IEEE P802.11  
Wireless LANs

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| Annex L update for the DBand | | | | |
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Abstract

This document proposes text that would add to Annex L the 60GHz transmission test vectors and resolve CIDs 6002/6293.

***Insert the following text***

## L.4 DBand Example Data Vectors

All of the example data text files referenced by clauses L.4 to L.8 of this annex are contained in a single ZIP file, **DBandEncodingExamples.zip**, that is embedded in document **11-12/0078r0**.

For each described node there is a cross-reference in this document that is of the form,

Reference: <**filename.txt**>

where the named text file is one of the files in the ZIP file embedded in 11-12/0078r0.

Depending on the node being illustrated, the text file may represent bit data, symbol data or sample data;

* For bit data the text file contains a time ordered sequence of 1 and 0 characters, separated by spaces and without any carriage control characters.
* For symbol data the text file contains a time ordered sequence of signed integers, separated by spaces and without any carriage control characters.
* For sample data the text file contains a time ordered sequence of complex values, formatted as ±<real>±<imag>j, separated by spaces and without any carriage control characters.

When referencing specific bits, symbols or samples in the files, they are considered to be numbered starting from 1.

This formatting of the text files has been chosen to facilitate import into other tools. For example, the files can be read using the MATLAB dlmread('filename') command.

For CPHY, SCPHY and LPSCPHY modulation samples, no spectrum shaping has been applied to the data because the implementation of spectrum shaping is not defined in the specification.

For OFDMPHY modulation samples, no symbol shaping has been applied to the data because the implementation of OFDM symbol shaping is not defined in the specification.

## L.5 DBand Example 1 - CPHY Encoding

### L.5.1 CPHY Preamble



Figure 1. CPHY Preamble expressed in Ga128 and Gb128 sequences

The CPHY preamble Short Training Field (STF) and Channel Equalization Field (CEF) are each constructed from a concatenation of real valued bipolar Golay sequences that is π/2-BPSK modulated.

The CPHY preamble is 7552 samples long.

Reference: **CPHY\_Preamble Samples.txt**.

### L.5.2 CPHY Header



Figure 2. CPHY Header Coding and Modulation

#### L.5.2.1 CPHY Header and Payload Bits

Figure 2 node ➀. The 5 octets of header data followed by the payload data. The first 6 octets of the data payload are used to complete the construction of the single LDPC codeword of the CPHY header.

For this example the CPHY header bit fields are set as listed in Table 1.

|  |  |
| --- | --- |
| **Field** | **Value** |
| Scrambler Initialization | 2 |
| Length | 120 |
| Packet Type | 0 |
| Training Length | 0 |
| SIFS response | 0 |
| Reserved bits | 0 |

Table 1. CPHY Header Settings

The data payload octets are provided by a count, modulo 256, starting at 0. The resulting header and payload sequence is 1000 bits long, of which the first 88 bits are encoded in the header modulation block.

For this example, with a payload of 120 octets, LDPFCW = 88, LDPCW = 152 and LDPLCW = 152.

These numbers illustrate that the payload is not simply packed 168 bits at a time into the LDPC encoding, with the last few bits (modulo 168) in the last packet getting disproportionate coding gain. The specified calculation ensures that the excess coding gain is spread evenly across all the packets, so the number of payload bits in each packet varies between approximately 120 and the maximum 168.

Reference: Bits 1 to 88 of the file **CPHY\_Header and Payload bits.txt**.

#### L.5.2.2 CPHY Scrambled Header and Payload Bits

Figure 2 node ➁. The 5 header plus 6 data = 11 octets after scrambling.

Reference: Bits 1 to 88 of the file **CPHY\_Scrambled Header and Payload bits.txt**.

#### L.5.2.3 CPHY LDPC Encoded Header Bits

Figure 2 node ➂. In this example there are 7 LDPC codewords, the first (after zero stripping) produces 88 + 168 = 256 bits, the remaining 6 each produce 152 + 168 = 320 bits, so there is a total of 256 + 6 x 320 = 2176 bits after LDPC encoding, of which the first 256 bits correspond to the LDPC encoded header.

Reference: Bits 1 to 256 of the file **CPHY\_LDPC Encoded Header and Payload bits.txt**.

#### L.5.2.4 CPHY Differentially Encoded Header Symbols

Figure 2 node ➃. The 256 LDPC encoded header bits are differentially encoded.

Reference: Symbols 1 to 256 of the file **CPHY\_Diff Encoded Header and Payload symbols.txt**.

#### L.5.2.5 CPHY Header Samples

Figure 2 node ➄. The 256 differentially encoded bipolar symbol values are spread using the Ga32 Golay sequence, then /2 rotated to produce 8192 chips at Fc = 1760 MHz.

Reference: Samples 1 to 8192 of the file **CPHY\_Header and Payload samples.txt**.

### L.5.3 CPHY Payload



Figure 3. CPHY Payload Coding and Modulation

#### L.5.3.1 CPHY Payload Bits

Figure 3 node ➀.

Reference: Bits 89 to 1000 of the file **CPHY\_Header and Payload bits.txt**.

#### L.5.3.2 CPHY Scrambled Payload Bits

Figure 3 node ➁.

Reference: Bits 89 to 1000 of the file **CPHY\_Scrambled Header and Payload bits.txt**.

#### L.5.3.3 CPHY LDPC Encoded Payload Bits.

Figure 3 node ➂.

Reference: Bits 257 to 2176 of the file **CPHY\_LDPC Encoded Header and Payload bits.txt**

#### L.5.3.4 CPHY Differentially Encoded Payload Symbols

Figure 3 node ➃.

Reference: Symbols 257 to 2176 of the file **CPHY\_Diff Encoded Header and Data symbols.txt**

#### L.5.3.5 CPHY Payload Samples

Figure 3 node ➄.

In this example, the 320 differentially encoded bipolar symbol values from each of the 6 payload bearing LDPC codewords, including the last one, gives a total of 6 x 320 = 1920 symbols which are then spread using the Ga32 Golay sequence and /2 rotated to produce 61440 chips at Fc = 1.76 GHz.

Reference: Samples 8193 to 69632 of the file **CPHY\_Header and Payload samples.txt.**

## L.6 DBand Example 2 – SCPHY Encoding

### L.6.1 SCPHY Preamble



Figure 4. SCPHY Preamble expressed in Ga128 and Gb128 sequences

The SCPHY preamble Short Training Field (STF) and Channel Equalization Field (CEF) are each constructed from a concatenation of real valued bipolar Golay sequences that is π/2-BPSK modulated.

The preamble is 3328 samples long.

Reference: **SCPHY\_Preamble Samples.txt.**

### L.6.2 SCPHY Header



Figure 5. SCPHY Header Coding and Modulation

#### L.6.2.1 SCPHY Header Bits

Figure 5 node ➀. The 8 octets of header data.

For this example the SCPHY header bit fields are set as listed in Table 2.

|  |  |
| --- | --- |
| **Field** | **Value** |
| Scrambler Initialization | 66 |
| MCS | 2 |
| Length | 1000 |
| Additional PPDU | 0 |
| Packet Type | 0 |
| Training Length | 0 |
| Aggregation | 0 |
| Beam Tracking Request | 0 |
| Last RSSI | 0 |
| SIFS response | 0 |
| Reserved bits | 0 |

Table 2. SCPHY Header Settings

Reference: **SCPHY\_MCS2\_Header bits.txt.**

#### L.6.2.2 SCPHY Scrambled Header Bits

Figure 5 node ➁. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **SCPHY\_MCS2\_Scrambled Header bits.txt**

#### L.6.2.3 SCPHY LDPC Encoded Header Bits

Figure 5 node ➂. The scrambled header data after LDPC encoding but prior to zero stripping.

Reference: **SCPHY\_MCS2\_LDPC Encoded Header bits.txt**

#### L.6.2.4 SCPHY LDPC Data Shortened Bits

Figure 5 node ➃. The dimension of SCPHY modulation blocks requires that the CS1 and CS2 sequences are each 224 bits long; this in turn requires that, in addition to the zeros, some of the parity bits are discarded in order to shorten the LDPC codewords to 224 bits.

The data for the second shortened LDPC codeword is given as they are before they are scrambled to provide CS2.

Reference: **SCPHY\_MCS2\_Shortened LDPC for CS1 bits.txt**

Reference: **SCPHY\_MCS2\_Shortened LDPC for CS2 bits.txt**

#### L.6.2.5 SCPHY CS1/CS2 Sequence Bits

Figure 5 node ➄. The 448 bit concatenated CS1/CS2 sequence including the PN scrambling of CS2.

Reference: **SCPHY\_MCS2\_Final CS1 CS2 Sequence bits.txt**

#### L.6.2.6 SCPHY Header Samples

Figure 5 node ➅. The fully modulated signal after BPSK mapping, duplication (with negation), Guard Interval addition and π/2 rotation are applied.

The 448 header bits are BPSK mapped to 448 modulation symbols and increased to 512 symbols by the addition of a 64 symbol Guard Interval. A second, negated, copy of the 448 modulation symbols is also increased to 512 symbols by the addition of a 64 symbol Guard Interval. The two 512 symbol blocks are concatenated and π/2 rotated to create 1024 samples.

Reference: **SCPHY\_MCS2\_Header Samples.txt**

### L.6.3 SCPHY Payload



Figure 6. SCPHY MCS1 Payload Coding and Modulation



Figure 7. SCPHY MCS2 - MCS12 Payload Coding and Modulation

#### L.6.3.1 SCPHY MCS1 Payload

##### L.6.3.1.1 Payload Bits

Figure 6 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS1 each rate 1/2 LDPC codeword encodes 168 bits (with repetition) so the payload padding calculation gives *N*CW = 48 and *N*DATA\_PAD = 64.

There are 1000 x 8 = 8000 payload bits plus 64 padding bits giving a total of 8064 bits.

Reference: **SCPHY\_MCS1\_Payload bits.txt**

##### L.6.3.1.2 Scrambled Payload Bits

Figure 6 node ➁. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY\_MCS1\_Scrambled Payload bits.txt**

##### L.6.3.1.3 1/2-Rate LDPC Encoded Bits before Scrambled Duplication

Figure 6 node ➂. The rate 1/2 LDPC encoding of each block of scrambled payload bits plus padding zero bits. In this example, the 8064 actual payload bits are doubled, by repetition, to an effective payload of 16128 bits, then doubled again to 32256 bits by LDPC encoding.

This node, unique to MCS1, is the raw LDPC encoded payload bits before scrambled duplication.

Reference: **SCPHY\_MCS1\_LDPC Encoder Output bits.txt**

##### L.6.3.1.4 1/2-Rate LDPC Encoded Bits after Scrambled Duplication

Figure 6 node ➃. The LDPC codewords after the zeros have been replaced by the re-scrambled data octets. The data at this node also includes the appended *N*BLK\_PAD scrambled zeros, however, in this example, *N*BLK\_PAD = 0, so we still have 32256 bits.

Each 448 bits in the reference file is the *N*CBPB = 448 bits required to build a modulation block of the MCS1 payload.

Reference: **SCPHY\_MCS1\_LDPC Encoded Payload Bits.txt**

##### L.6.3.1.5 Payload Samples

Figure 6 node ➄. The modulated signal after BPSK Mapping, Guard Interval addition and /2 rotation has been applied.

In this example the 32256 encoded bits are divided into 72 x 448 bit blocks. BPSK mapping converts this to 72 x 448 modulation symbols which the Guard Interval increases to 72 x 512 modulation symbols. When the closing 64 symbol Guard Interval is added we get a total of 72 x 512 + 64 = 36928 payload samples.

Reference: **SCPHY\_MCS1\_Payload Samples.txt**

#### L.6.3.2 SCPHY MCS5 Payload

##### L.6.3.2.1 Payload Bits

Figure 7 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS5 each rate 13/16 LDPC codeword encodes 546 bits so the payload padding calculation gives *N*CW = 15 and *N*DATA\_PAD = 190.

There are 1000 x 8 = 8000 payload bits plus 190 padding bits giving a total of 8190 bits.

Reference: **SCPHY\_MCS5\_Payload bits.txt**

##### L.6.3.2.2 Scrambled Payload Bits

Figure 7 node ➁. All 8190 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY\_MCS5\_Scrambled Payload bits.txt**

##### L.6.3.2.3 13/16-Rate LDPC Encoded Payload Bits

Figure 6 node ➂. The rate 13/16 LDPC encoding of each block of scrambled payload bits. In this example, the 8190 payload bits are increased to 10080 bits by the LDPC encoding.

The data at this node also includes the appended *N*BLK\_PAD scrambled zeros. In this example, *N*BLK\_PAD = 224, so we still have a total of 10080 + 224 = 10304 bits.

Reference: **SCPHY\_MCS5\_LDPC Encoded Payload Bits.txt**

##### L.6.3.2.4 Payload Samples

Figure 7 node ➃. The modulated signal after BPSK Mapping, Guard Interval addition and /2 rotation has been applied.

In this example the 10304 encoded bits are divided into 23 x 448 bit blocks. BPSK mapping converts this to 23 x 448 modulation symbols which the Guard Interval increases to 23 x 512 modulation symbols. When the closing 64 symbol Guard Interval is added we get a total of 23 x 512 + 64 = 11840 payload samples.

Reference: **SCPHY\_MCS5\_Payload Samples.txt**

#### L.6.3.3 SCPHY MCS7 Payload

##### L.6.3.3.1 Payload Bits

Figure 7 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS7 each rate 5/8 LDPC codeword encodes 420 bits so the payload padding calculation gives *N*CW = 20 and *N*DATA\_PAD = 400.

There are 1000 x 8 = 8000 payload bits plus 400 padding bits giving a total of 8400 bits.

Reference: **SCPHY\_MCS7\_Payload bits.txt**

##### L.6.3.3.2 Scrambled Payload Bits

Figure 6 node ➁. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY\_MCS7\_Scrambled Payload bits.txt**

##### L.6.3.3.3 5/8-Rate LDPC Encoded Payload Bits

Figure 7 node ➂. The rate 5/8 LDPC encoding of each block of scrambled payload bits. In this example, the 8400 payload bits are increased to 13440 bits by the LDPC encoding.

The data at this node also includes the appended *N*BLK\_PAD scrambled zeros. In this example, *N*BLK\_PAD = 0, so we still have a total of 13440 bits.

Reference: **SCPHY\_MCS7\_LDPC Encoded Payload Bits.txt**

##### L.6.3.3.4 Payload Samples

Figure 7 node ➃. The modulated signal after QPSK Mapping, Guard Interval addition and /2 rotation has been applied.

In this example the 13440 encoded bits are divided into 15 x 896 bit blocks. QPSK mapping converts this to 15 x 448 modulation symbols which the Guard Interval increases to 15 x 512 modulation symbols. When the closing 64 symbol Guard Interval is added we get a total of 15 x 512 + 64 = 7744 payload samples.

Reference: **SCPHY\_MCS7\_Payload Samples.txt**

#### L.6.3.4 SCPHY MCS12 Payload

##### L.6.3.4.1 Payload Bits

Figure 7 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS12 each rate 3/4 LDPC codeword encodes 504 bits so the payload padding calculation gives *N*CW = 16 and *N*DATA\_PAD = 64.

There are 1000 x 8 = 8000 payload bits plus 64 padding bits giving a total of 8064 bits.

Reference: **SCPHY\_MCS12\_Payload bits.txt**

##### L.6.3.4.2 Scrambled Payload Bits

Figure 7 node ➁. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **SCPHY\_MCS12\_Scrambled Payload bits.txt**

##### L.6.3.4.3 3/4-Rate LDPC Encoded Payload Bits

Figure 7 node ➂. The rate 3/4 LDPC encoding of each block of scrambled payload bits. In this example, the 8064 payload bits are increased to 10752 bits by the LDPC encoding.

The data at this node also includes the appended *N*BLK\_PAD scrambled zeros. In this example, *N*BLK\_PAD = 0, so we still have a total of 10752 bits.

Reference: **SCPHY\_MCS12\_LDPC Encoded Payload Bits.txt**

##### L.6.3.4.4 Payload Samples

Figure 7 node ➃. The modulated signal after 16QAM Mapping, Guard Interval addition and /2 rotation has been applied.

In this example the 10752 encoded bits are divided into 6 x 1792 bit blocks. 16QAM mapping converts this to 6 x 448 modulation symbols which the Guard Interval increases to 6 x 512 modulation symbols. When the closing 64 symbol Guard Interval is added we get a total of 6 x 512 + 64 = 3136 payload samples.

Reference: **SCPHY\_MCS12\_Payload Samples.txt**

## L.7 DBand Example 3 – OFDMPHY Encoding

### L.7.1 OFDMPHY Preamble



Figure 8. OFDMPHY Preamble

Figure 8 illustrates that the OFDMPHY preamble is similar to the SCPHY preamble but with the Gu512 and Gv512 parts of the CEF reversed. It is also resampled from 1.76GSa/s to 2.64GSa/s using the specified process of interpolation, resampling and decimation.

Thus the OFDMPHY preamble sample count increases from 3328 to 4992.

Reference: **OFDMPHY\_Preamble Samples.txt**

### L.7.2 OFDMPHY Header Coding



Figure 9. OFDMPHY Header Coding

#### L.7.2.1 OFDMPHY Header Bits

Figure 9 node ➀. The 8 octets of header data.

For this example the OFDMPHY header bit fields are set as listed in Table 3.

|  |  |
| --- | --- |
| **Field** | **Value** |
| Scrambler Initialization | 66 |
| MCS | 13 |
| Length | 1000 |
| Additional PPDU | 0 |
| Packet Type | 0 |
| Training Length | 0 |
| Aggregation | 0 |
| Beam Tracking Request | 0 |
| Tone Pairing Type | 0 |
| DTP Indicator | 0 |
| Last RSSI | 0 |
| SIFS response | 0 |
| Reserved bits | 0 |

Table 3. OFDMPHY Header Settings

Reference: **OFDMPHY\_MCS13\_Header bits.txt**

#### L.7.2.2 OFDMPHY Scrambled Header Bits

Figure 9 node ➁. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **OFDMPHY\_MCS13\_Scrambled Header bits.txt**

#### L.7.2.3 OFDMPHY LDPC Encoded Header Bits

Figure 9 node ➂. The scrambled header bits after LDPC encoding but prior to zero stripping.

Reference: **OFDMPHY\_MCS13\_LDPC Encoded Header Bits.txt**

#### L.7.2.4 OFDMPHY LDPC Data Shortened Bits

Figure 9 node ➃. The dimension of OFDMPHY modulation symbols requires that the CS1, CS2 and CS3 sequences are each 224 bits long; this in turn requires that, in addition to the zeros, some of the parity bits are discarded in order to shorten the LDPC codewords to 224 bits.

The data for the second and third shortened LDPC codewords are given as they are before they are scrambled to provide CS2 and CS3.

Reference: **OFDMPHY\_MCS13\_Shortened LDPC for CS1 bits.txt**

Reference: **OFDMPHY\_MCS13\_Shortened LDPC for CS2 bits.txt**

Reference: **OFDMPHY\_MCS13\_Shortened LDPC for CS3 bits.txt**

#### L.7.2.5 OFDMPHY CS1/CS2/CS3 Sequence Bits

Figure 5 node ➄. The 672 bit concatenated CS1/CS2/CS3 sequence including the PN scrambling of CS2 and CS3.

Reference: **OFDMPHY\_MCS13\_Final CS1 CS2 CS3 Sequence bits.txt**

### L.7.3 OFDMPHY Header Modulation



Figure 10. OFDMPHY Header Modulation

#### L.7.3.1 Constellation Mapped Data Points

Figure 10 node ➀. The LDPC encoded data is converted in the specified manner to 336 QPSK constellation point values prior to assignment to data carriers (in the same order as the data they were derived from). Note that because of the action of the *Q* matrix, these points look like 16QAM when plotted.

Reference: Samples 1 to 336 of the file **OFDMPHY\_MCS13\_Constellation Mapped Data Points.txt**

#### L.7.3.2 IFFT Input Samples Including Data, Pilot, DC and Null Carriers

Figure 10 node ➁. At this node the data points have been mapped to the data carriers, the pilots, DC and null carriers have been assigned, and the resulting 512 point frequency domain vector is in the correct order for input to the inverse Fourier transform, i.e. with positive frequencies in the first 256 locations and negative frequencies in the second 256 locations.

Reference: Samples 1 to 512 of the file **OFDMPHY\_MCS13\_FFT Input Samples.txt**

#### L.7.3.3 Header Samples

Figure 10 node ➂. At this node the signal has been inverse Fourier transformed to produce a time record and the cyclic prefix has been appended to create the 640 sample OFDM symbol.

Reference: **OFDMPHY\_MCS13\_Header Samples.txt**

### L.7.4 OFDMPHY Payload Coding



Figure 11. OFDMPHY Payload Coding

As illustrated in Figure 11, the LDPC encoding for the OFDMPHY case is identical to the SCPHY case, so no additional LDPC vectors are strictly necessary. However, the equations for computing the zero padding at the end of the payload are different from the SCPHY case so bit vectors for nodes 1, 2 and 3 are provided.

### L.7.5 OFDMPHY MCS14 Payload Modulation



Figure 12. OFDMPHY SQPSK Payload Modulation

#### L.7.5.1 Payload Bits

Figure 11 node ➀. The payload comprises 1000 x 8 bits. With *N*CBPS = 336 and rate 5/8 LDPC coding the OFDMPHY zero padding *N*PAD = 400, so the padded payload comprises 8400 bits.

Reference: **OFDMPHY\_MCS14\_ Payload bits.txt**

#### L.7.5.2 Scrambled Payload Bits

Figure 11 node ➁. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY\_MCS14\_Scrambled Payload bits.txt**

#### L.7.5.3 LDPC Encoded Payload Bits

Figure 11 node ➂. For this example, with *N*CBPS = 336 and rate 5/8 LDPC coding there are 20 LDPC codewords or 20 x 672 = 13440 bits at this node.

Reference: **OFDMPHY\_MCS14\_LDPC Encoded Payload bits.txt**

#### L.7.5.4 SQPSK Constellation Mapped Data Points

Figure 12 node ➀. For SQPSK modulation, each block of NCBPS = 336 LDPC encoded bits is converted in the specified manner to 168 QPSK constellation point values and their complex conjugates prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 336 LDPC encoded bits, so there are 40 sets of 336 constellation points (13440 point in total) at this node.

Reference: Samples 337 to 13776 of the file **OFDMPHY\_MCS14\_Constellation Mapped Data Points.txt**

#### L.7.5.5 Payload Samples

Figure 12 node ➁. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 40 OFDM symbols in this example payload giving a total of 40 x 640 = 25600 samples.

Reference: **OFDMPHY\_MCS14\_Payload Samples.txt**

### L.7.6 OFDMPHY MCS17 Payload Modulation



Figure 13. OFDMPHY QPSK Payload Modulation

#### L.7.6.1 Payload Bits

Figure 11 node ➀. The payload comprises 1000 x 8 bits. With *N*CBPS = 672 and rate 3/4 LDPC coding the OFDMPHY zero padding *N*PAD = 64, so the padded payload comprises 8064 bits.

Reference: **OFDMPHY\_MCS17\_ Payload bits.txt**

#### L.7.6.2 Scrambled Payload Bits

Figure 11 node ➁. All 8064 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY\_MCS17\_Scrambled Payload bits.txt**

#### L.7.6.3 LDPC Encoded Payload Bits

Figure 11 node ➂. For this example, with *N*CBPS = 672 and rate 3/4 LDPC coding there are 16 LDPC codewords or 16 x 672 = 10752 bits at this node.

Reference: **OFDMPHY\_MCS17\_LDPC Encoded Payload bits.txt**

#### L.7.6.4 QPSK Constellation Mapped Data Points

Figure 13 node ➀. For QPSK modulation, each block of NCBPS = 672 LDPC encoded bits is converted in the specified manner to 336 QPSK constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 672 LDPC encoded bits, so there are 16 sets of 336 constellation points (5376 point in total) at this node.

Reference: Samples 337 to 5712 of the file **OFDMPHY\_MCS17\_Constellation Mapped Data Points.txt**

#### L.7.6.5 Payload Samples

Figure 13 node ➁. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 16 OFDM symbols in this example payload giving a total of 16 x 640 = 10240 samples.

Reference: **OFDMPHY\_MCS17\_Payload Samples.txt**

### L.7.7 OFDMPHY MCS19 Payload Modulation



Figure 14. OFDMPHY 16QAM Payload Modulation

#### L.7.7.1 Payload Bits

Figure 11 node ➀. The payload comprises 1000 x 8 bits. With *N*CBPS = 1344 and rate 5/8 LDPC coding the OFDMPHY zero padding *N*PAD = 400, so the padded payload comprises 8400 bits.

Reference: **OFDMPHY\_MCS19\_ Payload bits.txt**

#### L.7.7.2 Scrambled Payload Bits

Figure 11 node ➁. All 8400 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY\_MCS19\_Scrambled Payload bits.txt**

#### L.7.7.3 LDPC Encoded Payload Bits

Figure 11 node ➂. For this example, with *N*CBPS = 1344 and rate 5/8 LDPC coding there are 20 LDPC codewords or 20 x 672 = 13440 bits at this node.

Reference: **OFDMPHY\_MCS19\_LDPC Encoded Payload bits.txt**

#### L.7.7.4 16QAM Constellation Mapped Data Points

Figure 14 node ➀. For 16QAM modulation, each block of NCBPS = 1344 LDPC encoded bits is converted in the specified manner to 336 16QAM constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 1344 LDPC encoded bits, so there are 10 sets of 336 constellation points (3360 points in total) at this node.

Reference: Samples 337 to 3696 of the file **OFDMPHY\_MCS19\_Constellation Mapped Data Points.txt**

#### L.7.7.5 Payload Samples

Figure 14 node ➁. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 10 OFDM symbols in this example payload giving a total of 10 x 640 = 6400 samples.

Reference: **OFDMPHY\_MCS19\_Payload Samples.txt**

### L.7.8 OFDMPHY MCS23 Payload Modulation



Figure 15. OFDMPHY 64QAM Payload Modulation

#### L.7.8.1 Payload Bits

Figure 11 node ➀. The payload comprises 1000 x 8 bits. With *N*CBPS = 2016 and rate 3/4 LDPC coding the OFDMPHY zero padding *N*PAD = 1072, so the padded payload comprises 9072 bits.

Reference: **OFDMPHY\_MCS23\_ Payload bits.txt**

#### L.7.8.2 Scrambled Payload Bits

Figure 11 node ➁. All 9072 bits are scrambled according to a scrambler initialization value of 66.

Reference: **OFDMPHY\_MCS23\_Scrambled Payload bits.txt**

#### L.7.8.3 LDPC Encoded Bits

Figure 11 node ➂. For this example, with *N*CBPS = 2016 and rate 3/4 LDPC coding there are 18 LDPC codewords or 18 x 672 = 12096 bits at this node.

Reference: **OFDMPHY\_MCS23\_LDPC Encoded Payload bits.txt**

#### L.7.8.4 64QAM Constellation Mapped Data Points

Figure 15 node ➀. For 64QAM modulation, each block of NCBPS = 2016 LDPC encoded bits is converted in the specified manner to 336 64QAM constellation point values prior to assignment to data carriers, in the same order as the data they were derived from.

There are 336 constellation points for each block of 2016 LDPC encoded bits, so there are 6 sets of 336 constellation points (2016 points in total) at this node.

Reference: Samples 337 to 2352 of the file **OFDMPHY\_MCS23\_Constellation Mapped Data Points.txt**

#### L.7.8.5 Payload Samples

Figure 15 node ➁. Each set of 336 constellation points is mapped to 512 frequency domain points then inverse Fourier transformed to 512 time domain points; adding the cyclic prefix creates a 640 sample OFDM symbol. There are 6 OFDM symbols in this example payload giving a total of 6 x 640 = 3840 samples.

Reference: **OFDMPHY\_MCS23\_Payload Samples.txt**

## L.8 DBand Example 4 – LPSCPHY Encoding

### L.8.1 LPSCPHY Preamble

The LPSCPHY preamble is identical to the SCPHY preamble.

### L.8.2 LPSCPHY Header



Figure 16. LPSCPHY Header Coding and Modulation

#### L.8.2.1 Header Bits

Figure 16 node ➀. The 8 octets of header data.

For this example the LPSCPHY header bit fields are set as follows;

|  |  |
| --- | --- |
| **Field** | **Value** |
| Scrambler Initialization | 66 |
| MCS | 26 |
| Length | 1000 |
| Additional PPDU | 0 |
| Packet Type | 0 |
| Training Length | 0 |
| Aggregation | 0 |
| Beam Tracking Request | 0 |
| Last RSSI | 0 |
| SIFS response | 0 |
| Reserved bits | 0 |

Table 4. LPSCPHY Header Settings

Reference: **LPSCPHY\_MCS26\_Header bits.txt**

#### L.8.2.2 Scrambled Header Bits

Figure 16 node ➁. The header bits after scrambling bits 8 to 64 of the header using the seed 66 (0x42).

Reference: **LPSCPHY\_MCS26\_Scrambled Header bits.txt**

#### L.8.2.3 RS(24,8) Encoded Header Bits

Figure 16 node ➂. The 8 octets of header data are RS(24,8) encoded. The 8 message octets followed by the 16 parity octets give the complete 24 octet RS codeword.

There are 24 x 8 = 192 bits at this node.

Reference: **LPSCPHY\_MCS26\_RS(24,8) Encoded Header bits.txt**

#### L.8.2.4 (16,8) Block Coded Header Bits

Figure 16 node ➃. The (16,8) block coder doubles the effective bits from 192 to 384, then a zero padding octet is added to take the bit count up to the 392 needed to compose a modulation block.

Reference: **LPSCPHY\_MCS26\_(16,8) Block Coded Header bits.txt**

#### L.8.2.5 Header Bit Interleaver Output

Figure 16 node ➄. The bit interleaver re-orders the 392 bits into a different time sequence.

Reference: **LPSCPHY\_MCS26\_Header Interleaver Output bits.txt**

#### L.8.2.6 Header Samples

node ➅. The 392 bits of the header interleaver output are BPSK mapped, prepended with a Ga64 sequence as a Guard Interval and punctuated by G8 (last 8 samples of Ga64) Guard Intervals, then /2 rotated; resulting in a 512 sample /2-BPSK header modulation block.

Reference: **LPSCPHY\_MCS26\_Header Samples.txt**

### L.8.3 LPSCPHY MCS26 Payload



Figure 17. LPSCPHY Payload Coding and Modulation

#### L.8.3.1 Payload Bits

Figure 17 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS26 the LPSCPHY payload padding calculation gives *N*DATA\_PAD = 368, however, unlike the other PHYs this padding data is not appended before FEC computation.

So there are just 1000 x 8 = 8000 payload bits.

Reference: **LPSCPHY\_MCS26\_Payload bits.txt**

#### L.8.3.2 Scrambled Payload Bits

Figure 17 node ➁. All 8000 bits are scrambled according to a scrambler initialization value of 66.

Reference: **LPSCPHY\_MCS26\_Scrambled Payload bits.txt**

#### L.8.3.3 RS(224,208) Encoded Payload Bits

Figure 17 node ➂. In this example there are 4 RS(224,208) codewords and one shortened RS(184,168) codeword, giving a total of (4 x 224 + 1 x 184) x 8 = 8640 bits at this node.

Reference: **LPSCPHY\_MCS26\_RS(224,208) Output bits.txt**

#### L.8.3.4 (12,8) Block Coded Payload Bits

Figure 17 node ➃. The (12,8) block coder increases the effective bits from 8640 to 12960.

Reference: **LPSCPHY\_MCS26\_Block Coded Payload bits.txt**

#### L.8.3.5 Interleaved Payload bits

Figure 17 node ➄. Before interleaving the block coder output is padded with *N*DATA\_PAD = 368 scrambled zeros to give 13328 bits (34 x 392). The interleaver then redistributes these bits in time, as specified.

Reference: **LPSCPHY\_MCS26\_RS Encoded and Interleaved Payload bits.txt**

#### L.8.3.6 Payload Samples

Figure 17 node ➅. Each block of 392 bits from the interleaver output is BPSK mapped to 392 modulation symbols, prepended with a Ga64 sequence as a Guard Interval and punctuated by G8 (last 8 samples of Ga64) Guard Intervals, then /2 rotated; resulting in a 512 symbol /2-BPSK modulation block.

In this example there are 34 modulation blocks and, as specified, the last one is followed by a terminating Ga64 Guard Interval sequence, so there are 34 x 512 + 64 = 17472 samples at this node.

Reference: **LPSCPHY\_MCS26\_Payload Samples.txt**

### L.8.4 LPSCPHY MCS30 Payload

#### L.8.4.1 Payload Bits

Figure 17 node ➀. The payload at node ➀ is a count, modulo 256, starting at 0.

For MCS30 the LPSCPHY payload padding calculation gives *N*DATA\_PAD = 472, however, unlike the other PHYs this padding data is not appended before FEC computation.

So there are just 1000 x 8 = 8000 payload bits.

Reference: **LPSCPHY\_MCS30\_Payload bits.txt**

#### L.8.4.2 Scrambled Payload Bits

Figure 17 node ➁. All 8000 bits are scrambled according to a scrambler initialization value of 66.

Reference: **LPSCPHY\_MCS30\_Scrambled Payload bits.txt**

#### L.8.4.3 RS(224,208) Encoded Payload Bits

Figure 17 node ➂. In this example there are 4 RS(224,208) codewords and one shortened RS(184,168) codeword, giving a total of (4 x 224 + 1 x 184) x 8 = 8640 bits at this node.

Reference: **LPSCPHY\_MCS30\_RS(224,208) Output bits.txt**

#### L.8.4.4 Spc(9,8) Block Coded Payload Bits

Figure 17 node ➃. The (9,8) block coder increases the effective bits from 8640 to 9720.

Reference: **LPSCPHY\_MCS30\_Block Coded Payload bits.txt**

#### L.8.4.5 Interleaved Payload bits

Figure 17 node ➄. Before interleaving the block coder output is padded with *N*DATA\_PAD = 472 scrambled zeros to give 10192 bits (26 x 392). The interleaver then redistributes these bits in time, as specified.

Reference: **LPSCPHY\_MCS30\_RS Encoded and Interleaved Payload bits.txt**

#### L.8.4.6 Payload Samples

Figure 17 node ➅. Each block of 784 bits from the interleaver output is QPSK mapped to 392 modulation symbols, prepended with a Ga64 sequence as a Guard Interval and punctuated by G8 (last 8 samples of Ga64) Guard Intervals, then /2 rotated; resulting in a 512 symbol /2-BPSK modulation block.

In this example there are 13 modulation blocks and, as specified, the last one is followed by a terminating Ga64 Guard Interval sequence, so there are 13 x 512 + 64 = 6720 samples at this node.

Reference: **LPSCPHY\_MCS30\_Payload Samples.txt**