IEEE P802.11  
Wireless LANs

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| Control Mode PPDU Transmission | | | | |
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Abstract

This document proposes specification text for subclause 30.4.2 and 30.4.5 of the spec describing Control mode PPDU transmission, [1], [2].

**Change to D0.35:** 30.4.1 (General)

*Change the third paragraph of 30.4.1 as follows*

~~All fields of an EDMG control mode PPDU except for the TRN field shall be transmitted using a single spatial stream. The TRN field of an EDMG control mode PPDU may be transmitted with multiple spatial streams, depending on the capability of the transmitter and receiver in supporting multiple streams.~~

If an EDMG control mode PPDU is transmitted with multiple transmit chains, all fields of the EDMG control mode PPDU except for the TRN field shall be transmitted using the non-EDMG duplicate format and, as defined in 30.9, the TRN field shall consist of *N* orthogonal waveforms, where *N* is the number of transmit chains used in the transmission of the EDMG control mode PPDU. The waveform of an EDMG Control Mode PPDU is defined in 30.4.5.

*Add the following paragraph at the end of 30.4.1*

The number of transmit chains used in the transmission of an EDMG control mode PPDU is indicated in its EDMG-Header-A, as defined in 30.3.3.3.2.2.

**Change to D0.35:** 30.4.2

*Editor: insert new subclause 30.4.2 with the following (including title), shift the rest of the sections numbering by one*

**30.4.2 Control mode transmitter block diagram**

**30.4.2.1 General**

EDMG and non-EDMG Control mode PPDU transmissions can be generated using a transmitter consisting of the following blocks:

* Scrambler scrambles the data to reduce the probability of long sequences of 0s and 1s; see 30.4.4.2.2 (Scrambler).
* LDPC encoder encodes the data to enable error correction. It performs bit padding to get an integer number of codewords; see 30.4.4.2.3 (Encoder).
* Constellation mapper maps the sequence of bits to constellation points; see 30.4.4.2.4 (Modulation and spreading).
* Spreader spreads out a single constellation point to 32 chips applying Ga Golay sequence of length 32; see 30.4.4.2.4 (Modulation and spreading).
* Golay builder builds π/2-BPSK modulated Ga and Gb Golay sequences comprising the L-STF, L-CEF, and TRN units; see 30.10;
* Cyclic shift (CSD) insertion prevents the signal from unintentional beamforming. A cyclic shift is specified per transmitter chain for non-EDMG duplicate and EDMG PPDU transmission.
* Pulse shaping performs convolution of constellation points with shape filter impulse response with possible sampling rate change. For duplicate channel transmission, pulse shaping may include a relative time delay between the primary and secondary channels. The exact definition of shape filter impulse response is out of scope of this standard and is implementation specific.

**30.4.2.2 Non-EDMG PPDU transmission**

Figure 1 shows the transmitter blocks used to generate the non-EDMG PPDU. The L-STF, L-CEF fields, and TRN units of PPDU are generated using Golay builder block. The L-Header and data part of PPDU are generated using scrambler, LDPC encoder, constellation mapper, and spreader. The encoded and modulated bit stream is mapped to the *NTX* transmit chains applying spatial expansion with relative cyclic shift over the chains as defined in 30.4.5.2.



Figure 1: Control mode transmitter block diagram for non-EDMG PPDU transmission

**30.4.2.3 EDMG PPDU transmission**

Figure 2 shows the transmitter blocks used to generate the EDMG PPDU. The L-STF, L-CEF fields, and TRN units of PPDU are generated using Golay builder block. The L-Header, EDMG-Header-A, and data part of PPDU are generated using scrambler, LDPC encoder, constellation mapper, and spreader. The encoded and modulated bit stream is mapped to the *NTX* transmit chains applying spatial expansion with relative cyclic shift over the chains as defined in 30.4.5.3. The cyclic shift is not applied to the TRN units appended to the frame and each chain transmits its own TRN unit as defined in 30.9.2.2.5.



Figure 2: Control mode transmitter block diagram for EDMG PPDU transmission

**Change to D0.35:** 30.4.5

*Editor: insert new subclause 30.4.5 with the following (including title), shift the rest of the sections numbering by one*

**30.4.5 Control mode PPDU transmission**

**30.4.5.1 General**

This subclause defines a waveform for Control mode non-EDMG duplicate and EDMG PPDU transmission over 2.16 GHz, 4.32 GHz, 6.48 GHz, and 8.64 GHz using *NTX* transmit chains.

The non-EDMG PPDU transmission shall be as defined in 30.4.5.2. The EDMG PPDU transmission shall be as defined in 30.4.5.3.

The frequently used symbol notations in this subclause are summarized in Table 1.

Table 1: Frequently used parameters

|  |  |
| --- | --- |
| **Symbol** | **Explanation** |
|  | Transmit chain number |
|  | Total number of transmit chains |
|  | SC chip rate, equal to 1.76 GHz |
|  | SC chip time duration, equal to 1/*Fc* |
|  | Number of contiguous 2.16 GHz channels used for PPDU transmission, 1 ≤ *NCB* ≤ 4 |
|  | Shaping filter impulse response defined at the *Nup*×1.76 GHz sampling rate, *Nup* defines an up-sampling factor |
|  | Up-sampling parameter |

**30.4.5.2 Non-EDMG duplicate PPDU transmission**

The Control mode non-EDMG PPDU waveform shall be defined at the SC chip rate equal to 1.76 GHz and include the following modulated fields:



where

*  is a duration of L-STF field of PPDU
*  is a total duration of L-STF and L-CEF fields of PPDU
*  is a total duration of L-STF, L-CEF, and L-Header fields of PPDU
*  is a total duration of L-STF, L-CEF, L-Header, and Data fields of PPDU

If not specified additionally, the chip index *n* is defined in the range [0, *NField*-1], where *NField* defines the total number of samples for given signal field.

The TRN field may be present in a 2.16 GHz PPDU transmission and shall not be present for 4.32 GHz, 6.48 GHz, or 8.64 GHz PPDU transmission.

The definition of L-STF, L-CEF, and L-Header fields is provided in 20.4.3.1.2, 20.4.3.1.3, and 20.4.3.2 accordingly.

To transmit a non-EDMG waveform using multiple transmit chains, a spatial expansion with Cyclic Shift Diversity (CSD) is applied. The non-EDMG PPDU waveform for the *iTX*-th transmit chain includes a cyclic shift  dependent on the particular transmit chain number. The time shift  is defined in SC chip units as (*iTX*-1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where

* 

The non-EDMG PPDU waveform for *iTX*-th transmit chain is obtained by up-sampling and filtering and then appropriate carrier frequency shift of the  waveform if required. The up-sampling procedure is applied by a factor of *Nup*. The filtering procedure is performed with a pulse shaping filter  defined at the *Nup*×1.76 GHz sampling rate as follows:



where

*  is a length of  in samples
* 

The pulse shaping filter impulse response  and *Nup* parameter definition is out of scope of this standard and is implementation specific.

The non-EDMG PPDU waveform for the *iTX*-th transmit chain with transmission over 2.16 GHz channel shall be defined as follows:



The non-EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 4.32 GHz channel shall be defined as follows:



where

* ∆*F* defines sub-channel spacing equal to 2.16 GHz
* time delays ∆*t1* and ∆*t2* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

The non-EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 6.48 GHz channel shall be defined as follows:



where

* time delays ∆*t1,* ∆*t2,* and ∆*t3* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

The non-EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 8.64 GHz channel shall be defined as follows:



where

* time delays ∆*t1,* ∆*t2,* ∆*t3*, and ∆*t4* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

**30.4.5.3 EDMG PPDU transmission**

The Control mode EDMG PPDU is composed of preamble, data and TRN field. The total number of transmit chains *NTX* shall be constant over the different fields of EDMG PPDU.

The preamble and data part shall be defined at the SC chip rate equal to 1.76 GHz and include the following modulated fields:



*  is a duration of L-STF field of PPDU
*  is a total duration of L-STF and L-CEF field of PPDU
*  is a total duration of L-STF, L-CEF, and L-Header fields of PPDU
*  is a total duration of L-STF, L-CEF, L-Header, and EDMG-Header-A fields of PPDU

The definition of L-STF, L-CEF, and L-Header fields is provided in 20.4.3.1.2, 20.4.3.1.3, and 30.3.3.2.5 accordingly.

To transmit the preamble and data part using multiple transmit chains, a spatial expansion with Cyclic Shift Diversity (CSD) is applied. The preamble and data part of PPDU waveform for the *iTX*-th transmit chain includes a cyclic shift  dependent on the particular transmit chain number. The time shift  is defined in SC chip units as (*iTX*-1)×*Nc*×*Tc*, where *Nc* is equal to 4 chips and *Tc* is a chip time duration.



where

* 

The EDMG PPDU waveform for *iTX*-th transmit chain is obtained by up-sampling and filtering and then appropriate carrier frequency shift of the  waveform if required. The up-sampling procedure is applied by a factor of *Nup*. The filtering procedure is performed with a pulse shaping filter  defined at the *Nup*×1.76 GHz sampling rate as follows:



where

*  is a length of  in samples
* 

The pulse shaping filter impulse response  and *Nup* parameter definition is out of scope of this standard and is implementation specific.

The preamble and data part of EDMG PPDU waveform for the *iTX*-th transmit chain with transmission over 2.16 GHz channel shall be defined as follows:



The preamble and data part of EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 4.32 GHz channel shall be defined as follows:



where

* ∆*F* defines sub-channel spacing equal to 2.16 GHz
* time delays ∆*t1* and ∆*t2* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

The preamble and data part of EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 6.48 GHz channel shall be defined as follows:



where

* time delays ∆*t1,* ∆*t2,* and ∆*t3* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

The preamble and data part of EDMG PPDU waveform for the *iTX*-th transmit chain with duplicate transmission over 8.64 GHz channel shall be defined as follows:



where

* time delays ∆*t1,* ∆*t2,* ∆*t3*, and ∆*t4* are in the range [0, *Tc*]
* the primary channel shall have a zero delay

The TRN field  shall be defined at the SC chip rate equal to *NCB*×1.76 GHz per *iTX*-th transmit chain as defined in 30.9.2.2.5. The TRN field is filtered and resampled with conversion rate ratio *Nup*/*NCB*.

For example, the resampling procedure for the ratio *Nup*/*NCB* = 3/2, can be defined as follows:



where

*  is a length of  in samples
* 

The Control mode EDMG PPDU waveform for *iTX*-th transmit chain concatenates the preamble and data part with TRN field and shall be defined as follows:



where

*  is a total duration of L-STF, L-CEF, L-Header, EDMG-Header-A, and Data fields of PPDU

**Change to D0.35:** 30.3.3.3.2.2 (Definition for EDMG control mode PPDU)

*Change Table 16 as follows*

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| TRN channel aggregation | 1 | 0 | If this field set to 0, the BW field specifies that the TRN field of the PPDU is appended on a 2.16 GHz, 4.32 GHz, 6.48 GHz or 8.64 GHz channel. If this field set to 1, the BW field specifies a 2.16+2.16 GHz or 4.32+4.32 GHz channel.  This field is reserved if the value of the EDMG TRN Length field is 0. |
| Number of transmit chains | 3 | 1 | Indicates the number of transmit chains used in the transmission of the PPDU |
| Reserved | 4 | 4 | Set to 0 by the transmitter and ignored by the receiver. |
| CRC | 16 | 8 | Header Check sequence. Calculation of the header check sequence is defined in 20.3.7. |

In case of channel aggregation transmission the total number of transmit chains *NTX* shall be an even number. The first *NTX*/2 transmit chains shall be allocated to the primary channel and the second *NTX*/2 transmit chains to the secondary channel.

The knowledge of the number of transmit chains *NTX* to receive the preamble and data part of PPDU is not required, because the data is duplicated over all transmit chains with CSD.

The *NTX* knowledge is needed to perform training using TRN units appended to the PPDU. The TRN units are defined using orthogonal sequences and allow channel estimation between *NTX* transmit chains and *NRX* receive chains. The receiver needs to know what number of TRN units (corresponding to *NTX* chains) were transmitted to perform channel measurements. Based on that information the receiver runs the appropriate number of correlators (*NTX*) for *iRX*-th receive chain.

**SP:**

Do you agree to define the Control PHY PPDU transmission as defined in (11-17-1040-00-00ay Control Mode PPDU Transmission)?

**References:**

1. Draft P802.11ay\_D0.35
2. IEEE802.11-2016