IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Proposed Draft Text: Mathematical description of signals | | | | |
| Date: 2020-12-03 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Yan Zhang | NXP |  |  |  |
| Ruchen Duan | Samgsung |  |  |  |
|  |  |  |  |  |

Abstract

This submission shows

* Mathematical description of signal

Revisions:

* Rev 0: Initial version of the document.
* Rev 1: Highlighted TBD topics in yellow
* Rev 2: Fixed tone index for 320/160+160MHz phase rotation Equations
* Rev 3: Added Hightlighted TBD text in yellow
* Rev 4: Remove TBD in D0.2 based on latest motions, Motion 137 ( Noncontiguous 80+80 MHz and 160+160 MHz are not defined), Motion 135 (no midamble in R1),

**36.3.10 Mathematical description of signals**

**36.3.10.1 Notation**

For a description of the conventions used for the mathematical description of the signals, see 17.3.2.5 (Mathematical

conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 36 (Extremely high throughput (EHT) PHY specification):

indicates the element in row and column of matrix, where and .

and are the number of rows and columns, respectively, of the matrix .

indicates a matrix consisting of columns to of matrix .

**36.3.10.2 Subcarrier indices in use**

For a description on subcarrier indices over which the signal is transmitted for non-HT, HT and VHT PPDUs, see 21.3.7 (Mathematical description of signals). For a description on subcarrier indices over which the signal is transmitted for HE PPDUs, see 27.3.10 (Mathematical description of signals).

For a 20 MHz non-OFDMA EHT PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal

is transmitted on all or a subset of subcarriers -122 to -2 and 2 to 122, with 0 being the center subcarrier.

For a 20 MHz OFDMA EHT PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is

transmitted on all or a subset of the subcarriers -122 to -4 and 4 to 122, with 0 being the center subcarrier.

For a 40 MHz non-OFDMA EHT PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal

is transmitted on subcarriers -244 to -3 and 3 to 244, with 0 being the center subcarrier.

For a 40 MHz OFDMA EHT PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is

transmitted on all or a subset of subcarriers -244 to -3 and 3 to 244, with 0 being the center subcarrier.

For an 80 MHz non-OFDMA EHT PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal

is transmitted on subcarriers -500 to -3 and 3 to 500, with 0 being the center subcarrier.

For an 80 MHz OFDMA EHT PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is

transmitted on all or a subset of the subcarriers -500 to -259, -253 to -12, 12 to 253, and 259 to 500, with 0 being the center subcarrier.

For a 160 MHz EHT PPDU transmission, each half 80 MHz bandwidth is divided into 1024 subcarriers, and the subcarriers on which the signal is transmitted in each 80 MHz bandwidth is identical to an 80 MHz EHT PPDU transmission, depending on non-OFDMA or OFDMA transmission within the corresponding 80 MHz.

For a 320 MHz EHT PPDU transmission, each half 160 MHz bandwidth is divided into 2048 subcarriers, and the subcarriers on which the signal is transmitted in each 160 MHz bandwidth is identical to an 160 MHz EHT PPDU transmission, depending on non-OFDMA or OFDMA transmission within the corresponding 160 MHz.

**34.3.10.3 Channel frequencies**

Let

(36-1)

(36-2)

(36-3)

where

and are defined in Table 36-15 (Fields to specify EHT channels).

**Table 36-15—Fields to specify EHT channels**

|  |  |
| --- | --- |
| **Field** | **Meaning** |
|  | Channel width. Possible values represent 20 MHz, 40 MHz, 80 MHz, 160 MHz, and 320 MHz channels. |
|  | For a 20 MHz, 40 MHz, 80 MHz, 160 MHz, or 320 MHz channel, denotes the channel center frequency. Valid range is 1 to 200 for 5GHz band, and 1 to 253 for 6GHz band. |
|  | Denotes the location of the primary 20 MHz channel.  Valid range is 1 to 200 for 5GHz band, and 1 to 253 for 6GHz band. |

When is 20 MHz, 40 MHz, 80 MHz, or160 MHz, the relationship between and is specified in Equation (21-5) in 21.3.7.3 (Channel frequencies).

When is 320 MHz, and shall have the relationship specified in Equation (36-4).

(36-4)

where

. is an integer with possible range .

When is 40 MHz, 80 MHz, 160 MHz, or 320 MHz, the relationship between and is specified in Equation (21-6), and the relationship between and is specified Equation (21-7) in 21.3.7.3 (Channel frequencies).

When is 80 MHz, 160 MHz, or 320 MHz, the relationship between and is specified in Equation (21-8), and the relationship between and are specified in Equation (21-9) in 21.3.7.3 (Channel frequencies).

When is 160 MHz, or 320 MHz, the relationship between and are specified in Equation (21-10) in 21.3.7.3 (Channel frequencies).

When is 320 MHz,

— The primary 160 MHz channel is the channel with 160 MHz bandwidth centered at   
 MHz, where is given in Equation (36-5)

— The secondary 160 MHz channel is the channel with 160 MHz bandwidth centered at   
 MHz, where is given in Equation (36-6)

(36-5)

(36-6)

where .

**36.3.10.4 Transmitted signal**

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal on

transmit chain is related to the complex baseband signal by the relation

shown in Equation (36-7).

**(36-7)**

where

represents the complex baseband signal of transmit chain .

represents the center frequency of the transmitted PPDU. Table 36-16 (Center frequency of the transmitted PPDU) shows as a function of the channel starting frequency, dot11CurrentChannelWidth and CH\_BANDWIDTH, where , , , , , and are described in 36.3.10.3 (Channel frequencies).

**Table 36-16—Center frequency of the transmitted PPDU**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **CH\_BANDWIDTH** |  | |
|  |  |
| 20 MHz | CBW20 |  |  |
| 40 MHz | CBW20 |  |  |
| CBW40 |  |  |
| 80 MHz | CBW20 |  |  |
| CBW40 |  |  |
| CBW80 |  |  |
| 160 MHz | CBW20 |  |  |
| CBW40 |  |  |
| CBW80 |  |  |
| CBW160 |  |  |
| 320 MHz | CBW20 |  |  |
| CBW40 |  |  |
| CBW80 |  |  |
| CBW160 |  |  |
| CBW320 |  |  |

The transmitted RF signal is derived by upconverting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 34-3.10-1 (Timing boundaries for EHT PPDU fields), where is the number of EHT-LTF symbols and is defined in Table 36-14 (Frequently used parameters), is the number of OFDM symbols in the EHT-SIG field present in an EHT MU PPDU, and is the number of data OFDM symbols.



Figure 36-32 – Timing Boundaries for EHT PPDU fields

NOTE – Data OFDM symbols are OFDM symbols in the Data field of an EHT PPDU.

The time offset, , determines the starting time of the corresponding field relative to the start of L-STF ().

The signal transmitted on transmit chain shall be as shown in Equation (36-8).

(36-8)

where

is only applicable to an EHT MU PPDU



















In an EHT MU PPDU, for each field excluding the PE field, is defined as the summation of one or more subfields. Each subfield, , is defined to be an inverse Fourier transform in Equation (36-9).

(36-9)

***Editor’s Note: Per the authors of 20/1337r3,***  ***in Equation (36-9) is TBD.***

In an EHT TB PPDU, transmitted by user *u* in the *r*-th occupied RU or MRU, each subfield, , is defined in Equation (36-10).

(36-10)

***Editor’s Note: Per the authors of 20/1337r3, in Equation (36-10) is TBD.***

In the remainder of this subclause, pre-EHT modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, U-SIG and EHT-SIG fields, while EHT modulated fields refer to EHT-STF, EHT-LTF, Data and PE fields, as shown in Figure 36-32 (Timing boundaries for EHT PPDU fields).

For an EHT MU PPDU, the total power of the time domain EHT modulated field signals summed over all transmit chains should not exceed the total power of the time domain pre-EHT modulated field signals summer over all transmit chains.

For an EHT TB PPDU, the total power of the time domain EHT modulated field signals summed over all transmit chains may exceed the total power of the time domain pre-EHT modulated field signals summer over all transmit chains by up to 3dB.

For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (36-9) and Equation (36-10) the following notations are used:

is a windowing function. An example function, , is given in 17.3.2.5 (Mathematical conventions in the signal descriptions).

is defined in Table 36-14 (Frequently used parameters)

For pre-EHT modulated fields, . For EHT modulated fields, for an EHT MU PPDU, and for an EHT TB PPDU, where and are given in Table 36-14 (Frequently used parameters).

is the power boost factor in the range of the *r*-th occupied RU or MRU in an EHT MU PPDU. For an EHT MU PPDU, an AP shall limit the ratio between the maximum value of and the minimum value of to 2 unless the Power Boost Factor Support subfield of the EHT PHY Capabilities Information field in the EHT Capabilities element from all recipient STAs is 1, in which case the AP can use a ratio of up to 4. For an EHT MU PPDU transmitted to single user, is always set to 1 (TBD).

For pre-EHT modulated fields, is the set of subcarriers indices in the allocated 20 MHz channels. For EHT modulated fields in a non-punctured non-OFDMA EHT PPDU, is the set of subcarriers indices from to as defined in Table 36-10 (Subcarrier allocation related constants for the EHT modulated fields in a full bandwidth non-OFDMA EHT PPDU) excluding DC subcarriers. For EHT modulated fields in a punctured non-OFDMA EHT PPDU and an OFDMA EHT PPDU, is the set of subcarriers indices for the tones in the *r*-th RU or MRU. Data and pilot subcarrier indices for RUs are defined in Table 27-7 (Data and pilot subcarrier indices for RUs in a 20 MHz HE PPDU and in a non-OFDMA 20 MHz HE PPDU), Table 27-8 (Data and pilot subcarrier indices for RUs in a 40 MHz HE PPDU and in a non-OFDMA 40 MHz HE PPDU), Table 36-5 (Data and pilot subcarrier indices for RUs in an 80 MHz EHT PPDU), Table 36-6 (Data and pilot subcarrier indices for RUs in a 160 MHz EHT), and Table 36-7 (Data and pilot subcarrier indices for RUs in a 320 MHz EHT PPDU). Data and pilot subcarrier indices for MRUs consist of the data and pilot subcarrier indices of all component RUs.

is the power normalization factor and is defined in Equation (36-11).

***Editor’s Note: Per the authors of 20/1337r2, in Equation (36-11) is TBD.***

(36-11)

Table 36-17 (Number of modulated subcarriers and guard interval duration values for EHT PPDU fields) summarizes the various values of as a function of bandwidth.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 36-17— Number of modulated subcarriers and guard interval duration values for EHT PPDU fields | | | | | | |
| Field | as a function of bandwidth | | | | | Guard interval duration | |
| 20 MHz | 40 MHz | 80 MHz | 160 MHz | 320 MHz |
| L-STF | 12 | 24 | 48 | 96 | 192 | - | |
| L-LTF | 52 | 104 | 208 | 416 | 832 | *TGI,*L-LTF | |
| L-SIG in an EHT PPDU | 56 | 112 | 224 | 448 | 896 | *TGI,*Pre-EHT | |
| L-SIG in a non-HT duplicate PPDU | - | 104 | 208 | 416 | 832 |
| RL-SIG | 56 | 112 | 224 | 448 | 896 | *TGI,*Pre-EHT | |
| U-SIG | 56 | 112 | 224 | 448 | 896 | *TGI,*Pre-EHT | |
| EHT-SIG | 56 | 112 | 224 | 448 | 896 | *TGI,*Pre-EHT | |
| NON\_HT\_DUP\_OFDM-Data (see NOTE) | - | 104 | 208 | 416 | 832 | *TGI,*Pre-EHT | |

(TBD)

is a set of 20 MHz channels where pre-EHT modulated fields are located. The set of 20 MHz channels contains one or more values in the range 0 to for an EHT MU PPDU with preamble puncturing, or an EHT TB PPDU, and it contains all values in the range 0 to for an EHT MU PPDU without preamble puncturing.

is the cardinality of the set of 20MHz channels .

is the cardinality of the set of subcarriers

is the cardinality of the set of modulated subcarriers within for the EHT-STF and Data fields. For EHT-LTF field,

is the power scale factor of the *k*-th subcarrier of a given field within an OFDM symbol for an EHT TB PPDU. For the pre-EHT modulated fields, is in the range of . For EHT modulated fields, (TBD).

is the spatial mapping matrix for subcarrier *k*. For EHT modulated fields, is a matrix with rows and columns. For pre-EHT modulated fields is a column vector with elements, with element being , where represents the cyclic shift for the transmitter chain whose value is defined in 36.3.11.2.1 (Cyclic shift for pre-EHT modulated fields).

is the spatial mapping matrix for user *u* on subcarrier *k*. For EHT modulated fields, is a matrix with rows and columns. For pre-EHT modulated fields is a column vector with elements, with element being , where represents the cyclic shift for the transmitter chain whose value is defined in 36.3.11.2.1 (Cyclic shift for pre-EHT modulated fields).

is the subcarrier frequency spacing. For pre-EHT modulated fields, given in Table 34-9 (Timing-related constants). For EHT modulated fields, given in Table 34-9 (Timing-related constants).

is given in Table 34-14 (Frequently used parameters).

is the frequency-domain symbol assigned for subcarrier *k* of user *u* in the *r*-th RU or MRU for the *m*-th spatial stream. Some of the within have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the null subcarriers in an EHT OFDMA PPDU, as well as the unmodulated tones of L-STF, EHT-STF, and EHT-LTF fields.

is the guard interval duration used for each OFDM symbol in the field. The value for each field is defined in Table 34-9 (Timing-related constants).

For pre-EHT modulated fields, . For EHT modulated fields, represents the cyclic shift per spatial stream, whose value is defined in 36.3.11.2.2 (Cyclic shift for EHT modulated fields).

is used to represent a phase rotation applied to the *k*-th subcarrier for a given bandwidth , which is determined by the TXVECTOR parameter CH\_BANDWIDTH as defined in Table 36-18 (CH\_BANDWIDTH and for pre-EHT modulated fields). For EHT modulated fields, for all subcarriers. For pre-EHT modulated fields, is defined as in 21.3.7.5 (Definition of tone rotation) for 20 MHz, 40 MHz, 80 MHz, and 160 MHz PPDU transmission, and in Equation (36-12) for 320 MHz PPDU transmission.

For a 320 MHz PPDU transmission,

(36-12)

|  |  |
| --- | --- |
| Table 36-18— CH\_BANDWIDTH and for pre-EHT modulated fields | |
| CH\_BANDWIDTH |  |
| CBW20 | *k,*20 |
| CBW40 | *k,*40 |
| CBW80 | *k,*80 |
| CBW160 | *k,*160 |
| CBW320 | *k,*320 |
| EHT-CBW-PUNC80 (TBD) | *k,*80 |
| EHT-CBW-PUNC160 (TBD) | *k,*160 |
| EHT-CBW-PUNC320 (TBD) | *k,*320 |