 - 0.3361i	-0.1135 - 0.5471i 0.1135 + 0.5471i	0.3361 + 0.2735i 0.2735 - 0.3361i
110010	50	0.5587 0.5000	0.2735 - 0.3361i 0.5000i	0.1135 + 0.5471i 0.5000	0.2735 - 0.3361i 0.5000i
110011	51	0.5587 0.5000	0.0880 - 0.2990i - 0.5000i	0.3361 - 0.2735i -0.5000	-0.3616 + 0.5216i - 0.5000i
110100	52	0.5587 0.5587	0.2990 + 0.0881i -0.2990 - 0.0880i	-0.3362 + 0.2735i -0.3361 + 0.2735i	0.5216 + 0.3616i -0.5216 - 0.3616i
110101	53	0.5636 0.5587	0.2741 - 0.1559i -0.2737 + 0.1492i	0.2672 + 0.3332i 0.2735 + 0.3361i	0.1081 + 0.6236i -0.1132 - 0.6245i
110110	54	0.5636 0.5587	0.1559 + 0.2741i -0.1492 - 0.2737i	-0.2672 - 0.3332i -0.2735 - 0.3361i	0.6236 - 0.1081i -0.6245 + 0.1132i
110111	55	0.3117 0.5000	0.4030 + 0.4903i 0.5000	-0.6025 - 0.1995i 0.5000	-0.1122 - 0.2908i 0.5000
111000	56	0.5000 0.5000	0.1913 + 0.4619i -0.1913 - 0.4619i	-0.3536 + 0.3536i -0.3536 + 0.3536i	-0.4619 - 0.1913i 0.4619 + 0.1913i
111001	57	0.3117 0.5000	0.3117 -0.5000	0.4030 - 0.4903i 0.5000	-0.4030 + 0.4903i 0.5000
111010	58	0.3117 0.3082	0.3117 -0.3152 - 0.0036i	0.4030 - 0.4903i 0.4076 - 0.4888i	-0.4030 + 0.4903i 0.4040 - 0.4872i
111011	59	0.3117 0.5000	0.3117i - 0.5000i	-0.4030 + 0.4903i -0.5000	0.4903 + 0.4030i - 0.5000i

Table 63—C(4,2,6)

111100	60	0.3117 0.3082	0.3117i 0.0036 - 0.3152i	-0.4030 + 0.4903i -0.4076 + 0.4888i	0.4903 + 0.4030i -0.4872 - 0.4040i
111101	61	0.3117 0.5000	0.2204 + 0.2204i -0.3536 - 0.3536i	0.4903 + 0.4030i 0.5000i	0.0618 + 0.6317i 0.3536 - 0.3536i
111110	62	0.3117 0.5000	-0.2204 + 0.2204i 0.3536 - 0.3536i	-0.4903 - 0.4030i - 0.5000i	0.6317 - 0.0618i -0.3536 - 0.3536i
111111	63	0.3117 0.3082	-0.2204 + 0.2204i 0.2254 - 0.2204i	-0.4903 - 0.4030i -0.4888 - 0.4076i	0.6317 - 0.0618i -0.6302 + 0.0588i

Table 64—C(4,3,6)

Binary Index	m	$C(4,3,4,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31}	c_{12} c_{22} c_{32}	c_{13} c_{23} c_{33}	c_{14} c_{24} c_{34}
000000	0	0.5000 0.5000 -0.5000	0.5000 -0.5000 -0.5000	0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000
000001	1	0.5000 0.5000 -0.5000	0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 -0.5000 -0.5000
000010	2	0.5000 -0.5000 -0.5000	0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000 0.5000 -0.5000
000011	3	0.5000 -0.5000 -0.5000	-0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000	-0.5000 0.5000 -0.5000
000100	4	0.5000 0.5000 -0.5000	0.5000 -0.5000i -0.5000i	0.5000 0.5000 0.5000	0.5000 -0.5000i 0.5000i
000101	5	0.5000 0.5000 -0.5000	0.5000i -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i -0.5000i
000110	6	0.5000 -0.5000 -0.5000	0.5000i -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000i 0.5000i -0.5000i
000111	7	0.5000 0.5000 -0.5000	0.5000i -0.5000i -0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000i
001000	8	0.5000 0.5000 -0.5000	0.5000 -0.5000 -0.5000i	0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000i

Table 64—C(4,3,6)

001001	9	0.5000 -0.5000 -0.5000	0.5000 -0.5000i 0.5000	0.5000 0.5000 0.5000	0.5000 0.5000i -0.5000i
001010	10	0.5000 0.5000 -0.5000	0.5000i -0.5000i -0.5000	0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000
001011	11	0.5000 -0.5000 -0.5000	0.5000i -0.5000 0.5000	0.5000 0.5000 0.5000	0.5000i 0.5000 -0.5000
001100	12	0.5000 0.5000 0.5000	0.5000 0.5000i -0.5000	0.5000 -0.5000 0.5000	-0.5000 0.5000i 0.5000
001101	13	0.5000 0.5000 0.5000	0.5000 -0.5000 -0.5000i	0.5000 0.5000 -0.5000	-0.5000 0.5000 -0.5000i
001110	14	0.5000 0.5000 0.5000	0.3536+0.3536i -0.3536+0.3536i 0.3536-0.3536i	0.5000i -0.5000i -0.5000i	-0.3536+0.3536i 0.3536+0.3536i -0.3536-0.3536i
001111	15	0.5000 0.5000 0.5000	-0.3536+0.3536i -0.3536-0.3536i 0.3536-0.3536i	-0.5000i 0.5000i -0.5000i	0.3536+0.3536i 0.3536-0.3536i -0.3536-0.3536i
001111 \approx 111111	16 \approx 63	NA			

The indexes from 16 to 63 are not used in 6-bits downlink PMI feedback for $M_t = 3$ codebook.

Table 65—C(4,4,6)

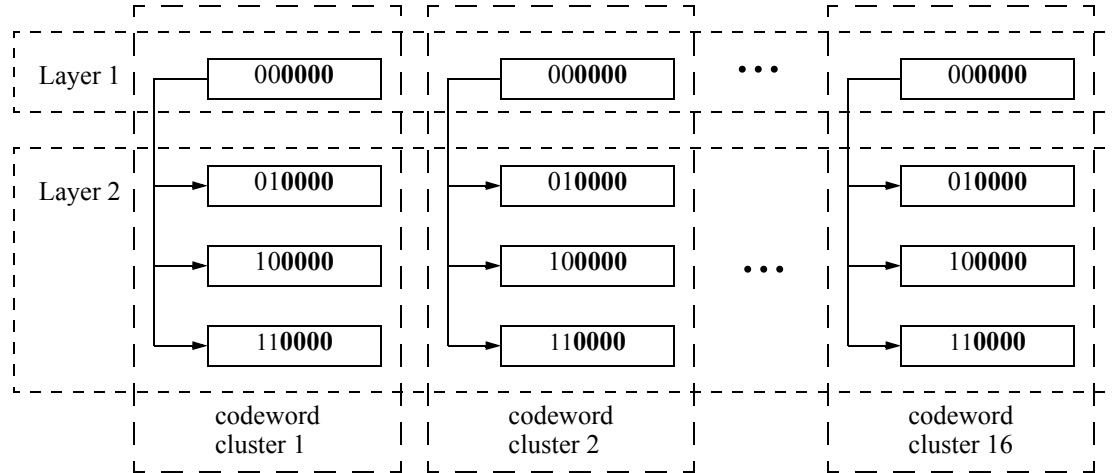
Binary Index	m	$C(4,3,4,m) = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} \\ c_{21} & c_{22} & c_{23} & c_{24} \\ c_{31} & c_{32} & c_{33} & c_{34} \\ c_{41} & c_{42} & c_{43} & c_{44} \end{bmatrix}^T$			
		c_{11} c_{21} c_{31} c_{41}	c_{12} c_{22} c_{32} c_{42}	c_{13} c_{23} c_{33} c_{43}	c_{14} c_{24} c_{34} c_{44}
000000	0	0.5000 0.5000 -0.5000 -0.5000	0.5000 -0.5000 -0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000 -0.5000
000001	1	0.5000 0.5000 -0.5000 -0.5000	0.5000i -0.5000i -0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000i -0.5000i

Table 65—C(4,4,6)

000010	2	0.5000 0.5000 -0.5000 -0.5000	0.5000 -0.5000 -0.5000i 0.5000i	0.5000 0.5000 0.5000 0.5000	0.5000 -0.5000 0.5000i -0.5000i
000011	3	0.5000 0.5000 -0.5000 -0.5000	0.0000+0.5000i 0.0000-0.5000i -0.5000 0.5000	0.5000 0.5000 0.5000 0.5000	0.5000i -0.5000i 0.5000 -0.5000
000100	4	0.5000 0.5000 0.5000 0.5000	0.5000 0.0000+0.5000i -0.5000 0.0000-0.5000i	0.5000 -0.5000 0.5000 -0.5000	-0.5000 0.5000i 0.5000 0.000-0.5000i
000101	5	0.5000 0.5000 0.5000 0.5000	0.3536+0.3536i -0.3536+0.3536i -0.3536-0.3536i 0.3536-0.3536i	0.5000i -0.5000i 0.5000i -0.5000i	-0.3536+0.3536i 0.3536+0.3536i 0.3536-0.3536i -0.3536-0.3536i
000110 \approx 111111	6 \approx 63	NA			

The indexes from 6 to 63 are not used in 6-bits downlink PMI feedback for $M_t=4$ codebook.

In terms of the chordal distance, the hierarchical structure of C(4,1,6) is depicted in Figure 34. In this hierarchical structure, it is shown that C(4,1,6) consists of 16 codeword clusters. Each codeword cluster has four codewords, of which one codeword is from Layer 1 and the three other codewords are from Layer 2. For any given Layer 2 codeword, its chordal distance to all other Layer 1 codewords of different clusters is always much larger than that distance to the Layer 1 codeword of its same cluster

**Figure 34—Chordal distance map of C(4,1,6)**

As a potential benefit, this hierarchical structure can facilitate codeword searching. More specifically, codeword searching in C(4,1,6) can start from all Layer 1 codewords. Only when a Layer 1 codeword satisfies a certain criterion, associated Layer 2 codewords within the same cluster need to be searched.

The binary indices of the codewords in cluster, $i, i \in [0, \dots, 15]$ is given by Table 66.

Table 66—Binary indices of the codewords in cluster i

Codeword in cluster i	Layer 1 codeword	Layer 2 codewords		
		Codeword 1	Codeword 2	Codeword 3
Binary index	$00x_{i3}x_{i2}x_{i1}x_{i0}$	$01x_{i3}x_{i2}x_{i1}x_{i0}$	$10x_{i3}x_{i2}x_{i1}x_{i0}$	$11x_{i3}x_{i2}x_{i1}x_{i0}$
$i = x_{i3} \times 2^3 + x_{i2} \times 2^2 + x_{i1} \times 2 + x_{i0}, x_{ij} \in [0, 1], i \in [0, \dots, 15], j \in [0, 1, 2, 3]$				

15.3.7.2.6.6.2.2.2 MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.2.1.

15.3.7.2.6.6.2.3 Base codebook for eight transmit antennas**15.3.7.2.6.6.2.3.1 SU-MIMO base codebook**

The base codebooks of SU-MIMO with eight transmit antennas consist of rank-1 codebook $C(8,1,4)$, rank-2 codebook $C(8,2,4)$, rank-3 codebook $C(8,3,4)$, rank-4 codebook $C(8,4,4)$, rank-5 codebook $C(8,5,4)$, rank-6 codebook $C(8,6,4)$, rank-7 codebook $C(8,7,4)$ and rank-8 codebook $C(8,8,4)$. Table 700 illustrates the rank-1 base codebook, and Table 68 illustrates the ranks 2,3,4,5,6,7,8 base codebooks.

Table 67— $C(8, 1, 4)$

Binary Index	m	$C(8,1,4,m) = [c_1; c_2; c_3; c_4; c_5; c_6; c_7; c_8]$							
		c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8
0000	0	0.3536	-0.3051 - 0.1786i	0.1732 + 0.3082i	0.0062 - 0.3535i	-0.1839 + 0.3020i	0.3112 - 0.1677i	-0.3533 - 0.0124i	0.2987 + 0.1892i
0001	1	0.3536	-0.2514 - 0.2486i	0.0041 + 0.3535i	0.2456 - 0.2543i	-0.3535 + 0.0082i	0.2571 + 0.2427i	-0.0123 - 0.3533i	-0.2397 + 0.2599i
0010	2	0.3536	-0.1697 - 0.3102i	-0.1907 + 0.2977i	0.3527 + 0.0244i	-0.1479 - 0.3211i	-0.2107 + 0.2839i	0.3502 + 0.0486i	-0.1254 - 0.3306i
0011	3	0.3536	-0.0614 - 0.3482i	-0.3322 + 0.1210i	0.1768 + 0.3062i	0.2708 - 0.2273i	-0.2709 - 0.2272i	-0.1767 + 0.3062i	0.3323 + 0.1208i
0100	4	0.3536	0.0638 - 0.3478i	-0.3306 - 0.1254i	-0.1830 + 0.3025i	0.2646 + 0.2345i	0.2784 - 0.2180i	-0.1642 - 0.3131i	-0.3376 + 0.1050i
0101	5	0.3536	0.1881 - 0.2994i	-0.1534 - 0.3185i	-0.3513 - 0.0395i	-0.2204 + 0.2764i	0.1168 + 0.3337i	0.3447 + 0.0786i	0.2499 - 0.2501i

Table 67—C(8, 1, 4)

Binary Index	m	C(8,1,4,m) = [c ₁ ; c ₂ ; c ₃ ; c ₄ ; c ₅ ; c ₆ ; c ₇ ; c ₈]							
		c ₁	c ₂	c ₃	c ₄	c ₅	c ₆	c ₇	c ₈
0110	6	0.3536	0.2892 - 0.2034i	0.1196 - 0.3327i	-0.0936 - 0.3409i	-0.2727 - 0.2251i	-0.3525 - 0.0272i	-0.3040 + 0.1805i	-0.1449 + 0.3225i
0111	7	0.3536	0.3461 - 0.0721i	0.3241 - 0.1412i	0.2885 - 0.2044i	0.2407 - 0.2590i	0.1828 - 0.3026i	0.1172 - 0.3336i	0.0467 - 0.3505i
1000	8	0.3536	0.3461 + 0.0721i	0.3241 + 0.1412i	0.2885 + 0.2044i	0.2407 + 0.2590i	0.1828 + 0.3026i	0.1172 + 0.3336i	0.0467 + 0.3505i
1001	9	0.3536	0.2892 + 0.2034i	0.1196 + 0.3327i	-0.0936 + 0.3409i	-0.2727 + 0.2251i	-0.3525 + 0.0272i	-0.3040 - 0.1805i	-0.1449 - 0.3225i
1010	10	0.3536	0.1881 + 0.2994i	-0.1534 + 0.3185i	-0.3513 + 0.0395i	-0.2204 - 0.2764i	0.1168 - 0.3337i	0.3447 - 0.0786i	0.2499 + 0.2501i
1011	11	0.3536	0.0638 + 0.3478i	-0.3306 + 0.1254i	-0.1830 - 0.3025i	0.2646 - 0.2345i	0.2784 + 0.2180i	-0.1642 + 0.3131i	-0.3376 - 0.1050i
1100	12	0.3536	-0.0614 + 0.3482i	-0.3322 - 0.1210i	0.1768 - 0.3062i	0.2708 + 0.2273i	-0.2709 + 0.2272i	-0.1767 - 0.3062i	0.3323 - 0.1208i
1101	13	0.3536	-0.1697 + 0.3102i	-0.1907 - 0.2977i	0.3527 - 0.0244i	-0.1479 + 0.3211i	-0.2107 - 0.2839i	0.3502 - 0.0486i	-0.1254 + 0.3306i
1110	14	0.3536	-0.2514 + 0.2486i	0.0041 - 0.3535i	0.2456 + 0.2543i	-0.3535 - 0.0082i	0.2571 - 0.2427i	-0.0123 + 0.3533i	-0.2397 - 0.2599i
1111	15	0.3536	-0.3051 + 0.1786i	0.1732 - 0.3082i	0.0062 + 0.3535i	-0.1839 - 0.3020i	0.3112 + 0.1677i	-0.3533 + 0.0124i	0.2987 - 0.1892i

The two rank-8 matrices used for rank-2 to rank-8 transmission for SU-MIMO are

$$V_1 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25 + 0.25i & -0.25 - 0.25i & -0.25 + 0.25i & 0.25 - 0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & 0.3536i & 0.3536i & -0.3536i & -0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & -0.25 + 0.25i & 0.25 - 0.25i & 0.25 + 0.25i & -0.25 - 0.25i \\ 0.3536 & 0.3536 & 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536 & -0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & -0.25 - 0.25i & 0.25 + 0.25i & 0.25 - 0.25i & -0.25 + 0.25i \\ 0.3536 & 0.3536 & -0.3536 & -0.3536 & -0.3536i & -0.3536i & 0.3536i & 0.3536i \\ 0.3536 & -0.3536 & -0.3536i & 0.3536i & 0.25 - 0.25i & -0.25 + 0.25i & -0.25 - 0.25i & 0.25 + 0.25i \end{bmatrix}$$

$$V_2 = \begin{bmatrix} 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 & 0.3536 \\ 0.3536 & -0.3536 & 0.3536i & -0.3536i & 0.25 + 0.25i & -0.25 - 0.25i & -0.25 + 0.25i & 0.25 - 0.25i \\ 0.25 + 0.25i & 0.25 + 0.25i & -0.25 - 0.25i & -0.25 - 0.25i & -0.25 + 0.25i & -0.25 + 0.25i & 0.25 - 0.25i & 0.25 - 0.25i \\ 0.25 + 0.25i & -0.25 - 0.25i & 0.25 - 0.25i & -0.25 + 0.25i & -0.3536 & 0.3536 & 0.3536i & -0.3536i \\ 0.3536i & 0.3536i & 0.3536i & 0.3536i & -0.3536i & -0.3536i & -0.3536i & -0.3536i \\ 0.3536i & -0.3536i & -0.3536 & 0.3536 & 0.25 - 0.25i & -0.25 + 0.25i & 0.25 + 0.25i & -0.25 - 0.25i \\ -0.25 + 0.25i & -0.25 + 0.25i & 0.25 - 0.25i & 0.25 - 0.25i & 0.25 + 0.25i & 0.25 + 0.25i & -0.25 - 0.25i & -0.25 - 0.25i \\ -0.25 + 0.25i & 0.25 - 0.25i & 0.25 + 0.25i & -0.25 - 0.25i & 0.3536i & -0.3536i & 0.3536 & -0.3536 \end{bmatrix}$$

The 4bits 8Tx base codebook for ranks 2 to 8 is constructed from the two 8×8 base matrices and is specified in Table 68. Note that only the column indices of the corresponding base matrices are shown in Table 68 for brevity.

Table 68—Ranks 2 to 8 of SU MIMO 4bit 8Tx base codebook

Codebook Matrix Index (CMI)	Base Matrix	C(8,2,4)	C(8,3,4)	C(8,4,4)	C(8,5,4)	C(8,6,4)	C(8,7,4)	C(8,8,4)
0	V_1	1 5	1 3 5	1537	12357	123567	1234567	12345678
1		2 6	2 4 6	2648	12468	124568	1234568	n/a
2		3 7	2 3 7	3726	23467	234678	1234678	n/a
3		4 8	1 4 8	4815	13458	134578	1234578	n/a
4		5 3	3 5 7	5372	23567	234567	2345678	n/a
5		4 6	4 6 8	6481	14568	134568	1345678	n/a
6		2 7	2 6 7	7264	24678	124678	1245678	n/a
7	V_2	8 1	1 5 8	8153	13578	123578	1235678	n/a
8		1 3	1 2 3	1234	12345	123456	1234567	12345678
9		2 4	1 2 4	1246	12456	124567	1245678	n/a
10		2 3	2 3 4	2437	23478	123478	1234578	n/a
11		1 4	1 3 4	1348	13478	134678	1234678	n/a
12		5 8	5 7 8	3578	23578	235678	1235678	n/a
13		6 7	6 7 8	4678	14678	145678	1345678	n/a
14		5 7	5 7 6	5678	35678	345678	2345678	n/a
15		6 8	5 6 8	1568	13568	123568	1234568	n/a

The indexes from 1 to 7 and 9 to 15 are not used in 4-bits downlink PMI feedback for $M_t=8$ codebook.

15.3.7.2.6.6.2.3.2 MU-MIMO base codebook

The base codebook for MU-MIMO is same as the rank 1 base codebook for SU-MIMO, defined in 15.3.7.2.6.6.2.3.1

15.3.7.2.6.6.2.4 Codebook subset selection

In codebook-based precoding with CL MIMO operation, the precoding matrix $W(k)$ shall be derived from a PMI within the base codebook or a subset thereof. Subset information is transmitted in BC_SI and CS indication.

Base Codebook Subset Indication (BC_SI) field determines which elements of the rank-1 codebook are restricted or recommended for PMI feedback in case of MIMO mode 2 and 4. If the i -th element of BC_SI is set to 0, then the i -th element of the rank-1 codebook, $C(N_t, 1, N_B, i)$, is restricted for PMI feedback. This field shall be ignored when CM is not set to 0b11. CM is transmitted in FBCH_Alloc_IE.

Codebook subsets

OL MIMO subset

The OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0 and MIMO mode 1.

The notation $C_{DL,OL,SU}(N_t, M_t, N_w)$ denotes the DL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t , and M_t denotes the number of streams. The notation $C_{DL,OL,SU}(N_t, M_t, N_w, i)$ denotes the i -th codebook entry of $C_{DL,OL,SU}(N_t, M_t, N_w)$.

OL SU-MIMO subset for two transmit antennas

Table 69 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 2Tx.

Table 69—Size of the DL 2TX OL SU-MIMO codebook subset

Rank	1	2
N_w	2	1

The codewords of the OL SU-MIMO codebook subset for two transmit antennas are given in Table 70 for each rank. The corresponding codewords of the DL base codebook for two transmit antennas are also given in Table 70.

Table 70— $C_{DL,OL,SU}(2,1,2)$ and $C_{DL,OL,SU}(2,2,1)$

$C_{DL,OL,SU}(2, 1, 2, n)$		$C_{DL,OL,SU}(2, 2, 1, n)$	
n	$C(2,1,3,m)$ in downlink base codebook	n	$C(2,2,3,m)$ in downlink base codebook
0	$C(2,1,3,2)$	0	$C(2,2,3,2)$
1	$C(2,1,3,6)$		

OL SU-MIMO subset for four transmit antennas

Table 71 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 4Tx.

Table 71—Size of the DL 4TX OL SU-MIMO codebook subset

Rank	1	2	3	4
N_w	4	4	2	1

The codewords of the OL SU-MIMO codebook subset for four transmit antennas are given in Table 72 for each rank. The corresponding codewords of the DL base codebook for four transmit antennas are given in Table 72.

Table 72— $C_{DL,OL,SU}(4,1,4)$, $C_{DL,OL,SU}(4,2,4)$, $C_{DL,OL,SU}(4,3,2)$ and $C_{DL,OL,SU}(4,4,1)$

$C_{DL,OL,SU}(4, 1, 4, n)$		$C_{DL,OL,SU}(4, 2, 4, n)$		$C_{DL,OL,SU}(4, 3, 2, n)$		$C_{DL,OL,SU}(4, 4, 1, n)$	
n	$C(4,1,6,m)$ in base codebook	n	$C(4,2,6,m)$ in base codebook	n	$C(4,3,6,m)$ in base codebook	n	$C(4,4,6,m)$ in base codebook
0	C(4,1,6,8)	0	C(4,2,6,23)	0	C(4,3,6,12)	0	C(4,4,6,4)
1	C(4,1,6,10)	1	C(4,2,6,29)	1	C(4,3,6,13)		
2	C(4,1,6,9)	2	C(4,2,6,27)				
3	C(4,1,6,11)	3	C(4,2,6,25)				

15.3.7.2.6.6.2.5.1.3 OL SU-MIMO subset for eight transmit antennas<<<need to create higher level Headers>>>

Table 73 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for 8Tx.

Table 73—Size of the DL 8Tx OL SU-MIMO codebook subset

Rank	1	2	3	4	5	6	7	8
N_w	8	4	4	2	2	2	2	1

The codewords of the OL SU-MIMO codebook subset for eight transmit antennas are given in Table 74 and Table 75 for each rank. The corresponding codewords of the DL base codebook for eight transmit antennas are given in Table 74 and Table 75.

Table 74— $C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$ and $C_{DL,OL,SU}(8,4,2)$

$C_{DL,OL,SU}(8, 1, 8, n)$		$C_{DL,OL,SU}(8, 2, 4, n)$		$C_{DL,OL,SU}(8, 3, 4, n)$		$C_{DL,OL,SU}(8, 4, 2, n)$	
n	$C(8,1,4,m)$ in base codebook	n	$C(8,2,4,m)$ in base codebook	n	$C(8,3,4,m)$ in base codebook	n	$C(8,4,4,m)$ in base codebook
0	C(8,1,4,0)	0	C(8,2,4,0)	0	C(8,3,4,0)	0	C(8,4,4,0)
1	C(8,1,4,3)	1	C(8,2,4,1)	1	C(8,3,4,1)	1	C(8,4,4,1)

Table 74— $C_{DL,OL,SU}(8,1,8)$, $C_{DL,OL,SU}(8,2,4)$, $C_{DL,OL,SU}(8,3,4)$ and $C_{DL,OL,SU}(8,4,2)$

$C_{DL,OL,SU}(8,1,8,n)$		$C_{DL,OL,SU}(8,2,4,n)$		$C_{DL,OL,SU}(8,3,4,n)$		$C_{DL,OL,SU}(8,4,2,n)$	
n	$C(8,1,4,m)$ in base codebook	n	$C(8,2,4,m)$ in base codebook	n	$C(8,3,4,m)$ in base codebook	n	$C(8,4,4,m)$ in base codebook
2	$C(8,1,4,5)$	2	$C(8,2,4,2)$	2	$C(8,3,4,2)$		
3	$C(8,1,4,7)$	3	$C(8,2,4,3)$	3	$C(8,3,4,5)$		
4	$C(8,1,4,9)$						
5	$C(8,1,4,11)$						
6	$C(8,1,4,13)$						
7	$C(8,1,4,15)$						

Table 75— $C_{DL,OL,SU}(8,5,2)$, $C_{DL,OL,SU}(8,6,2)$, $C_{DL,OL,SU}(8,7,2)$ and $C_{DL,OL,SU}(8,8,1)$

$C_{DL,OL,SU}(8,5,2,n)$		$C_{DL,OL,SU}(8,6,2,n)$		$C_{DL,OL,SU}(8,7,2,n)$		$C_{DL,OL,SU}(8,8,1,n)$	
n	$C(8,5,4,m)$ in base codebook	n	$C(8,6,4,m)$ in base codebook	n	$C(8,7,4,m)$ in base codebook	n	$C(8,8,4,m)$ in base codebook
0	$C(8,5,4,0)$	0	$C(8,6,4,0)$	0	$C(8,7,4,0)$	0	$C(8,8,4,0)$
1	$C(8,5,4,1)$	1	$C(8,6,4,1)$	1	$C(8,7,4,1)$		

15.3.7.2.6.6.2.5.2 CL SU-MIMO subset**15.3.7.2.6.6.2.5.2.1 CL SU-MIMO subset for four transmit antennas**

Codebook subset selection for four transmit antennas is specified in Table 76.

Table 76—Subset selection of the base codebook for four transmit antennas

Rank	One	Two	Three	Four
Subset selection	$C(4,1,6,m)$ $m = 0$ to 15	$C(4,2,6,m)$ $m = 0$ to 15	$C(4,3,6,m)$ $m = 0$ to 15	$C(4,4,6,m)$ $m = 0$ to 5

15.3.7.2.6.6.2.5.3 CL MU-MIMO subset**15.3.7.2.6.6.2.5.3.2. CL MU-MIMO subset for four transmit antennas**

The base codebook subset for MU-MIMO is the same as the rank 1 of the base codebook subset for SU-MIMO, defined in Table 76.

15.3.7.2.6.6.3 Transformation codebook based feedback mode

The base codebooks and their subsets of rank 1 for SU and MU MIMO can be transformed as a function of the ABS transmit correlation matrix. A quantized representation of the ABS transmit correlation matrix shall be fed back by the AMS as instructed by the ABS

For the transformation mode, the PMI feedback from a mobile station shall represent an entry of the transformed base codebook according to long term channel information.

In transformation mode, both ABS and AMS transform the rank 1 base codebook to a rank 1 transformed codebook using the correlation matrix.

The transformation for codewords of rank 1 is of the form in Equation (47)

$$\tilde{\mathbf{v}}_i = \frac{\mathbf{R}\mathbf{v}_i}{\|\mathbf{R}\mathbf{v}_i\|} \quad (47)$$

\mathbf{v}_i is the i -th codeword of the base codebook,

$\tilde{\mathbf{v}}_i$ is the i -th codeword of the transformed codebook,

\mathbf{R} is the $N_t \times N_t$ transmit correlation matrix.

After obtaining the transformed codebook, both AMS and ABS shall use the transformed codebook for the feedback and precoding process of rank 1. The codebooks of rank > 1 shall be used without transformation when the AMS is operating with transformation codebook-based feedback mode.

The correlation matrix \mathbf{R} shall be fed back to support transformation mode of codebook-based precoding.

\mathbf{R} is fed back periodically and one correlation matrix is valid for whole band.

During some time period and in the whole band, the correlation matrix is measured as

$$\mathbf{R} = \mathbf{E}(\mathbf{H}_{ij}^H \mathbf{H}_{ij}) \quad (48)$$

Where \mathbf{H}_{ij} is the correlated channel matrix in the i -th OFDM symbol period and j -th subcarriers.

The measured correlation matrix has the format of

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} \\ \text{conj}(r_{12}) & r_{22} \end{bmatrix} \quad (N_t = 2) \quad (49)$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} \\ \text{conj}(r_{12}) & r_{22} & r_{23} & r_{24} \\ \text{conj}(r_{13}) & \text{conj}(r_{23}) & r_{33} & r_{34} \\ \text{conj}(r_{14}) & \text{conj}(r_{24}) & \text{conj}(r_{34}) & r_{44} \end{bmatrix} \quad (N_t = 4) \quad (50)$$

$$\mathbf{R} = \begin{bmatrix} r_{11} & r_{12} & r_{13} & r_{14} & r_{15} & r_{16} & r_{17} & r_{18} \\ \text{conj}(r_{12}) & r_{22} & r_{23} & r_{24} & r_{25} & r_{26} & r_{27} & r_{28} \\ \text{conj}(r_{13}) & \text{conj}(r_{23}) & r_{33} & r_{34} & r_{35} & r_{36} & r_{37} & r_{38} \\ \text{conj}(r_{14}) & \text{conj}(r_{24}) & \text{conj}(r_{34}) & r_{44} & r_{45} & r_{46} & r_{47} & r_{48} \\ \text{conj}(r_{15}) & \text{conj}(r_{25}) & \text{conj}(r_{35}) & \text{conj}(r_{45}) & r_{55} & r_{56} & r_{57} & r_{58} \\ \text{conj}(r_{16}) & \text{conj}(r_{26}) & \text{conj}(r_{36}) & \text{conj}(r_{46}) & \text{conj}(r_{56}) & r_{66} & r_{67} & r_{68} \\ \text{conj}(r_{17}) & \text{conj}(r_{27}) & \text{conj}(r_{37}) & \text{conj}(r_{47}) & \text{conj}(r_{57}) & \text{conj}(r_{67}) & r_{77} & r_{78} \\ \text{conj}(r_{18}) & \text{conj}(r_{28}) & \text{conj}(r_{38}) & \text{conj}(r_{48}) & \text{conj}(r_{58}) & \text{conj}(r_{68}) & \text{conj}(r_{78}) & r_{88} \end{bmatrix} \quad (N_t = 8) \quad (51)$$

where the diagonal entries are positive and the non-diagonal entries are complex. Because of the symmetry of the correlation matrix, only the upper triangular elements shall be fed back after quantization.

The \mathbf{R} matrix is normalized by the maximum element amplitude, and then quantized to reduce the feedback overhead.

The equation of normalization is

$$\bar{R} = \frac{R}{\max(\text{abs}(r_{ij}))} \quad (i, j = 1, \dots, N_t) \quad (52)$$

The normalized diagonal elements are quantized by 1 bit, and the normalized complex elements are quantized by 4 bits.

The equation for quantization is

$$q = a \cdot e^{(j \cdot b \cdot 2\pi)} \quad (53)$$

$a=[0.6 \ 0.9]$ and $b=0$ for diagonal entries

Table 77—Quantization parameters for diagonal entries of \mathbf{R}

Diagonal Entries	a	b	q
q_1	0.6	0	0.6000
q_2	0.9	0	0.9000

$a=[0.1 \ 0.5]$ and $b=[0 \ 1/8 \ 1/4 \ 3/8 \ 1/2 \ 5/8 \ 3/4 \ 7/8]$ for non-diagonal upper triangular entries

Table 78—Quantization parameters for non-diagonal entries of R

Non-Diagonal Entries	a	b	q
q_1	0.1	0	0.1000
q_2	0.1	1/8	$0.0707 + 0.0707i$
q_3	0.1	1/4	$0.0000 + 0.1000i$
q_4	0.1	3/8	$-0.0707 + 0.0707i$
q_5	0.1	1/2	$-0.1000 + 0.0000i$
q_6	0.1	5/8	$-0.0707 - 0.0707i$
q_7	0.1	3/4	$-0.0000 - 0.1000i$
q_8	0.1	7/8	$0.0707 - 0.0707i$
q_9	0.5	0	0.5000
q_{10}	0.5	1/8	$0.3536 + 0.3536i$
q_{11}	0.5	1/4	$0.0000 + 0.5000i$
q_{12}	0.5	3/8	$-0.3536 + 0.3536i$
q_{13}	0.5	1/2	$-0.5000 + 0.0000i$
q_{14}	0.5	5/8	$-0.3536 - 0.3536i$
q_{15}	0.5	3/4	$-0.0000 - 0.5000i$
q_{16}	0.5	7/8	$0.3536 - 0.3536i$

The total number of bits of feedback is 6 bits for 2 transmit antennas and 28 bits for 4 transmit antenna. The AMS and ABS shall use the same transformation based on the correlation matrix fed back by the AMS.

15.3.7.2.6.6.4 Differential codebook-based feedback mode

The differential feedbacks exploit the correlation between precoding matrixes adjacent in time or frequencies. The feedback shall start initially and restart periodically by sending a one-shot feedback that fully depicts the precoder by itself. The codebook for the one-shot feedback is defined for the base mode.

Denote the feedback index, the correspondingly fed back matrix, and the corresponding precoder by t , $\mathbf{D}(t)$, and $\mathbf{V}(t)$, respectively. The sequential index is reset to 0 at $T_{max} + 1$. The index for the initial or the restart feedback is 0 and $\mathbf{V}(0) = \mathbf{D}(0)$. The indexes of the subsequent differential feedback are 1, 2, ..., T_{max} and the corresponding precoders are $\mathbf{V}(t) = \mathbf{Q}_{\mathbf{V}(t-1)} \mathbf{D}(t)$, where $\mathbf{Q}_{\mathbf{V}(t-1)}$ is a unitary $N_t \times N_t$ matrix computed from the previous precoder $\mathbf{V}(t-1)$; N_t is the number of transmit antennas. The dimension of the fed back matrix $\mathbf{D}(t)$ is $N_t \times N_s$ for $t = 0, 1, 2, \dots, T_{max}$, where N_s is the number of spatial streams.

The rotation matrix $\mathbf{Q}_{\mathbf{V}(t-1)}$ of $\mathbf{V}(t-1)$ has the form $\mathbf{Q}_{\mathbf{V}(t-1)} = [\mathbf{V}(t-1) \mathbf{V}^\perp(t-1)]$, where $\mathbf{V}^\perp(t-1)$ consists of columns each of which has a unit norm and is orthogonal to the other columns of $\mathbf{Q}_{\mathbf{V}(t-1)}$. Define the Householder matrix Ω_x of unit vector \mathbf{x} as:

$$\Omega_x = \begin{cases} I - \frac{2}{\|w\|^2} w w^H & \text{for } \|w\|, \|x\| > 0 \\ I & \text{otherwise} \end{cases}$$

where $\|x\| = 1$ and $w = e^{-j\theta} x - e_l$; θ is the phase of the first entry of x ; $e_l = [1 \ 0 \dots 0]$. For $N_s = 1$, $V(t-1)$ is an $N_t \times 1$ vector and $Q_{V(t-1)} = \Omega_{V(t-1)}$. For $N_s = 2$ and $N_t = 4$, $V(t-1)$ is 4×2 . Denote $V(t-1)$ as $B = [b_1 \ b_2]$. Two columns are appended to B as $M = [B \ e_i \ e_j]$, where e_i and e_j are vectors with all zeros except that the i^{th} and j^{th} entries are ones, respectively. The index i and j are selected. Let the i^{th} and j^{th} entries of $g = (|Re(B)| + |Im(B)|) \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ be the smallest and the second smallest, respectively, where $|A|$ converts A 's entries to their absolute values; $Re(B)$ and $Im(B)$ are the real and imaginary parts of B , respectively. Gram-Schmidt orthogonalization is applied on e_i as $m_3 = e_i - b_{i,1}^* b_1 - b_{i,2}^* b_2$, where $b_{k,l}^*$ is the conjugate of B 's entry of on the k^{th} row and l^{th} column. Normalization follows the orthogonalization as $b_3 = \frac{m_3}{\|m_3\|}$. The matrix B is extended by one column as $B = [b_1 \ b_2 \ b_3]$. The Gram-Schmidt process on e_j is $m_4 = e_j - b_{j,1}^* b_1 - b_{j,2}^* b_2 - b_{j,3}^* b_3$. The followed normalization is $b_4 = \frac{m_4}{\|m_4\|}$. Finally, $Q_{V(t-1)} = [V(t-1) \ b_3 \ b_4]$. The Gram-Schmidt orthogonalization is the same as the one applied in the transformed codebook. An illustration of the computation of $Q_{V(t-1)}$ is shown in <<Figure xxx>>. Let A be a vector or a matrix with two columns. Denote Q_A the rotation matrix of A .

The feedback matrix $D(t)$ is selected from a differential codebook. Denote the codebook by $D(N_t, N_s, N_w)$, where N_w is the number of codewords in the codebook. The codebooks $D(2,1,4)$, $D(2,2,4)$, $D(4,1,16)$, and $D(4,2,16)$ are listed in Table 77, Table 78, Table 79, Table 80. Denote $D_i(N_t, N_s, N_w)$ the i^{th} codeword of $D(N_t, N_s, N_w)$. The rotation matrixes Q_{D_i} of the $D_i(N_t, N_s, N_w)$ s comprises a set of N_t by N_t matrixes that is denoted by $Q_{D(N_t, N_s, N_w)}$.

The differential codebook $D(4,3,N_w)$ is computed from $Q_{D(4,1,N_w)}$. The i^{th} codeword of $D(4,3,N_w)$ denoted by $D_i(4,3,N_w)$ is computed as

$$D_i(4, 3, N_w) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix} \tilde{Q}_i(4, 1, N_w),$$

where $\tilde{Q}_i(4, 1, N_w)$ consists of the last three columns of the i^{th} matrix in $Q_{D(4,1,N_w)}$. The differential codebook $D(4,4,N_w)$ is computed from $Q_{D(4,2,N_w)}$. The i^{th} codeword of $D(4,4,N_w)$ is the i^{th} matrix in $Q_{D(4,2,N_w)}$. Two sets of differential codebooks are defined. One has a large step size for fast tracking capability and the other has a small step size for high tracking accuracy. For $t = 1$, the codebook with large step size shall be used. A 1-bit indicator may be fed back for the step size used for $t = 2, \dots, T_{\max}$.

Table 79— $D(2,1,4)$ codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$\begin{bmatrix} 1 & 0 \end{bmatrix}^T$	3	$\begin{bmatrix} \cos(15) & \sin(15) e^{j120} \end{bmatrix}^T$
	2	$\begin{bmatrix} \cos(15) & \sin(15) \end{bmatrix}^T$	4	$\begin{bmatrix} \cos(15) & \sin(15) e^{-j120} \end{bmatrix}^T$

Table 80— $D(2,2,4)$ codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$	3	$\begin{bmatrix} \cos(15) & \sin(15)e^{j120} \\ \sin(15)e^{j120} & -\cos(15) \end{bmatrix}$
	2	$\begin{bmatrix} \cos(15) & \sin(15) \\ \sin(15) & -\cos(15) \end{bmatrix}$	4	$\begin{bmatrix} \cos(15) & \sin(15)e^{-j120} \\ \sin(15)e^{-j120} & -\cos(15) \end{bmatrix}$

Table 81— $D(4,1,16)$ codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$[1 \ 0 \ 0 \ 0]^T$	9	$[\cos(20^\circ) \ 0.2553 + 0.1430i \ 0.0282 + 0.0897i \ 0.1469 + 0.0308i]^T$
	2	$[\cos(20^\circ) \ 0.2062 - 0.0657i \ 0.0485 - 0.2038i \ -0.0885 + 0.1358i]^T$	10	$[\cos(20^\circ) \ 0.0507 - 0.3289i \ 0.0276 + 0.0448i \ 0.0508 - 0.0297i]^T$
	3	$[\cos(20^\circ) \ -0.0531 - 0.0765i \ 0.0806 - 0.1811i \ -0.1432 - 0.2203i]^T$	11	$[\cos(20^\circ) \ -0.0352 + 0.2445i \ 0.0560 + 0.1197i \ -0.1178 - 0.1569i]^T$
	4	$[\cos(20^\circ) \ -0.0762 - 0.1024i \ -0.2492 - 0.1865i \ 0.0616 + 0.0028i]^T$	12	$[\cos(20^\circ) \ -0.0505 - 0.0233i \ -0.1061 + 0.3140i \ 0.0505 + 0.0382i]^T$
	5	$[\cos(20^\circ) \ -0.0475 - 0.0535i \ 0.0266 - 0.0109i \ 0.1997 + 0.2668i]^T$	13	$[\cos(20^\circ) \ -0.3407 - 0.0014i \ 0.0280 + 0.0108i \ 0.0021 + 0.0020i]^T$
	6	$[\cos(20^\circ) \ -0.0478 - 0.0010i \ -0.0229 + 0.0325i \ 0.2359 - 0.2397i]^T$	14	$[\cos(20^\circ) \ -0.0180 - 0.0100i \ 0.3300 + 0.0502i \ 0.0685 - 0.0205i]^T$
	7	$[\cos(20^\circ) \ 0.0030 + 0.1854i \ -0.1733 \ -0.1136 + 0.1992i]^T$	15	$[\cos(20^\circ) \ -0.0401 - 0.0885i \ 0.0946 + 0.1084i \ -0.2792 + 0.0942i]^T$
	8	$[\cos(20^\circ) \ 0.1926 - 0.0378i \ -0.1914 + 0.0534i \ -0.1467 - 0.1320i]^T$	16	$[\cos(20^\circ) \ -0.0436 + 0.2160i \ 0.0596 - 0.2318i \ 0.1057 + 0.0002i]^T$

Table 82—D(4,2,16) codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix}^T$	9	$\begin{bmatrix} 0.9770 & 0.1518 + 0.0929i \\ 0.0606 - 0.0773i & 0.0063 - \\ 0.0647i & -0.0507 - 0.1011i \\ -0.0981 + 0.8703i & -0.1618 - 0.0957i \\ -0.3914 + 0.1776i \end{bmatrix}^T$
	2	$\begin{bmatrix} 0.9571 & -0.0238 + 0.0314i & - \\ 0.0454 - 0.2541i & -0.0790 + \\ 0.0977i & -0.0965 + 0.0299i & 0.9114 + \\ 0.0872i & -0.0431 - 0.3386i & - \\ 0.1023 + 0.1567i \end{bmatrix}^T$	10	$\begin{bmatrix} -0.6295 & -0.5472 - 0.3123i \\ -0.0136 - 0.1891i & 0.2222 - \\ 0.3486i & 0.5496 - 0.3201i \\ -0.7539 - 0.0022i & 0.0440 + 0.0657i \\ -0.0189 + 0.1434i \end{bmatrix}^T$
	3	$\begin{bmatrix} -0.0262 & 0.7460 - 0.6224i \\ 0.2085 + 0.1061i & 0.0104 - \\ 0.0226i & 0.6933 + 0.5709i & 0.1217 + \\ 0.0055i & -0.1479 - 0.3702i & - \\ 0.1061 - 0.0917i \end{bmatrix}^T$	11	$\begin{bmatrix} 0.3622 & -0.8103 - 0.3554i \\ 0.0797 - 0.2550i & -0.1050 + \\ 0.0596i & -0.8270 + 0.3289i \\ -0.2410 - 0.0429i & -0.1349 - 0.3222i \\ -0.0937 + 0.1311i \end{bmatrix}^T$
	4	$\begin{bmatrix} 0.9990 & 0.0386 - 0.0212i \\ 0.0035 - 0.0023i & 0.0002 + \\ 0.0019i & -0.0343 - 0.0200i & 0.8730 + \\ 0.0488i & 0.3473 - 0.1714i & 0.2857 \\ -0.0483i \end{bmatrix}^T$	12	$\begin{bmatrix} -0.4402 & -0.8115 - 0.0841i \\ 0.0434 + 0.1299i & -0.1636 + \\ 0.3083i & -0.7666 + 0.1113i & 0.5535 + \\ 0.0180i & 0.0170 + 0.1186i & - \\ 0.1660 + 0.2268i \end{bmatrix}^T$
	5	$\begin{bmatrix} 0.9556 & 0.1479 - 0.0806i & - \\ 0.0215 + 0.1307i & -0.0706 - \\ 0.1894i & -0.0844 + 0.0610i & 0.8284 - \\ 0.3568i & 0.1996 - 0.1472i & - \\ 0.1478 + 0.3037i \end{bmatrix}^T$	13	$\begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & -0.8741 + 0.0445i & 0.3194 - \\ 0.1760i & 0.3172 - 0.0173i \end{bmatrix}^T$
	6	$\begin{bmatrix} -0.8726 & 0.1100 - 0.0735i & - \\ 0.4250 - 0.1821i & -0.0795 + \\ 0.0325i & 0.1648 + 0.1221i & 0.9722 - \\ 0.0007i & -0.0410 - 0.1039i & - \\ 0.0018 + 0.0180i \end{bmatrix}^T$	14	$\begin{bmatrix} -0.8851 & -0.3025 + 0.3449i \\ 0.0049 + 0.0437i & -0.0340 - \\ 0.0557i & 0.2630 + 0.2692i & -0.7941 - \\ 0.0049i & 0.2671 - 0.0632i & - \\ 0.2947 + 0.2561i \end{bmatrix}^T$
	7	$\begin{bmatrix} -0.6845 & -0.0048 - 0.7234i \\ 0.0310 - 0.0167i & 0.0831 + \\ 0.0006i & 0.0085 + 0.6243i & 0.6200 + \\ 0.0054i & -0.3294 - 0.2343i & - \\ 0.2292 - 0.0994i \end{bmatrix}^T$	15	$\begin{bmatrix} 0.8990 & -0.1582 - 0.1183i \\ 0.1246 - 0.0775i & -0.3616 - \\ 0.0214i & 0.0035 + 0.2203i & -0.8650 + \\ 0.3492i & -0.0464 + 0.0693i & - \\ 0.2338 + 0.1398i \end{bmatrix}^T$
	8	$\begin{bmatrix} 0.5617 & 0.8043 + 0.1719i & - \\ 0.0617 - 0.0099i & 0.0607 - \\ 0.0241i & 0.7006 - 0.1414i & -0.5130 - \\ 0.0152i & -0.1561 + 0.2422i & - \\ 0.3191 + 0.2023i \end{bmatrix}^T$	16	$\begin{bmatrix} 0.5212 & 0.3746 + 0.7570i \\ 0.0670 + 0.1016i & -0.0085 - \\ 0.0003i & 0.3025 - 0.7018i & -0.4381 + \\ 0.0708i & -0.2495 - 0.2784i & - \\ 0.2622 - 0.1028i \end{bmatrix}^T$

Table 83—D(8,1,16) codebook

	Index	Codeword	Index	Codeword
Codebook of large step size	1	$[\cos(20^\circ) \ 0 \ -0.1449 - 0.1483i \ 0.0019 + 0.0060i \ 0.0336 + 0.0253i \ -0.0242 - 0.1235i \ -0.2259 + 0.0069i \ 0.0409 - 0.0598i]^T$	9	$[\cos(20^\circ) \ 0 \ 0.1314 + 0.0144i \ 0.0509 + 0.0237i \ 0.0301 + 0.0390i \ 0.0311 + 0.0019i \ -0.0091 + 0.0202i \ 0.2958 + 0.0708i]^T$
	2	$[\cos(20^\circ) \ 0 \ -0.0005 + 0.0004i \ 0.0334 + 0.0152i \ 0.0022 + 0.0207i \ -0.0651 + 0.1824i \ 0.0153 + 0.2095i \ -0.0093 - 0.1830i]^T$	10	$[\cos(20^\circ) \ 0 \ 0.0292 + 0.0247i \ -0.3217 + 0.1076i \ -0.0073 + 0.0175i \ 0.0049 + 0.0013i \ 0.0048 - 0.0017i \ -0.0004 - 0.0001i]^T$
	3	$[\cos(20^\circ) \ 0.3402 - 0.0352i \ 0 \ 0 \ 0 \ 0 \ 0 \ 0]^T$	11	$[\cos(20^\circ) \ 0 \ 0.0702 - 0.0699i \ 0.0279 - 0.0024i \ 0.0380 + 0.0396i \ -0.0493 - 0.0118i \ -0.0215 + 0.1480i \ -0.1441 + 0.2401i]^T$
	4	$[\cos(20^\circ) \ 0 \ -0.0264 - 0.0267i \ 0.0602 + 0.0858i \ 0.0281 + 0.0282i \ 0.2700 + 0.1283i \ -0.0290 - 0.0870i \ -0.0700 + 0.0173i]^T$	12	$[\cos(20^\circ) \ 0 \ -0.1352 + 0.2709i \ 0.0727 + 0.1069i \ -0.0037 - 0.0066i \ -0.0406 - 0.0670i \ -0.0100 + 0.0186i \ -0.0156 + 0.0413i]^T$
	5	$[\cos(20^\circ) \ -0.2005 - 0.2771i \ 0 \ 0 \ 0 \ 0 \ 0 \ 0]^T$	13	$[\cos(20^\circ) \ 0 \ -0.1771 - 0.1261i \ 0.0068 + 0.0073i \ 0.0303 - 0.0033i \ -0.0678 + 0.0243i \ 0.2320 - 0.0669i \ 0.0581 + 0.0424i]^T$
	6	$[\cos(20^\circ) \ 0 \ -0.0368 + 0.0937i \ -0.0494 - 0.3041i \ 0.0844 + 0.0300i \ 0.0619 + 0.0044i \ 0.0004 - 0.0052i \ -0.0043 - 0.0018i]^T$	14	$[\cos(20^\circ) \ 0 \ 0.0091 - 0.0155i \ 0.0183 - 0.0622i \ -0.3302 + 0.0486i \ 0.0145 - 0.0213i \ 0.0072 - 0.0162i \ -0.0063 + 0.0050i]^T$
	7	$[\cos(20^\circ) \ 0 \ 0.1291 - 0.0176i \ 0.0518 + 0.0286i \ 0.0540 + 0.0451i \ 0.0479 - 0.2164i \ 0.1215 + 0.0023i \ -0.0800 - 0.1457i]^T$	15	$[\cos(20^\circ) \ 0 \ 0.0473 - 0.0160i \ 0.0085 - 0.0123i \ 0.0046 - 0.3373i \ 0.0003 - 0.0018i \ -0.0172 - 0.0097i \ -0.0070 - 0.0022i]^T$
	8	$[\cos(20^\circ) \ 0 \ 0.1048 + 0.0160i \ 0.0387 - 0.0003i \ 0.0357 + 0.0531i \ -0.1838 + 0.0992i \ -0.0685 - 0.2188i \ -0.0579 - 0.0243i]^T$	16	$[\cos(20^\circ) \ -0.1397 + 0.3122i \ 0 \ 0 \ 0 \ 0 \ 0 \ 0]^T$

3.3.3.2.5.7 Unquantized MIMO feedback for closed-loop transmit precoding**15.3.7.2.6.7.1 UL sounding**

To assist the ABS in determining the precoding matrix to use for SU-MIMO or MU-MIMO, the ABS may request the AMS transmit a sounding signal in an UL sounding channel. The ABS may translate the measured UL channel response to an estimated DL channel response. The transmitter and receiver hardware of ABS and AMS shall be calibrated.

The UL sounding channel defined in subclause [TBD] is used in MIMO transmission

3.3.3.3 Transmission schemes for control channels

For two ABS transmit antennas, the P-SFH, S-SFH, and A-MAP shall be transmitted using SFBC.

The input to the MIMO encoder is represented by a 2×1 vector.

$$\mathbf{s} = \begin{bmatrix} s_1 \\ s_2 \end{bmatrix} \quad (54)$$

The MIMO encoder generates the SFBC matrix.

$$\mathbf{X} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix} \quad (55)$$

The two-stream pilot pattern defined in 3.3.1.4.1 is used for SFH and A-MAP transmission.

3.3.3.4 MIMO transmission schemes for E-MBS

3.3.4 Uplink physical structure

Each uplink subframe is divided into 4 or fewer frequency partitions; each partition consists of a set of physical resource units across the total number of OFDMA symbols available in the subframe. Each frequency partition can include contiguous (localized) and/or non-contiguous (distributed) physical resource units. Each frequency partition can be used for different purposes such as fractional frequency reuse (FFR). Figure 484 illustrates the uplink physical structure in the example of two frequency partitions with frequency partition 2 including both contiguous and distributed resource allocations, where Sc stands for Subcarrier.

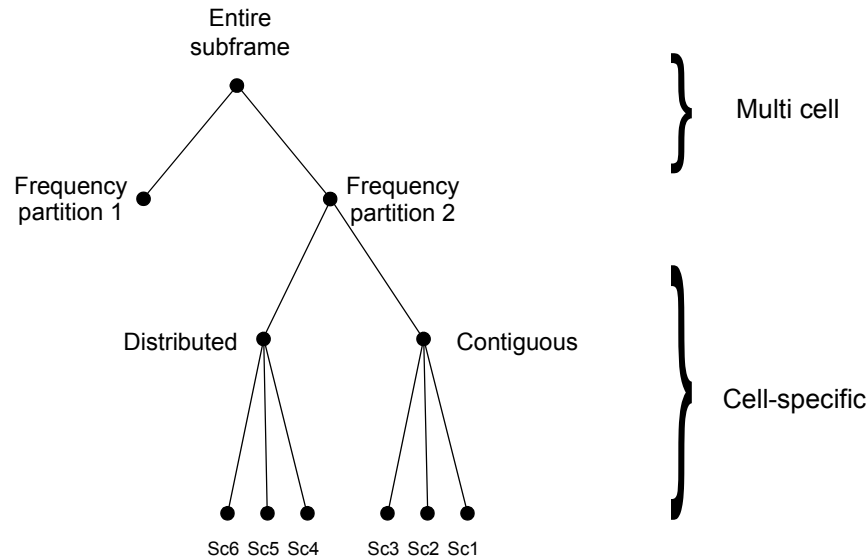


Figure 35—Example of uplink physical structure

3.3.4.1 Physical and logical resource unit

A physical resource unit (PRU) is the basic physical unit for resource allocation that comprises P_{sc} consecutive subcarriers by N_{sym} consecutive OFDMA symbols. P_{sc} is 18 and N_{sym} is 6, 7, 5, and 9 OFDMA symbols for type-1, type-2, type-3, and type-4 subframes, respectively. A logical resource unit (LRU) is the basic logical unit for distributed and localized resource allocations. An LRU has $P_{sc} \cdot N_{sym}$ subcarriers.

The LRU size for control channel transmission should be same as for data transmission. Multiple users are allowed to share one control LRU. The effective number of data subcarriers in an LRU depends on the number of allocated pilots and control channel presence.

3.3.4.1.1 Distributed logical resource unit

The distributed logical resource unit (DLRU) contains a group of subcarriers that are spread across the distributed resource allocations within a frequency partition. The size of the DLRU equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols. The minimum unit for forming the DRU is a tile. The uplink tile size is 6 x N_{sym} , where the value of N_{sym} depends on the subframe type.

3.3.4.1.2 Contiguous logical resource unit

The localized logical resource unit, also known as contiguous logical resource unit (CLR) contains a group of subcarriers that are contiguous across the resource allocations. The size of the CLR equals the size of a PRU, i.e., P_{sc} subcarriers by N_{sym} OFDMA symbols.

3.3.4.2 Multi-cell resource mapping

The UL multi-cell resource mapping consists of subband partitioning, miniband permutation and frequency partitioning and is defined in the following sub-clauses.

3.3.4.2.1 Subband Partitioning

The PRUs are first divided into subbands and minibands; a subband comprises of N_1 adjacent PRUs and a miniband comprises of N_2 adjacent PRUs where $N_1 = 4$ and $N_2 = 1$. Subbands are suitable for frequency selective allocations as they provide a continuous allocation of PRUs in frequency. Minibands are suitable for frequency diverse allocation and are permuted in frequency.

The number of subbands is denoted by K_{SB} . The number of PRUs allocated to subbands is $L_{SB} = N_1 \cdot K_{SB}$. A 4 or 3-bit (TBD) field called Uplink Subband Allocation Count (USAC) determines the value of K_{SB} depending on system bandwidth. The USAC is transmitted in the SFH. The remaining PRUs are allocated to minibands. The number of minibands in an allocation is denoted by K_{MB} . The number of PRUs allocated to minibands is $L_{MB} = N_2 \cdot K_{MB}$. The total number of PRUs is $N_{PRU} = L_{SB} + L_{MB}$. The maximum number of subbands that can be formed is denoted as N_{sub} where $N_{sub} = \lfloor N_{PRU} / N_1 \rfloor$. Mappings between USAC and K_{SB} are shown in Tables 714 through 716 for system bandwidths of 20MHz, 10MHz, and 5MHz, respectively.

Table 84—Mapping between USAC and K_{SB} for 20MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
0	0	16	16

Table 84—Mapping between USAC and K_{SB} for 20MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
1	1	17	17
2	2	18	18
3	3	19	19
4	4	20	20
5	5	21	21
6	6	22	N.A.
7	7	23	N.A.
8	8	24	N.A.
9	9	25	N.A.
10	10	26	N.A.
11	11	27	N.A.
12	12	28	N.A.
13	13	29	N.A.
14	14	30	N.A.
15	15	31	N.A.

Table 85—Mapping between USAC and K_{SB} for 10 MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
0	0	8	8
1	1	9	9
2	2	10	10
3	3	11	N.A.
4	4	12	N.A.
5	5	13	N.A.
6	6	14	N.A.
7	7	15	N.A.

Table 86—Mapping between USAC and K_{SB} for 5MHz

USAC	# of subbands allocated (K_{SB})	USAC	# of subbands allocated (K_{SB})
0	0	4	4
1	1	5	N.A.
2	2	6	N.A.
3	3	7	N.A.

The PRUs are partitioned and reordered into two groups: subband PRUs (PRU_{SB}), and miniband PRUs (PRU_{MB}). The set of PRU_{SB} is numbered from 0 to ($L_{SB} - 1$) and the set of PRU_{MB} from 0 to ($L_{MB} - 1$).

Equation (56) defines the mapping of PRUs into PRU_{SB} s. Equation (58) defines the mapping of PRUs to PRU_{MB} s. Figure 2 illustrates the PRU to PRU_{SB} s and PRU_{MB} s mapping for a 10 MHz bandwidth with K_{SB} equal to 7.

$$PRU_{SB}[j] = PRU[i]; \quad 0 \leq j \leq L_{SB} - 1 \quad (56)$$

where

$$i = N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{j}{N_1} \right\rfloor + \left\lfloor \frac{j}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{j\} \bmod \{N_1\} \quad (57)$$

$$PRU_{MB}[k] = PRU[i]; \quad k = 0, 1, \dots, L_{MB} - 1 \quad (58)$$

where

$$i = \begin{cases} N_1 \cdot \left\{ \left\lceil \frac{N_{sub}}{K_{SB}} \right\rceil \cdot \left\lfloor \frac{k + L_{SB}}{N_1} \right\rfloor + \left\lfloor \frac{k + L_{SB}}{N_1} \right\rfloor \cdot \frac{GCD(N_{sub}, \lceil N_{sub}/K_{SB} \rceil)}{N_{sub}} \right\} \bmod \{N_{sub}\} + \{k + L_{SB}\} \bmod \{N_1\} & K_{SB} > 0 \\ k & K_{SB} = 0 \end{cases} \quad (59)$$

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3.3.4.2.2 Miniband permutation

The miniband permutation maps the PRU_{MB} s to permuted- PRU_{MB} s ($PPRU_{MB}$ s) to insure allocation of frequency diverse PRUs to each frequency partition. Equation (60) describes the mapping from PRU_{MB} s to $PPRU_{MB}$ s.

$$PPRU_{MB}[j] = PRU_{MB}[i]; \quad 0 \leq j \leq L_{MB} - 1 \quad (60)$$

where:

$$i = (q(j) \bmod D) \cdot P + \left\lfloor \frac{q(j)}{D} \right\rfloor$$

$$P = \min(K_{MB}, N_1/N_2)$$

$$r(j) = \max\{j - ((K_{MB} \bmod P) \cdot D), 0\}$$

$$q(j) = j + \left\lfloor \frac{r(j)}{D-1} \right\rfloor$$

$$D = \left\lfloor \frac{K_{MB}}{P} + 1 \right\rfloor$$

Figure 37 illustrates the mapping from PRU to PRU_{SB} and PRU_{MB} .

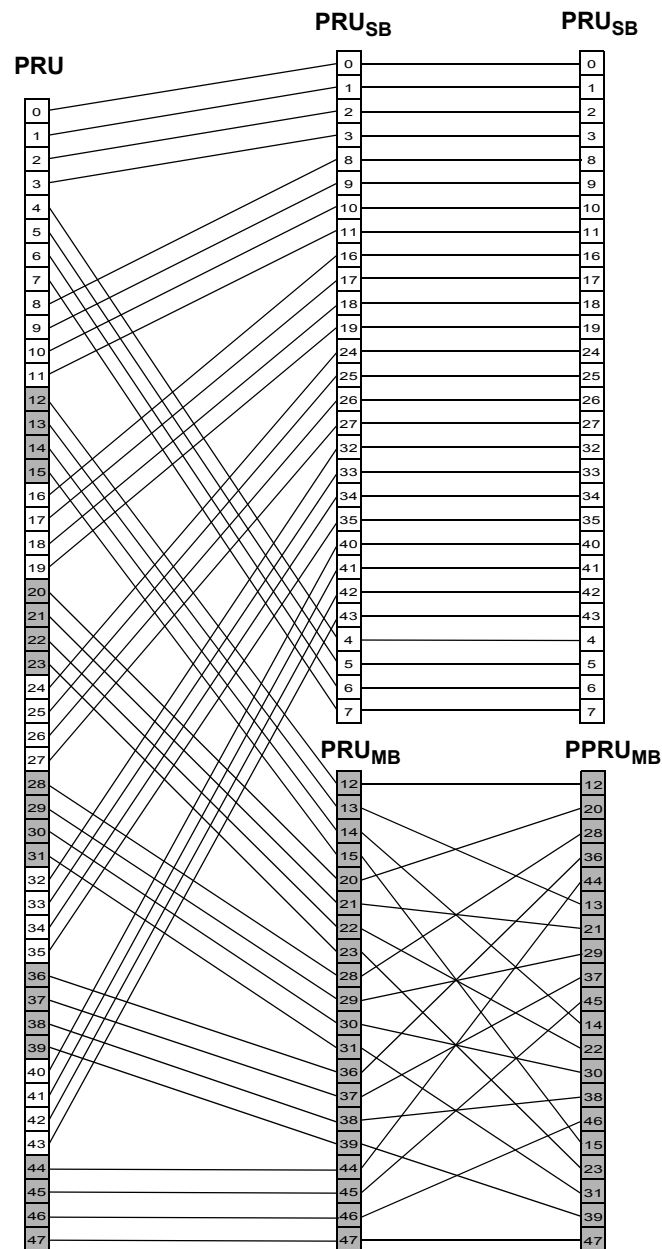


Figure 37—Mapping from PRUs to PRU_{SB} and PPRU_{MB} mapping for BW=10 MHz, K_{SB}=7

3.3.4.2.3 Frequency partitioning

The PRU_{SB}s and PPRU_{MB}s are allocated to one or more frequency partitions. By default, only one partition is present. The maximum number of frequency partitions is 4. The frequency partition configuration is trans-

mitted in the S-SFH SP1 in a 4, 3-bit composite field called the Uplink Frequency Partition Configuration (UFPC), depending on system bandwidth. The Frequency Partition Count (FPCT) defines the number of frequency partitions. The Frequency Partition Size (FPS_i) defines the number of PRUs allocated to FP_i . FPCT and FPS_i are determined from UFPC as shown in Table 87 through Table 89.

A 3, 2, or 1-bit called the Uplink Frequency Partition Subband Count ($UFPS_C$) defines the number of subbands allocated to FP_i , for $i > 0$. When $UFPC = 0$, $UFPS_C$ is equal to 0.

Table 87—Mapping between UFPC and frequency partitioning for 20MHz

UFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	FPCT	FPS_i ($i=0$)	FPS_i ($i>0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU} * 1/3$
2	1 : 1 : 1 : 1	4	$N_{PRU} * 1/4$	$N_{PRU} * 1/4$
3	3 : 1 : 1 : 1	4	$N_{PRU} * 1/2$	$N_{PRU} * 1/6$
4	5 : 1 : 1 : 1	4	$N_{PRU} * 5/8$	$N_{PRU} * 1/8$
5	9 : 1 : 1 : 1	4	$N_{PRU} * 9/12$	$N_{PRU} * 1/12$
6	9 : 5 : 5 : 5	4	$N_{PRU} * 3/8$	$N_{PRU} * 5/24$
7-15	Reserved			

Table 88—Mapping between UFPC and frequency partitioning for 10MHz

UFPC	Freq. Partitioning ($FP_0:FP_1:FP_2:FP_3$)	FPCT	FPS_i ($i=0$)	FPS_i ($i>0$)
0	1 : 0 : 0 : 0	1	N_{PRU}	0
1	0 : 1 : 1 : 1	3	0	$N_{PRU} * 1/3$
2	1 : 1 : 1 : 1	4	$N_{PRU} * 1/4$	$N_{PRU} * 1/4$
3	3 : 1 : 1 : 1	4	$N_{PRU} * 1/2$	$N_{PRU} * 1/6$
4	5 : 1 : 1 : 1	4	$N_{PRU} * 5/8$	$N_{PRU} * 1/8$
5	9 : 5 : 5 : 5	4	$N_{PRU} * 3/8$	$N_{PRU} * 5/24$
6-7	Reserved			

Table 89—Mapping between UFPC and frequency partitioning for 5MHz

UFPC	Freq. Partitioning (FP ₀ :FP ₁ :FP ₂ :FP ₃)	FPCT	FPS _i (i=0)	FPS _i (i>0)
0	1 : 0 : 0 : 0	1	N _{PRU}	0
1	0 : 1 : 1 : 1	3	0	N _{PRU} * 1/3
2	1 : 1 : 1 : 1	4	N _{PRU} * 1/4	N _{PRU} * 1/4
3	3 : 1 : 1 : 1	4	N _{PRU} * 1/2	N _{PRU} * 1/6
4	9 : 5 : 5 : 5	4	N _{PRU} * 3/8	N _{PRU} * 5/24
4-7	Reserved			

The number of subbands in the i^{th} frequency partition is denoted by K_{SB,FP_i} , as shown in Equation (61),

$$K_{SB,FP_i} = \begin{cases} K_{SB} - (FPCT - 1) \cdot UFPSC & i = 0, FPCT = 4 \\ UFPSC & i > 0, FPCT = 3 \quad \text{or} \quad 4 \\ K_{SB} & i = 0, FPCT = 1 \end{cases} \quad (61)$$

The number of minibands in the i^{th} frequency partition is denoted by K_{MB,FP_i} as shown in Equation (63),

$$K_{MB,FP_i} = (FPS_i - K_{SB,FP_i} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (62)$$

When UFPC = 1 and FPCT = 3, the number of subbands in FP_i (for $i > 0$) is given by $K_{SB,FP_i} = UFPSC$. The number of minibands in the i^{th} frequency partition is denoted by K_{MB,FP_i} as shown in Equation (63),

$$K_{MB,FP_i} = (FPS_i - K_{SB,FP_i} \cdot N_1) / N_2 \quad 0 \leq i < FPCT \quad (63)$$

The numbers of subband PRUs and miniband PRUs in each frequency partition are $L_{SB,FP_i} = N_1 \cdot K_{SB,FP_i}$ and $L_{MB,FP_i} = N_2 \cdot K_{MB,FP_i}$ respectively.

The mapping of subband PRUs and miniband PRUs to the frequency partition i is given by the following equations:

$$PRU_{FP_i}(j) = \begin{cases} PRU_{SB}(k_1) & 0 \leq j < L_{SB,FP_i} \\ PPRU_{MB}(k_2) & L_{SB,FP_i} \leq j < (L_{SB,FP_i} + L_{MB,FP_i}) \end{cases} \quad (64)$$

Where $k_1 = \sum_{m=0}^{i-1} L_{SB,FP_m} + j$ and $k_2 = \sum_{m=0}^{i-1} L_{MB,FP_m} + j - L_{SB,FP_i}$.

Figure 38 depicts the frequency partitioning for BW of 10 MHz, $K_{SB} = 7$, $FPCT = 4$, $FPS_0 = FPS_i = 12$, and $UFPSC = 2$.

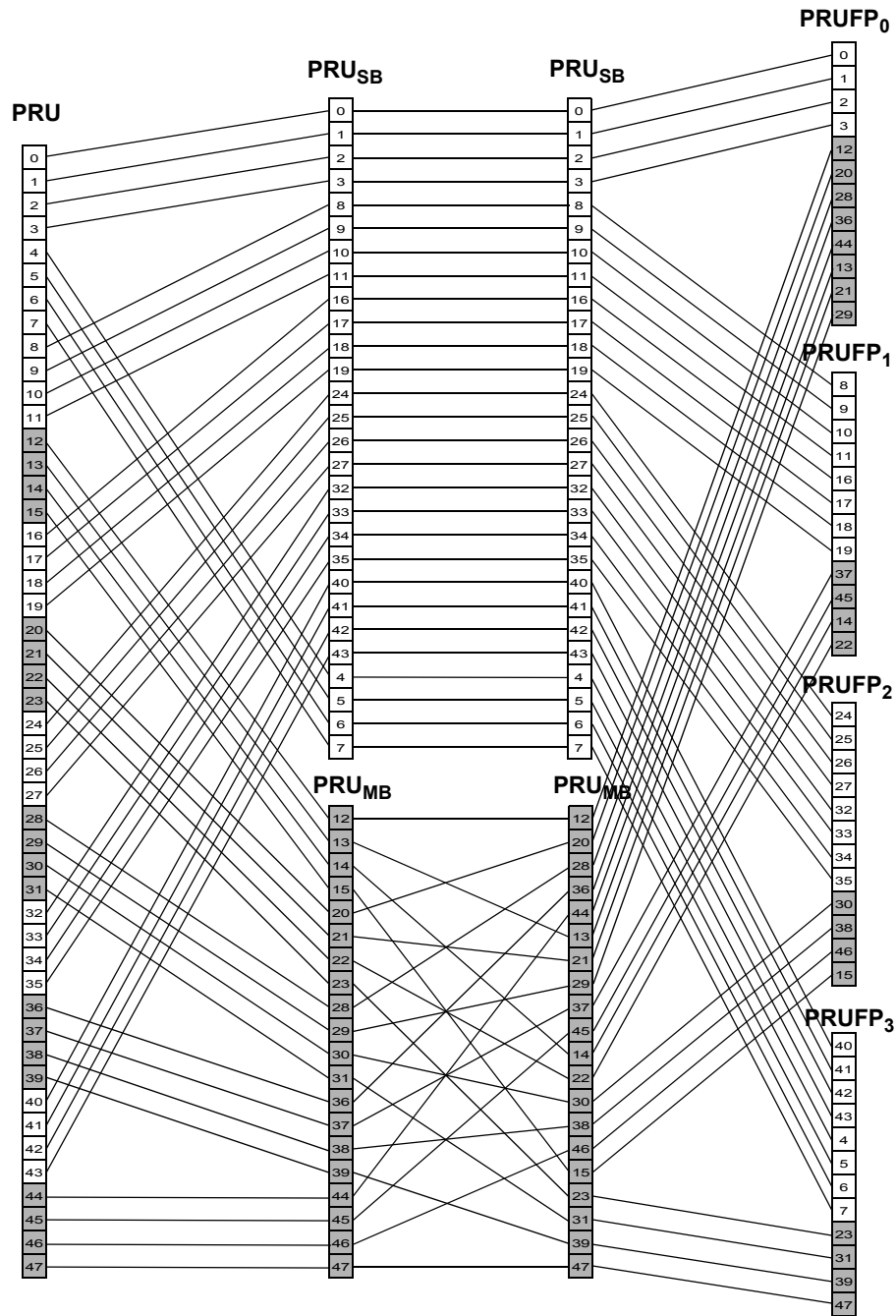


Figure 38—Frequency partition for BW=10 MHz, $K_{SB}=7$, FPCT=4, $FPS_0=FPS_i=12$, UFPSC=2

3.3.4.3 Cell-specific resource mapping

PRU_{FPI} s are mapped to LRUs. All further PRUs and tile permutations are constrained to the PRUs within a frequency partition.

3.3.4.3.1 CRU/DRU allocation

The partition between CRUs and DRUs is done on a sector specific basis. Let L_{SB-CRU,FP_i} and L_{MB-CRU,FP_i} denote the number of allocated subband CRUs and miniband CRUs for FP_i ($i > 0$). The number of total allocated CRUs, in units of a subband (i.e. N_1 PRUs), for FP_i (for $i > 0$) is given by uplink CRU allocation size, $UCAS_i$. The numbers of subband-based and miniband-based CRUs in FP_0 are given by $UCAS_{SB,0}$ and $UCAS_{MB,0}$, in units of a subband and miniband, respectively.

For FP_0 , the value of $UCAS_{SB,0}$ is explicitly signaled in the SFH as a 5, 4 or 3-bit field to indicate the number of subbands in unsigned-binary format. A 5, 4, or 3-bit uplink miniband-based CRU allocation size ($UCAS_{MB,0}$) is sent in the SFH only for partition FP_0 , depending on system bandwidth. The number of subband-based CRUs for FP_0 is given by the Equation (65).

$$L_{SB-CRU,FP_0} = N_1 \cdot UCAS_{SB,0} \quad (65)$$

The mapping between $UCAS_{MB,0}$ and the number of miniband-based CRUs for FP_0 is shown in the Table 90 through Table 92 for system bandwidths of 20 MHz, 10 MHz, and 5 MHz respectively.

Table 90—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 20 MHz

$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 (L_{MB-CRU,FP_0})	$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 (L_{MB-CRU,FP_0})
0	0	16	28
1	2	17	32
2	4	18	36
3	6	19	40
4	8	20	44
5	10	21	48
6	12	22	52
7	14	23	56
8	16	24	60
9	18	25	64
10	19	26	68
11	20	27	72
12	21	28	76
13	22	29	80
14	23	30	84
15	24	31	88

Table 91—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 10 MHz

$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 ($L_{MB,FP0}$)	$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 ($L_{MB,FP0}$)
0	0	8	16
1	2	9	18
2	4	10	20
3	6	11	22
4	8	12	24
5	10	13	38
6	12	14	40
7	14	15	42

Table 92—Mapping between $UCAS_{MB,0}$ and number of miniband-based CRUs for FP_0 for 5 MHz

$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 ($L_{MB,FP0}$)	$UCAS_{MB,0}$	# of miniband-based CRU for FP_0 ($L_{MB,FP0}$)
0	0	4	8
1	2	5	10
2	4	6	18
3	6	7	20

For FP_i ($i > 0$), only one value for $UCAS_i$ is explicitly signaled for all $i > 0$, in the SFH as a 3, 2 or 1-bit field to signal the same numbers of allocated CRUs for FP_i ($i > 0$). When $UFPC = 0$, $UCAS_i = 0$. For FP_i ($i > 0$), the number of subband CRUs ($L_{SB-CRU,FPi}$) and miniband CRUs ($L_{MB-CRU,FPi}$) are derived using Equation (66) and Equation (67) respectively.

$$L_{SB-CRU,FPi} = N_1 \cdot \min\{UCAS_i, K_{SB,FPi}\} \quad (66)$$

$$L_{MB-CRU,FPi} = \begin{cases} 0, & UCAS_i \leq K_{SB,FPi} \\ (UCAS_i - K_{SB,FPi}) \cdot N_1 & UCAS_i > K_{SB,FPi} \end{cases} \quad (67)$$

The total number of CRUs in frequency partition FP_i , for $0 \leq i < FPCT$, is denoted by $L_{CRU,FPi}$, calculated as shown in Equation (69).

$$L_{CRU, FPi} = L_{SB-CRU, FPi} + L_{MB-CRU, FPi} \quad (68)$$

The number of DRUs in each frequency partition is denoted by $L_{DRU, FPi}$, calculated as shown in Equation (69)

$$L_{DRU, FPi} = FPS_i - L_{CRU, FPi} \quad \text{for } 0 \leq i < FPCT \quad (69)$$

The mapping from PRU_{FPi} to CRU_{FPi} (for $0 \leq i < FPCT$) is given by Equation (70):

$$CRU_{FPi}[j] = \begin{cases} PRU_{FPi}[j], & 0 \leq j < L_{SB-CRU, FPi} \\ PRU_{FPi}[k + L_{SB-CRU, FPi}], & L_{SB-CRU, FPi} \leq j < L_{CRU, FPi} \end{cases} \quad (70)$$

where $k = s[j - L_{SB-CRU, FPi}]$.

$s[j]$ is the CRU/DRU allocation sequence defined in Equation (71) and $s[j] < FPS_i - L_{SB-CRU, FPi}$.

$$i[j] = \{ \text{PermSeq}(j) + \text{UL_PermBase} \} \bmod (FPS_i - L_{SB-CRU, FPi}) \quad (71)$$

where $\text{PermSeq}()$ is the permutation sequence of length $(FPS_i - L_{SB-CRU, FPi})$ and is determined by $\text{SEED} = \{\text{IDcell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in 3.3.5.3.3. The UL_PermBase is an interger set to preamble IDcell.

The mapping of PRU_{FPi} to DRU_{FPi} is given by Equation (72):

$$DRU_{FPi}[j] = PRU_{FPi}[k + L_{SB, FPi}], \quad 0 \leq j < L_{DRU, FPi} \quad (72)$$

where $k = s[j + L_{CRU, FPi} - L_{SB-CRU, FPi}]$.

Figure 5 presents an example to illustrate the various steps of subband partitioning, miniband permutation, frequency partitioning, and cell-specific resource mapping (CRU/DRU allocation) for the case of 10 MHz system bandwidth. For this example, $K_{SB} = \text{USAC} = 7$, $FPCT = 4$, $FPS_i = 12$ (for $i \geq 0$), $\text{UFPSC} = 2$, $\text{UCAS}_{SB,0} = 1$, $\text{UCAS}_{MB,0} = 2$, and $\text{UCAS}_i = 2$.

Table 93 presents a summary of the parameters used to configure the UL PHY structure.

Table 93—UL PHY Structure - Summary of parameters

	Operation Procedure	Related Signaling Field (BW20/10/5MHz)	Channel for Signaling	Parameters Calculated from Signaled Fields	Definition	Units
Sector Common	Sub-band Partitioning	USAC (5/4/3) bits	SFH - SP2	K_{SB}	Number of Subbands	Subbands
	Mini-band Partitioning			$L_{SB} = N_1 * K_{SB}$	Number of PRUs assigned to Subbands	PRUs
				L_{MB}	Number of PRUs assigned to minibands	PRUs
	Frequency Partitioning	UFPC (4/3/3 bit)		FPCT	Number of Frequency Partitions	Frequency Partitions
				FPS_i	Number of PRUs in FP_i	PRUs
		UFPSC (3/2/1 bit)		K_{SB, FP_i}	Number of SBs assigned to FP_i	Subbands
				K_{MB, FP_i}	Number of MiniBands assigned to FP_i	Subbands (Groups of N_1 PRUs)
				$L_{SB, FP_i} = N_1 * K_{SB, FP_i}$	Number of MiniBands assigned to FP_i	PRUs
				$L_{MB, FP_i} = N_2 * K_{MB, FP_i}$	Number of PRUs assigned to be Subbands in FP_i	PRUs
Sector Specific	CRU/DRU Allocation	$UCAS_{SB,0}$ (5/4/3 bit) $UCAS_{MB,0}$ (5/4/3 bit) $UCAS_i$ (3/2/1) bit	SFH - SP1	L_{SB-CRU, FP_i}	Number of Subband-based CRUs in FP_i	CRUs
				L_{MB-CRU, FP_i}	Number of Miniband-based CRUs in FP_i	CRUs
				$L_{CRU_FP_i} = L_{SB-CRU, FP_i} + L_{MB-CRU, FP_i}$	Number of CRUs in FP_i	CRUs
				$L_{DRU_FP_i} = FPS_i - L_{CRU_FP_i}$	Number of DRUs in FP_i	DRUs
	Tile Permutation	IDCell (10bit)	Obtained from SA-Preamble			

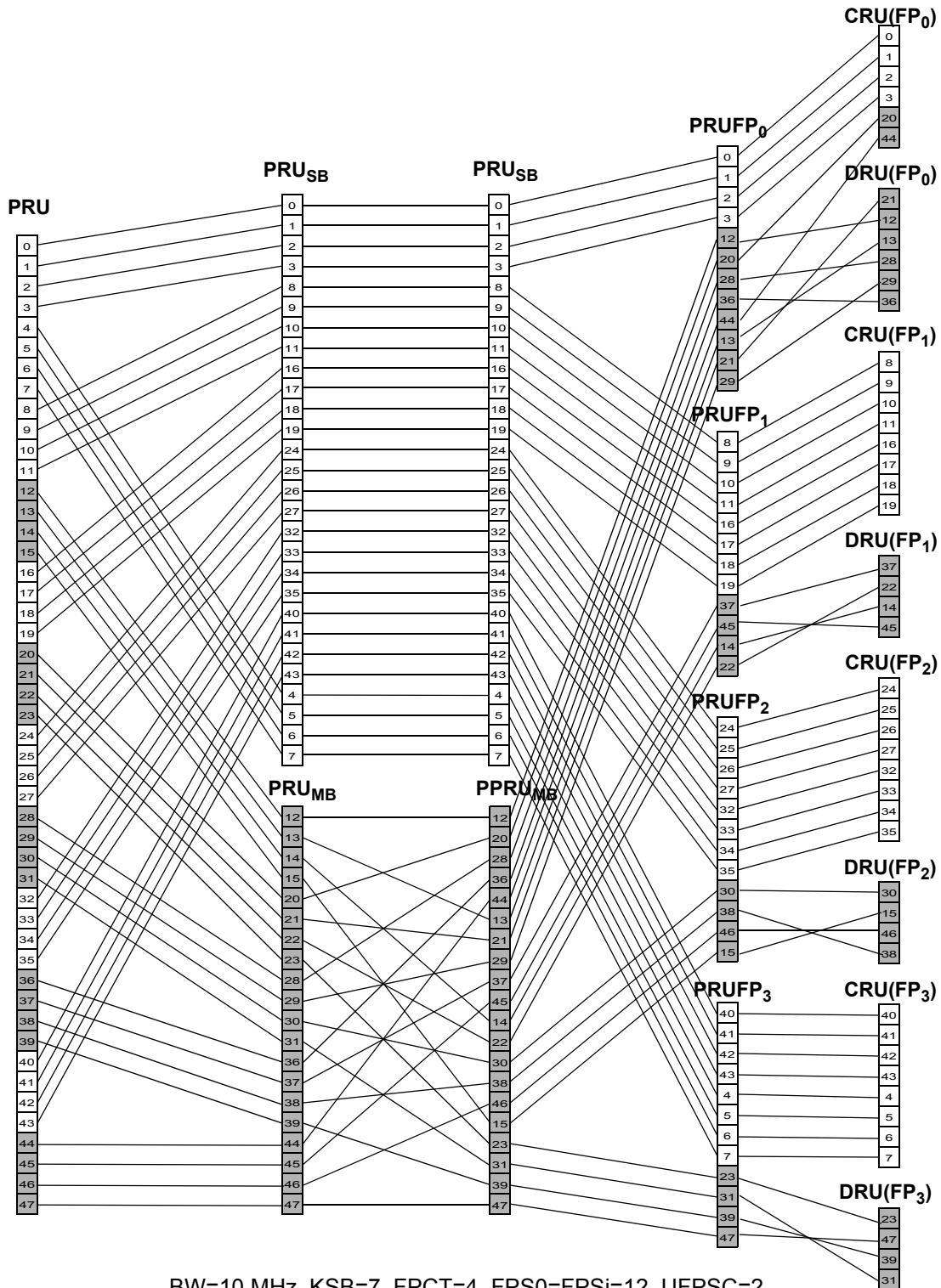


Figure 39—Frequency partition for BW=10 MHz.

3.3.4.3.2 Tile permutation

Each of the DRUs of an UL frequency partition is divided into 3 tiles of 6 adjacent subcarriers over N_{sym} symbols. The tiles within a frequency partition are collectively tile-permuted to obtain frequency-diversity across the allocated resources.

The tile permutation that allocates physical tiles of DRUs to logical tiles of subchannels is performed in the following manner:

$$Tile(s, n, t) = L_{DRU, FPI} \cdot n + g(PermSeq(), s, n, t) \quad (73)$$

where:

$Tiles(s, n, t)$ is the tile index of the n^{th} tile in the s^{th} distributed LRU of the t^{th} subframe.

n is the tile index, 0 to 2, in a distributed LRU.

t is the subframe index with respect to the frame.

s is the distributed LRU index, 0 to $L_{DRU, FPI}-1$.

$PermSeq()$ is the permutation sequence of length $L_{DRU, FPI}$ and is determined by $SEED = \{ID_{cell} * 343\} \bmod 2^{10}$. The permutation sequence is generated by the random sequence generation algorithm specified in Section <<15.3.5.3.4>>, and

$$g(PermSeq(), s, n, t) = \{PermSeq[(n + 107 * s + 1213 * t) \bmod L_{DRU, FPI}] + UL_PermBase\} \bmod L_{DRU, FPI}$$

3.3.4.3.3 Resource allocation and tile permutation for control channels

The distributed LRUs in each of uplink frequency partition may be further divided into data, bandwidth request, and feedback channels. The feedback channels can be used for both HARQ ACK/NAK and fast feedback. The allocation order of data channels and UL control channels are TBD.

3.3.4.3.3.1 Bandwidth request channels

The number of bandwidth request channels in frequency partition FP_i , $L_{BWR, FPI}$, is indicated by the (TBD)-bit field UL_BWREQ_SIZE in the S-SFH (TBD) in the unit of LRUs.

$$L_{BWR, FPI} = N_{bwr} \cdot UL_BWREQ_SIZE \quad (74)$$

Where N_{bwr} is 1 in MZone and 2 in LZone with PUSC.

Bandwidth request channels are not necessarily present in all subframes and the allocation can differ from subframe to next.

In MZone, the bandwidth request channels are of same size as LRUs, i.e. three 6-by-6 tiles. In LZone with PUSC, the bandwidth request channels consist of three 4-by-6 tiles. The bandwidth request channels use LRUs constructed from the tile permutation specified in 3.3.4.3.2.

3.3.4.3.3.2 Feedback Channels

Let $UL_FEEDBACK_SIZE$ distributed LRUs in frequency partition FP_i be reserved for feedback channels in the units of LRU. The number of feedback channels in frequency partition FP_i , is $L_{FB, FPI}$.

$$L_{FB, FPI} = N_{fb} \cdot UL_FEEDBACK_SIZE \quad (75)$$

where N_{fb} is 3 in MZone and 4 in LZone with PUSC.

The feedback channels are formed by 3 permuted 2-by-6 mini-tiles. The mini-tile reordering process applied to each distributed LRU is described below and illustrated in <<Figure UL- 1>>.

- 1) The uplink tiles in the distributed LRUs reserved for feedback channels are divided into 2-by-6 feedback mini-tiles (FMTs). The FMTs so obtained are numbered from 0 to $3 \cdot L_{FB,FPi} - 1$.
- 2) A mini-tile reordering is applied to the available 2-by-6 FMTs as specified by Equation (76) and Equation (77) to obtain the reordered FMTs (RFMTs).
- 3) Each group of three consecutive RFMTs forms a feedback channel.

The closed form expressions for the FMT reordering function used in step 2 above are as Equation (76) in MZone and Equation (77) in the LZone with PUSC:

$$MiniTile(s, n) = 9 \cdot floor\left(\frac{s}{3}\right) + mod(s, 3) + 3 \cdot n \quad (76)$$

$$MiniTile(s, n) = 6 \cdot floor\left(\frac{s}{2}\right) + mod(s, 2) + 2 \cdot n \quad (77)$$

Where

$MiniTile(s, n)$ is the n^{th} mini-tile of the s^{th} feedback channel.

n is the mini-tile index in a feedback channel. n can take a value of 0, 1 or 2.

s is the feedback channel index. s can take an integer value in the range 0 to $L_{FB,FPi} - 1$.

HARQ feedback channels

Each feedback channel constructed according to 3.3.4.3.3.2 can be used to transmit six HARQ feedback channels. The number of HARQ feedback channels is denoted by $L_{HFB,FPi}$.

A pair of HARQ feedback channels is formed by three reordered 2-by-2 HARQ mini-tiles (RHMT). The HMTs reordering process and the construction of HARQ feedback channel are described below and illustrated in Figure 74.

- 1) Each 2x6 RFMT is divided into three consecutively indexed 2-by-2 HMTs. The HMTs so obtained are numbered from 0 to $3 \cdot L_{HFB,FPi} - 1$.
- 2) A HMT reordering is applied to the HMTs as specified by Equation (78) to obtain the reordered HMTs (RHMTs).
- 3) Each group of three consecutive RHMTs forms a pair of HARQ feedback channels.

The closed form expression for the HMT reordering function used in step 2 above is as Equation (78).

$$HMT(k, m) = 9 \cdot floor\left(\frac{k}{3}\right) + mod(k + m, 3) + 3 \cdot m \quad (78)$$

where

$HMT(k, m)$ is the m -th HMT of the k -th HARQ feedback channel.

m is the HMT index in a HARQ feedback channel. m can take a value 0, 1 or 2.

k is the HARQ feedback channel index. k can take an integer value in the range 0 to $L_{HFB,FPi} - 1$.

$k' = \lfloor k/2 \rfloor$

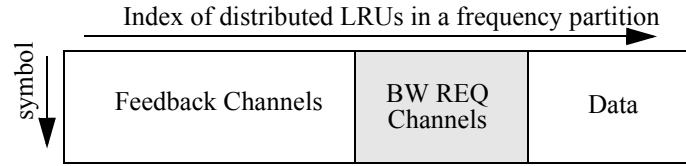
For persistent allocation, index k is specified in HFA of DL Individual Persistent A-MAP IE or DL Composite Persistent A-MAP IE.

For group resource allocation, index k for the l^{th} AMS in GRA allocation is $(i_{\text{start}} + \lfloor l \cdot L_{\text{HFB}} / N_{\text{GRA}} \rfloor) \bmod N_{\text{HFB}}$, where i_{start} is the ACK Channel Offset in DL group resource allocation A-MAP IE, L_{HFB} is the total number of HFBCCH configured, and N_{GRA} is the Use Bit Map Size in DL group resource allocation A-MAP IE.

For resource allocation using DL basic assignment A-MAP, index k is $(M(j) + n) \bmod L_{\text{HFB}}$, where j is HFBCCH Index Parameter in Non-user specific A-MAP IE, n is HFA in DL basic assignment A-MAP IE, $M(j)$ is STID when $j = 0$ and $M(j)$ is lowest LRU index of corresponding DL transmission when $j = 1$.

Fast Feedback Channels

A fast feedback channel consists of one feedback channel.



Allocation of UL control and data channels in the distributed LRUs of a frequency partition of an UL subframe.

Figure 40—Allocation of channels in the UL frequency partition

3.3.4.3.4 Logical Resource Unit Mapping

Both contiguous and distributed LRUs are supported in the uplink. The CRUs are directly mapped into contiguous LRUs. Precoding and/or boosting applied to the data subcarriers will also be applied to the pilot subcarriers. The DRUs are permuted as described in 3.3.4.3.2 to form distributed LRUs.

3.3.4.3.5 WirelessMAN-OFDMA Systems Support

When frame structure is supporting the WirelessMAN-OFDMA MSs in PUSC zone by FDM manner as defined in 3.3.3.4, a new symbol structure and subchannelization defined in the subclause are used.

3.3.4.3.5.1 Basic Symbol Structure for FDM based UL PUSC Zone Support

The subcarriers of an OFDMA are partitioned into $N_{g,\text{left}}$ left guard subcarriers, $N_{g,\text{right}}$ right guard subcarriers, and N_{used} used subcarriers. The DC subcarrier is not loaded. The N_{used} subcarriers are divided into multiple PUSC tiles. Basic symbol structures for various bandwidths are shown in Table 94, Table 95, and Table 96.

Table 94—512 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 256 (counting from 0)
$N_{g,\text{left}}$	52	Number of left guard subcarriers
$N_{g,\text{right}}$	51	Number of right guard subcarriers

Table 94—512 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
N_{used}	409	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

Table 95—1024 FFT OFDMA UL subcarrier allocations for DRU

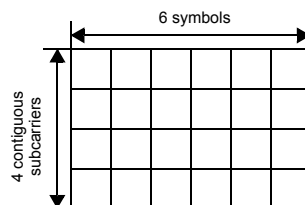
Parameters	Value	Comments
Number of DC subcarriers	1	Index 512 (counting from 0)
$N_{g,\text{left}}$	92	Number of left guard subcarriers
$N_{g,\text{right}}$	91	Number of right guard subcarriers
N_{used}	841	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

Table 96—2048 FFT OFDMA UL subcarrier allocations for DRU

Parameters	Value	Comments
Number of DC subcarriers	1	Index 1024 (counting from 0)
$N_{g,\text{left}}$	184	Number of left guard subcarriers
$N_{g,\text{right}}$	183	Number of right guard subcarriers
N_{used}	1681	Number of all subcarriers used in WirelessMAN-OFDMA PUSC zone within a symbol, including DC carrier

3.3.4.3.5.2 Resource Block for FDM based UL PUSC Zone Support

When supporting FDM based UL PUSC zone, a tile consists of 4 consecutive subcarriers and 6 OFDMA symbols, as shown in Figure 41.

**Figure 41—Resource block for FDM based UL PUSC zone support**

3.3.4.3.5.3 Subchannelization for FDM based UL PUSC Zone Support

When supporting FDM based UL PUSC zone, UL subchannelization shall conform the following rules:

- 1) For the WirelessMAN-OFDMA system bandwidth, all usable subcarriers given in Table 94, Table 95, and Table 96 are divided into PUSC tiles.
- 2) UL PUSC subchannelization is performed as described in section <<8.4.6.2.2>>.
- 3) Available subchannels for Advanced Air Interface AMS shall be specified through subchannel bit-map broadcasted by [system descriptor, TBD].
- 4) All PUSC tiles of specified subchannels from step 3 are extended in time domain from 3 OFDM symbols to N_{sym} OFDM symbols, where N_{sym} is dependent of subframe type.
- 5) Based on specified subchannels of step 3 with symbol extension tiles of step 4, DRUs for Advanced Air Interface are made up.
- 6) Repeat step 4 and step 5 for remained OFDMA symbols of every uplink subframe.

Overall process of subcarrier to subchannel mapping is shown in Figure 42.

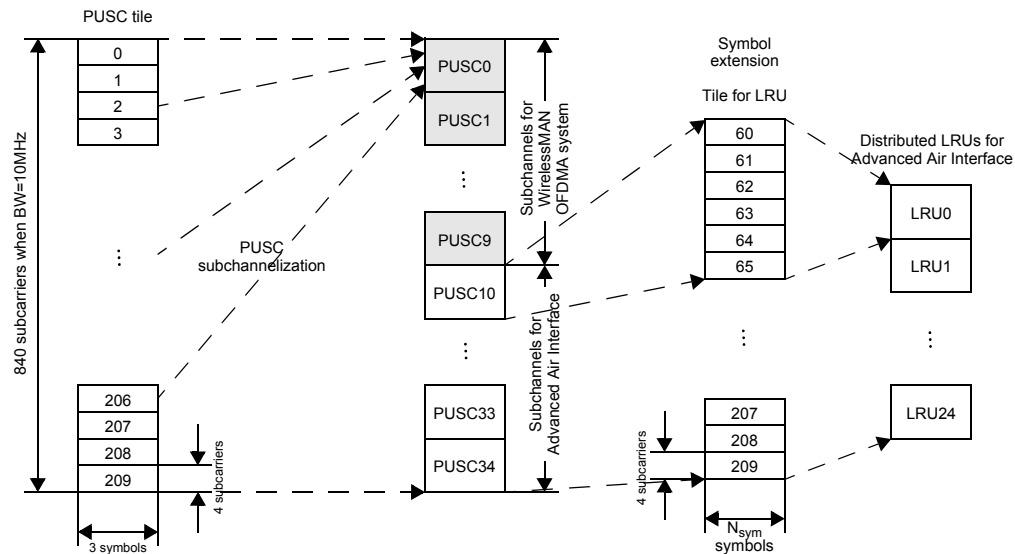


Figure 42—Example of subchannelization for FDM base UL PUSC zone support

3.3.4.4 Pilot structure

Uplink pilot is dedicated to each user and can be precoded or beamformed in the same way as the data subcarriers of the resource allocation. The pilot structure is defined for up to 4 transmission streams.

The pilot pattern may support variable pilot boosting. When pilots are boosted, each data subcarrier should have the same Tx power across all OFDM symbols in a resource block.

Figure 47 shows the pilot structure for contiguous LRUs where the number of streams is one, two, three or four. Note that the pilot patterns for UL contiguous LRUs are same as in the downlink case. Figure 43 and Figure 44 show the pilot structure for distributed LRUs where the number of streams is one or two, respectively. Figure 45 and Figure 46 contain the one and two-stream pilot patterns for the distributed PUSC LRU.

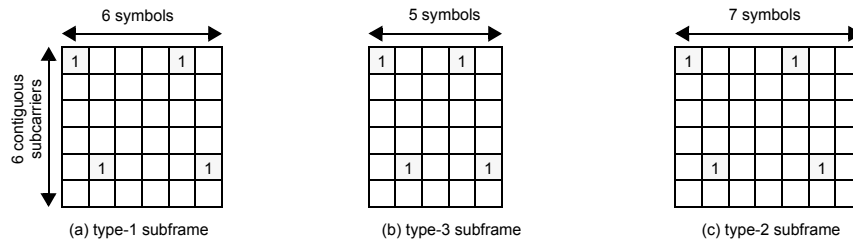


Figure 43—Pilot patterns of 1-Tx stream for distributed LRUs

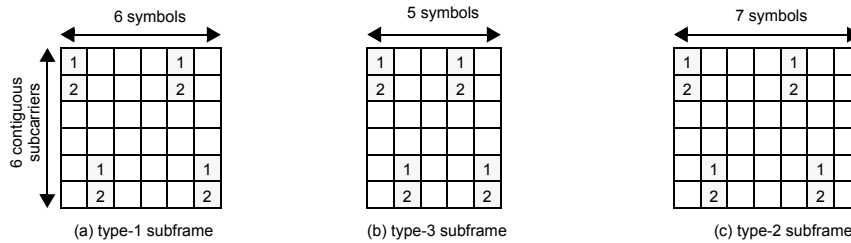


Figure 44—Pilot patterns of 2-Tx streams for distributed LRUs

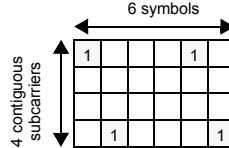


Figure 45—Pilot pattern of 1-Tx stream for distributed PUSC LRUs

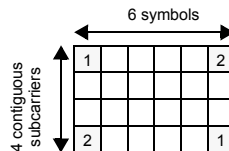


Figure 46—Pilot pattern of 2-Tx stream for distributed PUSC LRUs

1
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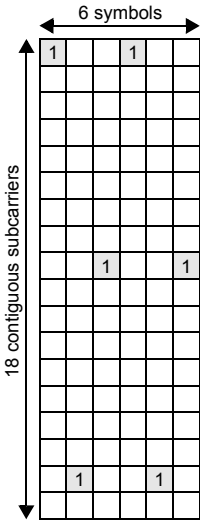


Figure 47—Pilot patterns for contiguous LRUs for 1 Tx stream

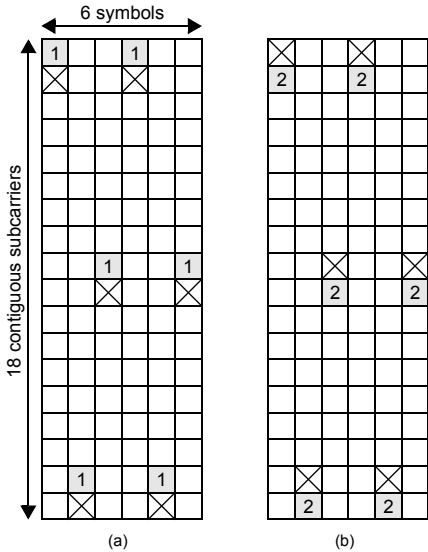


Figure 48—Pilot patterns for contiguous LRUs for 2 Tx streams

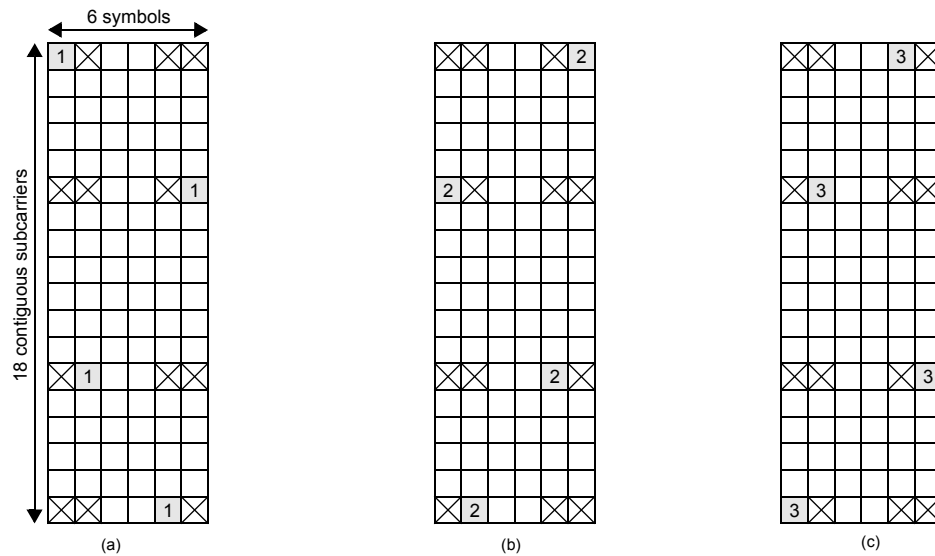


Figure 49—Pilot patterns for contiguous LRUs for 3 Tx streams

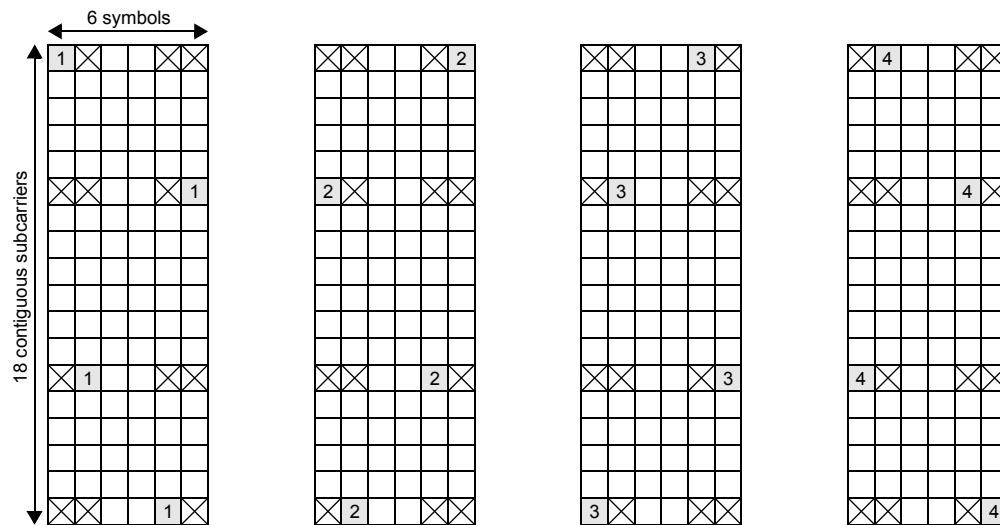


Figure 50—Pilot patterns for contiguous LRUs for 4 Tx streams

The pilot patterns of type-4 subframe are derived from the type-2 subframe patterns. The first seven symbols of type-4 subframe pilot patterns are identical to the type-2 subframe patterns. The last two symbols of type-4 subframe pilot patterns are generated by appending the first two symbols of type-2 subframe pilot patterns.

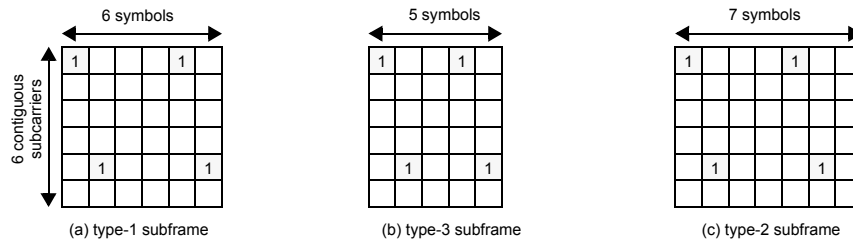


Figure 51—Pilot patterns of 1-Tx stream for distributed LRUs

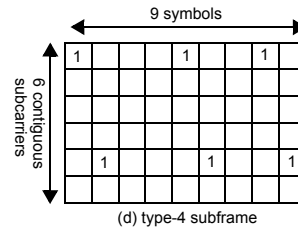


Figure 52—Pilot patterns of 1-Tx stream for type-4 subframe distributed LRUs

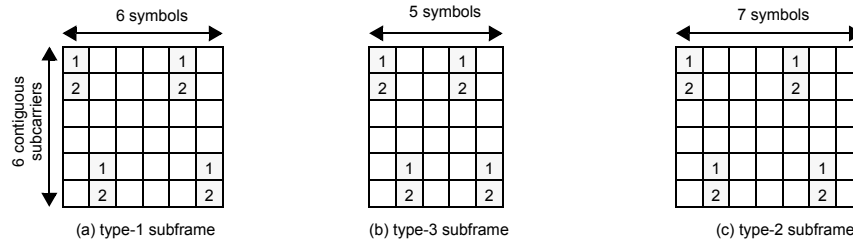


Figure 53—Pilot patterns of 2-Tx streams for distributed LRUs

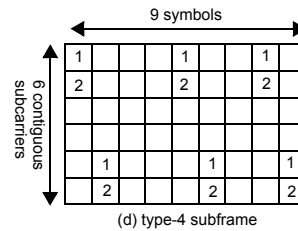


Figure 54—Pilot patterns of 2-Tx stream for type-4 subframe distributed LRUs

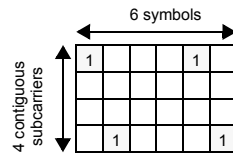


Figure 55—Pilot pattern of 1-Tx stream for distributed PUSC LRUs

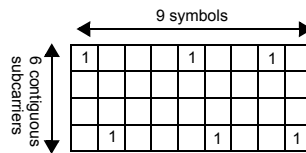


Figure 56—Pilot patterns of 1-Tx stream for type-4 subframe distributed PUSC LRUs

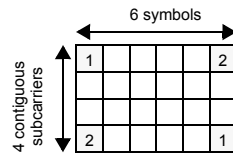


Figure 57—Pilot pattern of 2-Tx stream for distributed PUSC LRUs

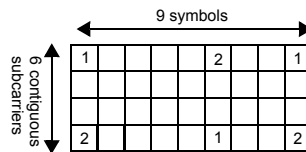


Figure 58—Pilot patterns of 2-Tx stream for type-4 subframe distributed PUSC LRUs

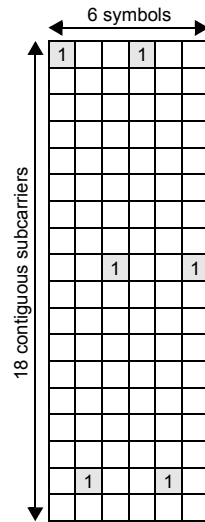


Figure 59—Pilot patterns for contiguous LRUs for 1 Tx stream

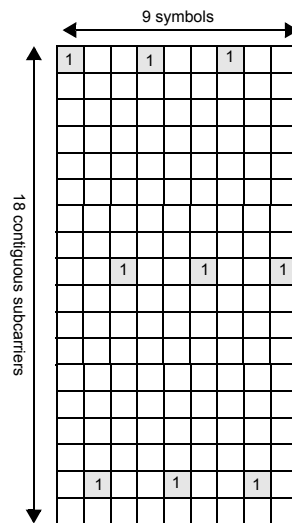


Figure 60—Pilot patterns of 1-Tx stream for type-4 subframe contiguous LRUs

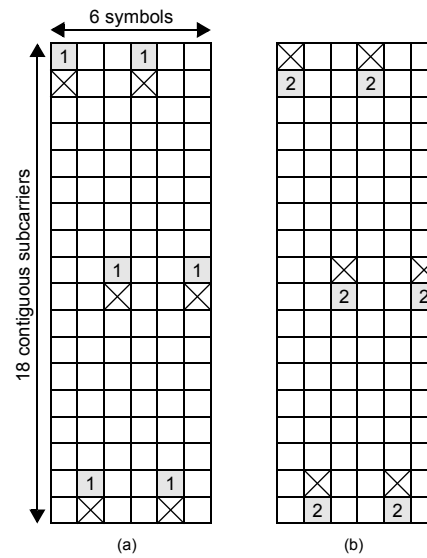


Figure 61—Pilot patterns for contiguous LRUs for 2 Tx streams

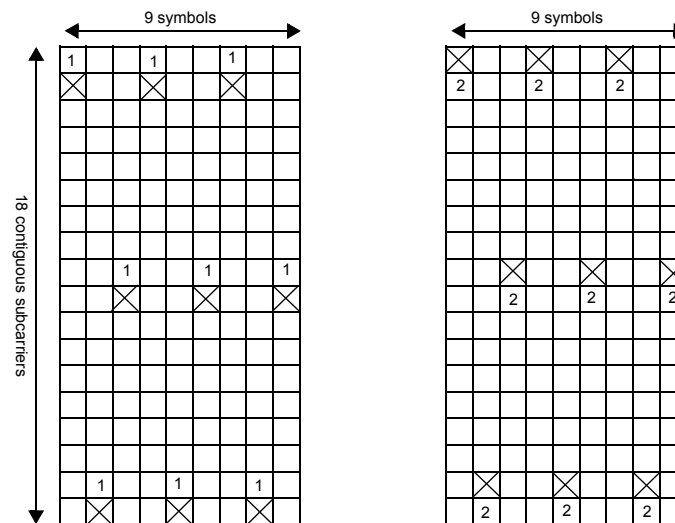


Figure 62—Pilot patterns of 2-Tx stream for type-4 subframe contiguous LRUs

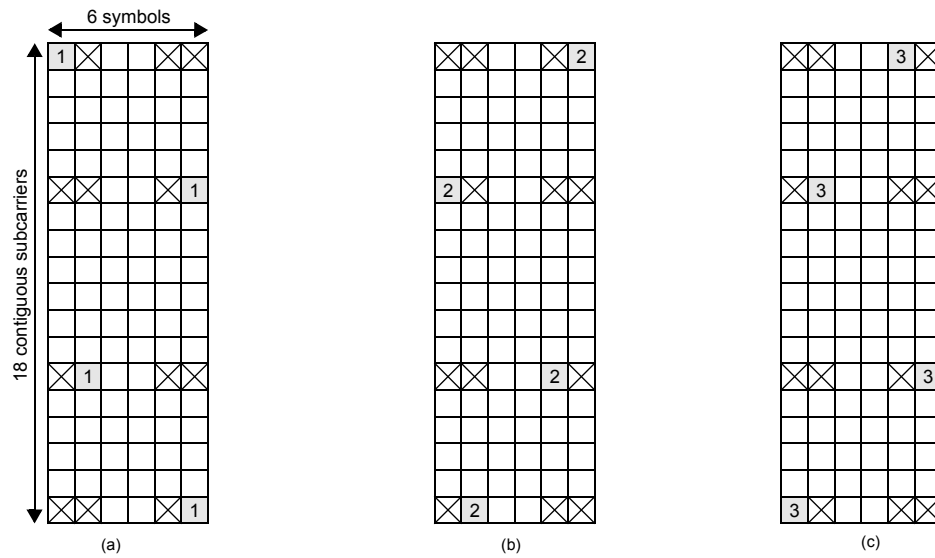


Figure 63—Pilot patterns for contiguous LRUs for 3 Tx streams

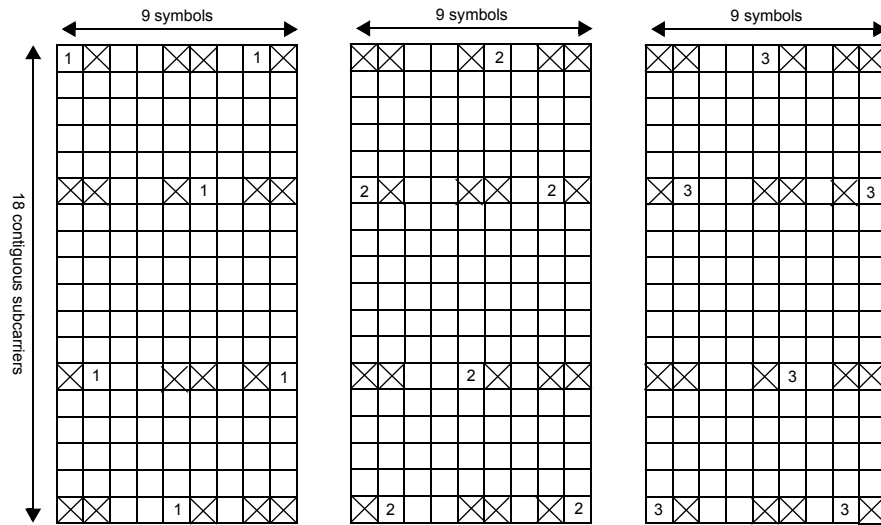


Figure 64—Pilot patterns of 2-Tx stream for type-4 subframe contiguous LRUs

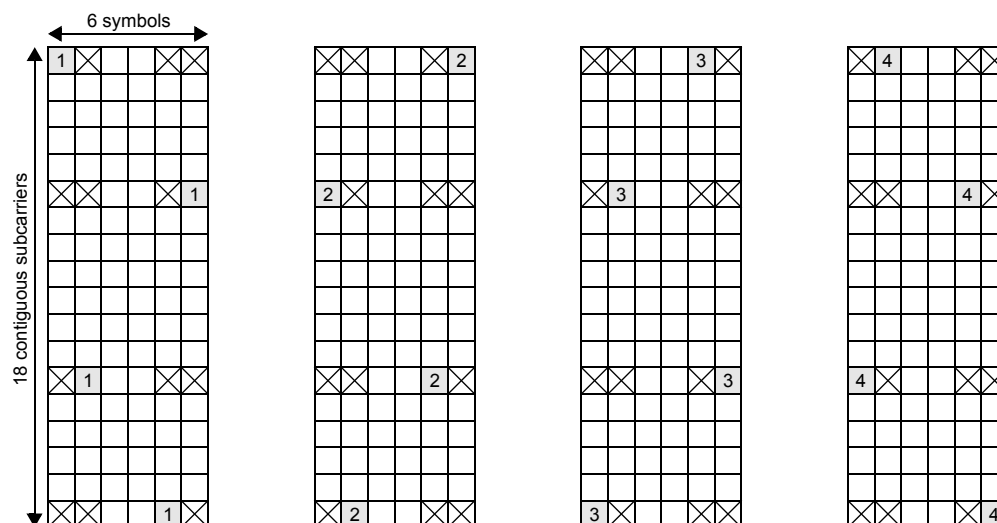


Figure 65—Pilot patterns for contiguous LRUs for 4 Tx streams

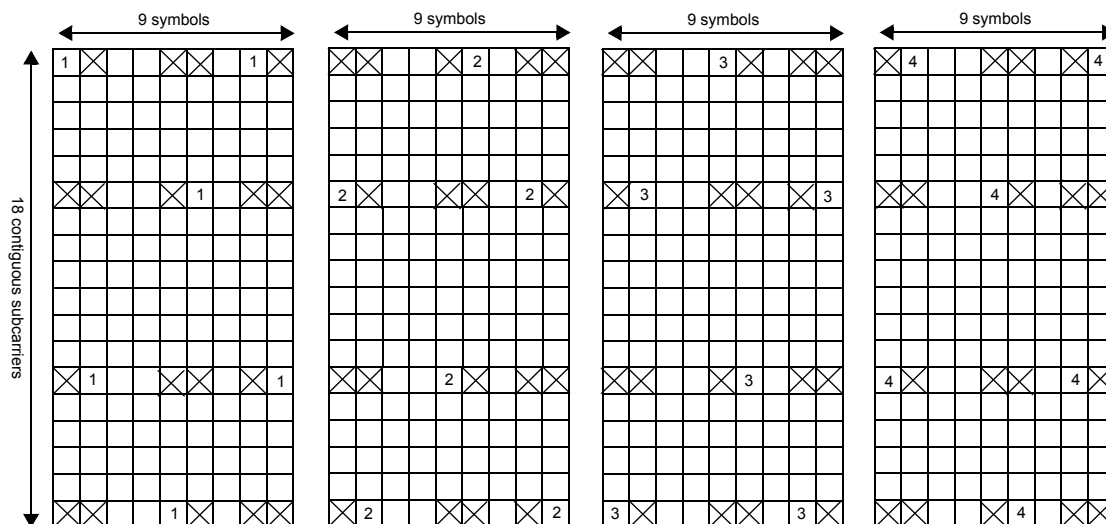


Figure 66—Pilot patterns of 4-Tx stream for type-4 subframe contiguous LRUs

3.3.4.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 15.3.8.1 and 15.3.8.4. The guard PRUs are used as miniband CRUs at partition FP0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth.

3.3.5 Uplink control channel

3.3.5.1 Physical uplink control channel

3.3.5.1.1 Fast feedback control channel

The DRUs are permuted by UL tile permutation as described in 3.3.4.3.2 to form distributed LRUs for both data and control resource/channel. A UL feedback mini-tile (FMT) is defined as 2 contiguous subcarriers by 6 OFDM symbols. The UL feedback control channels are formed by applying the UL mini-tile permutation to the LRUs allocated to the control resource. The fast feedback channels are comprised of 3 RFMTs. The details of feedback mini-tile permutation and the subchannelization of Fast feedback are described in 3.3.4.3.3.2.

3.3.5.1.1.1 Primary fast feedback channel

The primary fast feedback channel is comprised of 3 RFMTs. The construction process of primary fast feedback channels is described in 3.3.4.3.3.2.

3.3.5.1.1.2 Secondary fast feedback channel

The secondary fast feedback channel has the same physical control channel structure as the primary fast feedback channel. The secondary fast feedback channels are comprised of 3 RFMTs. The construction process of secondary fast feedback is described in 3.3.4.3.3.

3.3.5.1.2 HARQ feedback control channel

Each UL HARQ feedback resource consists of three RFMTs. A total resource of three distributed 2x6 RFMTs supports 6 UL HARQ feedback channels. The 2x6 RFMTs are further divided into UL HARQ mini-tiles (HMT). A UL HARQ mini-tile has a structure of 2 subcarriers by 2 OFDM symbols.

3.3.5.1.3 Sounding channel

Uplink channel sounding provides the means for the ABS to determine UL channel response for the purpose of UL closed-loop MIMO transmission and UL scheduling. In TDD systems, the ABS can also use the estimated UL channel response to perform DL closed-loop transmission to improve system throughput, coverage and link reliability. In this case ABS can translate the measured UL channel response to an estimated DL channel response when the transmitter and receiver hardware of ABS and AMS are appropriately calibrated.

3.3.5.1.3.1 Sounding PHY structure

The sounding signal occupies a single OFDMA symbol in the UL sub-frame. The sounding symbol in the UL sub-frame is located in the first symbol. Each UL sub-frame can contain only one sounding symbol. For type-1 subframe, the sounding signal shall not be transmitted in the LRU which contains other control channels. For type-2 subframe, sounding signals can be transmitted in any resource unit. For the six-symbol PRU case, the remaining 5 consecutive symbols are formed to be a five-symbol PRU used for data transmission, as shown in Figure 67. For the seven-symbol PRU case, the remaining 6 consecutive symbols are formed to be a six-symbol PRU for data transmission, as shown in Figure 67. Multiple UL subframes in a 5-ms radio frame can be used for sounding. The number of subcarriers for the sounding in a PRU is 18 adjacent subcarriers.

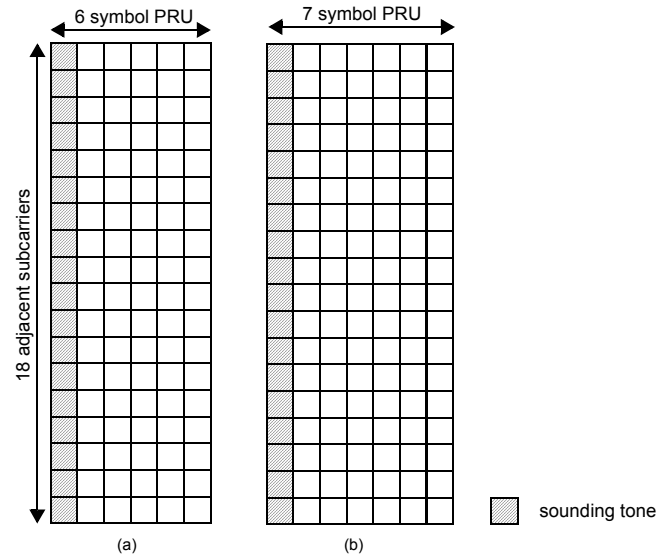


Figure 67—Sounding PHY structures for (a) 6-symbol PRU and (b) 7-symbol PRU cases.

3.3.5.1.4 Ranging channel

The UL ranging channel is used for UL synchronization. The UL ranging channel can be further classified into ranging channel for non-synchronized and synchronized AMSs. The ranging channel for synchronized AMSs is used for periodic ranging. The ranging channel for non-synchronized AMSs is used for initial access and handover.

3.3.5.1.4.1 Ranging channel structure for non-synchronized AMSs

The ranging channel for non-synchronized AMSs is used for initial network entry and association and for ranging against a target BS during handover.

A physical ranging channel for non-synchronized AMSs consists of the ranging preamble (RP) with length of T_{RP} depending on the ranging subcarrier spacing Δf_{RP} , and the ranging cyclic prefix (RCP) with length of T_{RCP} in the time domain.

A ranging channel occupies a localized bandwidth corresponding to 1 subband.

Power control operation described in 3.3.5.4.3 applies to ranging signal transmission.

Table 97 contains ranging channel formats and parameters.

Table 97—Ranging channel formats and parameters

Format No.	T_{RCP}	T_{RP}	Δf_{RP}
0	$k_1 \times T_g + k_2 \times T_b$	$2 \times T_b$	$\Delta f/2$
1	$3.5 \times T_g + 7 \times T_b$	$8 \times T_b$	$\Delta f/8$

where T_b , T_g and Δf are defined in 3.3.1.1.

(a). The T_{RCP} for Formats 0 depends on OFDMA parameters, and subframe types as:

$$k_1 = (N_{sym} + 1)/2 \text{ and } k_2 = (N_{sym} - 4)/2.$$

where N_{sym} is the number of OFDMA symbols in a subframe as defined in 3.3.4.1.

Ranging channel for non-synchronized AMSs is allocated in one or three UL subframes for Format 0 or Format 1, respectively. Format 0 has a repeated structure as shown in Figure 68. The transmission start time of the ranging channel is aligned with the UL subframe start time at the AMS. The remaining time duration of the subframes is reserved to prevent interference between the adjacent subframes.

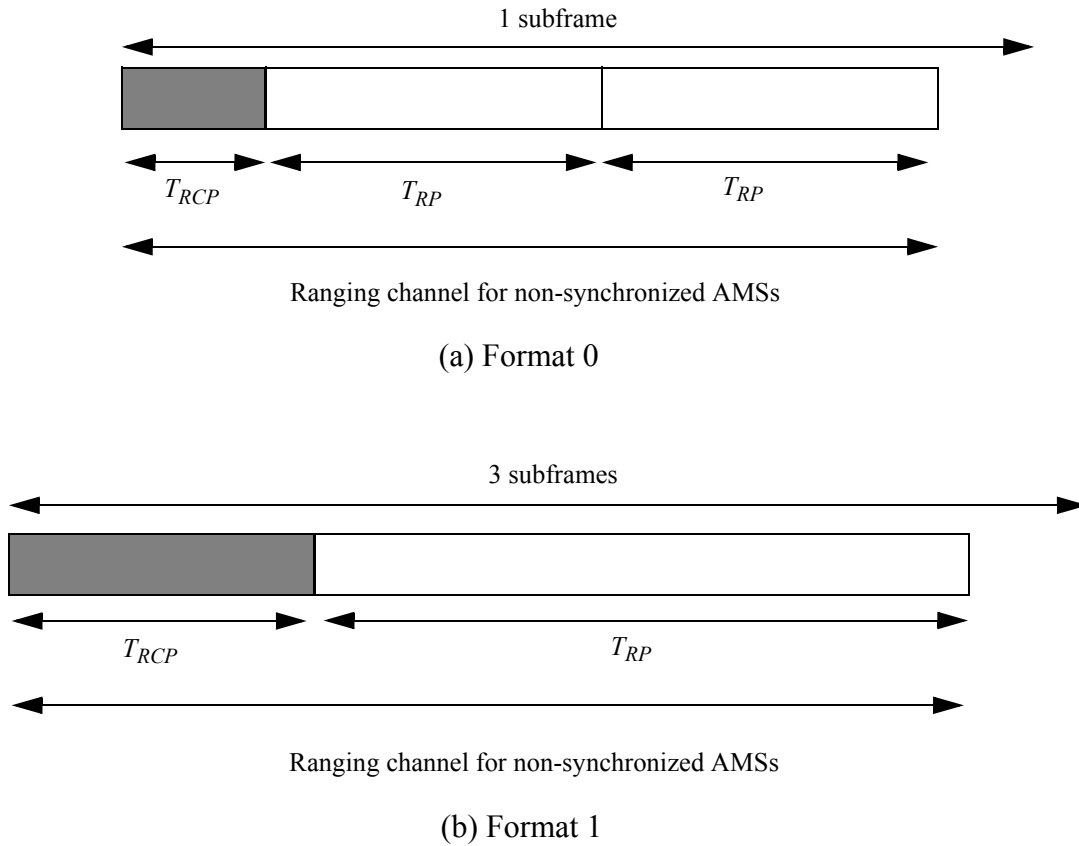


Figure 68—Ranging channel allocations in subframe(s)

3.3.5.1.4.2 Ranging channel structure for synchronized AMSs

The ranging channel for synchronized AMSs is used for periodic ranging. The AMSs that are already synchronized to the target ABS are allowed to transmit the periodic ranging signal. For femtocell, the ranging channel for synchronized AMSs can be used for initial ranging, handover ranging, and periodic ranging.

The physical structure in the ranging channel for synchronized AMSs occupies 72 subcarriers by K OFDMA symbol time. For femtocell, K is equal to 1 and the rest of subcarriers can be used for data transmission.

Power control operation described in 3.3.5.4.3 applies to ranging signal transmission.

3.3.5.1.4.3 Ranging Channel for FDM-based UL PUSC Zone Support

The ranging channel for FDM-based UL PUSC Zone Support is composed of 6 distributed LRUs by using the symbol structure defined in 3.3.4.3.5.1.

A ranging transmission for non-synchronized AMSs shall be performed during two consecutive symbols same as <<Figure 253>> in <<8.4.7.1>>. The same ranging code is transmitted on the ranging channel during each symbol, with no phase discontinuity between the two symbols. A time-domain illustration of the ranging transmission for non-synchronized AMSs is shown in Figure 69 (a).

A ranging transmission for synchronized AMSs shall be performed during a symbol same as <<Figure 255>> in <<8.4.7.2>>. A time-domain illustration of the ranging transmission for synchronized AMSs is shown in Figure 69 (b).

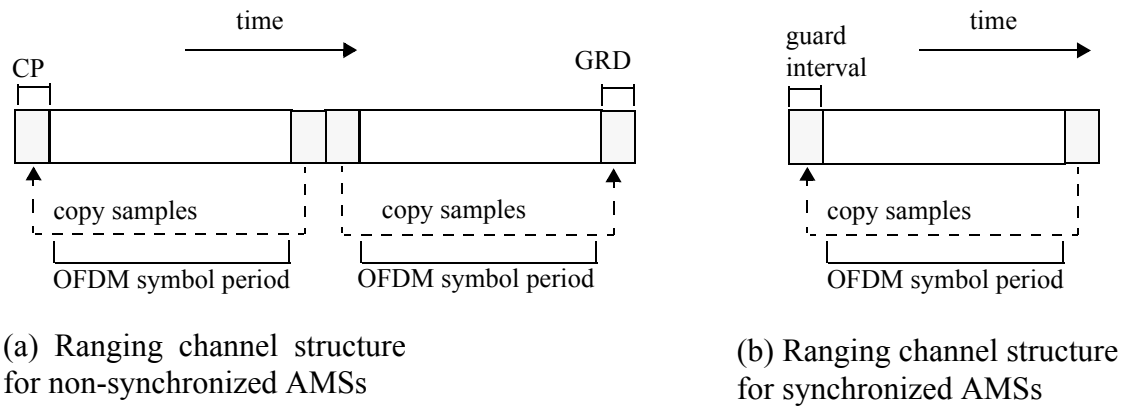


Figure 69—Ranging channel structure for FDM-based UL PUSC Zone Support

For ranging channel for non-synchronized AMSs, the transmitted signal is according to <<15.3.2.5>>, <<Equation (173)>>, except that $0 \leq t \leq 2T_s$.

Ranging channels for non-synchronized AMSs and ranging channel for synchronized AMSs are allocated in a UL subframe. Within the allocated ranging subframe, first 4 symbols in a UL subframe are occupied for the ranging structure for non-synchronized AMSs. The last symbol in the same UL subframe is occupied for the ranging channel for synchronized AMSs. A time-domain illustration of the ranging subframe is shown in Figure 70.

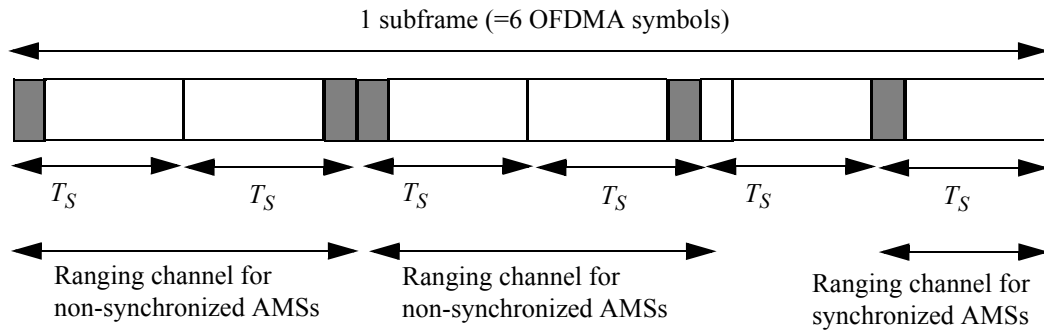


Figure 70—Ranging channel structures and allocations for FDM based UL PUSC Zone Support

3.3.5.1.5 Bandwidth request channel

Bandwidth request information is transmitted using contention based random access on this control channel. The bandwidth request (BR) channel contains resources for the AMS to send a BR preamble and an optional quick access message.

In the LZone with PUSC, a BW REQ tile is defined as four contiguous subcarriers by six OFDM symbols. The number of BW REQ tiles per BW REQ channel is three. Each BW REQ tile carries a BW REQ preamble only.

In the Mzone, a BW REQ tile is defined as six contiguous subcarriers by six OFDM symbols. Each BW REQ channel consists of three distributed BW-REQ tiles. Each BW REQ tile carries a BW REQ preamble and a quick access message. The AMS may transmit the access sequence only and leave the resources for the quick access message unused.

3.3.5.2 Uplink control channels physical resource mapping

3.3.5.2.1 Fast feedback control channel

There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH).

3.3.5.2.1.1 Primary fast feedback control channel

The primary fast feedback channels are comprised of three distributed FMTs. Figure 71 illustrates the mapping of the PFBCH.

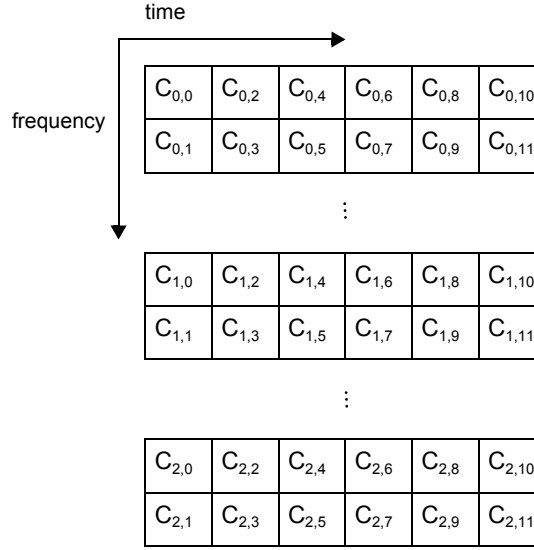


Figure 71—PF BCH comprised of three distributed 2x6 UL FMTs

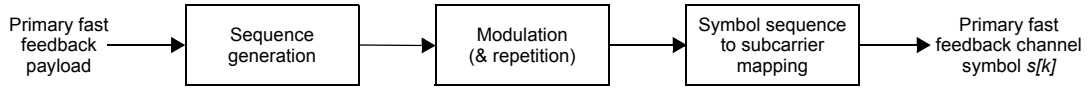


Figure 72—Mapping of information in the PF BCH

The process of composing the PF BCH is illustrated in Figure 72. The L PF BCH payload bits are used to generate PF BCH sequence according to Table 98. The resulting bit sequence is modulated, repeated and mapped to uplink PF BCH symbol $s[k]$ (0 mapped to +1 and 1 mapped to -1). The mapping of primary fast feedback channel symbol $s[k]$ to the UL FMTs is given by Equation (79). This set of sequences can carry up to six information bits.

$$C_{i,j} = s[K_i L[j]], \text{ for } i = 0, 1, 2, 0 \leq j \leq 11 \quad (79)$$

where

$K_i[j]$ denotes the j^{th} element of K_i

$$K_0 = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11\}$$

$$K_1 = \{9, 10, 11, 3, 4, 5, 0, 1, 2, 6, 7, 8\}$$

$$K_2 = \{3, 4, 5, 6, 7, 8, 9, 10, 11, 0, 1, 2\}$$

Table 98—Sequences for PFBCH

Index	Sequence	Index	Sequence
0	111111111111	32	101011001001
1	101111010110	33	111011100000
2	011010111101	34	001110001011
3	001010010100	35	011110100010
4	101010101010	36	100111111010
5	111010000011	37	110111010011
6	001111101000	38	000010111000
7	011111000001	39	010010010001
8	110011001100	40	111110011100
9	100011100101	41	101110110101
10	010110001110	42	011011011110
11	000110100111	43	001011110111
12	100110011001	44	101010011111
13	110110110000	45	111010110110
14	000011011011	46	001111011101
15	010011110010	47	011111110100
16	101011111100	48	111111001010
17	111011010101	49	101111100011
18	001110111110	50	011010001000
19	011110010111	51	001010100001
20	111110101001	52	110010101111
21	101110000000	53	100010000110
22	011011101011	54	010111101101
23	001011000010	55	000111000100
24	100111001111	56	100110101100
25	110111100110	57	110110000101
26	000010001101	58	000011101110
27	010010100100	59	010011000111
28	110010011010	60	110011111001
29	100010110011	61	100011010000

Table 98—Sequences for PFBCH

Index	Sequence	Index	Sequence
30	010111011000	62	010110111011
31	000111110001	63	000110010010

3.3.5.2.1.2 Secondary fast feedback control channel

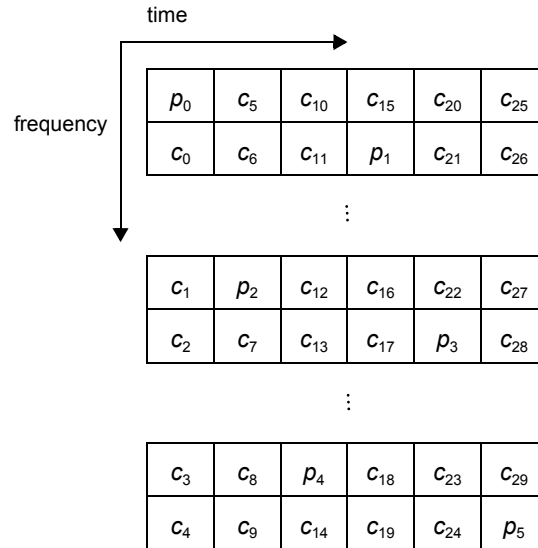
The SFBCCH is comprised of 3 distributed FMTs with 2 pilots allocated in each FMT. Pilot sequence $p_0 p_1 p_2 p_3 p_4 p_5$ are modulated as [1 1 1 1 1 1] with pilot boosting.

The SFBCCH symbol generation procedure is as follows. First, the SFBCCH payload information bits $a_0 a_1 a_2 \dots a_{l-1}$ are encoded to M bits $b_0 b_1 b_2 \dots b_{M-1}$ using the TBCC encoder described in <<15.3.12.2>>.

The values of parameters L and M are set to l and 60, respectively. The value of $K_{bufsize}$ should be set as Equation (80)

$$K_{bufsize} = \begin{cases} 30 & (l = 7, 8, 9) \\ 5l & (l = 10, 11) \\ 60 & (12 \leq l \leq 24) \end{cases} \quad (80)$$

The coded sequence $b_0 b_1 b_2 \dots b_{M-1}$ is then modulated to $M/2$ symbols $c_0 c_1 c_2 \dots c_{\frac{M}{2}-1}$ using QPSK. The modulated symbols are mapped to the data subcarriers of the SFBCCH FMTs as shown in Figure 73.

**Figure 73—SFBCCH comprising of three distributed 2x6 UL FMTs**

3.3.5.2.2 HARQ feedback control channel

The HARQ feedback control channel resource of three distributed FMTs shall be further divided into nine HARQ mini-tiles (HMTs), each having a structure of two subcarriers by two OFDM symbols. Each pair of HARQ feedback channels are allocated three HMTs, identified by similar patterns in the structure shown in Figure 74. The orthogonal sequence ($C_{i,0}, C_{i,1}, C_{i,2}, C_{i,3}$, where $i=0,1$ and 2) as shown in Table 99 is mapped to each HMT to form HARQ feedback channels, where i denotes HMT index. Each group of three RFMTs can therefore support six HARQ feedback channels.

When each channel carries one bit of HARQ feedback, two sequences are used to signal each ACK or NACK feedback. In one unit, four sequences are used for two HARQ channels, 1st and 2nd HARQ feedback channel. The sequence and mapping of the HARQ feedback are shown in Table 99.

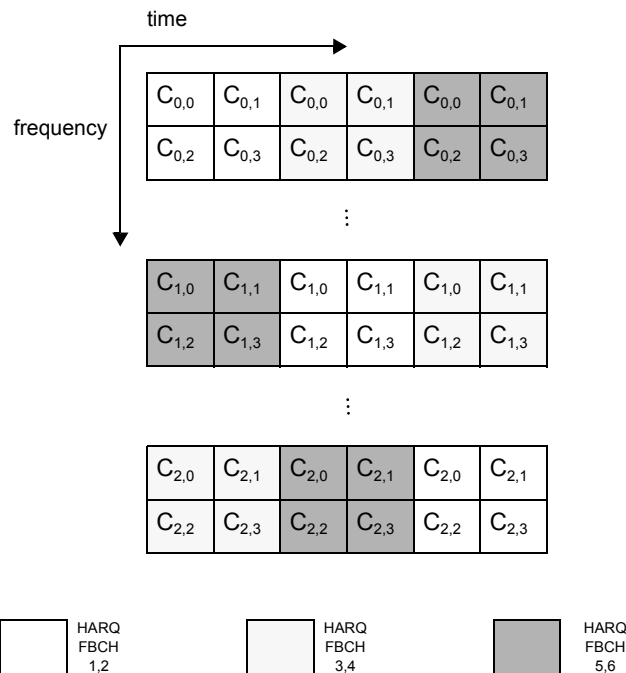


Figure 74—2x2 HMT structure

Table 99—Orthogonal sequences for UL HARQ feedback channel

Sequence index	Orthogonal sequence	1-bit Feedback
0	[+1 +1 +1 +1]	Even numbered channel ACK
1	[+1 -1 +1 -1]	Even numbered channel NACK
2	[+1 +1 -1 -1]	Odd numbered channel ACK
3	[+1 -1 -1 +1]	Odd numbered channel NACK

3.3.5.2.3 Sounding channel

3.3.5.2.3.1 Sounding sequence

Define b_k as the complex coefficients modulating all subcarriers in the sounding symbol, $0 \leq k \leq N_{used} - 1$ (N_{used} is used a number of used subcarriers dependent on FFT size), such that the signal transmitted by the AMS is defined by Equation (81):

$$s(t) = \text{Re} \left\{ e^{j2\pi f_c t} \sum_{\substack{k=0 \\ k \neq \frac{N_{used}-1}{2}}}^{k=N_{used}-1} b_k \cdot e^{j2\pi \left(k - \frac{N_{used}-1}{2}\right) \Delta f (t - T_g)} \right\} \quad (81)$$

For decimation separation (multiplexing type 0), the occupied subcarriers are decimated (where D is a sub-carrier decimation value transmitted in the SFH) starting with offset g relative to the first used subcarrier ($k = 0$). The occupied subcarriers for each transmit device (AMS or AMS antenna) shall be modulated by BPSK symbols extracted from the Golay sequence according to Equation (82):

$$= \begin{cases} 2 \cdot \sqrt{D} \cdot \left(\frac{1}{2} - G([k + u + \text{offset}_D(\text{fft})] \bmod 2048) \right), & k \in B, k \neq \frac{N_{used}-1}{2}, k \bmod D = \\ 0, & \text{otherwise} \end{cases} \quad (82)$$

where k is the subcarrier index ($0 \leq k \leq N_{used} - 1$), N_{used} is the number of used subcarriers in the sounding symbol, $G(x)$ is the Golay sequence defined in Table 100 $0 \leq x \leq 2047$. fft is the FFT size used, u is a shift value, where the actual value of u is derived from $u = \text{mod}(\text{ID}_{\text{cell}}, 256)$, $\text{offset}_D(\text{fft})$ is an FFT size specific offset as defined in Table 101, B is the group of all allocated subcarriers according to the sounding instructions, D is the decimation value, g is the actual decimation offset.

For cyclic shift separation (multiplexing type 1), the sequence used by a Tx device (AMS or AMS antenna) associated with the n -th cyclic shift index is determined according to Equation (83):

$$b_k = \begin{cases} 2 \cdot \left(\frac{1}{2} - G([k + u + \text{offset}_D(\text{fft})] \bmod 2048) \right) \cdot e^{-j2\pi \frac{k}{P} n}, & k \in B, k \neq \frac{N_{used}-1}{2} \\ 0, & \text{otherwise} \end{cases} \quad (83)$$

where k is the subcarrier index $0 \leq k \leq N_{used} - 1$, N_{used} is the number of used subcarriers in the sounding symbol, $G(x)$ is the Golay sequence defined in Table 100 ($0 \leq x \leq 2047$), P is the max cyclic shift index (transmitted in SFH), n is the cyclic time shift index, which ranges from 0 to $P-1$, B is the group of allocated subcarriers according to the sounding instructions, u is a shift value defined from $u = \text{mod}(\text{ID}_{\text{cell}}, 256)$, fft is the FFT size used, and $\text{offset}_D(\text{fft})$ is an FFT size specific offset as defined in Table 101.

Table 100—Golay sequence of length 2048 bits

0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
---------	---------	---------	---------	---------	---------	---------	---------

Table 100—Golay sequence of length 2048 bits

0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0x121D,	0x12E2,	0xEDE2,	0x12E2,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0xEDE2,	0xED1D,	0xEDE2,	0x12E2,	0xEDE2,	0xED1D,	0x121D,	0xED1D,
0x121D,	0x12E2,	0x121D,	0xED1D,	0xEDE2,	0xED1D,	0x121D,	0xED1D

Note: hexadecimal series should be read, left-to-right, as a sequence of bits where each 16 bit word is started at the MSB and ends at the LSB where the second word MSB follows. First bit of sequence is referenced as offset 0.

Table 101—Sounding sequence offset values

FFT Size	Offset
2048	30
1024	60
512	542

3.3.5.2.3.2 Multiplexing for multi-antenna and multi-AMS

The uplink sounding channels of multiple AMS and multiple antennas per AMS can be multiplexed through decimation separation or cyclic shift separation in each sounding allocation. Also, in case of multiple UL subframes for sounding, time division separation can be applied by assigning different AMS to different UL subframe. For cyclic shift separation each AMS occupies all subcarriers within sounding allocation and uses the different sounding waveform. For frequency decimation separation each AMS uses decimated subcarrier subset from the sounding allocation set with different frequency offset.

For antenna switching capable AMS and multi-antenna AMS, ABS can command the AMS to switch the physical transmit antenna(s) for sounding transmission. For sounding with antenna switching, the AMS shall transmit sounding symbol with the i -th antenna ($0, 1, \dots, N_t-1$) on frames $t = j \cdot 2^{(p-1)} + i$, where $t=0$ corresponds to the frame where UL sounding command A-MAP IE is received, p is periodicity in UL sounding

command A-MAP IE, and j is a running index ($j = 0, 1, 2, \dots$ for $p \neq 0$ and $j = 0$ for $p = 0$). For sounding with antenna switching and periodical sounding allocation ($p \neq 0$), the assigned periodicity $2^{(p-1)}$ shall be larger or equal to the number of AMS transmit antennas N_t .

3.3.5.2.4 Ranging channel

3.3.5.2.4.1 Ranging channel for non-synchronized AMSs

Ranging preamble codes

The ranging preamble codes are classified into initial ranging and handover ranging preamble codes. The initial ranging preamble codes shall be used for initial network entry and association. Handover ranging preamble codes shall be used for ranging against a target ABS during handover. For a ranging code opportunity, each AMS randomly chooses one of the ranging preamble codes from the available ranging preamble codes set in a cell, except that in the handover ranging case where a dedicated ranging code is assigned, the AMS shall use the assigned dedicated preamble code.

The Zadoff-Chu sequences with cyclic shifts are used for the ranging preamble codes. The p^{th} ranging preamble code $x_p(k)$ is defined by

$$x_p(k) = \exp\left(-j \cdot \pi \cdot \frac{r_p \cdot k(k+1) + 2 \cdot k \cdot s_p \cdot N_{CS}}{N_{RP}}\right), k = 0, 1, \dots, N_{RP} - 1 \quad (84)$$

where

p is the index for p^{th} ranging preamble code which is made as the s_p^{th} cyclic shifted sequence from the root index r_p of Zadoff-Chu sequence.

$$r_p = \text{mod}((1 - 2 \cdot \text{mod}(\lfloor p/M_{ns} \rfloor, 2)) \cdot (\lfloor p/M_{ns}/2 \rfloor + r_{ns0}) + N_{RP}, N_{RP}), p=0,1,\dots,N_{TOTAL}-1 \quad (85)$$

$$(86)$$

$$s_p = \text{mod}(p, M_{ns}), p=0,1,\dots,N_{TOTAL}-1$$

where r_{ns0} is broadcasted in the S-SFH and M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 102. N_{TOTAL} is the total number of initial ($0 \sim N_{IN}-1$) and handover preamble codes ($N_{IN} \sim N_{IN}+N_{HO}-1$) per sector.

N_{CS} is the unit of cyclic shift according to the cell size. It is defined by $N_{CS} = \lfloor N_{RP}/M_{ns} \rfloor$, where M_{ns} is the number of cyclic shifted codes per ZC root index according to Table 102.

N_{RP} is the length of ranging preamble codes defined as $N_{RP}=139$ for ranging channel Format 0 in Table 97 and $N_{RP}=557$ for ranging channel Format 1 in Table 97.

The number of cyclic shifted codes per root index (M), the start root index of ZC code (r_{ns0}), and the ranging preamble code partition information are broadcasted by S-SFH. The number of cyclic shifted codes per root

index is defined in Table 102. The start root index of ZC code is defined by $r_{ns0} = 4 \cdot k + 1 = (1, 5, 9, \dots, 65)$. The ranging preamble code partition information indicate the number of initial and handover ranging preamble codes and is defined in Table 103.

Table 102—The number of cyclic shifted codes per ZC root index, M_{ns}

index	0	1	2	3
M_{ns}	1	2	4	8

Table 103—Ranging preamble code partition information table, N_{IN} and N_{HO}

Partition Index	0	1	2	3	4	5	6	7	8	9	0	11	12	13	14	15
Number of initial ranging preamble codes, N_{IN}	8	8	8	8	16	16	16	16	24	24	24	24	32	32	32	32
Number of handover ranging preamble codes, N_{HO}	8	16	24	32	8	16	24	32	8	16	24	32	8	16	24	32

Ranging channel configurations

The information for ranging time resource allocation is indicated by the S-SFH in a regular allocation. The information of ranging channel allocation consists of the ranging configuration with subframe-offset (O_{SF}) for ranging resource allocation in the time domain. The information for ranging frequency resource allocation, i.e., the subband index for ranging resource allocation is determined by the $IDCell$ and the allocated number of subbands K_{SB} according to the Equation (87), where $IDCell$ is defined in 3.3.2.1.2 and K_{SB} is defined in 3.3.4.2.1.

$$I_{SB} = \text{mod}(IDCell, K_{SB}) \quad (87)$$

where I_{SB} denotes the subband index ($0, \dots, K_{SB}-1$) for ranging resource allocation among K_{SB} subbands.

Table 104 shows the information of ranging channel allocation in a regular allocation, which is indicated by the S-SFH.

- (1) It indicates the subframe allocating ranging channel for Format 0 and 1. For Format 1, it indicates the starting subframe for allocating ranging channel subframe in contiguous 3 subframes.

The ranging channel for handover ranging can also be allocated by AMAP based on ABS scheduling decision in any subframe, except the subframe that has already been used for a regular allocation.

Table 104—Ranging channel allocations by S-SFH

Configurations	The subframe allocating Ranging channel ⁽¹⁾
0	O_{SF}^{th} UL subframe in every frame
1	O_{SF}^{th} UL subframes in the first frame in every superframe
2	O_{SF}^{th} UL subframe in the first frame in every even numbered superframe, i.e., $\text{mod}(\text{superframe number}, 2) = 0$
3	O_{SF}^{th} UL subframe of the first frame in every 4 superframes, i.e. $\text{mod}(\text{superframe number}, 4) = 0$

Ranging signal transmission

Equation (88) specifies the transmitted signal voltage to the antenna, as a function of time, during ranging channel format 0 or 1.

$$s(t) = \text{Re} \left\{ e^{j2\pi f_c t} \sum_{k=-(N_{RP}-1)/2}^{(N_{RP}-1)/2} x_p(k + (N_{RP}-1)/2) \cdot e^{j2\pi(k + K_{offset})\Delta f_{RP}(t - T_{RCP})} \right\} \quad (88)$$

where

t is the elapsed time since the beginning of the subject ranging channel.

N_{RP} is the length of ranging preamble code in frequency domain.

$x_p(n)$ is the p -th ranging preamble code with length N_{RP} .

K_{offset} is the parameter related to the frequency position and is defined by

$$K_{offset} = -\{(N_{used} - 1)/2 - P_{SC} \cdot (k_0 - 2) + \lfloor 2 \cdot k_0 / N_{PRU} \rfloor\} \cdot \Delta f / \Delta f_{RP}$$

N_{PRU} is the total number of PRUs as defined in <<3.3.4.2.1 Subband partitioning>>.

k_0 is the lowest PRU index of the assigned ranging channel.

P_{sc} is the number of the consecutive subcarriers within a PRU in frequency domain as defined in <<15.3.8.1 Physical and logical resource unit>>.

Δf_{RP} is the ranging subcarrier spacing.

3.3.5.2.4.2 Ranging channel for synchronized AMSs

The Padded Zadoff-Chu codes with cyclic shifts are used for the ranging preamble basic codes. The p^{th} ranging preamble code $x_n(n, k)$ is defined by

$$x_p(n, k) = \exp\left(-j \cdot \pi \cdot \frac{r_p \cdot (k + s_p \cdot m)(k + s_p \cdot m + 1)}{N_{RP} - 1}\right) \cdot c_q(n), \quad k = 0, 1, \dots, N_{RP} - 1 \quad (89)$$

where

p is the index for p^{th} ranging preamble code for n^{th} OFDMA symbols within a basic unit which is made as the s_p^{th} cyclic shifted sequence from the root index r_p of Zadoff-Chu sequence.

The start root index, r_{s0} , is broadcasted. N_{TOTAL} is the number of periodic ranging preamble codes per sector ($0 \sim N_{PE} - 1$) which is defined by Table (t.1). For femtocell, N_{TOTAL} is the total number of initial ($0 \sim N_{IN} - 1$), handover ($N_{IN} \sim N_{IN} + N_{HO} - 1$) and periodic ranging preamble codes ($N_{IN} + N_{HO} \sim N_{IN} + N_{HO} + N_{PE} - 1$) per sector which is defined by Table 738 and Table (t.1).

m is the unit of cyclic shift.

N_{RP} is the length of ranging preamble codes.

$C_q(n)$ is [TBD].

The start root index of ZC code ($rs0$), and the ranging preamble code information are broadcasted. The ranging preamble code information indicates the number of periodic ranging preamble codes.

Ranging channel configurations

The information of ranging channel allocation consists of the ranging configuration with subframe-offset (O_{SF}) for ranging resource allocation in the time domain where OSF is same subframe-offset of ranging channel for non-synchronized AMSs defined in 3.3.5.2.4.1.

Table 105 shows the information of ranging channel allocation when number of UL subframe per frame (N^{UL}) is larger than 1.

Table 105—Ranging channel allocations for synchronized AMSs

Configurations	Subframe allocating ranging channel
0	$\text{mod}(O_{SF}+1, N_{UL})^{\text{th}}$ UL subframe in every frame
1	$\text{mod}(O_{SF}+1, N_{UL})^{\text{th}}$ UL subframe in the first frame in every superframe
2	$\text{mod}(O_{SF}+1, N_{UL})^{\text{th}}$ UL subframe in the first frame in every [TBD] th superframe
3	$\text{mod}(O_{SF}+1, N_{UL})^{\text{th}}$ UL subframe in the first frame in every [TBD] th superframe

3.3.5.2.4.3 Ranging Channel for FDM-based UL PUSC Zone Support

When frame structure is supporting the WirelessMAN-OFDMA MSs in UL PUSC zone by FDM manner as defined in <<3.3.8.3.5>>, the ranging codes for WirelessMAN-OFDMA in the <<8.4.7.3>> are used for AMSs.

The binary codes are the pseudonoise codes produced by the PRBS described in Figure 75, which implements the polynomial generator $1+X^1+X^4+X^7+X^{15}$. The PRBS generator shall be initialized by the seed $b_{14} \dots b_0 = 0, 0, 1, 0, 1, 0, 1, 1, s_0, s_1, s_2, s_3, s_4, s_5, s_6$, where s_6 is the LSB of the PRBS seed, and $s_6:s_0 = \text{UL_PermBase}$, where s_6 is the MSB of the UL_PermBase.

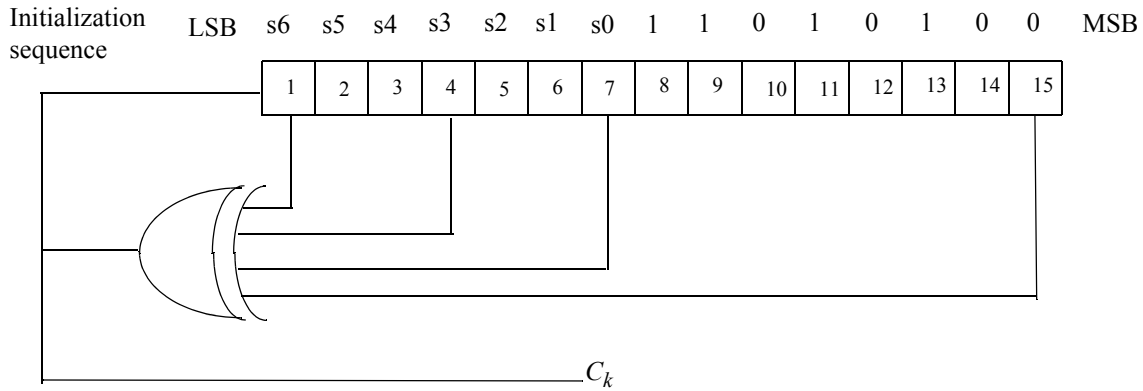


Figure 75—PRBS generator for ranging code generation

The binary ranging codes are subsequences of the pseudonoise sequence appearing at its output C_k . The length of each ranging code is 144 bits. These bits are used to modulate the subcarriers in a group of six adjacent distributed LRUs, where distributed LRUs are considered adjacent if they have successive LRU numbers. The bits are mapped to the subcarriers in increasing frequency order of the subcarriers so that the lowest indexed bit modulates the subcarrier with the lowest frequency index and the highest indexed bit modulates the subcarrier with the highest frequency index. The six distributed LRUs are called a ranging LRU.

The number of available codes is 256, numbered 0, ..., 255. Each ABS uses a subgroup of these codes, where the subgroup is defined by a number S , $0 \leq S \leq 255$. The group of codes shall be between S and $((S + O + N + M) \bmod 256)$.

- The first N codes produced are for initial ranging. Clock the PRBS generator $144 \times (S \bmod 256)$ times to $144 \times ((S + N) \bmod 256) - 1$ times.
- The next O codes produced are for handover ranging. Clock the PRBS generator $144 \times ((S + N) \bmod 256)$ times to $144 \times ((S + N + O) \bmod 256) - 1$ times.
- The next M codes produced are for periodic ranging. Clock the PRBS generator $144 \times ((S + N + O) \bmod 256)$ times to $144 \times ((S + N + O + M) \bmod 256) - 1$ times.

3.3.5.2.5 Bandwidth request channel

Each BR channel shall comprise of 3 distributed BR tiles for frequency diversity. A BR tile in the M-Zone is defined as 6 contiguous subcarriers by 6 OFDM symbols. As shown in Figure 76, the BWREQ tile is made up of two parts - a preamble portion and a data portion. The preamble portion transmits the BR preamble on a resource that spans 4 subcarriers by 6 OFDM symbols. The data portion of the BWREQ tile spans 2 contiguous subcarriers by 6 OFDM symbols and transmits the quick access message for the 3-step BR. The procedure for the formation of BR channel is defined in 3.3.4.3.3.1.

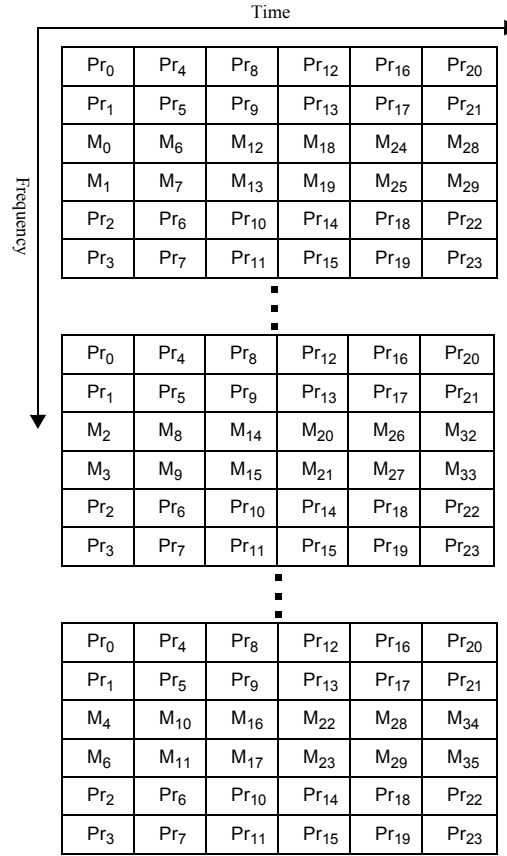


Figure 76—6x6 BR Tile Structure in the Advance Air Interface

For the 3-step BR, 16 bits of BW request information is constructed from 12 bits of STID and 4bits of pre-defined BR information described in <<Section 15.2.11.1.5.1>>. Let $s_0s_1s_2s_3s_4s_5s_6s_7s_8s_9s_{10}s_{11}$ and $s_{12}s_{13}s_{14}s_{15}$ denote the STID and pre-defined BR information respectively. By reordering the bits of STID and pre-defined BR information, 16bits of BW request information is formed as

$$b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}b_{13}b_{14}b_{15} = s_0s_1s_2s_3s_4s_5s_6s_7s_8s_9s_{10}s_{11}s_{12}d_0d_1d_2 \quad (90)$$

where

$$d_i = \text{mod}(s_i + s_{i+3} + s_{i+6} + s_{i+9} + s_{i+13}, 2) \quad 0 \leq i < 3$$

3 bits of the 16 information bits shall be carried in the BR preamble using the preamble index. The combined resource in the data portions of the three tiles that form the BR channel shall be used to transmit the remaining 13 bits of information. The frame number and 16 bits of the bandwidth request message shall be used to select three sequences of length 24 from Table 106 in order to construct 72 preamble symbols.

Table 106—BR channel Preamble sequences

u	$P_u(K), 0 \leq k < 24$																							
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	0	1	0	1	1	1	0	0	0	1	0	1	0	1	0	1	1	1	0	0	0	1	0
2	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0	1
3	1	1	0	0	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	1	1	0	0	0
4	1	0	1	0	0	1	0	1	1	1	0	0	1	0	1	0	0	1	0	1	1	1	0	0
5	1	0	0	1	0	0	1	0	1	1	1	0	1	0	0	1	0	0	1	0	1	1	1	0
6	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1
7	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1	1
8	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0	1
9	1	1	1	1	0	0	0	1	0	0	1	0	1	1	1	1	0	0	0	1	0	0	1	0
10	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0	1
11	1	1	0	1	1	1	0	0	0	1	0	0	1	1	0	1	1	1	0	0	0	1	0	0
12	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
13	1	0	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1
14	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1	1	0
15	1	1	0	0	1	0	1	1	1	0	0	0	0	0	1	1	0	1	0	0	0	1	1	1
16	1	0	1	0	0	1	0	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	1	1
17	1	0	0	1	0	0	1	0	1	1	1	0	0	1	1	0	1	1	0	1	0	0	0	1
18	1	0	0	0	1	0	0	1	0	1	1	1	0	1	1	1	0	1	1	0	1	0	0	0
19	1	1	0	0	0	1	0	0	1	0	1	1	0	0	1	1	1	0	1	1	0	1	0	0
20	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0	1	0
21	1	1	1	1	0	0	0	1	0	0	1	0	0	0	0	0	1	1	1	0	1	1	0	1
22	1	0	1	1	1	0	0	0	1	0	0	1	0	1	0	0	0	1	1	1	0	1	1	0
23	1	1	0	1	1	1	0	0	0	1	0	0	0	0	1	0	0	0	1	1	1	0	1	1

The preamble sequences transmitted in the three BR tiles of a BR channel are defined as

$$P_u(K), 0 \leq k < 24 \quad (91)$$

where k is symbol index, u is sequence index.

The mapping between the combination of the frame number and the 16 bits of the bandwidth request message $b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}b_{13}b_{14}b_{15}$ to the physical preamble index u is as below equation.

$$u = \text{mod}(q + \text{bin2dec}(b_{13}b_{14}b_{15}) + 8r, 24) \quad (92)$$

where

$$r = \text{mod}\left(\sum_{i=0}^{+} \text{bin2dec}(b_{3i}b_{3i+1}b_{3i+2}), 3\right) \quad (93)$$

$$q = \lfloor \text{bin2dec}(b_0b_1b_2b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11})/24 \rfloor \times t \quad (94)$$

and t is frame number.

The selected preamble sequence $P_u(0), P_u(1), \dots, P_u(23)$ shall be BPSK modulated (0 mapped to +1 and 1 mapped to -1) and mapped to $Pr_0, Pr_1, \dots, Pr_{23}$.

The 16 bit information in the quick access message transmitted in the BR channel shall be used to generate 5 bits CRC $r_0r_1r_2r_3r_4$ using generating polynomial $x^5 + x^4 + x^2 + 1$. The 13 bits information together with the 5 CRC bits, $b_3b_4b_5b_6b_7b_8b_9b_{10}b_{11}b_{12}b_{13}b_{14}b_{15}r_0r_1r_2r_3r_4$, shall be encoded into 72 bits $c_0, c_1, c_2, \dots, c_{71}$ using the TBCC code with parameters $L=18$, $K_{bufsize}=72$ and $M=72$. The 72 coded bits shall then be QPSK modulated and scrambled to generate 36 data symbols M_0, M_1, \dots, M_{35} . The combined resource of the data portion in the three distributed BR tiles that form the BR channel shall be used to transmit these data symbols.

In order to support operation in the legacy mode, a BR tile shall be defined as 4 contiguous subcarriers by 6 OFDM symbols. As shown in Figure 77, only the BR preamble shall be transmitted in all 24 subcarriers that form the BR tile. In this case, the preamble index u shall be randomly selected from 0 to 23.

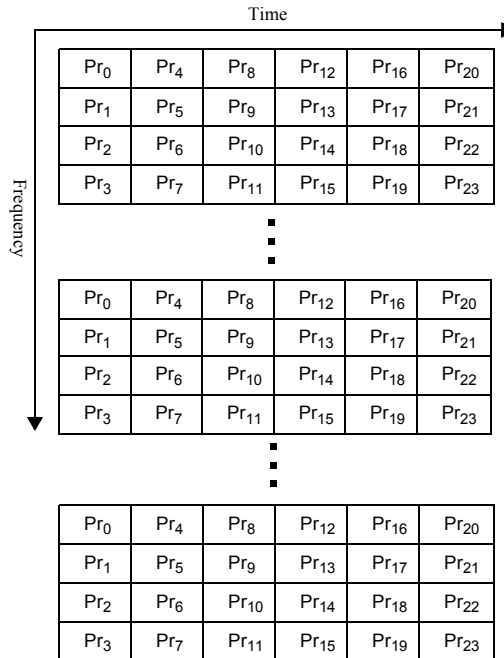


Figure 77—4x6 BR tile structure

For AMS with multiple transmission antennas, the multi-antenna transmission of BR shall be limited to 1-stream mode 1 uplink MIMO scheme defined in 3.3.6.

3.3.5.3 Uplink control information content

The UL control channels carry multiple types of control information to support air interface procedures. Information carried in the control channels is classified into the following categories:

- 1) Channel quality feedback
- 2) MIMO feedback
- 3) HARQ feedback (ACK/NACK)
- 4) Uplink synchronization signals
- 5) Bandwidth requests
- 6) E-MBS feedback.
- 7) Frequency partition selection (for DRU only) (TBD)

3.3.5.3.1 Fast feedback control channel

The UL fast feedback channel shall carry channel quality feedback and MIMO feedback. There are two types of UL fast feedback control channels: primary fast feedback channel (PFBCH) and secondary fast feedback channels (SFBCH). The UL fast feedback channel starts at a pre-determined location, with the size defined in a DL broadcast control message. Fast feedback allocations to an AMS can be periodic and the allocations are configurable.

3.3.5.3.1.1 Primary fast feedback control channel

The UL PFBCH carries 6 bits of information, providing feedback contents in Table 107.

Table 107—PFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
CQI	0,1,2,3,4,5,6,7	1) Wideband CQI 2) Subband CQI for Best -1 subband
STC Rate Indicator	0,1,2,3	
Subband index	2,3,5,6	Subband selection for best-1 subband
PMI	3,4,6,7	1) wideband PMI 2) subband PMI for best-1 subband
Event-driven Indicator (EDI) for request for switching MFM	N/A	Indicate request to switch MIMO feedback mode between distributed and localized allocations.

Table 107—PFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Event-driven Indicator (EDI) for Bandwidth Request Indicator	N/A	This is used to request UL bandwidth. 2 sequences (two services)
Event-driven Indicator (EDI) for Frequency partition selection (FPS)	N/A	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
Event-driven Indicator (EDI) for Buffer management	N/A	Indicates occupancy status of HARQ soft buffer

For PFBCH transmission, three encoding types are defined. Encoding type corresponding to MFM and feedback format in Feedback Allocation A-MAP IE is used.

PFBCH Encoding Type 0

Table 108—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
0	STC rate = 1, MCS=0000	
1	STC rate = 1, MCS=0001	
2	STC rate =1, MCS=0010	
3	STC rate =1, MCS=0011	
4	STC rate =1, MCS=0100	
5	STC rate =1, MCS=0101	
6	STC rate =1, MCS=0110	
7	STC rate =1, MCS=0111	
8	STC rate =1, MCS=1000	
9	STC rate =1, MCS=1001	
10	STC rate =1, MCS=1010	
11	STC rate =1, MCS=1011	
12	STC rate =1, MCS=1100	
13	STC rate =1, MCS=1101	
14	STC rate =1, MCS=1110	

Table 108—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
15	STC rate =1, MCS=1111	
16	STC rate =2, MCS=0000	
17	STC rate =2, MCS=0001	
18	STC rate =2, MCS=0010	
19	STC rate =2, MCS=0011	
20	STC rate =2, MCS=0100	
21	STC rate =2, MCS=0101	
22	STC rate =2, MCS=0110	
23	STC rate =2, MCS=0111	
24	STC rate =2, MCS=1000	
25	STC rate =2, MCS=1001	
26	STC rate =2, MCS=1010	
27	STC rate =2, MCS=1011	
28	STC rate =2, MCS=1100	
29	STC rate =2, MCS=1101	
30	STC rate =2, MCS=1110	
31	STC rate =2, MCS=1111	
32	STC rate =3, MCS=0100	
33	STC rate =3, MCS=0101	
34	STC rate =3, MCS=0110	
35	STC rate =3, MCS=0111	
36	STC rate =3, MCS=1000	
37	STC rate =3, MCS=1001	
38	STC rate =3, MCS=1010	
39	STC rate =3, MCS=1011	
40	STC rate =3, MCS=1100	
41	STC rate =3, MCS=1101	
42	STC rate =3, MCS=1110	
43	STC rate =3, MCS=1111	
44	STC rate =4, MCS=1000	
45	STC rate =4, MCS=1001	
46	STC rate =4, MCS=1010	

Table 108—Contents Encoding Type 0 in PFBCH

Index	Content (Value)	Description/Notes
47	STC rate =4, MCS=1011	
48	STC rate =4, MCS=1100	
49	STC rate =4, MCS=1101	
50	STC rate =4, MCS=1110	
51	STC rate =4, MCS=1111	
52	Reserved	
53	Reserved	
54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

PFBCH Encoding Type 1

Table 109—Contents Encoding Type 1 in PFBCH

Index	Content (Value)	Description/Notes
0	Subband index 0	Subband index for Best-1 subband (refer 15.3.9.3.1.4 feedback format)
1	Subband index 1	
2	Subband index 2	
3	Subband index 3	
4	Subband index 4	
5	Subband index 5	
6	Subband index 6	
7	Subband index 7	
8	Subband index 8	
9	Subband index 9	
10	Subband index 10	
11	Subband index 11	
12	Subband index 12	
13	Subband index 13	
14	Subband index 14	
15	Subband index 15	
16	Subband index 16	
17	Subband index 17	
18	Subband index 18	
19	Subband index 19	
20	Subband index 20	
21	Subband index 21	
22	Subband index 22	
23	Subband index 23	
24	Reserved	Reserved
...	...	
54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	

Table 109—Contents Encoding Type 1 in PFBCH

Index	Content (Value)	Description/Notes
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request
63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	

PFBCH Encoding Type 2

Encoding Type 2 in PFBCH is used for PMI reporting. The PMI of the i -th codebook entry, $C(N_t, M_t, N_B, i)$, is mapped into sequence index i in PFBCH.

PFBCH Encoding Type 2

Table 742 - Contents Encoding Type 3 in PFBCH

Table 110—Contents Encoding type 3 in PFBCH

Index	Content (Value)	Description/Notes
0	STC rate = 1/2, MCS=0000	
1	STC rate = 1/2, MCS=0001	
2	STC rate =1/2, MCS=0010	
3	STC rate =1/2, MCS=0011	
4	STC rate =1/2, MCS=0100	
5	STC rate =1/2, MCS=0101	
6	STC rate =1/2, MCS=0110	
7	STC rate =1/2, MCS=0111	
8	STC rate =1/2, MCS=1000	
9	STC rate =1/2, MCS=1001	
10	STC rate =1/2, MCS=1010	
11	STC rate =1/2, MCS=1011	
12	STC rate =1/2, MCS=1100	
13	STC rate =1/2, MCS=1101	
14	STC rate =1/2, MCS=1110	
15	STC rate =1/2, MCS=1111	
16~54	Reserved	
55	Event-driven Indicator (EDI) for Buffer management (80% full)	Event-driven for buffer management
56	Event-driven Indicator (EDI) for Buffer management (full)	
57	Event-driven Indicator (EDI) for request for switching MFM	Indicate request to switch MIMO feedback Mode between distributed and localized allocations
58	Event driven indicator (EDI) for frequency partition 0 indication (reuse-1)	AMS informs ABS about the frequency partition index (for MIMO feedback modes 0,1,4,7)
59	Event driven indicator (EDI) for frequency partition 1 indication (reuse-3)	
60	Event driven indicator (EDI) for frequency partition 2 indication (reuse-3)	
61	Event driven indicator (EDI) for frequency partition 3 indication (reuse-3)	
62	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 1)	Event-driven Indicator for Bandwidth request

Table 110—Contents Encoding type 3 in PFBCH

63	Event-driven Indicator (EDI) for Bandwidth Request Indicator (sequence 2)	
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3.3.5.3.1.2 Secondary fast feedback control channel

The UL SFBCH carries narrowband CQI and MIMO feedback information. The number of information bits carried in the SFBCH ranges from 7 to 24. The number of bits carries in the fast feedback channel can be adaptive.

Table 111—SFBCH Feedback Content

PFBCH Feedback Content	Related MIMO feedback mode	Description/Notes
Subband CQI	2,3,5,6	Reporting of average and differential CQI of selected sub-bands.
Subband index	2,3,5,6	Indicating the selected subbands
Subband PMI	3,6	Precoding Matrix Indicator of one sub-band for CL MIMO
Stream Indicator	5	It is needed for OL MU MIMO only and used to indicate which spatial stream to estimate CQI
STC Rate Indicator	2,3,5,6	
PFBCH Indicator	2,3,5,6	One bit indicator is used for indicating the transmission of PFBCH in the next SFBCH opportunity. In the transmission of PFBCH, encoding type 0 is used.

3.3.5.3.1.3 Channel quality indicator (CQI) definition

The CQI feedback together with the rank feedback (when applicable) composes the spectral efficiency value reported by the AMS. This value corresponds to the measured block error rate which is the closest, but not exceeding, a specific target error rate.

The AMS reports the CQI by selecting a nominal MCS index from table X. MCS index should be selected assuming 4 LRUs in type-1 subframe as a resource allocation, and 10% as a target error rate for the first HARQ transmission. In order to allocate the AMS with MCS level and rank appropriate for the actual requirements, the ABS should make adjustments to the AMS reported spectral efficiency, by considering parameters values different from the reference ones and by adapting to delay and mobility conditions.

The nominal MCS for CQI feedback shall be selected from Table 112.

Table 112—MCS table for CQI

MCS Index	Modulation	Code Rate
0000	QPSK	31/256
0001	QPSK	48/256
0010	QPSK	71/256
0011	QPSK	101/256
0100	QPSK	135/256
0101	QPSK	171/256
0110	16QAM	102/256
0111	16QAM	128/256
1000	16QAM	155/256
1001	16QAM	184/256
1010	64QAM	135/256
1011	64QAM	157/256
1100	64QAM	181/256
1101	64QAM	205/256
1110	64QAM	225/256
1111	64QAM	237/256

For MU-MIMO feedback modes with codebook-based feedback, the CQI is calculated at the AMS assuming that the interfering users are scheduled by the serving ABS using rank-1 precoders orthogonal to each other and orthogonal to the rank-1 precoder represented by the reported PMI.

3.3.5.3.1.4 Feedback format

The detailed format for MIMO feedback mode 3 with differential codebook is in Table 118. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE. For $M > 1$, two long term reports will puncture two short term reports continuously according to long term feedback period in feedback allocation A-MAP IE. For $M = 1$, the long term report will puncture one short term report according to long term feedback period in feedback allocation A-MAP IE.

Feedback format for MFM 0,1,4,7

Feedback formats for MFM 0, 1, 4, and 7 are listed in Table 113. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report if $MFM = 4$ or 7, or by puncturing the 2^q -th short period report if $MFM = 0$ or 1, where q is defined in the feedback allocation A-MAP IE. The wideband CQI is one average CQI corresponding to the MIMO mode signaled by the combination MFM and STC rate, with averaging over the whole band. In the case where the number of DL frequency partitions $FPCT > 1$, the wideband CQI is one average CQI over the corresponding frequency partition.

Table 113 shows feedback formats for MIMO feedback mode 0, 1, 4, and 7 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region):

Table 113—Feedback formats for MIMO feedback mode 0, 1, 4, and 7

MFM	FBCH	Number of reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0	PFBCH	2	Short	Wideband CQI and STC rate	N/A	Joint encoding of CQI and STC rate Encoding type 0
			Long	Wideband CQI and STC rate	N/A	Joint encoding of CQI and STC rate Encoding type 0 Long term FPI for FFR
1	PFBCH	2	Short	Wideband CQI and STC rate	N/A	Joint encoding of CQI and STC rate Encoding type 0
			Long	Wideband CQI and STC rate	N/A	Joint encoding of CQI and STC rate Encoding type 0. Long term FPI for FFR
4	PFBCH	2	Short	Wideband CQI	N/A	STC rate = 1 Encoding type 0
			Long	Wideband PMI	N/A	PMI for rank 1 Encoding type 2
7	PFBCH	2	Short	Wideband CQI	N/A	STC rate = 1 Encoding type 0
			Long	Wideband PMI	N/A	PMI for rank 1 Encoding type 2

Table 114 shows Feedback formats for MIMO feedback mode 0, 1, 4, and 7 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region)

Table 114—Feedback formats for MIMO feedback mode 0, 1, 4, and 7

MFM	FBCH	Number of Reports	Report Period	Feedback Fields	Size in Bits	Description/Notes
0	PFBCH	1	Short	Wideband CQI and STC rate	N/A	Joint encoding of CAI and STC rate Encoding type 0
1	PFBCH	1	Short	Wideband CQI	N/A	CQI for STC rate = 1/2 Encoding type 3

Feedback format for MFM 2

The detailed format is listed in Table 115. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term

feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are $\{-1, 0, +1, +2\}$. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

Table 115 shows Feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b0 in Feedback Allocation A-MAP IE (operation outside the open-loop region)

Table 115—Feedback formats for MIMO feedback mode 2

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0 ($M = 1$)	PFBCH	2	Short	Subband CQI and STC rate (rate=1 and 2)	N/A	Joint encoding of CQI and STC rate with PFBCH encoding Type 0
			Long	Subband index	N/A	PFBCH encoding Type 1
1 ($M = 1$)	SFBCH	1	Subband index Subband CQI STC rate PFBCH indicator		3, 4, or 5 4 1~3 1	Subband index for 5, 10, or 20MHz Support of STC rate 1 to 8
2 ($M = 3$)	SFBCH	2	Short	Subband avg CQI differential CQI	4 2x3=6	Subband index for 5, 10, or 20MHz
			Long	Subband index Wideband STC rate PFBCH indicator	5, 8 or 11 1~3 1	
3 ($M = 5$)	SFBCH	2	Short	Subband avg CQI differential CQI	4 2x5=10	
			Long	Subband index Wideband STC rate PFBCH indicator	3, 10 or 16 1~3 1	

Table 116 shows Feedback formats for MIMO feedback mode 2 when Measurement Method Indication = 0b1 in Feedback Allocation A-MAP IE (operation inside the open-loop region)

Table 116—Feedback formats for MIMO feedback mode 2

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0 (M=1)	PFBCH	2	Short	Subband CQI for STC rate = 1/2	N/A	Joint encoding of CQI with STC rate = 1/2 PFBCH encoding type 3
			Long	Subband index	N/A	PFBCH encoding type 1
1 (M=1)	SFBCH	1	Subband index Subband CQI PFBCH indicator		3, 4 or 5 4 1	
2 (M=3)	SFBCH	2	Short	Subband avg CQI Differential CQI	4 2x3=6	Subband index for 5, 10 or 20MHz STC rate = 1/2
			Long	Subband index PFBCH indicator	5, 8 or 11 1	
3 (M=5)	SFBCH	2	Short	Subband avg CQI Differential CQI	4 2x5=10	
			Long	Subband index PFBCH indicator	3, 10 or 16 1	

Feedback format for MFM 3

The detailed format is listed in Table 117. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first after subband index. Subband CQI and subband PMI are then transmitted alternately and subband index is transmitted in the long term period by PFBCH encoding type 1. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are $\{-1, 0, +1, +2\}$. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

Table 117—Feedback formats for MIMO feedback mode 3

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0(M = 1)	PFBCCH	3	Short	Subband CQI	N/A	PFBCCH encoding Type 0
			Short	Subband PMI	N/A	PFBCCH encoding Type 2 STC rate = 1
			Long	Subband index	N/A	PFBCCH encoding Type 1
1(M = 2)	SFBCCH	2	Short	Subband differential CQI Subband PMI	2x2 (3~6)x2	Subband index for 5, 10, or 20MHz
			Long	Subband index Wideband STC rate Subband avg CQI PFBCCH indicator	4, 7, or 9 1~3 4 1	
2(M = 3)	SFBCCH	2	Short	Subband differential CQI subband PMI	2x3 (3~6)x3	
			Long	Subband index Wideband STC rate Subband avg CQI PFBCCH indicator	5, 8, or 11 1~3 4 1	
3(M = 4)	SFBCCH	2	Short	Subband differential CQI Subband PMI	2x4 (3~4)x4	
			Long	Subband index Wideband STC rate Subband avg CQI PFBCCH indicator	4, 9, or 14 1~3 4 1	

Table 118—Feedback formats for MIMO feedback mode 3 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0 (M = 1)	SFBCCH	2	Short	Subband CQI Differential PMI Padding	4 2-4 0-1	Diff. PMI (Nt=2: 2 bit, Nt=4: 4 bit, Nt=8: 4 bit) Padding 1: if Nt = 2 0: otherwise
			Long	Subband index STC rate Base PMI PFBCCH indicator	3, 4 or 5 1 to 3 3-6 1	Subband index for 5, 10, or 20MHz PMI for reset.

Table 118—Feedback formats for MIMO feedback mode 3 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/Notes
1 (M=2)	SFBCH	3	Short	Diff CQI Differential PMI	$2 \times 2 = 4$ $2 \times 2 \sim 2 \times 4 = 4 \sim 8$	Diff. PMI(Nt=2: 2 bits per sub-band, Nt=4: 4 bits per sub-band, Nt=8: 4 bits per sub-band)
			Long	Subband index Avg CQI PFBCH indicator	4, 7 or 9 4 1	Subband index for 5, 10, or 20MHz
			Long	Base PMI STC rate	$2 \times 3 \sim 2 \times 6 = 6 \sim 12$ 1~3	
2 (M=3)	SFBCH	3	Short	Diff CQI Differential PMI	$3 \times 2 = 6$ $3 \times 2 \sim 3 \times 4 = 6 \sim 12$	Diff. PMI (Nt=2: 2 bits per sub-band, Nt=4: 4 bits per sub-band, Nt=8: 4 bits per sub-band)
			Long	Subband index STC rate Avg CQI PFBCH indicator	8 or 10 1~3 4 1	Subband index for 5, 10, or 20MHz
			Long	Base PMI	$3 \times 3 \sim 3 \times 6 = 9 \sim 18$	
3 (M=4)	SFBCH	3	Short	Diff CQI Differential PMI	$4 \times 2 = 8$ $4 \times 2 \sim 4 \times 4 = 8 \sim 16$	Diff. PMI (Nt=2: 2 bits per sub-band Nt=4: 4 bits per sub-band Nt=8: 4 bits per sub-band)
			Long	Subband index STC rate Avg CQI PFBCH indicator	4, 9 or 14 1~3 4 1	Subband index for 5, 10, or 20MHz (Nt=2: 3 bits per sub-band, Nt=4: 4 bits per sub-band, Nt=8: 4 bits per sub-band)
			Long	Base PMI	$4 \times 3 \sim 4 \times 4 = 12 \sim 16$	

Feedback format for MFM 5

The detailed format is listed in Table 119. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are $\{-1, 0, +1, +2\}$. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

Table 119—Feedback formats for MIMO feedback mode 5

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/ Notes
0 ($M=1$)	SFBCH	1	Short	Subband index Subband CQI Stream Index PFBCH indicator	3, 4, or 5 4 1~2 1	Subband index for 5, 10, or 20MHz
1 ($M=2$)	SFBCH	2	Short	Subband avg_CQI Subband differential CQI Stream Index	4 2x2=4 (1~2)x2	
			Long	Subband index PFBCH indicator	4, 7, or 9 1	Subband index for 5, 10, or 20MHz
2 ($M=3$)	SFBCH	2	Short	Subband avg_CQI Subband differential CQI Stream Index	4 2x3=6 3x(1~2)	
			Long	Subband index PFBCH indicator	5, 8, or 11 1	Subband index for 5, 10, or 20MHz
3 ($M=5$)	SFBCH	3	Short	Subband avg_CQI Subband differential CQI Stream Index	4 2x5=10 (1~2) x5	
			Long	Subband index PFBCH indicator	3, 10, or 16 1	Subband index for 5, 10, or 20MHz

Feedback format for MFM 6

The detailed format is listed in Table 120. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE, long term report will puncture short term report according to long term feedback period in feedback allocation A-MAP IE. The long period report shall start by puncturing the first short period report. For feedback format 0 with 3 reports using the PFBCH, Subband PMI shall be transmitted first after subband index. Subband CQI and subband PMI are then transmitted alternately and subband index is transmitted in the long term period by PFBCH encoding type 1. If the PFBCH indicator in SFBCH is set to '1', PFBCH is transmitted by puncturing SFBCH in the next feedback opportunity regardless of short-term and long-term feedback using encoding type 0.

The CQI of subband m shall be computed as follows for the first short period report following a long period report: (Subband m CQI index) = (Subband avg CQI index) + (Subband m differential CQI). Subband avg CQI index is an average measure of the CQI over the M reported subbands. The possible differential CQI values are $\{-1, 0, +1, +2\}$. The AMS shall ensure that the reported differential CQI will produce a value of subband m CQI in the range of 0 to 15.

Table 120—Feedback formats for MIMO feedback mode 6

Feedback Format	FBCH	Number of reports	Report Period	Feedback Fields	Size in bits	Description/ Notes
0(M = 1)	PFBCH	3	Short	Subband CQI	N/A	PFBCH encoding Type 0
			Short	Subband PMI	N/A	PFBCH encoding Type 2
			Long	Subband index	N/A	PFBCH encoding Type 1
1(M = 2)	SFBCH	2	Short	Subband differential CQI Subband PMI	2x2 (3~6)x2	Subband index for 5, 10, or 20MHz
			Long	Subband index Subband avg CQI PFBCH indicator	4, 7 or 9 4 1	
2(M = 3)	SFBCH	2	Short	Subband differential CQI Subband PMI	2x3 (3~6)x3	
			Long	Subband index Subband avg CQI PFBCH indicator	5, 8 or 11 4 1	
3(M = 4)	SFBCH	2	Short	Subband differential CQI Subband PMI	2x4 (3~4)x4	
			Long	Subband index Subband avg CQI PFBCH indicator	4, 9 or 14 4 1	

The detailed format for MIMO feedback mode 6 with differential codebook is in Table 121. Short term report happens in every reporting period as defined in feedback allocation A-MAP IE. For $M > 1$, two long term reports will puncture two short term reports continuously according to long term feedback period in feedback allocation A-MAP IE. For $M = 1$, the long term report will puncture one short term report according to long term feedback period in feedback allocation A-MAP IE

Table 121—Feedback formats for MIMO feedback mode 6 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/Notes
0 (M=1)	SFBCH	2	Short	Subband CQI Differential PMI Padding	4 2~4 0~1	Diff. PMI (Nt=2: 2 bit, Nt=4: 4 bit, Nt=8: 4 bit) Padding 1: if Nt=2 0: otherwise
			Long	Subband selection Base PMI PFBCH indicator	3, 4 or 5 3-6 1	PMI for reset.
1 (M=2)	SFBCH	3	Short	Diff CQI Differential PMI	$2 \times 2 = 4$ $2 \times 2 \sim 2 \times 4 = 4 \sim 8$	Diff. PMI(Nt=2: 2 bits per sub- band, Nt=4: 4 bits per sub- band, Nt=8: 4 bits per sub- band)
			Long	Subband selection Avg CQI Base PMI PFBCH indicator	4, 7 or 9 4 1	
			Long	Base PMI	$2 \times 3 \sim 2 \times 6 = 6 \sim 12$	
2 (M=3)	SFBCH	3	Short	Diff CQI Differential PMI	$3 \times 2 = 6$ $3 \times 2 \sim 3 \times 4 = 6 \sim 12$	Diff. PMI (Nt=2: 2 bits per subband, Nt=4: 4 bits per sub- band, Nt=8: 4 bits per sub- band)
			Long	Subband selection Avg CQI PFBCH indicator	5, 8 or 10 4 1	
			Long	Base PMI	$3 \times 3 \sim 3 \times 6 = 9 \sim 18$	

Table 121—Feedback formats for MIMO feedback mode 6 for differential codebook

Feedback Format	FBCH	Number of Reports	Report Period	Feedback Fields	Size in bits	Description/Notes
3 (M=4)	SFBCH	3	Short	Diff CQI Differential PMI	4×2=8 4×2~4×4=8~16	Diff. PMI (Nt=2: 2 bits per subband Nt=4: 4 bits per subband Nt=8: 4 bits per subband)
			Long	Subband index Avg CQI PFBCH indicator	4, 9 or 14 4 1	Subband index for 5, 10, or 20MHz Base PMI (Nt=2: 3 bits per subband, Nt=4: 4 bits per subband, Nt=8: 4 bits per subband)
			Long	Base PMI	4×3~4×4=12~16	

3.3.5.3.2 HARQ feedback control channel**3.3.5.3.3 Bandwidth request channel**

The quick access message contains a 12-bit MSID and 4-bit predefined BR information.

3.3.5.4 Uplink Power Control

Uplink power control is supported for both an initial calibration and periodic adjustment on transmit power without loss of data. The uplink power control algorithm determines the transmission power of an OFDM symbol to compensate for the pathloss, shadowing and fast fading. Uplink power control shall intend to control inter-cell interference level.

A transmitting AMS shall maintain the same transmitted power density, unless the maximum power level is reached. In other words, when the number of active LRU allocated to a user is reduced, the total transmitted power shall be reduced proportionally by the AMS, as long as there is no additional change of parameters for power control. When the number of LRU is increased, the total transmitted power shall also be increased proportionally. However, the transmitted power level shall not exceed the maximum levels dictated by signal integrity considerations and regulatory requirements. In closed-loop power control, the AMS shall interpret PC-A-MAP IE as the required changes to the transmitted power density.

For interference level control, current interface level of each ABS may be shared among ABSs.

3.3.5.4.1 UL Open-Loop Power Control

When the open-loop power control is used, the power per subcarrier and per transmission antenna shall be maintained for the UL transmission as indicated in Equation (95).

$$P(\text{dBm}) = L + \text{SINR}_{\text{Target}} + NI + \text{Offset}_{\text{AMS}_{\text{perAMS}}} + \text{Offset}_{\text{ABS}_{\text{perAMS}}} \quad (95)$$

Where:

$SINR_{Target}$ is the target uplink SINR received by the ABS. The mode used to calculate this value is signaled through a power control message.

P is the TX power level (dBm) per stream and per subcarrier for the current transmission.

L is the estimated average current UL propagation loss. It shall include AMS's Tx antenna gain and path loss.

NI is the estimated average power level (dBm) of the noise and interference per subcarrier at the ABS, not including ABS's Rx antenna gain.

$Offset_{AMS_{perAMS}}$ is a correction term for AMS-specific power offset. It is controlled by the AMS. Its initial value is zero.

(TBD)

$Offset_{ABS_{perAMS}}$ is a correction term for AMS-specific power offset. It is controlled by the ABS through power control messages.

The estimated average current UL propagation loss, L , shall be calculated based on the total power received on the active subcarriers of the frame preamble.

The $Offset_ABS_{perAMS}$ can be updated by ABS. Once AMS recognized this parameter, AMS should increase and decrease the $Offset_ABS_{perAMS}$ according to this value sent by ABS.

When the user connects to network, it can negotiate the parameters using Equation (96)

:

$$SINR_{Target} = \begin{cases} 10 \log 10 \left(\max \left(10^{\Lambda \left(\frac{SINR_{MIN}(dB)}{10} \right)}, \gamma_{IoT} \times SINR_{DL} - \alpha \right) \right) - \beta \times 10 \log 10(TNS), & OLPC \text{ Mode 1} \\ C/N, & OLPC \text{ Mode 2} \end{cases} \quad (96)$$

Where

C/N is the normalized C/N of the modulation/FEC rate for the current transmission, as appearing in Table 122.

OLPC Mode 1 is the target SINR value for IoT control and tradeoff between overall system throughput and cell edge performance, decided by the control parameter γ_{IoT} and $SINR_{MIN}$. Each parameter used in OLPC mode1 is explained as follows:

Where

$SINR_{MIN}$ is the SINR requirement for the minimum rate expected by ABS which is set by a unicast power control message. $SINR_{MIN}$ has 4 bits to represent the value in dB among $\{-\infty, -3, -2.5, -2, -1.5, -1, -0.5, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5\}$.

γ_{IoT} is the fairness and IoT control factor, broadcast by the ABS. It has 4 bits to represent the value among $\{0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.1, 1.2, 1.3, 1.4, 1.5\}$. It can also be different for each frequency partition. Details on signaling of γ_{IoT} is found in section 15.2.x.2.

SIR_{DL} is the ratio of the downlink signal to. interference power, measured by the AMS.

α is the factor according to the number of receive antennas at the ABS. It is signaled from MAC power control mode signaling by 3 bits to express $\{1, 1/2, 1/4, 1/8, 1/16, 0, \text{reserved}, \text{reserved}\}$.

β is set to be zero or one by one bit of MAC power control mode signaling.

TNS is the Total Number of Streams in the LRU indicated by UL A-MAP IE. In case of SU-MIMO, this value shall be set to M_t where M_t is the number of streams for AMS. In case of CSM, *TNS* is the aggregated number of streams. In case of control channel transmission, this value shall be set to one.

Table 122—Normalized C/N per modulation

Type	Modulation/FEC rate	Required C/N
Control Channel	ACK/NAK	
	CQI	
	Ranging code	
	P-FBCH	
	S-FBCH	
	Analog Feedback	
	Bandwidth Request	
	Sounding	
Rank 1 MCS (Index)	'0000	'
	'0001	'
	'0010	'
	'0011	'
	'0100	'
	'0101	'
	'0110	'
	'0111	'
	'1000	'
	'1001	'
	'1010	'
	'1011	'
	'1100	'
	'1101	'
	'1110	'
	'1111	'

Table 122—Normalized C/N per modulation

Type	Modulation/FEC rate	Required C/N
Rank 2 MCS (Index)	'0000	'
	'0001	'
	'0010	'
	'0011	'
	'0100	'
	'0101	'
	'0110	'
	'0111	'
	'1000	'
	'1001	'
	'1010	'
	'1011	'
	'1100	'
	'1101	'
	'1110	'
	'1111	'
(TBD)	(TBD)	(TBD)

3.3.5.4.2 UL Closed-Loop Power Control

To maintain at the ABS a power density consistent with the modulation and FEC rate used by each AMS, the ABS may change the AMS's TX power through direct power adjustment signaling such as PC-A-MAP. Closed loop power control is defined in Equation (97).

$$P_{tx} = P_{last} + \Delta_{SINR} + \Delta_{PowerAdjust} \quad (97)$$

where:

P_{tx} is transmit power level per subcarrier.

P_{last} is the latest transmitted maximum power level among different uplink physical channels transmitted concurrently.

Δ_{SINR} is the difference of the desired SINRs between the previous and new MCS levels for a uplink physical channel. Desired SINR for each MCS level is TBD.

$\Delta_{PowerAdjust}$ is the value indicated by PC-A-MAP.

Power correction values are defined in Table 123.

Table 123—Power correction offset values

Power Correction Value	Offset (dB)
0b00	-0.5
0b01	0.0
0b10	0.5
0b11	1.0

3.3.5.4.3 Initial Ranging Channel Power Control

For initial ranging, AMS sends initial ranging code at a randomly selected ranging channel. The initial transmission power is decided according to measured RSS. If AMS does not receive a response, it may increase its power level by $P_{IR,Step}$ and may send a new initial ranging code, where $P_{IR,Step}$ is the step size to ramp up, which is 2 dB (TBD). AMS could further increase the power until maximum transmit power is reached.

The initial transmission power of AMS is calculated as:

$P_{TX_IR_MIN} = EIRxP_{IR,min} + BS_EIRP - RSS$, where $EIRxP_{IR,min}$ is the minimum targeting receiving power and BS_EIRP is the transmission power of the BS, which are obtained from S-SFH SP2 (TBD, and RSS is the received signal strength measured by the AMS.

In the case that the Rx and Tx gain of the AMS antenna are different, the AMS shall use Equation (98):

$$P_{TX_IR_MIN} = EIRxP_{IR,min} + BS_EIRP - RSS + (G_{Rx_MS} - G_{Tx_MS}) \quad (98)$$

Where

G_{Rx_MS} is the antenna gain of AMS RX.

G_{Tx_MS} is the antenna gain of AMS TX.

RSS is the measured receiving signaling strength by AMS.

3.3.5.4.4 Sounding Channel Power Control

Power control for the UL sounding channel is supported to manage the sounding quality. AMS's transmit power for UL sounding channel is controlled separately according to its sounding channel target CINR value. The power per subcarrier shall be maintained for the UL sounding transmission as shown in Equation (95) of 3.3.5.4.1.

In Equation (95), $SINR_{target}$ is the sounding channel target SINR, which is set according to the DL SINR of the AMS. In order to maintain the UL sounding quality, the different target SINR values are assigned according to the DL SINR of each AMS; the AMS with high DL SINR applies relatively high target SINR and the AMS with low DL SINR applies relatively low target SINR.

The $SINR_{target}$ for sounding channel shall be calculated from equation <<(246)>> using the following parameter settings: $SINR_{MIN}$ is the minimum SINR requirement expected by ABS which is set to 0dB, $\gamma_{IoT} = 1.2$ is the fairness and IoT control factor for sounding channel, $SINR_{DL}$ is the ratio of the downlink signal vs. noise and interference power, measured by the AMS, α and β parameters shall be set to 0.

When calculated sounding $SINR_{target}$ is higher than 10 dB, the $SINR_{target}$ shall be set to 10 dB.

3.3.5.4.5 Concurrent transmission of uplink control channel and data

When the data and uplink control channels are transmitted concurrently in the same symbol, the reliability of control channels shall be supported by assigning the priorities over data.

3.3.5.5 Uplink physical structure for multicarrier support

Guard subcarriers between carriers form integer multiples of PRUs. The structure of guard PRU is the same as the structure defined in 15.3.8.1 and 15.3.8.4. The guard PRUs are used as miniband CRUs at partition FP0 for data transmission only. The number of useable guard subcarriers is predefined and should be known to both AMS and ABS based on carrier bandwidth.

3.3.6 Uplink MIMO transmission schemes

3.3.6.1 Uplink MIMO architecture and data processing

The architecture of uplink MIMO at the transmitter side is shown in Figure 78.

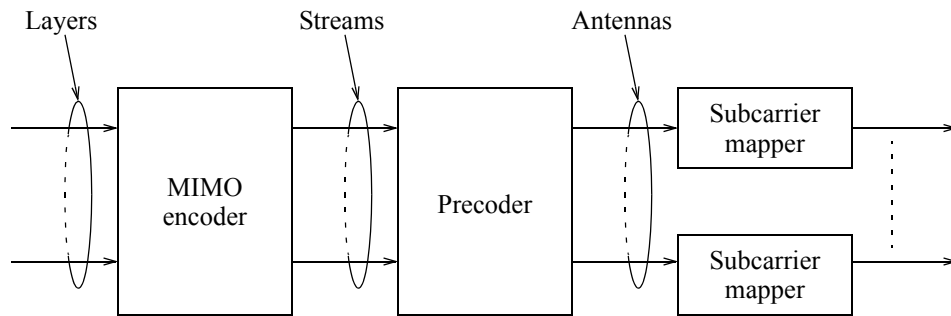


Figure 78—UL MIMO architecture

The MIMO encoder block maps a single layer ($L = 1$) onto M_t ($M_t \geq L$) streams, which are fed to the Precoder block. A layer is defined as a coding and modulation path fed to the MIMO encoder as an input. A stream is defined as an output of the MIMO encoder which is passed to the precoder.

For SU-MIMO and Collaborative spatial multiplexing (MU-MIMO), only one FEC block exists in the allocated RU (vertical MIMO encoding at transmit side).

The Precoder block maps stream(s) to antennas by generating the antenna-specific data symbols according to the selected MIMO mode.

The MIMO encoder and precoder blocks shall be omitted when the AMS has one transmit antenna.

The subcarrier mapping blocks map antenna-specific data to the OFDM symbol.

3.3.6.1.1 Layer to stream mapping

Layer to stream mapping is performed by the MIMO encoder. The uplink MIMO encoder is identical to the downlink MIMO encoder described in section “Layer to stream mapping” on page 112.

Horizontal encoding (MEF = 0b10) is not supported for uplink transmissions.

A AMS with 1 transmit antenna shall use vertical encoding (MEF = 0b01) for uplink transmissions.

3.3.6.1.1.1 SFBC encoding

Uplink SFBC encoding is identical to the downlink SFBC encoding described in section “SFBC encoding” on page 113.

SFBC encoding format shall not be allocated to an AMS with 1 transmit antenna.

3.3.6.1.1.2 Vertical encoding

Uplink vertical encoding is identical to the downlink vertical encoding described in section “Vertical encoding” on page 114.

Vertical encoding with 1 stream ($M_t = 1$) format shall be allocated to an AMS with 1 transmit antenna.

3.3.6.1.2 Stream to antenna mapping

Stream to antenna mapping is performed by the precoder. The uplink mapping is identical to the downlink mapping described in section “Stream to antenna mapping” on page 115.

3.3.6.1.2.1 Non-adaptive precoding

There is no precoding if there is only one transmit antenna at the MS.

With non-adaptive precoding, the precoding matrix is an $N_t \times M_t$ matrix $\mathbf{W}(k)$, where N_t is the number of transmit antennas, M_t is the numbers of streams, and k is the physical index of the subcarrier where $\mathbf{W}(k)$ is applied. The matrix \mathbf{W} is selected from a subset of size N_H precoders of the base codebook for a given rank. \mathbf{W} belongs to one of the subsets of the base codebook specified in <<<Section 15.3.7.2.6.6.2.4.1>>>, according to the type of allocation, MEF, N_t and M_t , as specified in Table 124 and Table 125.

Table 124—Codebook subsets used for non-adaptive precoding in UL diversity allocations (DLRU and NLRU)

MEF	RU with M_t pilot streams
SFBC	$C_{\text{ULOLSU}}(N_t, M_t, N_w), M_t = 2$
VE	$C_{\text{ULOLSU}}(N_t, M_t, N_w), M_t = 1, \dots, 4$

Table 125—Codebook subsets used for non-adaptive precoding in UL SLRU

MEF	RU with M_t pilot streams
SFBC	na
VE	$N_t=2$: $C_{\text{base,UL}}(2, M_t, 4), M_t=1,2$ $N_t=4$: $C_{\text{base,UL}}(4, M_t, 6), M_t=1,2,3,4$

In a RU allocated in a subframe with MEF = 0b00 (SFBC) or 0b01 (VE) and non-adaptive precoding, the matrix \mathbf{W} changes every $N_t P_{SC}$ contiguous physical subcarriers according to Equation (99), and it does not depend on the subframe number. The $N_t \times M_t$ precoding matrix $\mathbf{W}(k)$ applied on subcarrier k in physical sub-band s is selected as the codeword of index i in the open-loop codebook subset of rank M_t , where i is given by

$$i = s \bmod N_W, \quad s = 1 \dots N_{sub}-1 \quad (99)$$

where N_{sub} denotes the number of physical subbands across the entire system bandwidth.

3.3.6.1.2.2 Adaptive precoding

There is no precoding if there is only one transmit antenna at the AMS.

With adaptive precoding, the precoder \mathbf{W} is derived at the ABS or at the AMS, as instructed by the ABS.

With 2Tx or 4Tx at the AMS in FDD and TDD systems, unitary codebook based adaptive precoding is supported. In this mode, a AMS transmits a sounding signal on the uplink to assist the precoder selection at the ABS. The ABS then signals the uplink precoding matrix index to be used by the AMS in the UL A-MAP IE.

With 2Tx or 4Tx at the AMS in TDD systems, adaptive precoding based on the measurements of downlink reference signals is supported. The AMS chooses the precoder based on the downlink measurements. The form and derivation of the precoding matrix does not need to be known at the ABS.

3.3.6.1.3 Uplink MIMO transmission modes

There are five MIMO transmission modes for UL MIMO transmission as listed in Table 126.

Table 126—Uplink MIMO modes

Mode Index	Description	MIMO encoding format (MEF)	MIMO Precoding
Mode 0	OL SU-MIMO	SFBC	non-adaptive
Mode 1	OL SU-MIMO (SM)	VE	non-adaptive
Mode 2	CL SU-MIMO (SM)	VE	adaptive
Mode 3	OL Collaborative spatial multiplexing (MU-MIMO)	VE	non-adaptive
Mode 4	CL Collaborative spatial multiplexing (MU-MIMO)	VE	adaptive

The allowed values of the parameters for each UL MIMO mode are shown in Table 127.

Table 127—UL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	R	M_t	N_F	L
MIMO mode 0	2	1	2	2	1
	4	1	2	2	1

Table 127—UL MIMO parameters

	Number of transmit antennas	STC rate per layer	Number of streams	Number of subcarriers	Number of layers
	N_t	R	M_t	N_F	L
MIMO mode 1	1	1	1	1	1
MIMO mode 1 and MIMO mode 2	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1
	4	4	4	1	1
MIMO mode 3 and MIMO mode 4	1	1	1	1	1
	2	1	1	1	1
	2	2	2	1	1
	4	1	1	1	1
	4	2	2	1	1
	4	3	3	1	1

M_t refers to the number of streams transmitted from one AMS.

In mode 3 and 4, N_t refers to the number of transmit antennas at one AMS involved in CSM.

3.3.6.2 Transmission schemes for data channels

3.3.6.2.1 Encoding and precoding of SU-MIMO modes

3.3.6.2.1.1 Encoding of SU-MIMO modes

MIMO mode 0: SFBC encoding of section 3.3.6.1.1.1 shall be used with MIMO mode 0.

MIMO mode 1: Vertical encoding of section 3.3.6.1.1.2 shall be used with MIMO mode 1. The number of streams is $M_t \leq \min(N_p, N_r)$, where N_r is the number of receive antennas and M_t is no more than 4.

MIMO mode 2: Vertical encoding of section 3.3.6.1.1.2 shall be used with MIMO mode 2. The number of streams is $M_t \leq \min(N_p, N_r)$, where M_t is no more than 4.

3.3.6.2.1.2 Precoding of SU-MIMO modes

MIMO mode 0: Non-adaptive precoding with $M_t = 2$ streams shall be used with MIMO mode 0.

MIMO mode 1: Non-adaptive precoding with M_t streams shall be used with MIMO mode 1.

MIMO mode 2: Adaptive precoding shall be used with MIMO mode 2.

3.3.6.2.2 Encoding and precoding of collaborative spatial multiplexing (MU-MIMO)

AMSs can perform collaborative spatial multiplexing onto the same RU. In this case, the ABS assigns different pilot patterns for each AMS.

3.3.6.2.2.1 Encoding of MU-MIMO modes

MIMO mode 3: Vertical encoding shall be used with MIMO mode 3.

MIMO mode 4: Vertical encoding shall be used with MIMO mode 4.

3.3.6.2.2.2 Precoding of MU-MIMO modes

MIMO mode 3: Non-adaptive precoding shall be used with MIMO mode 3.

MIMO mode 4: Adaptive precoding shall be used with MIMO mode 4.

3.3.6.2.3 Mapping of data subcarriers

Consecutive symbols for each antenna at the output of the MIMO precoder are mapped in a frequency domain first order across LRUs of the allocation, starting from the data subcarrier with the smallest OFDM symbol index and smallest subcarrier index, and continuing to subcarrier index with increasing subcarrier index. When the edge of the allocation is reached, the mapping is continued on the next OFDM symbol.

3.3.6.2.4

3.3.6.2.5 Usage of MIMO modes

The following table shows the permutations supported for each MIMO mode outside the OL region. The definition of tile based DRU, mini-band based CRU, and subband based CRU are in 3.3.4.

Table 128—Supported permutation for each UL MIMO mode

	Tile based DRU	Mini-band based CRU (diversity allocation)	Sub-band based CRU (localized allocation)
MIMO mode 0	Yes	Yes	No
MIMO mode 1	Yes, with $M_t \leq 2$	Yes	Yes
MIMO mode 2	Yes, with $M_t \leq 2$	Yes	Yes
MIMO mode 3	Yes, with $M_t = 1$	Yes	Yes
MIMO mode 4	Yes, with $M_t = 1$	Yes	Yes

3.3.6.2.6 Downlink signaling support of UL-MIMO modes

3.3.6.2.6.1 Broadcast information

The ABS shall send parameters necessary for UL MIMO operation in a unicast message. The parameters may be transmitted depending on the type of operation. The unicast information is carried in the A-MAP IE, in the FBCH Alloc IE, on the Sounding_IE.

Table 129 specifies the DL control parameters required for UL MIMO operation.

Table 129—UL MIMO control parameters

Parameter	Description	Value	Control channel (IE)	Notes
MEF	MIMO Encoding Format	SFBC Vertical encoding	A-MAP IE	MIMO encoding format
CSM	Collaborative Spatial Multiplexing	Disabled or enabled	A-MAP IE	SU MIMO if CSM is disabled MU MIMO if CSM is enabled
M_t	Number of streams	1 to 4	A-MAP IE	Number of streams in the AMS transmission.
TNS	Total number of streams in the LRU	1 to 4	A-MAP IE	Enabled when CSM is enabled. Indication of the total number of streams in the LRU
SI	First pilot index	1 to 4	A-MAP IE	Enabled when CSM is enabled. 1 bit for 2Tx, 2 bit for 4Tx
PF	Precoding flag	non adaptive precoding or adaptive codebook precoding	A-MAP IE	Cannot be applied to AMS with 1 transmit antenna
PMI Indicator	PMI indicator	0b0: the AMS shall use the precoder of rank M_t of its choice 0b1: the indicated PMI of rank M_t shall be used by the AMS for precoding	A-MAP IE	This field is relevant only when PF indicates adaptive codebook precoding. PMI indication = 0b0 may be used in TDD When PMI indication = 0b1, the AMS selects the precoder to use at the AMS.
PMI	Precoding matrix index in the UL base codebook	0 to 9 when $N_t = 2$ 0 to 63 when $N_t = 4$	A-MAP IE	Enabled when PF indicates adaptive codebook precoding, and PMI indication = 0b1.

3.3.6.3 Codebook for closed-loop transmit precoding

The notation $C_{base, UL}(N_p, M_p, NB)$ denotes the rank- M_t uplink base codebook, which consists of 2^{NB} complex matrices of dimension N_t by M_t , and M_t denotes the number of streams.

The notation $C_{base, UL}(N_p, M_p, NB, i)$ denotes the i^{th} codebook entry of $C_{base, UL}(N_p, M_p, NB)$.

3.3.6.3.1 Base codebook for two transmit antenna

3.3.6.3.1.1 SU-MIMO base codebook

The base codebooks of SU-MIMO with two transmit antennas consist of rank-1 codebook $C(2, 1, 4)$ and rank-2 codebook $C(4, 2, 3)$. Table 130 is included to illustrate the rank-1 base codebooks.

Table 130— $C(2, 1, 4)$

Binary Index	M	$C(2, 1, 4, m) = [c_1; c_2]$	
		c_1	c_2
0000	0	0.7071	-0.7071
0001	1	0.7071	-0.5000 - 0.5000i
0010	2	0.7071	- 0.7071i
0011	3	0.7071	0.5000 - 0.5000i
0100	4	0.7071	0.7071
0101	5	0.7071	0.5000 + 0.5000i
0110	6	0.7071	0.7071i
0111	7	0.7071	-0.5000 + 0.5000i
1000	8	1	0
1001	9	0	1
1010-1111	10-15	-	-

The rank-2 base codebook $C(2, 3, 4)$ for uplink 2 Tx is the same as the downlink 2 Tx rank-2 base codebook

3.3.6.3.1.2 MU-MIMO base codebook

The base codebook for UL collaborative spatial multiplexing MIMO is the same as the base codebook for SU-MIMO, defined in 3.3.6.3.1.1.

3.3.6.3.2 Base codebook for four transmit antennas

3.3.6.3.2.1 SU-MIMO base codebook

The uplink base codebook of SU-MIMO with four transmit antennas consist of rank-1 codebook $C_{base, UL}(4, 1, 6)$, rank-2 codebook $C_{base, UL}(4, 2, 6)$, rank-3 codebook $C_{base, UL}(4, 3, 6)$ and rank-4 codebook

$C_{base, UL}(4, 4, 6)$. Rank-1 codebook entry $C_{base, UL}(4, 1, 6, m)$ consists of the first column of $C_{base, UL}(4, 4, 6, m)$. Rank-2 codebook entry $C_{base, UL}(4, 2, 6, m)$ consists of the first two columns of $C_{base, UL}(4, 4, 6, m)$. Rank-3 codebook entry $C_{base, UL}(4, 3, 6, m)$ consists of the first three columns of $C_{base, UL}(4, 4, 6, m)$. Table 131 specifies the rank-4 base codebook.

Table 131— $C_{base, UL}(4, 4, 6)$

Binary Index	m	$C_{base, UL}(4, 4, 6, m) = [c_1; c_2; c_3; c_4]$			
		c_1	c_2	c_3	c_4
000000	0	0.5000 0.5000i -0.5000 -0.5000i	0.5000 -0.5000 0.5000 -0.5000	0.5000 -0.5000i -0.5000 0.5000i	0.5000 0.5000 0.5000 0.5000
000001	1	0.5000 0.2357 - 0.4410i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 -0.2357 + 0.4410i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 -0.4410 - 0.2357i 0.4619 + 0.1913i 0.1913 - 0.4619i
000010	2	0.5000 -0.4157 + 0.2778i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 -0.2778 - 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 - 0.2778i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i -0.3536 - 0.3536i
000011	3	0.5000 0.4976 - 0.0490i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 -0.4976 + 0.0490i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 -0.0490 - 0.4976i 0.1913 + 0.4619i -0.4619 + 0.1913i
000100	4	0.5000 -0.4619 - 0.1913i -0.5000i 0.5000	0.5000 0.1913 - 0.4619i 0.5000i -0.5000i	0.5000 0.4619 + 0.1913i -0.5000i -0.5000	0.5000 -0.1913 + 0.4619i 0.5000i 0.5000i
000101	5	0.5000 0.3172 + 0.3865i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 -0.3865 + 0.3172i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 -0.3172 - 0.3865i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 0.3865 - 0.3172i -0.1913 + 0.4619i 0.4619 + 0.1913i
000110	6	0.5000 -0.0975 - 0.4904i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.4904 - 0.0975i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 -0.4904 + 0.0975i -0.3536 + 0.3536i 0.3536 - 0.3536i
000111	7	0.5000 -0.1451 + 0.4785i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 -0.4785 - 0.1451i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.1451 - 0.4785i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 0.4785 + 0.1451i -0.4619 + 0.1913i -0.1913 - 0.4619i
001000	8	0.5000 0.3536 - 0.3536i 0.5000 0.5000i	0.5000 0.3536 + 0.3536i -0.5000 0.5000	0.5000 -0.3536 + 0.3536i 0.5000 -0.5000i	0.5000 -0.3536 - 0.3536i -0.5000 -0.5000
001001	9	0.5000 -0.4785 + 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 -0.1451 - 0.4785i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 0.4785 - 0.1451i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 0.1451 + 0.4785i -0.4619 - 0.1913i -0.1913 + 0.4619i

Table 131—C_{base,UL}(4,4,6)

001010	10	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 -0.0975 + 0.4904i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.4904 - 0.0975i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.0975 - 0.4904i -0.3536 - 0.3536i 0.3536 + 0.3536i
001011	11	0.5000 -0.3865 - 0.3172i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 0.3172 - 0.3865i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 -0.3172 + 0.3865i -0.1913 - 0.4619i 0.4619 - 0.1913i
001100	12	0.5000 0.1913 + 0.4619i 0.5000i -0.5000	0.5000 -0.4619 + 0.1913i -0.5000i 0.5000i	0.5000 -0.1913 - 0.4619i 0.5000i 0.5000	0.5000 0.4619 - 0.1913i -0.5000i -0.5000i
001101	13	0.5000 0.0490 - 0.4976i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 -0.0490 + 0.4976i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 -0.4976 - 0.0490i 0.1913 - 0.4619i -0.4619 - 0.1913i
001110	14	0.5000 -0.2778 + 0.4157i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.4157 - 0.2778i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.2778 - 0.4157i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 - 0.3536i -0.3536 + 0.3536i
001111	15	0.5000 0.4410 - 0.2357i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 -0.4410 + 0.2357i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 -0.2357 - 0.4410i 0.4619 - 0.1913i 0.1913 + 0.4619i
010000	16	0.5000 -0.5000 -0.5000 -0.5000i	0.5000 -0.5000i 0.5000 -0.5000	0.5000 0.5000 -0.5000 0.5000i	0.5000 0.5000i 0.5000 0.5000
010001	17	0.5000 0.4410 + 0.2357i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 -0.2357 + 0.4410i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 -0.4410 - 0.2357i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 0.2357 - 0.4410i 0.4619 + 0.1913i 0.1913 - 0.4619i
010010	18	0.5000 -0.2778 - 0.4157i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 0.4157 - 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.4157 + 0.2778i 0.3536 + 0.3536i -0.3536 - 0.3536i
010011	19	0.5000 0.0490 + 0.4976i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 -0.4976 + 0.0490i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 -0.0490 - 0.4976i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 0.4976 - 0.0490i 0.1913 + 0.4619i -0.4619 + 0.1913i
010100	20	0.5000 0.1913 - 0.4619i -0.5000i 0.5000	0.5000 0.4619 + 0.1913i 0.5000i -0.5000i	0.5000 -0.1913 + 0.4619i -0.5000i -0.5000	0.5000 -0.4619 - 0.1913i 0.5000i 0.5000i
010101	21	0.5000 -0.3865 + 0.3172i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 -0.3172 - 0.3865i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 0.3865 - 0.3172i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 0.3172 + 0.3865i -0.1913 + 0.4619i 0.4619 + 0.1913i

Table 131—C_{base,UL}(4,4,6)

010110	22	0.5000 0.4904 - 0.0975i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.0975 + 0.4904i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.4904 + 0.0975i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 -0.0975 - 0.4904i -0.3536 + 0.3536i 0.3536 - 0.3536i
010111	23	0.5000 -0.4785 - 0.1451i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 0.1451 - 0.4785i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 0.4785 + 0.1451i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 -0.1451 + 0.4785i -0.4619 + 0.1913i -0.1913 - 0.4619i
011000	24	0.5000 0.3536 + 0.3536i 0.5000 0.5000i	0.5000 -0.3536 + 0.3536i -0.5000 0.5000	0.5000 -0.3536 - 0.3536i 0.5000 -0.5000i	0.5000 0.3536 - 0.3536i -0.5000 -0.5000
011001	25	0.5000 -0.1451 - 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.4785 - 0.1451i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 -0.4785 + 0.1451i -0.4619 - 0.1913i -0.1913 + 0.4619i
011010	26	0.5000 -0.0975 + 0.4904i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 -0.4904 - 0.0975i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.0975 - 0.4904i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.4904 + 0.0975i -0.3536 - 0.3536i 0.3536 + 0.3536i
011011	27	0.5000 0.3172 - 0.3865i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 0.3865 + 0.3172i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 -0.3172 + 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 -0.3865 - 0.3172i -0.1913 - 0.4619i 0.4619 - 0.1913i
011100	28	0.5000 -0.4619 + 0.1913i 0.5000i -0.5000	0.5000 -0.1913 - 0.4619i -0.5000i 0.5000i	0.5000 0.4619 - 0.1913i 0.5000i 0.5000	0.5000 0.1913 + 0.4619i -0.5000i -0.5000i
011101	29	0.5000 0.4976 + 0.0490i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 -0.0490 + 0.4976i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 -0.4976 - 0.0490i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 0.0490 - 0.4976i 0.1913 - 0.4619i -0.4619 - 0.1913i
011110	30	0.5000 -0.4157 - 0.2778i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.2778 - 0.4157i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.4157 + 0.2778i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 -0.2778 + 0.4157i 0.3536 - 0.3536i -0.3536 + 0.3536i
011111	31	0.5000 0.2357 + 0.4410i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 -0.4410 + 0.2357i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 -0.2357 - 0.4410i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 0.4410 - 0.2357i 0.4619 - 0.1913i 0.1913 + 0.4619i
100000	32	0.5000 -0.5000i -0.5000 -0.5000i	0.5000 0.5000 0.5000 -0.5000	0.5000 0.5000i -0.5000 0.5000i	0.5000 -0.5000 0.5000 0.5000
100001	33	0.5000 -0.2357 + 0.4410i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 -0.4410 - 0.2357i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 0.2357 - 0.4410i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 0.4410 + 0.2357i 0.4619 + 0.1913i 0.1913 - 0.4619i

Table 131—C_{base,UL}(4,4,6)

100010	34	0.5000 0.4157 - 0.2778i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 0.2778 + 0.4157i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.4157 + 0.2778i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.2778 - 0.4157i 0.3536 + 0.3536i -0.3536 - 0.3536i
100011	35	0.5000 -0.4976 + 0.0490i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 -0.0490 - 0.4976i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 0.4976 - 0.0490i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 0.0490 + 0.4976i 0.1913 + 0.4619i -0.4619 + 0.1913i
100100	36	0.5000 0.4619 + 0.1913i - 0.5000i 0.5000	0.5000 -0.1913 + 0.4619i 0.5000i - 0.5000i	0.5000 -0.4619 - 0.1913i -0.5000i -0.5000	0.5000 0.1913 - 0.4619i 0.5000i 0.5000i
100101	37	0.5000 -0.3172 - 0.3865i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 0.3865 - 0.3172i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 0.3172 + 0.3865i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 -0.3865 + 0.3172i -0.1913 + 0.4619i 0.4619 + 0.1913i
100110	38	0.5000 0.0975 + 0.4904i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.4904 + 0.0975i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.0975 - 0.4904i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 0.4904 - 0.0975i -0.3536 + 0.3536i 0.3536 - 0.3536i
100111	39	0.5000 0.1451 - 0.4785i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 0.4785 + 0.1451i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 -0.1451 + 0.4785i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 -0.4785 - 0.1451i -0.4619 + 0.1913i -0.1913 - 0.4619i
101000	40	0.5000 -0.3536 + 0.3536i 0.5000 0.5000i	0.5000 -0.3536 - 0.3536i -0.5000 0.5000	0.5000 0.3536 - 0.3536i 0.5000 -0.5000i	0.5000 0.3536 + 0.3536i -0.5000 -0.5000
101001	41	0.5000 0.4785 - 0.1451i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 0.1451 + 0.4785i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 -0.4785 + 0.1451i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 -0.1451 - 0.4785i -0.4619 - 0.1913i -0.1913 + 0.4619i
101010	42	0.5000 -0.4904 - 0.0975i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 0.0975 - 0.4904i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 0.4904 + 0.0975i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.0975 + 0.4904i -0.3536 - 0.3536i 0.3536 + 0.3536i
101011	43	0.5000 0.3865 + 0.3172i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 -0.3172 + 0.3865i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 -0.3865 - 0.3172i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3172 - 0.3865i -0.1913 - 0.4619i 0.4619 - 0.1913i
101100	44	0.5000 -0.1913 - 0.4619i 0.5000i -0.5000	0.5000 0.4619 - 0.1913i - 0.5000i 0.5000i	0.5000 0.1913 + 0.4619i 0.5000i 0.5000	0.5000 -0.4619 + 0.1913i -0.5000i -0.5000i
101101	45	0.5000 -0.0490 + 0.4976i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 -0.4976 - 0.0490i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 0.0490 - 0.4976i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 0.4976 + 0.0490i 0.1913 - 0.4619i -0.4619 - 0.1913i

Table 131—C_{base,UL}(4,4,6)

101110	46	0.5000 0.2778 - 0.4157i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 0.4157 + 0.2778i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.2778 + 0.4157i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 -0.4157 - 0.2778i 0.3536 - 0.3536i -0.3536 + 0.3536i
101111	47	0.5000 -0.4410 + 0.2357i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 -0.2357 - 0.4410i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 0.4410 - 0.2357i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 0.2357 + 0.4410i 0.4619 - 0.1913i 0.1913 + 0.4619i
110000	48	0.5000 0.5000 -0.5000 -0.5000i	0.5000 0.5000i 0.5000 -0.5000	0.5000 -0.5000 -0.5000 0.5000i	0.5000 -0.5000i 0.5000 0.5000
110001	49	0.5000 -0.4410 - 0.2357i -0.4619 - 0.1913i -0.4619 - 0.1913i	0.5000 0.2357 - 0.4410i 0.4619 + 0.1913i -0.1913 + 0.4619i	0.5000 0.4410 + 0.2357i -0.4619 - 0.1913i 0.4619 + 0.1913i	0.5000 -0.2357 + 0.4410i 0.4619 + 0.1913i 0.1913 - 0.4619i
110010	50	0.5000 0.2778 + 0.4157i -0.3536 - 0.3536i -0.3536 + 0.3536i	0.5000 -0.4157 + 0.2778i 0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.2778 - 0.4157i -0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 0.4157 - 0.2778i 0.3536 + 0.3536i -0.3536 - 0.3536i
110011	51	0.5000 -0.0490 - 0.4976i -0.1913 - 0.4619i 0.1913 + 0.4619i	0.5000 0.4976 - 0.0490i 0.1913 + 0.4619i 0.4619 - 0.1913i	0.5000 0.0490 + 0.4976i -0.1913 - 0.4619i -0.1913 - 0.4619i	0.5000 -0.4976 + 0.0490i 0.1913 + 0.4619i -0.4619 + 0.1913i
110100	52	0.5000 -0.1913 + 0.4619i - 0.5000i 0.5000	0.5000 -0.4619 - 0.1913i 0.5000i - 0.5000i	0.5000 0.1913 - 0.4619i -0.5000i -0.5000	0.5000 0.4619 + 0.1913i 0.5000i 0.5000i
110101	53	0.5000 0.3865 - 0.3172i 0.1913 - 0.4619i 0.1913 - 0.4619i	0.5000 0.3172 + 0.3865i -0.1913 + 0.4619i -0.4619 - 0.1913i	0.5000 -0.3865 + 0.3172i 0.1913 - 0.4619i -0.1913 + 0.4619i	0.5000 -0.3172 - 0.3865i -0.1913 + 0.4619i 0.4619 + 0.1913i
110110	54	0.5000 -0.4904 + 0.0975i 0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.0975 - 0.4904i -0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 0.4904 - 0.0975i 0.3536 - 0.3536i 0.3536 + 0.3536i	0.5000 0.0975 + 0.4904i -0.3536 + 0.3536i 0.3536 - 0.3536i
110111	55	0.5000 0.4785 + 0.1451i 0.4619 - 0.1913i -0.4619 + 0.1913i	0.5000 -0.1451 + 0.4785i -0.4619 + 0.1913i 0.1913 + 0.4619i	0.5000 -0.4785 - 0.1451i 0.4619 - 0.1913i 0.4619 - 0.1913i	0.5000 0.1451 - 0.4785i -0.4619 + 0.1913i -0.1913 - 0.4619i
111000	56	0.5000 -0.3536 - 0.3536i 0.5000 0.5000i	0.5000 0.3536 - 0.3536i -0.5000 0.5000	0.5000 0.3536 + 0.3536i 0.5000 -0.5000i	0.5000 -0.3536 + 0.3536i -0.5000 -0.5000
111001	57	0.5000 0.1451 + 0.4785i 0.4619 + 0.1913i 0.4619 + 0.1913i	0.5000 -0.4785 + 0.1451i -0.4619 - 0.1913i 0.1913 - 0.4619i	0.5000 -0.1451 - 0.4785i 0.4619 + 0.1913i -0.4619 - 0.1913i	0.5000 0.4785 - 0.1451i -0.4619 - 0.1913i -0.1913 + 0.4619i

Table 131— $C_{\text{base,UL}}(4,4,6)$

111010	58	0.5000 0.0975 - 0.4904i 0.3536 + 0.3536i 0.3536 - 0.3536i	0.5000 0.4904 + 0.0975i -0.3536 - 0.3536i -0.3536 - 0.3536i	0.5000 -0.0975 + 0.4904i 0.3536 + 0.3536i -0.3536 + 0.3536i	0.5000 -0.4904 - 0.0975i -0.3536 - 0.3536i 0.3536 + 0.3536i
111011	59	0.5000 -0.3172 + 0.3865i 0.1913 + 0.4619i -0.1913 - 0.4619i	0.5000 -0.3865 - 0.3172i -0.1913 - 0.4619i -0.4619 + 0.1913i	0.5000 0.3172 - 0.3865i 0.1913 + 0.4619i 0.1913 + 0.4619i	0.5000 0.3865 + 0.3172i -0.1913 - 0.4619i 0.4619 - 0.1913i
111100	60	0.5000 0.4619 - 0.1913i 0.5000i -0.5000	0.5000 0.1913 + 0.4619i -0.5000i 0.5000i	0.5000 -0.4619 + 0.1913i 0.5000i 0.5000	0.5000 -0.1913 - 0.4619i -0.5000i -0.5000i
111101	61	0.5000 -0.4976 - 0.0490i -0.1913 + 0.4619i -0.1913 + 0.4619i	0.5000 0.0490 - 0.4976i 0.1913 - 0.4619i 0.4619 + 0.1913i	0.5000 0.4976 + 0.0490i -0.1913 + 0.4619i 0.1913 - 0.4619i	0.5000 -0.0490 + 0.4976i 0.1913 - 0.4619i -0.4619 - 0.1913i
111110	62	0.5000 0.4157 + 0.2778i -0.3536 + 0.3536i 0.3536 + 0.3536i	0.5000 -0.2778 + 0.4157i 0.3536 - 0.3536i 0.3536 - 0.3536i	0.5000 -0.4157 - 0.2778i -0.3536 + 0.3536i -0.3536 - 0.3536i	0.5000 0.2778 - 0.4157i 0.3536 - 0.3536i -0.3536 + 0.3536i
111111	63	0.5000 -0.2357 - 0.4410i -0.4619 + 0.1913i 0.4619 - 0.1913i	0.5000 0.4410 - 0.2357i 0.4619 - 0.1913i -0.1913 - 0.4619i	0.5000 0.2357 + 0.4410i -0.4619 + 0.1913i -0.4619 + 0.1913i	0.5000 -0.4410 + 0.2357i 0.4619 - 0.1913i 0.1913 + 0.4619i

3.3.6.3.2.2 MU-MIMO base codebook

The base codebook for UL collaborative spatial multiplexing MIMO is same as the base codebook for UL SU-MIMO, defined in 3.3.6.3.2.1.

3.3.6.4 Codebook subsets for open-loop non-adaptive transmit precoding

3.3.6.4.1 OL SU-MIMO subset

The UL OL SU-MIMO codebook subset shall be used for non-adaptive precoding with MIMO mode 0 and MIMO mode 1.

The notation $C_{\text{UL,OL,SU}}(N_t, M_t, N_w)$ denotes the UL OL SU-MIMO codebook subset, which consists of N_w complex matrices of dimension N_t by M_t , and M_t denotes the number of streams. The notation $C_{\text{UL,OL,SU}}(N_t, M_t, N_w, i)$ denotes the i -th codebook entry of $C_{\text{UL,OL,SU}}(N_t, M_t, N_w)$.

$C_{\text{UL,OL,SU}}(N_t, M_t, N_w)$ shall be used for precoding with N_t transmit antennas and M_t streams with MIMO mode 0 and MIMO mode 1.

3.3.6.4.1.1 OL SU-MIMO subset for two transmit antennas

The UL OL SU-MIMO codebook subset for 2Tx is the same as the DL OL SU-MIMO codebook subset for 2Tx. $C_{\text{UL,OL,SU}}(2, M_t, N_w) = C_{\text{DL,OL,SU}}(2, M_t, N_w)$, and it shall be used for precoding with 2 transmit antennas and M_t streams with MIMO mode 0 and MIMO mode 1.

3.3.6.4.1.2 OL SU-MIMO subset for four transmit antennas

Table 132 gives the number of codewords N_w for each rank of the OL SU-MIMO codebook subset for four transmit antennas.

Table 132—Size of the UL 4Tx OL SU-MIMO codebook subset

Rank	1	2	3	4
N_w	4	4	4	4

The codewords $C_{UL,OL,SU}(4, M_p, 4, n)$ of the OL SU-MIMO codebook subset for four transmit antennas, $C_{UL,OL,SU}(4, M_p, 4)$ are given in Table 133 for each rank M_p . The corresponding codewords $C_{base,UL}(4, M_p, 6, m)$ of the uplink base codebook for four transmit antennas $C_{base,UL}(4, M_p, 6)$ are given in Table 133.

Table 133— $C_{UL,OL,SU}(4,1,4)$, $C_{UL,OL,SU}(4,2,4)$, $C_{UL,OL,SU}(4,3,4)$ and $C_{UL,OL,SU}(4,4,4)$

$C_{UL,OL,SU}(4, 1, 4, n)$		$C_{UL,OL,SU}(4, 2, 4, n)$		$C_{UL,OL,SU}(4, 3, 4, n)$		$C_{UL,OL,SU}(4, 4, 4, n)$	
n	$C_{base,UL}(4, 1, 6, m)$	n	$C_{base,UL}(4, 2, 6, m)$	n	$C_{base,UL}(4, 3, 6, m)$	n	$C_{base,UL}(4, 4, 6, m)$
0	$C_{base,UL}(4, 1, 6, 9)$	0	$C_{base,UL}(4, 2, 6, 9)$	0	$C_{base,UL}(4, 3, 6, 9)$	0	$C_{base,UL}(4, 4, 6, 9)$
1	$C_{base,UL}(4, 1, 6, 15)$	1	$C_{base,UL}(4, 2, 6, 15)$	1	$C_{base,UL}(4, 3, 6, 15)$	1	$C_{base,UL}(4, 4, 6, 15)$
2	$C_{base,UL}(4, 1, 6, 49)$	2	$C_{base,UL}(4, 2, 6, 49)$	2	$C_{base,UL}(4, 3, 6, 49)$	2	$C_{base,UL}(4, 4, 6, 49)$
3	$C_{base,UL}(4, 1, 6, 55)$	3	$C_{base,UL}(4, 2, 6, 55)$	3	$C_{base,UL}(4, 3, 6, 55)$	3	$C_{base,UL}(4, 4, 6, 55)$