**101.3.2.4 FEC encoding process**

The {EPoC\_PMD\_Name} encodes the transmitted data using Low-Density Parity-Check (LDPC) (FC, FP) code. The CLT {EPoC\_PMD\_Name} PCS operating on active CCDN shall encode the transmitted data using one of the LDPC (FC, FP) codes per Table 101-1, as selected using register TBD. The CNU {EPoC\_PMD\_Name} PCS operating on active CCDN shall encode the transmitted data using one of the LDPC (FC, FP) codes per Table 101-2, as selected using register TBD.

Annex 101A gives an example of LDPC (FC, FP) FEC encoding. {we will need to select one of the codes from the family of codes we use in either downstream or upstream and then generate examples}

TABLE101-1: LDCP codes used by the CLT {EPoC\_PMD\_Name} PCS for active CCDN

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Codeword FC[bits] | Payload FP[bits] | Parity FR[bits] | Payload | Parity |
| 65-bit blocksBQ | Padding bitsBP | 64-bit blocksCQ | Parity bits in last block CPL | Padding bitsCP |
| 16200 | 14400 | 1800 | 221 | 35 | 29 | 8 | 56 |

{content of this table was taken from the approved baseline: [prodan\_3bn\_01a\_0713.pdf](http://www.ieee802.org/3/bn/public/jul13/prodan_3bn_01a_0713.pdf), separated into upstream and downstream directions}

TABLE 101-2: LDCP codes used by the CNU {EPoC\_PMD\_Name} PCS for active CCDN

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Codeword FC[bits] | Payload FP[bits] | Parity FR[bits] | Payload | Parity |
| 65-bit blocksBQ | Padding bitsBP | 64-bit blocksCQ | Parity bits in last block CPL | Padding bitsCP |
| 16200 | 14400 | 1800 | 221 | 35 | 29 | 8 | 56 |
| 5940 | 5040 | 900 | 77 | 35 | 15 | 4 | 60 |
| 1120 | 840 | 280 | 12 | 60 | 5 | 24 | 40 |

{content of this table was taken from the approved baseline: [prodan\_3bn\_01a\_0713.pdf](http://www.ieee802.org/3/bn/public/jul13/prodan_3bn_01a_0713.pdf), separated into upstream and downstream directions; more FEC codes are likely to be }

{The following matrices were extracted from [EPoC FEC for active coax plants (rev 01b)](http://www.ieee802.org/3/bn/public/jul13/prodan_3bn_01b_0713.pdf), as updated. This material with technical changes has not been yet adopted as baseline proposal.}

The LDCP (16200, 14400) code has a rate of 8/9, with the code definition matrix of 5 × 45 elements, as presented in Table 1.

Table 1a: LDCP (16200, 14400) code matrix, columns 1-15

|  |  |
| --- | --- |
| **Row** | **Column** |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** |
| **1** | 93 | 271 | -1 | 83 | 26 | 208 | 245 | 200 | -1 | 175 | 331 | 17 | 86 | -1 | 337 |
| **2** | 274 | 115 | 329 | 338 | 124 | -1 | 293 | -1 | 69 | 64 | 342 | -1 | 88 | 139 | -1 |
| **3** | 134 | 355 | 175 | 24 | 253 | 242 | -1 | 187 | 94 | 26 | 87 | 302 | -1 | 191 | 323 |
| **4** | -1 | -1 | 184 | 70 | 247 | 14 | 22 | 7 | 285 | 54 | -1 | 352 | 26 | 108 | 10 |
| **5** | 253 | 273 | 90 | -1 | -1 | 151 | 311 | 320 | 339 | -1 | 295 | 148 | 48 | 91 | 62 |

Table 1b: LDCP (16200, 14400) code matrix, columns 16-30

|  |  |
| --- | --- |
| **Row** | **Column** |
| **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** |
| **1** | -1 | 238 | 81 | -1 | 307 | -1 | 165 | -1 | 47 | 76 | 73 | 150 | 349 | 139 | 331 |
| **2** | 137 | 212 | -1 | 157 | 195 | 357 | 81 | 194 | 1 | 159 | 56 | 72 | 126 | 277 | 156 |
| **3** | 22 | -1 | 245 | 294 | 240 | 84 | 76 | 342 | 345 | 174 | 269 | 329 | -1 | 214 | -1 |
| **4** | 298 | 123 | 139 | 117 | -1 | 336 | 49 | 202 | 359 | 342 | -1 | 224 | 106 | -1 | 273 |
| **5** | 100 | 232 | 146 | 200 | 135 | 12 | -1 | 179 | -1 | -1 | 232 | -1 | 21 | 331 | 313 |

Table 1c: LDCP (16200, 14400) code matrix, columns 31-45

|  |  |
| --- | --- |
| **Row** | **Column** |
| **31** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** | **40** | **41** | **42** | **43** | **44** | **45** |
| **1** | 118 | 345 | 27 | 294 | -1 | 145 | 279 | 97 | 106 | 160 | 143 | -1 | -1 | -1 | -1 |
| **2** | 32 | 111 | 175 | -1 | 306 | 224 | -1 | 206 | -1 | 29 | 106 | 334 | -1 | -1 | -1 |
| **3** | -1 | -1 | -1 | 218 | 104 | 40 | 197 | 73 | 229 | 63 | -1 | 270 | 72 | -1 | -1 |
| **4** | 177 | 245 | 98 | 355 | 178 | 176 | 147 | -1 | 280 | -1 | -1 | -1 | 221 | 208 | -1 |
| **5** | 349 | 34 | 97 | 187 | 38 | -1 | 235 | 52 | 170 | 58 | -1 | -1 | -1 | 257 | 0 |

The LDCP (5940, 5040) code has a rate of 28/33, with the code definition matrix of 5 × 33 elements, as presented in Table 2.

Table 2a: LDCP (5940, 5040) code matrix, columns 1-11

|  |  |
| --- | --- |
| **Row** | **Column** |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **1** | 142 | 158 | 113 | 124 | 92 | 44 | 93 | 70 | 172 | 3 | 25 |
| **2** | 54 | 172 | 145 | 28 | 55 | 19 | 159 | 22 | 96 | 12 | 85 |
| **3** | 63 | 11 | 112 | 114 | 61 | 123 | 72 | 55 | 114 | 20 | 53 |
| **4** | 28 | 160 | 102 | 44 | 8 | 84 | 126 | 9 | 169 | 174 | 147 |
| **5** | 52 | 159 | 75 | 74 | 46 | 71 | 42 | 11 | 108 | 153 | -1 |

Table 2b: LDCP (5940, 5040) code matrix, columns 12-22

|  |  |
| --- | --- |
| **Row** | **Column** |
| **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** |
| **1** | 44 | 141 | 160 | 50 | 45 | 118 | 84 | -1 | 64 | 66 | 97 |
| **2** | -1 | 128 | 5 | 158 | 120 | 51 | 171 | 65 | 141 | -1 | 42 |
| **3** | 114 | 42 | 33 | 4 | 66 | 163 | 50 | 46 | 17 | 175 | -1 |
| **4** | 24 | 145 | -1 | 26 | -1 | -1 | -1 | 67 | 82 | 4 | 177 |
| **5** | 72 | -1 | 163 | -1 | 9 | 2 | 168 | 158 | -1 | 1 | 49 |

Table 2c: LDCP (5940, 5040) code matrix, columns 23-33

|  |  |
| --- | --- |
| **Row** | **Column** |
| **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** | **32** | **33** |
| **1** | 1 | 115 | 8 | 108 | -1 | -1 | 22 | -1 | -1 | -1 | -1 |
| **2** | 83 | 7 | -1 | 39 | 121 | 84 | 101 | 171 | -1 | -1 | -1 |
| **3** | -1 | -1 | 92 | -1 | 41 | 138 | -1 | 34 | 74 | -1 | -1 |
| **4** | 151 | 131 | 139 | 117 | 36 | 18 | -1 | -1 | 23 | 8 | -1 |
| **5** | 89 | 63 | 179 | 10 | 75 | 161 | -1 | -1 | -1 | 177 | 19 |

The LDCP (1120, 840) code has a rate of 3/4, with the code definition matrix of 5 × 20 elements, as presented in Table 3.

Table 3a: LDCP (1120, 840) code matrix, columns 1-10

|  |  |
| --- | --- |
| **Row** | **Column** |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| **1** | 5 | 14 | 12 | 1 | 2 | 37 | 45 | 26 | 24 | 0 |
| **2** | 0 | 35 | 1 | 26 | 0 | 10 | 16 | 16 | 34 | 4 |
| **3** | 12 | 28 | 22 | 46 | 3 | 16 | 51 | 2 | 25 | 29 |
| **4** | 0 | 51 | 16 | 31 | 13 | 39 | 27 | 33 | 8 | 27 |
| **5** | 36 | 6 | 3 | 51 | 4 | 19 | 4 | 45 | 48 | 9 |

Table 3b: LDCP (1120, 840) code matrix, columns 11-20

|  |  |
| --- | --- |
| **Row** | **Column** |
| **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** |
| **1** | 3 | -1 | 34 | 7 | 46 | 10 | -1 | -1 | -1 | -1 |
| **2** | 2 | 23 | 0 | 51 | -1 | 49 | 20 | -1 | -1 | -1 |
| **3** | 19 | 18 | 52 | -1 | 37 | -1 | 34 | 39 | -1 | -1 |
| **4** | 53 | 13 | -1 | 52 | 33 | -1 | -1 | 38 | 7 | -1 |
| **5** | -1 | 11 | 22 | 23 | 43 | -1 | -1 | -1 | 14 | 1 |

**101.3.2.4.1 LDPC algorithm**

QC-LDPC (n, k) code parity-check matrix can be divided into blocks of L by L submatrices, where L represents the submatrix size or lifting factor. The parity-check matrix in compact circulant form is represented by an m by n block matrix:



Each submatrix Hi,j is a L by L all-zero submatrix or a cyclic right-shifted Identity submatrix.

The parity-check matrix tables consist of entries {-1, 0,…, L-1}, where the value of “-1” represents an all zero submatrix, and the remaining values represent an identity submatrix which has been cyclically right-shifted by the specified value.

The Hbase matrix can be represented as [H1 | H2] where H2 represents the parity portion. The code rate is (n-m)/n and a codeword length is n L bits.

{this material was taken from the approved baseline: [prodan\_3bn\_01a\_0713.pdf](http://www.ieee802.org/3/bn/public/jul13/prodan_3bn_01a_0713.pdf), and needs further development into a consistent and short (as possible) description – I will be looking for some help here – otherwise, I will only convert what was approved with simple text edits. Note that we need to avoid defining the code itself and rather point to any normative or informative publication (publicly available at best) which provides all the necessary details of the code. At best, we should only have to define the code rate and any parameters of the LDCP code that we use later on in the definitions}

**101.3.2.4.2 LDPC encoding process within CLT (downstream)**

The process of padding FEC codewords and appending FEC parity octets in the {EPoC\_PMD\_Name} CLT transmitter is illustrated in Figure 101-1. The 64B/66B encoder produces a stream of 66-bit blocks, which are then delivered to the FEC encoder. The FEC encoder accumulates BQ (see Table 101-1 for CLT PCS and Table 101-2 for CNU PCS) of these 66-bit blocks to form the payload of a FEC codeword, removing the redundant first bit (i.e., sync header bit <0>) in each 66-bit block received from the 64B/66B encoder. The first bit <0> of the sync header in the 66-bit block in the transmit direction is guaranteed to be the complement of the second bit <1> of the sync header – see 49.2.4.3 for more details.

Next, the FEC encoder prepends BP (see Table 101-1 for CLT PCS and Table 101-2 for CNU PCS) padding bits (binary 0) to the previously aggregated series of 65-bit blocks (blocks number 1 through BQ), forming the payload of the FEC codeword as shown in Figure 101-1. This data is then LDPC-encoded, resulting in the FR bits of parity data. The parity data is then divided into CQ 64-bit blocks, each of which is then prepended with one bit sync header <1> with the value of binary “1”. The last 64-bit block of the parity data contains CPL bits of parity data, and the remaining 56 bits are filled with padding (binary “0”).



FIGURE 101-1: PCS Transmit bit ordering within CLT (downstream)

**101.3.2.4.3 LDPC codeword transmission order within CLT (downstream)**

Once the process of calculating FEC parity is complete, the BQ 65-bit blocks with payload data, followed by CQ 65-bit blocks with parity data and padding are then transferred towards the PMA across the PMA service interface, one 65-bit block at a time. Note that the BP padding bits used to generate the FEC codeword are not transmitted across the PMA service interface. The CP padding bits in the last parity codeword (block number CQ) are transmitted to PMA, where they are the discarded prior to encoding into OFDM medium.

**101.3.2.4.4 State diagrams**

{State Diagrams for FEC will be added once we agree on the operational details, how padding is used and what we are actually aggregating at what time and in what fashion}

**101.3.2.5 Data Detector**

{The presence of the Data Detector remains for discussion at this time, given that EPoC does not use lasers and there was no clear need demonstrated until now for anything like a Data Detector function}