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Re:	This document provides the OFDM topic for the MAC-PHY Ad Hoc output before the Session #15 of IEEE 802.16.
Abstract	The document contains the OFDM specific constructions suggested for the 802.16ab document
Purpose	The document intended to the review by MAC-PHY Ad Hoc group
Notice	
Release	
Patent Policy and Procedures	

OFDM MAC-PHY Interface

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This document provides the OFDM topic for the MAC-PHY Ad Hoc output before the Session #15 of IEEE 802.16.

8.3.4.3 OFDM PHY Burst Definition and MAP Messages

8.3.4.3.1 Uplink Channel Descriptor (UCD) Message Parameters

No change in the UCD format comparatively to [Ref to D4], 6.2.2.3.1 "Uplink Channel Descriptor (UCD) message". The OFDM specific Overall Channel Parameters and Burst profile Parameters are specified in 11.1.1

8.3.4.3.2 Downlink Channel Descriptor (DCD) Message Parameters

No change in the DCD format comparatively to [Ref to D4], 6.2.2.3.2 "Uplink Channel Descriptor (DCD) message". The OFDM specific Overall Channel Parameters and Burst profile Parameters are specified in 11.1.2.

8.3.4.3.3 Mini-slot Definition

<<< To be removed to "Common" >>>

8.3.4.3.4 Frame Structure

Frame means interval that starts from the beginning of the preamble preceding the downlink FCH burst (see 8.3.4.3.6) that contains at least one DL-MAP or DL-UL-MAP message and lasts up to the start of the preamble preceding the next burst of the same type.

This definition does not require the frames to be of the same size.

The frame interval contains both transmissions (PHY PDUs) of BS and SSs and intervals of silence (gaps). The frame length is encoded in the Frame Length Code in the PHY Synchronization Field, see 8.3.4.3.7.1. This field allows for the reception of the next PCH burst.

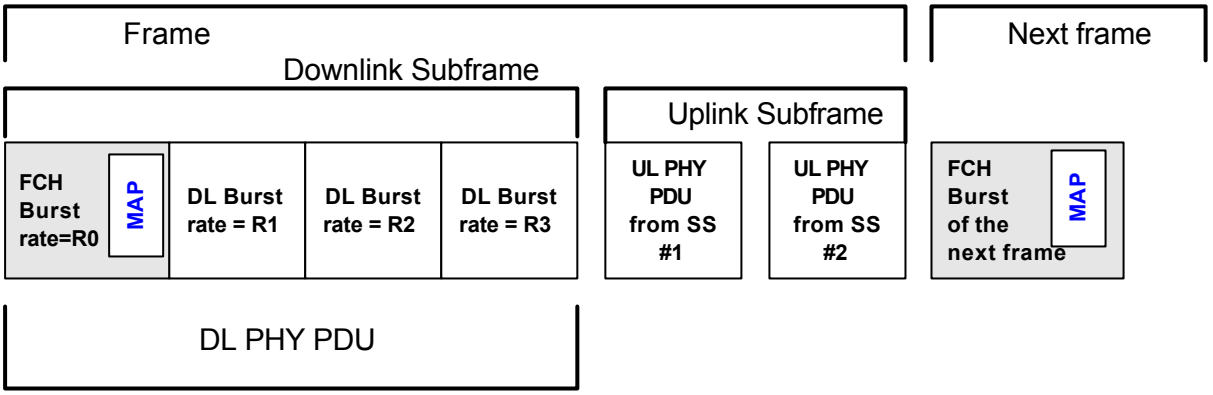


Figure 1. Frame Structure

PHY PDU consists of one or several bursts; each one transmitted with fixed PHY parameters. PHY PDU always starts from a preamble. The bursts MAY be separated by mid-ambles.

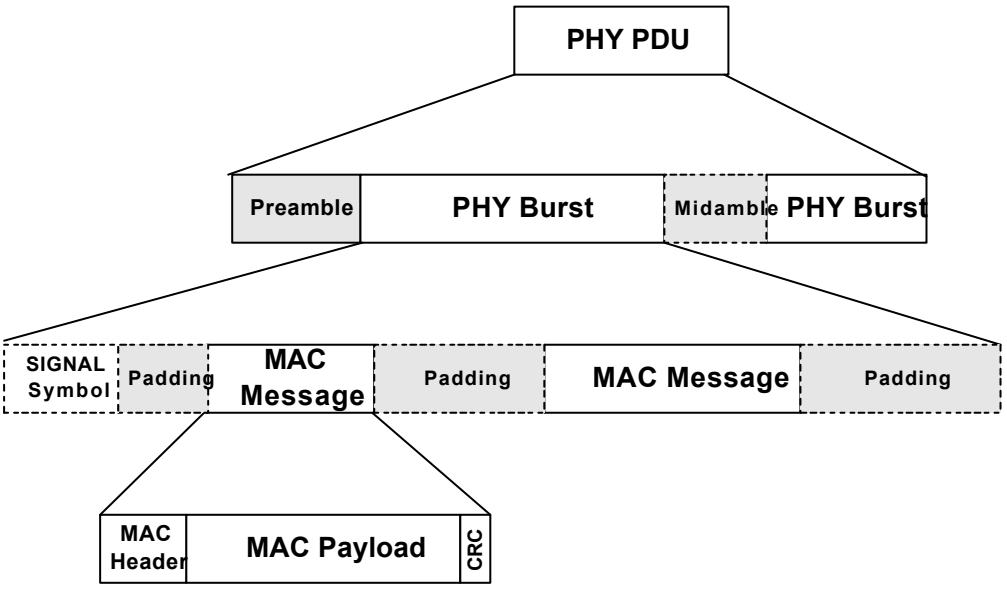


Figure 2. Burst Structure

To form an integer number of OFDM symbols, a burst payload may be padded by the bytes 0xFF. The padding may appear in any location between MAC Messages. Then the payload should be scrambled, encoded and modulated using a FEC type and a modulation type specified by this standard.

8.3.4.3.5 Preambles

A burst MAY start from a preamble that can be of one of the following types:

- Long

Used in the cases when the receiver needs to acquire precise information on the timing of the transmission. For example, an SS may need to acquire such information when started synchronizing to the downlink (within the Network Entry procedure).

- Short

Used for the synchronization purposes in the cases when the receiver has already acquired timing information.

- Mid-amble

May be inserted for channel estimation purposes between consequent bursts.

See [Reference to PHY part] for the definition of the abovementioned waveforms.

8.3.4.3.6 FCH Burst and DL Frame prefix

A special PHY burst format (FCH or Frame Control Header) is used for DL Frame prefix to make possible initial synchronization and acquisition of DL and UL channels parameters. Such a burst always has a long preamble and contains DL Frame prefix. It may contain also MAC messages, such as DL-MAP, UL-MAP, DCD, UCD, and MAC padding that includes octets 0xFF to complete the OFDM symbol.

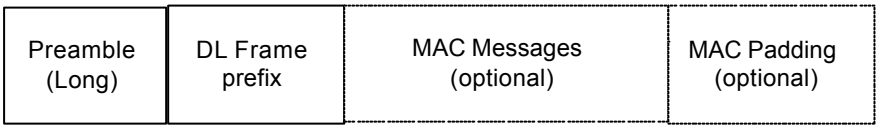


Figure 3. FCH Burst

FCH burst is one symbol long; it is transmitted at the following well-known modulation/coding:

It contains the **DL Frame Prefix** information on the PHY parameters and length of the ***next burst*** that MAY contain DL-MAP, UL-MAP, UCD and DCD messages. The next burst should not be separated from the FCH by mid-amble.

The next figure describes the structure of DL Frame Prefix:

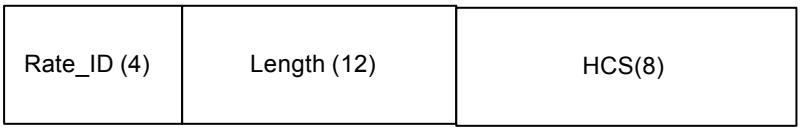


Figure 4. DL Frame Prefix

The following are the fields of DL Frame Prefix.

Rate_ID: Field that defines the modulation / coding parameters of the following burst. Encoding is specified in the following table:

Rate_ID	Modulation	Coding Rate	RS Code
0	**QPSK**	**1/2**	**(32,24,4)**

1	**QPSK**	**3/4**	**(40,36,2)**
2	**16 QAM**	**1/2**	**(64,48,8)**
3	**16 QAM**	**3/4**	**(80,72,4)**
4	**64 QAM**	**2/3**	**(108,96,6)**
5	**64 QAM**	**3/4**	**(120,108,6)**

Length: Number of OFDM symbols (PHY payload) in the following burst.

HCS: An 8-bit Header Check Sequence used to detect errors in the DL Frame Prefix. The generator polynomial is $g(D)= D^8 + D^2 + D + 1$

FCH burst MAY contain also MAP messages.

8.3.4.3.7 MAP Messages

The following are the Management Message Types allocated to MAP messages in the case of OFDM (see the definition of the DL IE types 1 and 2 in 8.3.4.3.7.2)

Message Function	Type	Comments
DL-MAP with IEs type 1	TBD	
DL-MAP with IEs type 2	TBD	
UL-MAP	TBD	
DL-UL-MAP with DL IEs type 1	TBD	
DL-UL-MAP with DL IEs type 2	TBD	

8.3.4.3.7.1 Synchronization Field

<<< Still under discussion >>

The following is the structure of PHY Synchronization Field of the DL-MAP message.

Field	Size, bits	Notes
Synchronization_ Field {	8	The allowable frame duration Codes are given by the table [TBD]
Frame Duration Code	8	The allowable frame duration Codes are given by the table [TBD]
Frame Number	24	The Frame Number is incremented by 1 every frame and eventually wraps around to zero
}		

The following codes are used

Code = N	Meaning
0	UNDEFINED. Means that the frame lasts up to the arrival of the next DL-MAP message
1 255	TBD

8.3.4.3.7.2 DL MAP Information Element Format

DL MAP Information Elements have the following format:

Syntax	Size	Notes
DL-MAP_Information_Element() {		
DIUC	4	
Start Time	12	
}		

- **Downlink Interval Usage Code**

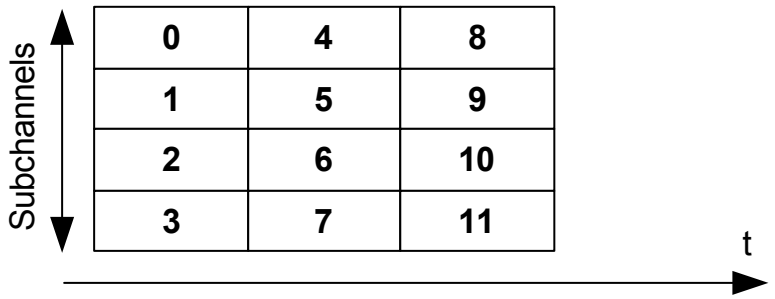
A four-bit Uplink Interval Usage Code (UIUC) shall be used to define the type of uplink access and the burst type associated with that access. A Burst Descriptor shall be included for each Interval Usage Code that is to be used in the UL-MAP. The Interval Usage Code shall be one of the values defined in the table XXX.

- **Start Time**

For the IE type 1 indicates the start time, in units of symbol duration, relative to the start of the PHY PDU where the DL-MAP message is transmitted. Consequently the first IE will have an offset of 0. The end of the last allocated burst is indicated by allocating a NULL burst (CID = 0 and UIUC = 10) with zero duration. The time instants indicated by the Start Time values are the transmission times of the first symbol of the burst including preamble.

For the IE type 2 indicates the start of the burst in the sub-channel units (one sub-channel = 48 subcarriers) assuming that the sub-channels are numbered in the order "subcarriers first" (see the picture below for FFT-256). The value 0 corresponds to the first symbol of the PHY PDU where the DL-MAP message is transmitted.

Note. The numbering of the subcarriers is performed not necessarily in the order of increasing or decreasing frequency but according to the permutation rules defined in PHY section.



<<< For OFDM with 48 subcarriers for 3.5 MHz channel the allocation range for IEs type 1 can be estimated as 2^{12} * 18 usec = 73728 usec. Using e.g. mini-slots instead of symbol time, as units in the offset would decrease the range down to 900 usec that clearly is not enough. The allocation range for IEs type 2 with 256 subcarriers can be estimated as 2^{10} * 18 usec = 18432 usec >>>

8.3.4.3.7.3 UL MAP Information Element Format

UL-MAP elements (PHY Specific Section) define the physical parameters and the start time for UL PHY bursts. The format of UL-MAP elements is the following:

Table 1. UL-MAP Element

Name	Size, bits	Notes
UL-MAP_Information_Element() {		
CID	16	
UIUC	4	
Offset	12	
}		

- **Connection Identifier (CID)**

Represents the assignment of the IE to a unicast, multicast, or broadcast address. When specifically addressed to allocate a bandwidth grant, the CID may be either the Basic CID of the SS or a Traffic CID for one of the connections of the SS.

- **Uplink Interval Usage Code (UIUC)**

A four-bit Uplink Interval Usage Code (UIUC) shall be used to define the type of uplink access and the burst type associated with that access. A Burst Descriptor shall be included for each Interval Usage Code that is to be used in the UL-MAP. The Interval Usage Code shall be one of the values defined in.

- **Offset**

The offset indicates the start time, in units of mini-slots, of the burst relative to the Allocation Start Time given in the UL-MAP message. Consequently the first IE will have an offset of 0. The end of the last allocated burst is indicated by allocating a NULL burst (CID = 0 and UIUC = 10) with zero duration. The time instants indicated by the offsets are the transmission times of the first symbol of the burst including preamble.

8.3.4.3.7.4 DIUC Allocation

The following table contains DIUC values used in **DL MAP Information Element.**

Table 2. DIUC Values

DIUC	Usage
0	Long preamble
1	Short preamble
2	Midamble
3-12	Different Burst profiles
13	Gap
14	End of Map

15	Extended DIUC (TBD)

8.3.4.3.7.5 UIUC Allocation

Table 3. UIUC Values

UIUC	Usage
0	Long preamble
1	Short preamble
2	SBP (Subcarrier Based polling) Slot
3 12	Different Burst profiles
13	Gap
14	End of Map
15	Extended UIUC (TBD)

8.3.4.3.7.6 MAP Relevance and Synchronization

All the timing information in DL-MAP, UL-MAP, DL-UL-MAP is relative. The following time instants are used as a reference for the timing information

- DL-MAP and the correspondent part of DL-UL-MAP: the start of the first symbol of PHY PDU where the message is transmitted
- UL-MAP and the correspondent part of DL-UL-MAP: the start of the first symbol of PHY PDU where the message is transmitted + Allocation Start Time value

11.1.1 "UCD message encodings"

<<< The following is to change the Table 122 UCD Channel Encodings in the section 11.1.1 "UCD message encodings" of D4 document >>>

The "roll-off factor" parameter should be replaced with the following:

<<< This encoding covers both OFDM and OFDMA cases >>>

Name	Type (1 byte)	Length (1 byte)	Value (1 byte)
FFT Size Code	8	1	The following is the encoding for the possible parameter values: 0 = FFT-64 1 = FFT-128 2 = FFT-256 3 = FFT-512 4 = FFT-1024 5 = FFT-2048 6-255 = Reserved

11.1.1.2 UCD Burst Profile Encodings

<<< The following is to replace the Table 123 UCD Burst Profile Encodings from 11.1.1.2 "UCD Burst Profile Encodings" of D4 document >>>

Table 123 UCD Burst Profile Encodings

Name	Type (1 byte)	Length (1 byte)	Value (1 bytes)
Modulation type	2	1	The following codes are used: 0 = BPSK 1 = QPSK 2 = 16QAM 3 = 64QAM 4 = 256QAM 5-255 = Reserved
Convolutional FEC Code Type	3	1	TBD
Reed Solomon FEC Code Type	4	1	TBD
DIUC mandatory exit threshold	5	2	C/(N+I) at or below which this UIUC can no longer be used and at which a change to a more robust DIUC is required, in 0.25 dB units
DIUC minimum entry threshold	6	2	The minimum C/(N+I) required to start using this UIUC when changing from a more robust UIUC is required, in 0.25 dB units

11.1.2.2 DCD burst profile encodings

<<< The following is to change the Table 125 DCD Burst Profile Encodings from "11.1.2.2 DCD Burst Profile Encodings" of D4 document >>>

Table 125 DCD Burst Profile Encodings

Name	Type (1 byte)	Length (1 byte)	Value (1 bytes)
Modulation type	2	1	The following codes are used: 0 = BPSK 1 = QPSK 2 = 16QAM 3 = 64QAM 4 = 256QAM 5-255 = Reserved
Convolutional FEC Code Type	3	1	TBD

Reed Solomon FEC Code Type	4	1	TBD
DIUC mandatory exit threshold	5	2	C/(N+I) at or below which this DIUC can no longer be used and at which a change to a more robust DIUC is required, in 0.25 dB units
DIUC minimum entry threshold	6	2	The minimum C/(N+I) required to start using this DIUC when changing from a more robust DIUC is required, in 0.25 dB units

11.1.4 "RNG-RSP message encodings"

<<< The following should be the change in the Table 127RNG-RSP Message Encodings from the section 11.1.4 "RNG-RSP message encodings" of D4 >>>

Name	Type (1 byte)	Length (1 byte)	Value (4 bytes)
Timing Adjust	1	4	Tx timing offset adjustment (signed 32-bit, units of sample duration). The time by which to advance SS transmission so that frames arrive at the expected time instance at the BS

<<< This section describes MAC functions related to Subcarrier Based Polling >>>

8.3.6.5 Subcarrier Based Polling (SBP)

8.3.6.5.1. Arrangement of SBP Multicast Groups

BS divides all the SSs participating in SBP into multicast groups each one identified by certain CID. A special protocol is used to inform each SS on the group it belongs to plus the SS Index (or range of indexes) within the group.
The following new parameters should be added to the table 109, 11.1.4.1 MCA-REQ and MCA-RSP TLV Encodings.

Name	Type	Length	Value
SBP Group Index Assignment	3	2	0 to TBD, index value
SBP Group Start Index Assignment	4	2	0 to TBD, start index value
SBP Group End Index Assignment	5	2	0 to TBD, end index value

TLV with Type = 3 appears only together with Multicast CID (Type = 1).
TLVs with Types = 4, 5 appear only together and together with Multicast CID (Type = 1).

8.3.6.5.2 Allocation of Transmission Opportunities

When BS allocates one or several time slot for the given CID. It means that all the SSs belonging to the group have to transmit. The space of transmission opportunities is two-dimensional (time-subcarrier space). The opportunities are numbered in the order "subcarriers first". Each SS chooses for the transmission the opportunity (opportunities) that corresponds its index (range of indexes) in the group (Figure XXX). For example,

- If SS got an index 54, it means that the transmission opportunity is the subcarrier number 6 at the second symbol duration interval (assuming 48 subcarriers in use)
- If SS got an index range 112-115, it means that the transmission opportunity is the set of subcarriers with numbers 16 to 19 at the 3d symbol duration interval: 112 = 48 * 2 + 16

Transmission / reception may be performed in two modes:

1. Transmission present / absent means that SS has / does not have demand
2. Transmission contains one bit modulated using by TBD modulation. Then

BS decides on the presence of demand according to majority voting rule for all transmissions received from the given SS at the current act of polling.

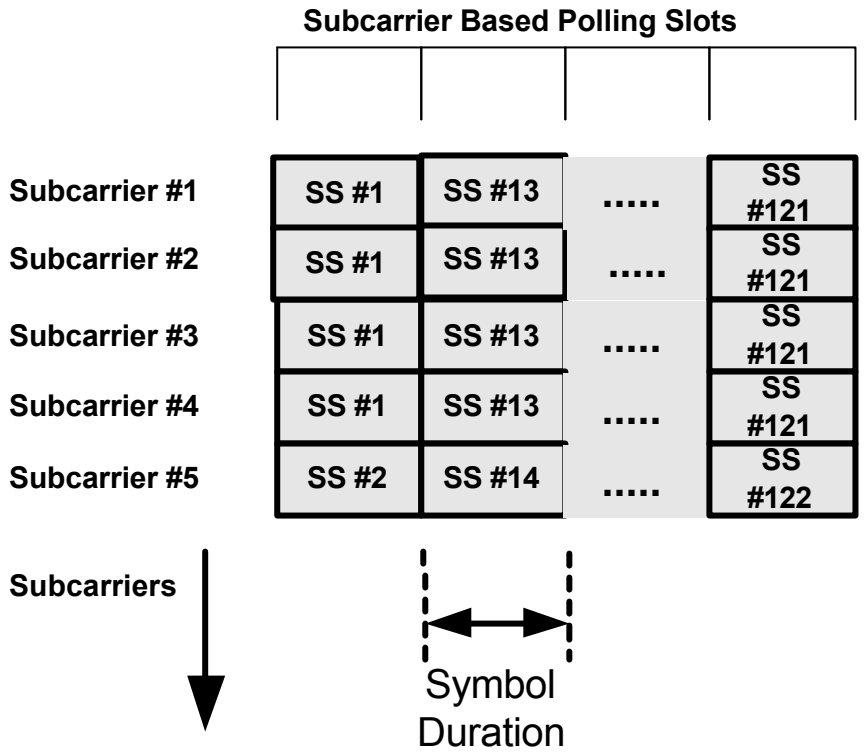


Figure XXX. SBP Transmission Example