# Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

**Submission Title:** [IL Comments Resolution]
**Date Submitted:** [ 12 November, 2008]
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**Re:** []

**Abstract:** [This document proposed resolutions to comments on DF02]

**Purpose:** [For consideration and discussion by IEEE 802.15 TG3C.]

- **Comment 103**: There is no code rate between 1/2 and 3/4. This causes large jumps in the available rates.
- **Suggested Resolution**: Add the following LDPC rate 5/8 parity check matrix to both SC and HSI-OFDM (red = - )

**Rate 5/8 Parity Check Matrix**

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | - | - | 5 | - | 18 | 16 | - | - | - | 3 | 6 | 10 | - | - | 0 | - | 7 | - | 5 | - | - | 4 | 4 | - | 10 | - | 5 | - | 7 | - | 19 |
| 2 | - | - | 6 | - | 7 | - | - | - | - | 2 | - | - | - | - | 9 | - | 20 | - | - | - | 4 | - | - | - | - | - | 19 | - | 10 | - | - | - |
| 3 | - | 18 | - | - | - | - | - | 0 | 10 | - | - | - | - | 16 | - | - | - | - | 9 | - | - | 12 | - | - | 4 | - | - | - | - | - | 17 | - |
| 4 | 5 | 0 | - | - | - | - | 18 | 16 | 6 | - | - | 3 | 0 | 10 | - | - | 5 | - | 7 | - | 4 | - | - | 4 | 5 | - | 10 | - | 19 | - | 7 | - |
| 5 | - | - | - | 6 | - | 7 | - | - | - | - | 2 | - | - | - | - | 9 | - | 20 | - | - | - | 4 | - | - | - | - | - | 19 | - | 10 | - | - |
| 6 | - | - | 18 | - | 0 | - | - | - | - | 10 | - | - | - | - | 16 | - | - | - | - | 9 | - | - | 12 | - | - | 4 | - | - | - | - | - | 17 |
| 7 | - | 5 | 0 | - | 16 | - | - | 18 | 3 | 6 | - | - | - | 0 | 10 | - | - | 5 | - | 7 | 4 | 4 | - | - | - | 5 | - | 10 | - | 19 | - | 7 |
| 8 | 6 | - | - | - | - | - | 7 | - | - | - | - | 2 | 9 | - | - | - | - | - | 20 | - | - | - | 4 | - | 19 | - | - | - | - | - | 10 | - |
| 9 | - | - | - | 18 | - | 0 | - | - | - | - | 10 | - | - | - | - | 16 | 9 | - | - | - | - | - | - | 12 | - | - | 4 | - | 17 | - | - | - |
| 10 | - | - | 5 | 0 | 18 | 16 | - | - | - | 3 | 6 | - | - | - | 0 | 10 | 7 | - | 5 | - | - | 4 | 4 | - | 10 | - | 5 | - | 7 | - | 19 | - |
| 11 | - | 6 | - | - | - | - | - | 7 | 2 | - | - | - | - | 9 | - | - | - | - | - | 20 | - | - | - | 4 | - | 19 | - | - | - | - | - | 10 |
| 12 | 18 | - | - | - | - | - | 0 | - | - | - | - | 10 | 16 | - | - | - | - | 9 | - | - | 12 | - | - | - | - | - | - | 4 | - | 17 | - | - |

- **Comment 231, 244, 103**: Too much gap between rate 1/2 and 3/4, add a rate in the middle (Add rate 5/8 add an MCS using 16QAM and LDPC rate 5/8 in HSI-OFDM)
- **Suggested Resolution:**

Add the following MCSs to SC:

| | | | | |
|---|---|---|---|---|
| Class 3 | HR1 | 3402 Mbps | π/2-8PSK | LDPC(672,504) |
| Class 3 | HR2 | 3780 Mbps | π/2-16QAM | LDPC(672,420) |

Add the followings HSI-OFDM MCS:

| MCS | Data Rate | Modulation | Coding Mode | Spreading |
|---|---|---|---|---|
| | 5670 Mbps | 64-QAM | 5/8 | 1 |

- **Comment 234, 238, 241, 243, 246,249,251,295** : Remove sub-clause 12.2.2.2.4 (Pad Bits) or remove from Table 106
- **Suggested Resolution:**
- 12.2.5 Data field

The data field is the last component of the frame, and is constructed as shown in Figure 144.

The data field shall be constructed as follows:

a) compute the FCS over frame payload,

b) form the data field by appending the 4-octet FCS to the frame payload,

c) scramble the resulting combination according to 12.2.5.1,

d) encode the scrambled data field into NFEC codewords as specified in 12.2.2.2. The number of FEC codewords is calculated as follows:

$$N_{FEC} = \left\lceil \frac{LENGTH \times 8}{L_{FEC} \times R_{FEC}} \right\rceil$$

where $L_{FEC}$ is the FEC codeword length, *LENGTH* is the length of the frame payload defined in the header field (in octets), and $R_{FEC}$ is the code rate. The FEC codeword length, $L_{FEC}$, is 2040 for the Reed Solomon FEC specified in 12.2.2.2.1, 672 for the irregular LDPC specified in 12.2.2.2.2, and 1440 for the rate 14/15 irregular LDPC specified in 12.2.2.3.

e) the encoded data field shall be concatenated with $N_{PAD}$ pad bits in order to ensure that the resulting data field is aligned on the sub-block symbol boundary. The pad bits shall be set to zero and than scrambled using the continuation of the scrambler sequence that scrambled the frame payload and FCS in step a). The number of pad bits, $N_{PAD}$ , shall be computed as follow. The number of encoded bits in the data field is given by:

$$N_{EBITS} = 8 \times (LENGTH + 4) + N_{FEC} \times (1 - R_{FEC})$$

The number of symbol sub-blocks, $N_{SBLKS}$ , and the number of pad bits, NPAD, are calculated as follows:

$$N_{SBLKS} = \lceil N_{EBITS} / N_{CBPS} \rceil$$
$$N = N_{SBLKS} \times N_{CBPS} - N_{EBITS}$$

where $N_{CBPS}$ is the number of coded bits per symbol sub-block as specified in **Table 102b**.

f) spread the encoded and scrambled data field using the appropriate spreading sequence as detailed in 12.2.2.3,

g) map the resulting data field onto the appropriate constellation as specified in 12.2.2.1,

h) build symbol sub-blocks from the spread data field according to 12.2.5.5.1,

i) insert the PCES periodically as described in 12.2.5.5.2,

j) apply a chip level $\pi/2$-continous rotation to the resulting data field as described in 12.2.2.1.

# Table 102a—Data field rate-dependent parameters

| MCS Class | MCS Identifier | Data Rate PHY-SAP ($N_{PW}$ = 64) $R$ (Mbps) | Data Rate PHY-SAP ($N_{PW}$ = 0) $R$ (Mbps) | Modulation Scheme | Spreading Factor $SF$ | FEC Type | FEC Rate $R_{FEC}$ |
|---|---|---|---|---|---|---|---|
| CMS | CMS | 25.31 | 25.31 | π/2–BPSK/(G)MSK | 64 | RS(255,239) | 0.94 |
| Class1 | LR1-SF4 | 354.3 | 404.9 | π/2–BPSK/(G)MSK | 4 | RS(255,239) | 0.937 |
| | LR1-SF2 | 708.6 | 809.8 | π/2–BPSK/(G)MSK | 2 | RS(255,239) | 0.937 |
| | LR1-SF1 | 1417.1 | 1619.6 | π/2–BPSK/(G)MSK | 1 | RS(255,239) | 0.937 |
| | LR2-SF2 | 567.0 | 648.0 | π/2–BPSK/(G)MSK | 2 | LDPC(672,504) | 0.750 |
| | LR2-SF1 | 1134.0 | 1296.0 | π/2–BPSK/(G)MSK | 1 | LDPC(672,504) | 0.750 |
| | LR3-SF2 | 378.0 | 432.0 | π/2–BPSK/(G)MSK | 2 | LDPC(672,336) | 0.500 |
| | LR3-SF1 | 648.0 | 740.6 | π/2–BPSK/(G)MSK | 1 | LDPC(672,336) | 0.500 |
| Class2 | MR1 | 1512.0 | 1728.0 | π/2-QPSK | 1 | LDPC(672,336) | 0.500 |
| | MR2 | 2268.0 | 2592.0 | π/2-QPSK | 1 | LDPC(672,504) | 0.750 |
| | MR3 | 2646.0 | 3024.0 | π/2-QPSK | 1 | LDPC(672,588) | 0.875 |
| | MR4 | 2822.4 | 3225.6 | π/2-QPSK | 1 | LDPC(1440,1344) | 0.933 |
| Class3 | HR1 | 4251.4 | 4858.7 | π/2-*8QAM | 1 | RS(255,239) | 0.937 |
| | HR2 | 4233.6 | 4838.4 | π/2-8PSK | 1 | LDPC(1440,1344) | 0.933 |
| | HR3 | 3780.0 | 4320.0 | π/2-16QAM | 1 | LDPC(672,420) | 0.625 |

# Table 102b—Rate dependent bits per symbol

| MCS Identifier | Coded Bits Per Subblock (with $N_{PW}$ = 64) $N_{CBPS}$ | Coded Bits Per Subblock (with $N_{PW}$ = 0) $N_{CBPS}$ |
|---|---|---|
| CMS | Not Available | 8 |
| LR1-SF4 | 112 | 128 |
| LR1-SF2 | 224 | 256 |
| LR1-SF1 | 448 | 512 |
| LR2-SF2 | 224 | 256 |
| LR2-SF1 | 448 | 512 |
| LR3-SF2 | 224 | 256 |
| LR3-SF1 | 448 | 512 |
| MR1 | 896 | 1024 |
| MR2 | 896 | 1024 |
| MR3 | 896 | 1024 |
| MR4 | 896 | 1024 |
| HR1 | 1344 | 1536 |
| HR2 | 1344 | 1536 |
| HR3 | 1792 | 2048 |

- 12.3.2 Data field

  The data field is the last component of the frame, and is constructed as shown in Figure 155.

  The data field shall be constructed as follows:

  a) compute the FCS over frame payload,

  b) form the data field by appending the 4-octet FCS to the frame payload,

  c) scramble the resulting combination according to 12.3.2.2,

  d) encode the scrambled data field into NFEC codewords and interleave the result as specified in 12.3.2.3. The number of FEC codewords is calculated as follows:

$$N_{FEC} = \left\lceil \frac{LENGTH \times 8}{L_{FEC} \times R_{FEC}} \right\rceil$$

  where $L_{FEC}$ = 672 is the LDPC codeword length, *LENGTH* is the length of the frame payload defined in the header field (in octets), and $R_{FEC}$ is the code rate.

  e) the resulting data field shall be concatenated with $N_{PAD}$ pad bits in order to ensure that the resulting data field is aligned on the OFDM symbol boundary. The pad bits shall be set to zero and than scrambled using the continuation of the scrambler sequence that scrambled the frame payload and FCS in step a). The number of pad bits, $N_{PAD}$ , shall be computed as follow. The number of encoded bits in the data field is given by:

$$N_{EBITS} = 8 \times (LENGTH + 4) + N_{FEC} \times (1 - R_{FEC})$$

The number of OFDM symbols, $N_{SBLKS}$ , and the number of pad bits, $N_{PAD}$, are calculated as follows:

$$N_{SBLKS} = \lceil N_{EBITS} / N_{CBPS} \rceil$$
$$N = N_{SBLKS} \times N_{CBPS} - N_{EBITS}$$

where $N_{CBPS}$ is the number of coded bits per symbol sub-block as specified in Table 126.

f) map the resulting data field onto the appropriate constellation as specified in 12.3.2.4,

g) spread the QPSK and QAM modulated signal as described in Table 12.3.2.5

h) interleave the data with the tone interleaver as described in 12.3.2.6,

i) modulate the resulting complex values with the OFDM modulator described in 12.3.2.7, and

j) insert PCES periodically as described in 12.3.2.8.

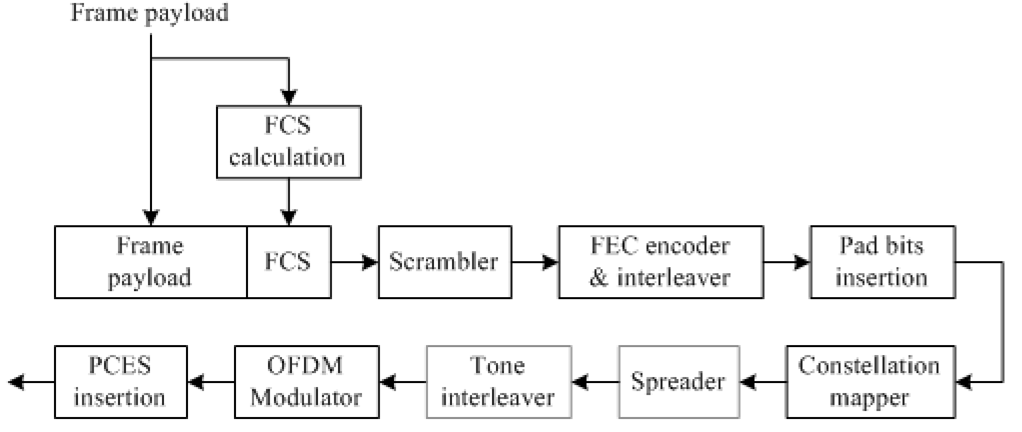


Fig 155. Data field construction process

- Remove Stuff chips subclause 12.2.2.2.4 and stuff chips from Table 106
- Remove pad bits 12.3.2.1 and pad bits from Table 129
- Same procedures should be applied to the headers in both SC and HSI-OFDM

- **Comment 235**: Simplify SC CES structure and sequences in the preamble (12.2.3, P.92)
- **Suggested Resolution: (see next slide)**

- CMS preamble:

| CES/SFD | SYNC |
|---|---|
| $-\mathbf{b}_{128}\ \mathbf{u}_{512}$ (repeated 6 times) $-\mathbf{u}_{512}\ \mathbf{u}_{512}$ | $\mathbf{a}_{128}$ (repeated 64 times) |

- Long preamble:

| | CES/SFD | SYNC |
|---|---|---|
| **Header with SF = 2** | $-\mathbf{b}_{128}\ \mathbf{u}_{512}\ \mathbf{u}_{512}$ | $\mathbf{a}_{128}$ (repeated 32 times) |
| **Header with SF =8** | $+\mathbf{b}_{128}\ \mathbf{v}_{512}\ \mathbf{v}_{512}$ | $\mathbf{a}_{128}$ (repeated 32 times) |

- Short preamble

| CES/SFD | SYNC |
|---|---|
| $-\mathbf{b}_{128}\ \mathbf{u}_{512}$ | $\mathbf{a}_{128}$ (repeated 8 times) |

**Transmission direction** ←

- $\mathbf{u}_{512} = [+\mathbf{a}_{256}\ +\mathbf{b}_{256}]$, $\mathbf{v}_{512} = [-\mathbf{a}_{256}\ +\mathbf{b}_{256}]$,
- $\mathbf{b}_{256} = [-\mathbf{a}_{128}\ -\mathbf{b}_{128}]$, $\mathbf{a}_{256} = [\mathbf{a}_{128}\ -\mathbf{b}_{128}]$,
- PCES = [CES/SFD $\mathbf{a}_{128}$]

- **Comment 236, 247, 248**: Simplify OFDM CES structure and sequences (12.2.2.4), Is there a need for short and long CES?
- **Suggested Resolution:**

Long preamble (MCS-0):

| CES/SFD | SFD | SYNC |
|---|---|---|
| $-\mathbf{b}_{128}\ \mathbf{u}_{512}$ (repeated 8 times) | $\mathbf{u}_{512}\ \mathbf{u}_{512}\ -\mathbf{u}_{512}\ \mathbf{u}_{512}$ | $\mathbf{a}_{128}$ (repeated 128 times) |

Short preamble:

| | CES | SFD | SYNC |
|---|---|---|---|
| **Short CES** | $-\mathbf{b}_{128}\ \mathbf{u}_{512}\ \mathbf{u}_{512}$ | $\mathbf{u}_{512}$ | $\mathbf{a}_{128}$ (repeated 16 times) |
| **Long CES** | $-\mathbf{b}_{128}\ \mathbf{u}_{512}\ \mathbf{u}_{512}\ \mathbf{u}_{512}\mathbf{u}_{512}$ | $\mathbf{v}_{512}$ | $\mathbf{a}_{128}$ (repeated 16 times) |

**Transmission direction** ←

- $\mathbf{u}_{512} = [+\mathbf{a}_{256}\ +\mathbf{b}_{256}]$, $\mathbf{v}_{512} = [-\mathbf{a}_{256}\ +\mathbf{b}_{256}]$,
- $\mathbf{b}_{256} = [-\mathbf{a}_{128}\ -\mathbf{b}_{128}]$, $\mathbf{a}_{256} = [\mathbf{a}_{128}\ -\mathbf{b}_{128}]$,
- PCES = [CES $\mathbf{a}_{128}$]

- **Comment 239**: Restrict usage of long preamble to common mode only, same for base header (12.2.4.1)
- **Suggested Resolution:**

  Long preamble renamed CMS preamble.

  Base header rate of 12.3 Mbps is used only with CMS.

- **Comment 245**: Add a rate for 16QAM with spreading that provides frequency diversity and is equivalent to QPSK but better performance
- **Suggested Resolution:**

withdraw

- **Comment 250**: Should beam tracking index be part of header for both SC & OFDM? (12.3.1.9, P104)
- **Suggested Resolution:**

  Withdraw

- **Comment 253**: Add more description on the effect of switched antennas and sectored antennas on the 2-level beamforming
- **Suggested Resolution:**

13.4, P60, lines 40-41: replace the following lines

"The beam forming protocol consists of a mandatory two-level training mechanism and an optional tracking"

with

"The beam forming protocol consists of a two-level training mechanism and an optional tracking"

- **Comment 255**: Revisit Feedback stage in the two level beamforming for devices that are omni capable on Tx or Rx
- **Suggested Resolution:**

  Withdraw