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| Vertical MIMO Coding for SC and OFDM Mode | | | | |
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Abstract

This document proposes changes required to support vertical MIMO coding for SC and OFDM mode, [1].

SC part

**30.3.3.3.2.3 Definition for EDMG SC mode and EDMG OFDM mode PPDUs**

*Editor: remove Table 25, modify Table 24, 26, and 31 in D0.5 as shown below*

**Table 24 – EDMG-Header-A field structure and definition for a SU PPDU**

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| EDMG-MCS | 21 | 41 | The EDMG-MCS field is as defined in Table 26. |

**Table 26 – EDMG-MCS field definition**

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| Base MCS | 5 | 0 | Indicates the lowest index of the modulation and coding scheme that is used to define the modulation and coding scheme of the spatial streams. |
| Differential  EDMG-MCS1 | 2 | 5 | Each of these differential MCS subfields is set as follows:   * 0: indicates the same MCS as the Base MCS subfield * 1: indicates one higher order modulation than the Base MCS subfield with the same code rate * 2: indicates two higher order modulation than the Base MCS subfield with the same code rate * 3: indicates three higher order modulation than the Base MCS subfield with the same code rate   If the MCS indicated by the value of the Base MCS subfield has a code rate of 1/2, then each of the differential MCS subfields shall not be set to the value that indicates 64-QAM/NUC modulation. |
| Differential  EDMG-MCS2 | 2 | 7 |
| Differential  EDMG-MCS3 | 2 | 9 |
| Differential  EDMG-MCS4 | 2 | 11 |
| Differential  EDMG-MCS5 | 2 | 13 |
| Differential  EDMG-MCS6 | 2 | 15 |
| Differential  EDMG-MCS7 | 2 | 17 |
| Differential  EDMG-MCS8 | 2 | 19 |

**Table 31 – EDMG-Header-B field structure and definition**

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
|  |  |  |  |
|  |  |  |  |
| Base MCS | 5 | 29 | Indicates the lowest index of the modulation and coding scheme that is used to define the modulation and coding scheme of the spatial streams. |
| Differential  EDMG-MCS1 | 2 | 34 | Each of these differential MCS subfields is set as follows:   * 0: indicates the same MCS as the Base MCS subfield * 1: indicates one higher order modulation than the Base MCS subfield with the same code rate * 2: indicates two higher order modulation than the Base MCS subfield with the same code rate * 3: indicates three higher order modulation than the Base MCS subfield with the same code rate   If the MCS indicated by the value of the Base MCS subfield has a code rate of 1/2, then each of the differential MCS subfields shall not be set to the value that indicates 64-QAM/NUC modulation. |
| Differential  EDMG-MCS2 | 2 | 36 |

**30.5.3 Transmitter block diagram**

*Editor: introduce the modifications to the subclause 30.5.3 in D0.5 as below*

**30.5.3.1 General**

EDMG and non-EDMG SC 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 20.3.9 (Scrambler).
* It pads the data with zeros
* Stream parser divides the output of LDPC encoder into the groups of bits that are sent to different mapping devices. The sequence of the bits sent to different mapping device is called a spatial stream; see 30.5.8.4.
* Constellation mapper maps the sequence of bits in each stream to constellation points (complex numbers); see 30.5.8.5.
* Interleaver performs interleaving inside a SC symbol block; see 30.5.8.5.4.
* STBC encoder spreads constellation points from *NSS* spatial streams into *NSTS* space-time streams using a space-time block code. SC mode defines single STBC scheme with *NSS* = 1 and *NSTS* = 2; see 30.5.8.5.3.
* GI insertion prepends the SC symbol block with guard interval defined as a π/2-BPSK modulated Golay sequence; see 30.5.8.2.
* Preamble builder builds π/2-BPSK modulated Ga and Gb Golay sequences comprising the L-STF, L- CEF, EDMG-STF, and EDMG-CEF fields; see 30.10.
* Spatial mapper maps space-time streams to transmit chains. This may include one of the followings; see 30.5.9.2 (Spatial mapping):
  + Direct mapping: constellation points from each space-time stream are mapped directly into the transmit chains .
  + Indirect mapping: constellation points from each space-time stream are mapped to each transmit chain.
  + Digital beamforming: each vector of constellation points from all of the space-time streams is multiplied by a matrix of steering vectors to produce the input to the transmit chains.
* Cyclic shift (CSD) insertion prevents the signal transmission from unintentional beamforming. A cyclic shift is specified per transmitter chain for non-EDMG duplicate PPDU transmission; see 30.5.3.3.1 (Pre-EDMG fields of 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.

**30.5.3.3.2 EDMG portion of SU PPDU transmission**

Figure 81 shows the transmitter blocks used to generate the EDMG portion of SU PPDU. The EDMG-STF and EDMG-CEF fields are generated using the Preamble builder block. The TRN field is generated using TRN builder block. The data part of PPDU is generated using the scrambler, LDPC encoder, constellation mapper, interleaver, and GI insertion blocks. If STBC encoder is applied, then a single spatial stream is mapped to two space-time streams as defined in 30.5.8.5.3. The *NSTS* space-time streams are further mapped to *NTX* transmit chains, where *NSTS* ≤ *NTX*.



**Figure 81 – Transmitter bock diagram for EDMG portion of SU PPDU transmission**

NOTE – Interleaver is applied to π/2-64-QAM and π/2-64-NUC modulations only.

**30.5.3.3.3 EDMG portion of MU PPDU transmission**

Figure 82 shows the transmitter blocks used to generate the EDMG portion of MU PPDU. The EDMG-STF and EDMG-CEF fields are generated using Preamble builder block. The TRN field is generated using TRN builder block. The EDMG- Header-B and data part of PPDU are generated using scrambler, LDPC encoder, constellation mapper, interleaver, and GI insertion blocks. The PPDU encoding uses seed value defined in EDMG-Header-B and has independent flow per user. However, transmitter keeps the common space-time streams numeration over all users. If STBC encoder is applied, then a single spatial stream is mapped to two space-time streams as defined in 30.5.8.5.3. The *NSTS* space-time streams are further mapped to *NTX* transmit chains, where *NSTS* ≤ *NTX*.



**Figure 82 – Transmitter block diagram for EDMG portion of MU PPDU transmission**

NOTE – Interleaver is applied to π/2-64-QAM and π/2-64-NUC modulations only.

**30.5.8.4.1 General**

*Editor: introduce the changes into Table 54 in D0.5 as shown below*

Table 54 - Frequently used parameters

|  |  |
| --- | --- |
| Symbol | Explanation |
|  | Spatial stream number |
|  | Total number of spatial streams for *iuser*-th user |
|  | User number |
|  | Total number of users in a multi user transmission |
|  | Space-time stream number for *iuser*-th user |
|  | Total number of space-time streams for *iuser*-th user |
|  | Space-time stream number over all users |
|  | Total number of space-time streams over all users |
|  | PSDU length in octets for *iuser*-th user |
|  | LDPC codeword length in bits, it can be equal to 468, 504, 624, 672, 936, 1008, 1248, and 1344 |
|  | LDPC codeword length in bits for *iuser*th user |
|  | Number of systematic data bits per LDPC codeword |
|  | Number of parity bits per LDPC codeword |
|  | Repetition factor for *iuser*th user; is equal to 2 for MCS 1 and equal to 1 for all other MCSs |
|  |  |
|  |  |
|  | LDPC code rate for *iuser*th user and ; can be equal to ½, 5/8, 2/3, ¾, 13/16, 5/6, 7/8 |
|  | Total number of LDPC codewords for *iuser*th user |
|  | Number of pad bits for the *iuser*th user to reach an integer number of LDPC codewords |
|  | Total number of SC symbol blocks for the *iuser*th user |
|  | Minimum number of total SC symbol blocks for BRP PPDU transmission |
|  |  |
|  | Number of pad bits for the *iuser*th user to reach an integer number of SC symbol blocks |
|  | Number of contiguous 2.16 GHz channels used for PPDU transmission |
|  | Number of coded bits per SC symbol block; depends on modulation type and is different for different GI types as defined in Table 55. |
|  | Number of coded bits per symbol (constellation point) for the *iuser*th user and *iSS*th spatial stream |
|  |  |
|  | Number of symbols (constellation points) per SC symbol block; depends on the GI type as defined in Table 56. |
|  |  |
|  | Maximum number of SC symbol blocks over all users |
|  | The number of pad SC symbol blocks for the *iuser*th user that is required to align PPDUs over different users in time |

**30.5.8.4.3 LDPC encoding**

*Editor: introduce the modifications to the subclause 30.5.8.4.3 in D0.5 as below*

This subclause defines a SC mode EDMG SU PSDU or MU PSDU per user basis encoding. The LDPC encoding may employ codeword lengths *LCW* = 468, 504, 624, 672, 936, 1008, 1248, or 1344 and code rates *R* = ½, 5/8, 2/3, ¾, 13/16, 5/6, or 7/8.

The LDPC encoding process for the *iuser*-th user shall be as follows:

1. Compute the number of data pad bits , using the number of LDPC codewords :





The scrambled PSDU is concatenated with  zero bits. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU input bits.

1. Convert the scrambled PSDU bits to LDPC codewords as follows:
   1. If ρ = 1 and *LCW* = 672, 1344:
      1. The output stream of scrambler is broken into the blocks of length *LCWD* = *LCW*×*R* bits such that the *m*-th data word is 
      2. To each data word, parity bits , *LCWP* = *LCW* - *LCWD*, are added to create the codeword  such that 
   2. If ρ = 1 and *LCW* = 624, *R* = 7/8:
      1. The output stream of scrambler is broken into the blocks of length 546 bits such that the *m*-th data word is 
      2. To each data word, parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 672, *R* = 13/16 LDPC matrix
      3. Finally, the first 48 parity bits are discarded (punctured) to create the output codeword 
   3. If ρ = 1 and *LCW* = 1248, *R* = 7/8:
      1. The output stream of scrambler is broken into the blocks of length 1092 bits such that the *m*-th data word is 
      2. To each data word, parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 1344, *R* = 13/16 LDPC matrix
      3. Finally, the first 96 parity bits are discarded (punctured) to create the output codeword 
   4. If ρ = 2 and *LCW* = 672, *R* = 1/2:
      1. The output stream of scrambler is broken into the blocks of length 168 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that 
      3. Finally, the zero bits are replaced with word  repetition XORed by PN sequence that is generated from the LFSR used for MCS 1 scrambling as defined in 30.5.8.3.2. The LFSR is initialized to all ones initial seed value and reinitialized to the same seed after every codeword.
   5. If ρ = 2 and *LCW* = 1344, *R* = 1/2:
      1. The output stream of scrambler is broken into the blocks of length 336 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that 
      3. Finally, the zero bits are replaced with word  repetition XORed by PN sequence that is generated from the LFSR used for MCS 1 scrambling as defined in 30.5.8.3.2. The LFSR is initialized to all ones initial seed value and reinitialized to the same seed after every codeword.
   6. If ρ = 1 and *LCW* = 504, *R* = 2/3:
      1. The output stream of scrambler is broken into the blocks of length 336 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 672, *R* = ¾ LDPC matrix
      3. Finally, the zero bits are discarded to create the output codeword 
   7. If ρ = 1 and *LCW* = 1008, *R* = 2/3:
      1. The output stream of scrambler is broken into the blocks of length 672 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 1344, *R* = ¾ LDPC matrix
      3. Finally, the zero bits are discarded to create the output codeword 
   8. If ρ = 1 and *LCW* = 504, *R* = 5/6:
      1. The output stream of scrambler is broken into the blocks of length 420 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying for *LCW* = 672, *R* = 7/8 LDPC matrix
      3. Finally, the zero bits are discarded to create the output codeword 
   9. If ρ = 1 and *LCW* = 1008, *R* = 5/6:
      1. The output stream of scrambler is broken into the blocks of length 840 bits such that the *m*-th data word is 
      2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 1344, *R* = 7/8 LDPC matrix
      3. Finally, the zero bits are discarded to create the output codeword 
   10. If ρ = 1 and *LCW* = 468, *R* = 5/6:
       1. The output stream of scrambler is broken into the blocks of length 390 bits such that the *m*-th data word is 
       2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 672, *R* = 13/16 LDPC matrix
       3. Finally, the zero bits are discarded and the first 48 parity bits are discarded (punctured) to create the output codeword 
   11. If ρ = 1 and *LCW* = 936, *R* = 5/6:
       1. The output stream of scrambler is broken into the blocks of length 780 bits such that the *m*-th data word is 
       2. To each data word, zero bits  and parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 1344, *R* = 13/16 LDPC matrix
       3. Finally, the zero bits are discarded and the first 96 parity bits are discarded (punctured) to create the output codeword 
2. Concatenate LDPC codewords one after the other to create the coded bits stream .
3. Compute the number of coded pad bits, , using the number of SC symbol blocks, :









Concatenate coded bits with  zero bits. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU bits and data pad bits at the step a).

1. Distribute the encoded and padded bits over the  spatial streams on the group basis with the number of  bits in the group. The first group of bits comes to the first spatial stream, the second group of bits comes to the second spatial stream, and so on. The procedure is repeated when the maximum number of spatial streams  is reached. The procedure ends up when all PSDU encoded bits including  pad bits are distributed over the  spatial streams.

For each user, if STBC coding is applied, then a single spatial stream  is mapped to two space-time streams  as defined in 30.5.8.5.3. Otherwise, a one-to-one mapping of  spatial streams to  space-time streams shall be applied.

NOTE— is defined on a per user basis in the Requested BRP SC Blocks field within a responder’s EDMG Capabilities element. If the Requested BRP SC Blocks field is not included in the EDMG Capabilities element, then  = aBRPminSCblocks.

**30.5.8.5.4 Block interleaver**

*Editor: introduce the modifications to the subclause 30.5.8.5.4 in D0.5 as below*

The block interleaver is defined for π/2-64-QAM and π/2-64-NUC modulations. It performs modulated complex symbols interleaving inside a SC symbol block and its parameters depend on the , , , , and  parameters.

The input to interleaver scheme for *iSS*-th spatial stream is a SC symbol block  of length *NSPB* × *NCB* composed of π/2-64-QAM or π/2-64-NUC symbols:

* , where *q* denotes a SC symbol block number, *q* = 0, 1, …, .

The output of interleaver scheme for *iSS*-th spatial stream is a permuted SC symbol block  of the same length defined as follows:

* , where *idx* defines the array of permutation indexes.

The array of permutation indexes *idx* is constructed as follows:

* , where *i* = 0, 1, …, *Nx* -1 and *j* = 0, 1, …, *Ny* - 1.
* .
* .
* .

OFDM part

**30.6.2 Transmitter block diagram**

*Editor: introduce changes to the subclause 30.6.2 proposed in [2] as below*

**30.6.2.1 General**

EDMG OFDM PPDU transmissions can be generated using a transmitter consisting of the following blocks:

1. Scrambler scrambles the data to reduce the probability of long sequences of 0s and 1s; see 20.3.9 (Scrambler).
2. It pads the data with zeros
3. Stream parser divides the output of LDPC encoder into the groups of bits that are sent to different mapping devices. The sequence of the bits sent to different mapping device is called a spatial stream; see 30.6.7.3 (Encoding).
4. Constellation mapper maps the sequence of bits in each stream to constellation points (complex numbers); see 30.6.7.4 (Modulation mapping).
5. Interleaver performs interleaving inside an OFDM symbol; see (30.6.7.4.4 Block interleaver)
6. STBC encoder spreads constellation points from *NSS* spatial streams into *NSTS* space-time streams using a space-time block code. OFDM mode defines single STBC scheme with *NSS* = 1 and *NSTS* = 2; see 30.6.7.4.3 (Space-time block coding).
7. Preamble builder builds symbols of EDMG-STF and EDMG-CEF fields in frequency domain; see 30.6.3 (EDMG-STF definition) and 30.6.4 (EDMG-CEF definition).
8. TRN builder builds symbols of TRN field; see 30.9.2.2.5 (TRN field definition).
9. Spatial mapper maps space-time streams to transmit chains. The spatial mapping is applied per subcarrier basis and may include one of the followings; see 30.6.8.2 (Spatial mapping):
   1. Direct mapping: constellation points from each space-time stream are mapped directly into the transmit chains.
   2. Indirect mapping: constellation points from each space-time stream are mapped to each transmit chain.
   3. Digital beamforming: each vector of constellation points from all of the space-time streams is multiplied by a matrix of steering vectors to produce the input to the transmit chains.
10. Cyclic shift (CSD) insertion prevents the transmission from unintentional beamforming. A cyclic shift is specified per transmitter chain for pre-EDMG portion of PPDU transmission; see 30.5.3.3.1 (Pre-EDMG fields of PPDU transmission).
11. IDFT applies Inverse Discrete Fourier Transform to the input block of subcarriers.
12. GI insertion and windowing prepends the OFDM symbol with guard interval defined as a cyclic extension of the OFDM symbol in time domain and applies window function; see 30.6.7.2 (OFDM modulation).

**30.6.2.2 EDMG PPDU transmission**

**30.6.2.2.1 Pre-EDMG portion of PPDU transmission**

See 30.5.3.3.1.

**30.6.2.2.2 EDMG portion of SU PPDU transmission**

Figure 1 shows the transmitter blocks used to generate the EDMG portion of SU PPDU. The EDMG-STF, and EDMG-CEF fields are generated using the Preamble builder, IDFT, and GI insertion blocks. The TRN field is generated using the TRN builder, IDFT, and GI insertion blocks. The data part of PPDU is generated using the scrambler, LDPC encoder, constellation mapper, interleaver, IDFT, and GI insertion blocks. If STBC encoder is applied, then a single spatial stream is mapped to two space-time streams as defined in 30.6.7.1. The *NSTS* space-time streams are further mapped to *NTX* transmit chains, where *NSTS* ≤ *NTX*.



Figure 1: Transmitter block diagram for EDMG portion of SU PPDU transmission.

NOTE – Interleaver is applied to 16-QAM and 64-QAM modulations only.

**30.6.2.2.3 EDMG portion of MU PPDU transmission**

Figure 2 shows the transmitter blocks used to generate the EDMG portion of MU PPDU. The EDMG-STF, and EDMG-CEF fields are generated using the preamble builder, IDFT, and GI insertion blocks. The TRN field is generated using the TRN builder, IDFT, and GI insertion blocks. The EDMG-Header-B and data part of PPDU are generated using scrambler, LDPC encoder, constellation mapper, interleaver, IDFT, and GI insertion blocks. The PPDU encoding uses the seed value defined in the EDMG-Header-B and has independent flow per user. However, transmitter keeps the common space-time streams numeration over all users. If STBC encoder is applied, then a single spatial stream is mapped to two space-time streams as defined in 30.6.7.1. The *NSTS* space-time streams are further mapped to *NTX* transmit chains, where *NSTS* ≤ *NTX*.



Figure 2: Transmitter block diagram for EDMG portion of MU PPDU transmission.

NOTE – Interleaver is applied to 16-QAM and 64-QAM modulations only.

**30.6.7.3 Encoding**

*Editor: It is proposed to add the text in the current subclause to the spec draft [1].*

**30.6.7.3.1 General**

An EDMG OFDM PSDU is encoded by a systematic LDPC block code. Each data word of *LCWD* information bits is concatenated with *LCWP* parity bits to create a codeword of length *LCW* = *LCWD* + *LCWP* bits. The EDMG LDPC encoding can employ the codeword lengths *LCW* = 624, 672, 1248, and 1344 and code rates *R* = ½, 5/8, ¾, 13/16, and 7/8.

Table 1 provides a summary of LDPC code rates.

Table 1: LDPC code rates

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Code rate** | **Codeword length - *LCW*** | | **Number of data bits - *LCWD*** | |
| **Short** | **Long** | **Short** | **Long** |
| ½ | 672 | 1344 | 336 | 672 |
| 5/8 | 672 | 1344 | 420 | 840 |
| ¾ | 672 | 1344 | 504 | 1008 |
| 13/16 | 672 | 1344 | 546 | 1092 |
| 7/8 | 624 or 672 | 1248 or 1344 | 546 or 588 | 1092 or 1176 |

The LDPC encoding with codeword length *LCW* = 672 and 1344 is performed by solving the linear system of equations  defined by the parity matrix **H** of size *LCWP* by *LCW*, where  defines the *m*-th LDPC codeword,  defines the *m*-th data word, and  defines parity bits for *m*-th LDPC codeword.

The LDPC encoding with codeword length *LCW* = 624 and 1248 employs the original matrices **H** with *LCW* = 672 and 1344 for code rate *R* = 13/16 and then applies puncturing procedure to get a desired code rate *R* = 7/8. For *LCW* = 624, first 48 parity bits are discarded and for *LCW* = 1248, first 96 parity bits are discarded.

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

Table 2: Frequently used parameters

|  |  |
| --- | --- |
| **Symbol** | **Explanation** |
|  | Spatial stream number |
|  | Total number of spatial streams for *iuser*-th user |
|  | User number |
|  | Total number of users in multi user transmission |
|  | Space-time stream number for *iuser*-th user |
|  | Total number of space-time streams for *iuser*-th user |
|  | Space-time stream number over all users |
|  | Total number of space-time streams over all users |
|  | PSDU length in octets for *iuser*-th user |
|  | LDPC codeword length in bits, it can be equal to 624, 672, 1248, and 1344 |
|  | LDPC codeword length for *iuser*-th |
|  | Number of systematic data bits per LDPC codeword |
|  | Number of parity bits per LDPC codeword |
|  | LDPC code rate for *iuser*-th user, it can be equal to ½, 5/8, ¾, 13/16, 7/8 |
|  | Total number of LDPC codewords for *iuser*-th user |
|  | Number of pad bits for *iuser*-th user to get integer number of LDPC codewords |
|  | Total number of OFDM symbols for *iuser*-th user |
|  | Minimum number of total OFDM symbols for BRP PPDU transmission |
|  | Number of pad bits for *iuser*-th user to get integer number of OFDM symbols |
|  | Number of coded bits per OFDM symbol |
|  | Number of coded bits per constellation point for *iuser*-th user and *iSS*-th spatial stream |
|  | Maximum number of OFDM symbols over all users |
|  | The number of pad OFDM symbols for *iuser*-th user required to align PPDUs over different users in time |

Table 3 defines the number of coded bits per OFDM symbol, *NCBPS*, for different modulation types and the number of data subcarriers *NSD*.

Table 3: Values of NCBPS for different modulation types and number of data subcarriers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Symbol mapping** | ***NSD* = 336** | ***NSD* = 734** | ***NSD* = 1134** | ***NSD* = 1532** |
| SQPSK | 336 | 734 | 1134 | 1532 |
| QPSK | 672 | 1468 | 2268 | 3064 |
| 16-QAM | 1344 | 2936 | 4536 | 6128 |
| 64-QAM | 2016 | 4404 | 6804 | 9192 |

The parity check matrices are defined in 30.6.7.3.2. The LDPC encoding is defined in 30.6.7.3.3. The MU PPDU padding and space-time stream mapping procedure is defined in 30.6.7.3.4.

**30.6.7.3.2 Parity check matrices**

See 30.3.6.

**30.6.7.3.3. LDPC encoding**

This subclause defines an OFDM mode EDMG SU PSDU or MU PSDU per user basis encoding. The EDMG LDPC encoding can employ the codeword lengths *LCW* = 624, 672, 1248, and 1344 and code rates *R* = ½, 5/8, ¾, 13/16, and 7/8.

*Editor: D0.5: add field Superimposed Code Applied to indicate codeword length for 7/8 LDPC code in EDMG-Header-A (Table 24) and EDMG-Header-B (Table 31), shift the rest of the fields by 1 bit accordingly*

**Table 19 – EDMG-Header-A field structure and definition for a SU PPDU**

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| Superimposed Code Applied | 1 | 15 | Set to 1 to indicate superimposed code with codeword length 672 or 1344 application for LDPC code with rate 7/8.  Set to 0 to indicate puncturing code with codeword length 624 or 1248 application for LDPC code with rate 7/8. |

**Table 26 – EDMG-Header-B field structure and definition**

|  |  |  |  |
| --- | --- | --- | --- |
| **Field** | **Number of bits** | **Start bit** | **Description** |
| Superimposed Code Applied | 1 | 35 | Set to 1 to indicate superimposed code with codeword length 672 or 1344 application for LDPC code with rate 7/8.  Set to 0 to indicate puncturing code with codeword length 624 or 1248 application for LDPC code with rate 7/8. |

The EDMG LDPC encoding process for *iuser*-th user includes the following steps:

1. Compute the number of data pad bits , using the number of LDPC codewords :





The scrambled PSDU is concatenated with  zero bits. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU input bits.

1. Convert the scrambled PSDU bits to LDPC codewords as follows:
   1. If *LCW* = 672, 1344:
      1. The output stream of scrambler is broken into the blocks of length *LCWD* = *LCW*×*R* bits such that the *m*-th data word is 
      2. To each data word, parity bits , *LCWP* = *LCW* - *LCWD*, are added to create the codeword  such that 
   2. If *LCW* = 624, *R* = 7/8:
      1. The output stream of scrambler is broken into the blocks of length 546 bits such that the *m*-th data word is 
      2. To each data word, parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 672, *R* = 13/16 LDPC matrix
      3. Finally, the first 48 parity bits are discarded (punctured) to create the output codeword 
   3. If *LCW* = 1248, *R* = 7/8:
      1. The output stream of scrambler is broken into the blocks of length 1092 bits such that the *m*-th data word is 
      2. To each data word, parity bits  are added to create the codeword  such that , parity bits are computed applying *LCW* = 1344, *R* = 13/16 LDPC matrix
      3. Finally, the first 96 parity bits are discarded (punctured) to create the output codeword 
2. Concatenate LDPC codewords one after the other to create the coded bits stream .
3. Compute the number of coded pad bits, , using the number of OFDM symbols, :









Concatenate coded bits with  zero bits. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU bits and data pad bits at the step a).

1. Distribute the encoded and padded bits over the  spatial streams on the group basis with the number of  bits in the group. The first group of bits comes to the first spatial stream, the second group of bits comes to the second spatial stream, and so on. The procedure is repeated when the maximum number of spatial streams  is reached. The procedure ends up when all PSDU encoded bits including  pad bits are distributed over the  spatial streams.

For each user, if STBC coding is applied, then a single spatial stream  is mapped to two space-time streams  as defined in 30.6.7.1. Otherwise, a one-to-one mapping of  spatial streams to  space-time streams shall be applied.

NOTE – The  is defined per user basis as  = aBRPminOFDMblocks.

**30.6.7.3.4 MU PPDU padding and space-time streams mapping**

For MU PPDU transmission, all user PPDUs shall be aligned in time. If necessary to achieve this, user PSDUs shall be padded according to the following steps:

1. Compute the maximum number of OFDM symbols over all users  for *iuser* = 1, 2, …, *Nuser*.
2. Update the number of OFDM symbols at step e) in 30.6.7.3.3 as  for *iuser* = 1, 2, …, *Nuser*. Update the number of pad bits for *iuser*-th user accordingly.
3. The number of pad OFDM symbols for MU PPDU transmission for *iuser*-th user is defined as .

The number of pad symbols  takes into account MU PPDU padding only and does not include the regular padding described in 30.6.7.3.3.

A receiver can compute the number of pad OFDM symbols  using overall PPDU time duration computed using MCS and PSDU *Length* defined in the L-Header, MCS and PSDU *Length* defined in the EDMG-Header-B, and TRN field duration defined in the EDMG-Header-A. In case of non-zero spoofing error and if spoofing error duration is shorter than one OFDM symbol duration (*TOFDM-SYM = TDFT + TGI*), the fractional part of OFDM symbol is discarded.

In case of non-zero spoofing error and if spoofing error duration is longer than or equal to OFDM symbol duration, the one OFDM symbol and possible fractional part of OFDM symbol are discarded. The second case is signalled by Spoofing error indicator bit defined in the EDMG-Header-B.

The described procedure allows receiver unambiguously to find the beginning of TRN field if one appended to the MU PPDU.

The space-time stream index per user  is mapped to the space-time stream index over all users  as follows:



NOTE -  is a function of  and  indices. However, to simplify notations this dependence is not indicated explicitly in other equations.

**30.6.7.4.8 Symbol interleaver**

This subclause defines a symbol interleaver for 16-QAM and 64-QAM modulation. It performs modulated complex symbols interleaving inside the OFDM symbol and its parameters depend on the , , , , and  parameters.

The input to the interleaver scheme for *iSS*-th spatial stream is an OFDM data block  of length *NSD* composed of 16-QAM or 64-QAM symbols:

* , where *q* denotes OFDM symbol number, *q* = 0, 1, …, *NSYM*-1.

The interleaving is performed inside the block of length *NSD* + *Np*, where *Np* parameter is equal to 0, 34, 18, and 4 for *NCB* equal to 1, 2, 3, and 4 accordingly.

The output of the interleaver scheme for *iSS*-th spatial stream is a permuted OFDM data block of the same length defined as follows:

* , where *idx* defines the array of permutation indexes.

The array of permutation indexes *idx* is constructed as follows:

* , where *i* = 0, 1, …, *Nx*-1 and *j* = 0, 1, …, *Ny*-1.
* .
* ,
* .

After permutation, the padded zeros at the first step are discarded (punctured) to form the output array of length *NSD*.

**References:**

1. Draft P802.11ay\_D0.5