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Abstract

This document proposes comment resolution for CID 1, 2, 23, 525 [1], [2].

**30.5.6.2 Scrambler**

*It is proposed to add the text in the current subclause to the spec draft [2].*

**30.5.6.2.1 Data scrambler**

The operation of the scrambler applied for the data bits is defined in 20.3.9. The scrambling of the SU PSDU continues the scrambling of L-Header and EDMG-Header-A. The initial seed value is defined in the L-Header.

The scrambling of the MU PSDU is performed on per user basis and continues the scrambling of EDMG-Header-B with reset of a seed value. The initial seed value is defined in the EDMG-Header-B on per user basis.

**30.5.6.2.2 MCS 1 scrambler**

The repeated systematic part of LDPC codeword in MCS 1 encoding defined in 30.5.6.3.2 shall be scrambled by XORing each bit in turn with a length 127 periodic sequence generated by polynomial . For the codeword length equal to 672 bits the 168 repeated systematic bits shall be scrambled in turn starting from bit 1 and ending with bit 168. For the codeword length equal to 1344 bits the 336 repeated systematic bits shall be scrambled in turn starting from bit 1 and ending with bit 336. The generation of the sequence and the XOR operation are shown in Figure 1.



Figure 1: MCS 1 sequence scrambler

For each codeword, the transmitter shall reload the seed value to all ones (bits x1 through x7). Each data bit is then XORed with the scrambler output  and then scrambler content is shifted once.

**30.5.6.3 Encoding**

**30.5.6.3.1 General**

*It is proposed to replace the text in the current subclause 30.5.6.3.1 in the spec draft [2] with the text provided in this document.*

An EDMG SC 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 |
|  | 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 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, it can be equal to 2 for MCS 1 and equal to 1 for all other MCSs |
|  | Repetition factor for *iuser*-th user and *iSS*-th spatial stream, it can be equal to 2 for MCS 1 and equal to 1 for all other MCSs |
|  | LDPC code rate for *iuser*-th user and *iSS*-th spatial stream, it can be equal to ½, 5/8, ¾, 13/16, 7/8 |
|  | Total number of LDPC codewords for *iuser*-th user |
|  | Total number of LDPC codewords for *iuser*-th user and *iSS*-th spatial stream |
|  | Number of pad bits for *iuser*-th user to get integer number of LDPC codewords |
|  | Total number of SC symbol blocks for *iuser*-th user |
|  | Minimum number of total SC symbol blocks for BRP PPDU transmission |
|  | Number of pad bits for *iuser*-th user to get integer number of SC symbol blocks |
|  | Number of pad bits for *iuser*-th user and *iSS*-th spatial stream to get 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 for *iuser*-th user, depends on modulation type and different for different GI types, defined in Table 2 |
|  | Number of coded bits per symbol (constellation point) for *iuser*-th user and *iSS*-th spatial stream |
|  | Number of bits in the group for *iuser*-th user and *iSS*-th spatial stream in the round robin distribution procedure |
|  | Number of symbols (constellation points) per SC symbol block, depends on the GI type, defined in Table 3 |
|  | Total number of users in multi user transmission |
|  | Maximum number of SC symbol blocks over all users |
|  | The number of pad SC symbol blocks for *iuser*-th user required to align PPDUs over different users in time |

Table 2 defines the number of coded bits per SC symbol block *NCBPB* for different types of GI.

Table 3: Values of NCBPB for different types of GI

|  |  |  |  |
| --- | --- | --- | --- |
| **Symbol mapping** | **Short GI** | **Normal GI** | **Long GI** |
| π/2-BPSK | 480 | 448 | 384 |
| π/2-QPSK | 960 | 896 | 768 |
| π/2-16QAM | 1920 | 1792 | 1536 |
| π/2-64QAM/64-NUC | 2880 | 2688 | 2304 |

Table 3 defines the number of symbols (constellation points) per SC symbol block *NSPB* for different types of GI.

Table 4: Values of NSPB for different types of GI

|  |  |  |
| --- | --- | --- |
| **Short GI** | **Normal GI** | **Long GI** |
| 480 | 448 | 384 |

The parity check matrices are defined in 30.5.6.3.2. The LDPC encoding for single spatial stream transmission is defined in 30.5.6.3.3. The LDPC encoding for multiple spatial streams transmission is defined in 30.5.6.3.4. The LDPC encoding for multiple spatial streams transmission is defined in 30.5.6.3.5.

**30.5.6.3.2 Parity check matrices**

See 30.3.6

**30.5.6.3.3 LDPC encoding for single spatial stream (*iSS* = 1)**

*It is proposed to replace the text in the current subclause 30.5.6.3.3 in the spec draft [2] with the text provided in this document.*

This subclause defines a SC PHY EDMG SU PSDU or MU PSDU per user basis encoding in case of single spatial stream transmission. 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.

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 data bits to LDPC codewords depending on the repetition factor, codeword length, and code rate:
	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 , 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 , 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 30.5.6.2.2. 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 30.5.6.2.2. The LFSR is initialized to all ones initial seed value and reinitialized to the same seed after every 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, :









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

For each user, if STBC coding is applied, then a single spatial stream  is mapped to two space-time streams  as defined in 30.5.6.4.3. Otherwise, a single spatial stream  is mapped to a single space-time stream .

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

**30.5.6.3.4 LDPC encoding for multiple spatial streams (*iSS* > 1)**

*It is proposed to replace the text in the current subclause 30.5.6.3.4 in the spec draft [2] with the text provided in this document.*

This subclause defines a SC PHY EDMG SU PSDU or MU PSDU per user basis encoding in case of multiple spatial streams transmission. 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.

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 per *iSS*-th spatial stream :





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. Distribute the PSDU scrambled bits over  spatial streams. Bits distribution is performed on the group basis with the number of bits in the group . The first group of bits comes to the first stream, the second group of bits comes to the second stream and so on. The procedure is repeated when the maximum number of spatial streams  is reached.
2. For each spatial stream convert the scrambled PSDU bits to LDPC codewords as described in subclause 30.5.6.3.3 step b).
3. For each spatial stream concatenate LDPC codewords one after the other to create the coded bits stream .
4. Compute the number of coded pad bits per *iSS*-th spatial stream, , using the number of SC symbol blocks, :







1. Concatenate coded bits for *iSS*-th spatial stream with  zero bits. They are scrambled using the continuation of the scrambler sequence that scrambled the PSDU input bits and data pad bits at step a). The pad bits of the first spatial stream are scrambled first, the pad bits of the second spatial stream are scrambled second, and so on.

For each user a one-to-one mapping of  spatial streams to  space-time streams shall be applied.

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

*It is proposed to add this subclause into the spec draft [2].*

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 SC symbol blocks over all users  for *iuser* = 1, 2, …, *Nuser*.
2. Update the number of SC symbol blocks at step d) in 30.5.6.3.3 and step e) in 30.5.6.3.4 as  for *iuser* = 1, 2, …, *Nuser*. Update the number of pad bits for *iuser*-th user accordingly.
3. The number of pad SC symbol blocks for MU PPDU transmission for *iuser*-th user is defined as .

The number of pad blocks  takes into account MU PPDU padding only and does not include the regular padding described in 30.5.6.3.3 and 30.5.6.3.4.

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.

**References:**

1. 11-17-0649-01-00ay-comments-on-11ay-d0-3 (6)
2. Draft P802.11ay\_D0.3