# 3GPP TS 38.212 V15.1.1 (2018-04)

*Technical Specification*

**3rd Generation Partnership Project;**
**Technical Specification Group Radio Access Network;**
**NR;**
**Multiplexing and channel coding**
**(Release 15)**

Keywords

3GPP, New Radio, Layer 1

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# Contents

# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

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# 1 Scope

The present document specifies the coding, multiplexing and mapping to physical channels for 5G NR.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 38.201: "NR; Physical Layer – General Description"

[3] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[4] 3GPP TS 38.211: "NR; Physical channels and modulation"

[5] 3GPP TS 38.213: "NR; Physical layer procedures for control"

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data"

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

[8] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

BCH Broadcast channel
CBG Code block group
CBGTI Code block group transmission information
CQI Channel quality indicator
CRC Cyclic redundancy check
CRI CSI-RS resource indicator

| | |
|---|---|
| CSI | Channel state information |
| CSI-RS | CSI reference signal |
| DAI | Downlink assignment index |
| DCI | Downlink control information |
| DL | Downlink |
| DL-SCH | Downlink shared channel |
| DMRS | Dedicated demodulation reference signal |
| HARQ | Hybrid automatic repeat request |
| HARQ-ACK | Hybrid automatic repeat request acknowledgement |
| LDPC | Low density parity check |
| LI | Layer indicator |
| MCS | Modulation and coding scheme |
| OFDM | Orthogonal frequency division multiplex |
| PBCH | Physical broadcast channel |
| PCH | Paging channel |
| PDCCH | Physical downlink control channel |
| PDSCH | Physical downlink shared channel |
| PMI | Precoding matrix indicator |
| PRB | Physical resource block |
| PRACH | Physical random access channel |
| PTRS | Phase-tracking reference signal |
| PUCCH | Physical uplink control channel |
| PUSCH | Physical uplink shared channel |
| RACH | Random access channel |
| RI | Rank indicator |
| RSRP | Reference signal received power |
| SFN | System frame number |
| SR | Scheduling request |
| SRS | Sounding reference signal |
| SS | Synchronisation signal |
| SUL | Supplementary uplink |
| TPC | Transmit power control |
| UCI | Uplink control information |
| UE | User equipment |
| UL | Uplink |
| UL-SCH | Uplink shared channel |
| VRB | Virtual resource block |
| ZP CSI-RS | Zero power CSI-RS |

# 4 Mapping to physical channels

## 4.1 Uplink

Table 4.1-1 specifies the mapping of the uplink transport channels to their corresponding physical channels. Table 4.1-2 specifies the mapping of the uplink control channel information to its corresponding physical channel.

**Table 4.1-1**

| TrCH | Physical Channel |
|---|---|
| UL-SCH | PUSCH |
| RACH | PRACH |

**Table 4.1-2**

| Control information | Physical Channel |
|---|---|
| UCI | PUCCH, PUSCH |

## 4.2 Downlink

Table 4.2-1 specifies the mapping of the downlink transport channels to their corresponding physical channels. Table 4.2-2 specifies the mapping of the downlink control channel information to its corresponding physical channel.

**Table 4.2-1**

| TrCH | Physical Channel |
|---|---|
| DL-SCH | PDSCH |
| BCH | PBCH |
| PCH | PDSCH |

**Table 4.2-2**

| Control information | Physical Channel |
|---|---|
| DCI | PDCCH |

# 5 General procedures

Data and control streams from/to MAC layer are encoded /decoded to offer transport and control services over the radio transmission link. Channel coding scheme is a combination of error detection, error correcting, rate matching, interleaving and transport channel or control information mapping onto/splitting from physical channels.

## 5.1 CRC calculation

Denote the input bits to the CRC computation by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ , and the parity bits by $p_0, p_1, p_2, p_3, \ldots, p_{L-1}$ , where $A$ is the size of the input sequence and $L$ is the number of parity bits. The parity bits are generated by one of the following cyclic generator polynomials:

- $g_{\text{CRC24A}}(D) = [D^{24} + D^{23} + D^{18} + D^{17} + D^{14} + D^{11} + D^{10} + D^7 + D^6 + D^5 + D^4 + D^3 + D + 1]$ for a CRC length $L = 24$ ;
- $g_{\text{CRC24B}}(D) = [D^{24} + D^{23} + D^6 + D^5 + D + 1]$ for a CRC length $L = 24$ ;
- $g_{\text{CRC24C}}(D) = [D^{24} + D^{23} + D^{21} + D^{20} + D^{17} + D^{15} + D^{13} + D^{12} + D^8 + D^4 + D^2 + D + 1]$ for a CRC length $L = 24$ ;
- $g_{\text{CRC16}}(D) = [D^{16} + D^{12} + D^5 + 1]$ for a CRC length $L = 16$ ;
- $g_{\text{CRC11}}(D) = [D^{11} + D^{10} + D^9 + D^5 + 1]$ for a CRC length $L = 11$ ;
- $g_{\text{CRC6}}(D) = [D^6 + D^5 + 1]$ for a CRC length $L = 6$ .

The encoding is performed in a systematic form, which means that in GF(2), the polynomial:

$$a_0 D^{A+L-1} + a_1 D^{A+L-2} + \ldots + a_{A-1} D^L + p_0 D^{L-1} + p_1 D^{L-2} + \ldots + p_{L-2} D^1 + p_{L-1}$$

yields a remainder equal to 0 when divided by the corresponding CRC generator polynomial.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$ , where $B = A + L$ . The relation between $a_k$ and $b_k$ is:

$b_k = a_k$ for $k = 0,1,2,\ldots, A-1$

$b_k = p_{k-A}$ for $k = A, A+1, A+2, ..., A+L-1$ .

# 5.2 Code block segmentation and code block CRC attachment

## 5.2.1 Polar coding

The input bit sequence to the code block segmentation is denoted by $a_0, a_1, a_2, a_3, ..., a_{A-1}$ , where $A > 0$ .

if $I_{seg} = 1$

Number of code blocks: $C = 2$ ;

else

Number of code blocks: end if

$A' = \lceil A/C \rceil \cdot C$ ;

for $i = 0$ to $A' - A - 1$

$a'_i = 0$ ;

end for

for $i = A' - A$ to $A' - 1$

$a'_i = a_{i-(A'-A)}$ ;

end for

$s = 0$ ;

for $r = 0$ to $C - 1$

for $k = 0$ to $A'/C - 1$

$c_{rk} = a'_s$ ;

$s = s + 1$ ;

end for

The sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, ..., c_{r(A'/C-1)}$ is used to calculate the CRC parity bits $p_{r0}, p_{r1}, p_{r2}, ..., p_{r(L-1)}$ according to Subclause 5.1 with a generator polynomial of length $L$ .

for $k = A'/C$ to $A'/C + L - 1$

$c_{rk} = p_{r(k-A'/C)}$ ;

end for

end for

The value of $A$ is no larger than 1706.

### 5.2.2 Low density parity check coding

The input bit sequence to the code block segmentation is denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$, where $B > 0$. If $B$ is larger than the maximum code block size $K_{cb}$, segmentation of the input bit sequence is performed and an additional CRC sequence of $L = 24$ bits is attached to each code block.

For LDPC base graph 1, the maximum code block size is:

- $K_{cb} = 8448$.

For LDPC base graph 2, the maximum code block size is:

- $K_{cb} = 3840$.

Total number of code blocks *C* is determined by:

if $B \le K_{cb}$

$L = 0$

Number of code blocks: $C = 1$

$B' = B$

else

$L = 24$

Number of code blocks: $C = \lceil B / (K_{cb} - L) \rceil$.

$B' = B + C \cdot L$

end if

The bits output from code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $0 \le r < C$ is the code block number, and $K_r = K$ is the number of bits for the code block number $r$.

Number of bits in each code block:

$K' = B' / C$;

For LDPC base graph 1,

$K_b = 22$.

For LDPC base graph 2,

if $B > 640$

$K_b = 10$;

elseif $B > 560$

$K_b = 9$;

elseif $B > 192$

$K_b = 8$;

else

$K_b = 6$ ;

end if

find the minimum value of $Z$ in all sets of lifting sizes in Table 5.3.2-1, denoted as $Z_c$, such that $K_b \cdot Z_c \geq K'$, and set $K = 22Z_c$ for LDPC base graph 1 and $K = 10Z_c$ for LDPC base graph 2;

$s = 0$ ;

for $r = 0$ to $C - 1$

for $k = 0$ to $K' - L - 1$

$c_{rk} = b_s$ ;

$s = s + 1$ ;

end for

if $C > 1$

The sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K'-L-1)}$ is used to calculate the CRC parity bits $p_{r0}, p_{r1}, p_{r2}, \ldots, p_{r(L-1)}$ according to Subclause 5.1 with the generator polynomial $g_{\text{CRC24B}}(D)$ .

for $k = K' - L$ to $K' - 1$

$c_{rk} = p_{r(k+L-K')}$ ;

end for

end if

for $k = K'$ to $K - 1$ -- Insertion of filler bits

$c_{rk} = <NULL>$ ;

end for

end for

# 5.3 Channel coding

Usage of coding scheme for the different types of TrCH is shown in table 5.3-1. Usage of coding scheme for the different control information types is shown in table 5.3-2.

**Table 5.3-1: Usage of channel coding scheme for TrCHs**

| TrCH | Coding scheme |
|---|---|
| UL-SCH | LDPC |
| DL-SCH | |
| PCH | |
| BCH | Polar code |

**Table 5.3-2: Usage of channel coding scheme for control information**

| Control Information | Coding scheme |
|---|---|
| DCI | Polar code |
| UCI | Block code |
| | Polar code |

## 5.3.1 Polar coding

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits to encode. After encoding the bits are denoted by $d_0, d_1, d_2, \ldots, d_{N-1}$, where $N = 2^n$ and the value of $n$ is determined by the following:

Denote by $E$ the rate matching output sequence length as given in Subclause 5.4.1;

If $E \le (9/8) \cdot 2^{(\lceil \log_2 E \rceil - 1)}$ and $K/E < 9/16$

$n_1 = \lceil \log_2 E \rceil - 1$;

else

$n_1 = \lceil \log_2 E \rceil$;

end if

$R_{\min} = 1/8$;

$n_2 = \lceil \log_2 (K/R_{\min}) \rceil$;

$n = \max\{\min\{n_1, n_2, n_{\max}\}, n_{\min}\}$

where $n_{\min} = 5$.

### 5.3.1.1 Interleaving

The bit sequence $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$ is interleaved into bit sequence $c'_0, c'_1, c'_2, c'_3, \ldots, c'_{K-1}$ as follows:

$c'_k = c_{\Pi(k)}$, $k = 0, 1, \ldots, K-1$

where the interleaving pattern $\Pi(k)$ is given by the following:

if $I_{IL} = 0$

$\Pi(k) = k$, $k = 0, 1, \ldots, K-1$

else

$k = 0$;

for $m = 0$ to $K_{IL}^{\max} - 1$

if $\Pi_{IL}^{\max}(m) \ge K_{IL}^{\max} - K$

$\Pi(k) = \Pi_{IL}^{\max}(m) - (K_{IL}^{\max} - K)$;

$k = k + 1$;

end if

end for

end if

where $\Pi_{IL}^{max}(m)$ is given by Table 5.3.1.1-1 and $K_{IL}^{max}=164$ .

**Table 5.3.1.1-1: Interleaving pattern $\Pi_{IL}^{max}(m)$**

| $m$ | $\Pi_{IL}^{max}(m)$ | $m$ | $\Pi_{IL}^{max}(m)$ | $m$ | $\Pi_{IL}^{max}(m)$ | $m$ | $\Pi_{IL}^{max}(m)$ | $m$ | $\Pi_{IL}^{max}(m)$ | $m$ | $\Pi_{IL}^{max}(m)$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 28 | 67 | 56 | 122 | 84 | 68 | 112 | 33 | 140 | 38 |
| 1 | 2 | 29 | 69 | 57 | 123 | 85 | 73 | 113 | 36 | 141 | 144 |
| 2 | 4 | 30 | 70 | 58 | 126 | 86 | 78 | 114 | 44 | 142 | 39 |
| 3 | 7 | 31 | 71 | 59 | 127 | 87 | 84 | 115 | 47 | 143 | 145 |
| 4 | 9 | 32 | 72 | 60 | 129 | 88 | 90 | 116 | 64 | 144 | 40 |
| 5 | 14 | 33 | 76 | 61 | 132 | 89 | 92 | 117 | 74 | 145 | 146 |
| 6 | 19 | 34 | 77 | 62 | 134 | 90 | 94 | 118 | 79 | 146 | 41 |
| 7 | 20 | 35 | 81 | 63 | 138 | 91 | 96 | 119 | 85 | 147 | 147 |
| 8 | 24 | 36 | 82 | 64 | 139 | 92 | 99 | 120 | 97 | 148 | 148 |
| 9 | 25 | 37 | 83 | 65 | 140 | 93 | 102 | 121 | 100 | 149 | 149 |
| 10 | 26 | 38 | 87 | 66 | 1 | 94 | 105 | 122 | 103 | 150 | 150 |
| 11 | 28 | 39 | 88 | 67 | 3 | 95 | 107 | 123 | 117 | 151 | 151 |
| 12 | 31 | 40 | 89 | 68 | 5 | 96 | 109 | 124 | 125 | 152 | 152 |
| 13 | 34 | 41 | 91 | 69 | 8 | 97 | 112 | 125 | 131 | 153 | 153 |
| 14 | 42 | 42 | 93 | 70 | 10 | 98 | 114 | 126 | 136 | 154 | 154 |
| 15 | 45 | 43 | 95 | 71 | 15 | 99 | 116 | 127 | 142 | 155 | 155 |
| 16 | 49 | 44 | 98 | 72 | 21 | 100 | 121 | 128 | 12 | 156 | 156 |
| 17 | 50 | 45 | 101 | 73 | 27 | 101 | 124 | 129 | 17 | 157 | 157 |
| 18 | 51 | 46 | 104 | 74 | 29 | 102 | 128 | 130 | 23 | 158 | 158 |
| 19 | 53 | 47 | 106 | 75 | 32 | 103 | 130 | 131 | 37 | 159 | 159 |
| 20 | 54 | 48 | 108 | 76 | 35 | 104 | 133 | 132 | 48 | 160 | 160 |
| 21 | 56 | 49 | 110 | 77 | 43 | 105 | 135 | 133 | 75 | 161 | 161 |
| 22 | 58 | 50 | 111 | 78 | 46 | 106 | 141 | 134 | 80 | 162 | 162 |
| 23 | 59 | 51 | 113 | 79 | 52 | 107 | 6 | 135 | 86 | 163 | 163 |
| 24 | 61 | 52 | 115 | 80 | 55 | 108 | 11 | 136 | 137 | | |
| 25 | 62 | 53 | 118 | 81 | 57 | 109 | 16 | 137 | 143 | | |
| 26 | 65 | 54 | 119 | 82 | 60 | 110 | 22 | 138 | 13 | | |
| 27 | 66 | 55 | 120 | 83 | 63 | 111 | 30 | 139 | 18 | | |

### 5.3.1.2 Polar encoding

The Polar sequence $Q_0^{N_{max}-1}=\{Q_0^{N_{max}},Q_1^{N_{max}},\ldots,Q_{N_{max}-1}^{N_{max}}\}$ is given by Table 5.3.1.2-1, where $0\le Q_i^{N_{max}}\le N_{max}-1$ denotes a bit index before Polar encoding for $i=0,1,\ldots,N_{max}-1$ and $N_{max}=1024$ . The Polar sequence $Q_0^{N_{max}-1}$ is in ascending order of reliability $W(Q_0^{N_{max}})<W(Q_1^{N_{max}})¿\ldots<W(Q_{N_{max}-1}^{N_{max}})$ , where $W(Q_i^{N_{max}})$ denotes the reliability of bit index $Q_i^{N_{max}}$ .

For any code block encoded to $N$ bits, a same Polar sequence $Q_0^{N-1}=\{Q_0^N, Q_1^N, Q_2^N, \ldots, Q_{N-1}^N\}$ is used. The Polar sequence $Q_0^{N-1}$ is a subset of Polar sequence $Q_0^{N_{\max}-1}$ with all elements $Q_i^{N_{\max}}$ of values less than $N$, ordered in ascending order of reliability $W(Q_0^N)<W(Q_1^N)<W(Q_2^N)<\ldots<W(Q_{N-1}^N)$.

Denote $\bar{Q}_I^N$ as a set of bit indices in Polar sequence $Q_0^{N-1}$, and $\bar{Q}_F^N$ as the set of other bit indices in Polar sequence $Q_0^{N-1}$, where $\bar{Q}_I^N$ and $\bar{Q}_F^N$ are given in Subclause 5.4.1.1, $|\bar{Q}_I^N|=K+n_{PC}$, $|\bar{Q}_F^N|=N-|\bar{Q}_I^N|$, and $n_{PC}$ is the number of parity check bits.

Denote $G_N=(G_2)^{\otimes n}$ as the $n$ -th Kronecker power of matrix $G_2$, where $G_2=\begin{bmatrix}1 & 0\\ 1 & 1\end{bmatrix}$.

For a bit index $j$ with $j=0,1,\ldots,N-1$, denote $g_j$ as the $j$ -th row of $G_N$ and $w(g_j)$ as the row weight of $g_j$, where $w(g_j)$ is the number of ones in $g_j$. Denote the set of bit indices for parity check bits as $Q_{PC}^N$, where $|Q_{PC}^N|=n_{PC}$. A number of $(n_{PC}-n_{PC}^{wm})$ parity check bits are placed in the $(n_{PC}-n_{PC}^{wm})$ least reliable bit indices in $\bar{Q}_I^N$. A number of $n_{PC}^{wm}$ other parity check bits are placed in the bit indices of minimum row weight in $\tilde{Q}_I^N$, where $\tilde{Q}_I^N$ denotes the $(|\bar{Q}_I^N|-n_{PC})$ most reliable bit indices in $\bar{Q}_I^N$; if there are more than $n_{PC}^{wm}$ bit indices of the same minimum row weight in $\tilde{Q}_I^N$, the $n_{PC}^{wm}$ other parity check bits are placed in the $n_{PC}^{wm}$ bit indices of the highest reliability and the minimum row weight in $\tilde{Q}_I^N$.

Generate $u=[u_0 u_1 u_2 \ldots u_{N-1}]$ according to the following:

$k=0$;

if $n_{PC}>0$

$y_0=0$; $y_1=0$; $y_2=0$; $y_3=0$; $y_4=0$;

for $n=0$ to $N-1$

$y_t=y_0$; $y_0=y_1$; $y_1=y_2$; $y_2=y_3$; $y_3=y_4$; $y_4=y_t$;

if $n\in\bar{Q}_I^N$

if $n\in Q_{PC}^N$

$u_n=y_0$;

else

$u_n=c_k'$;

$k=k+1$;

$y_0=y_0\oplus u_n$;

end if

else

$u_n=0$;

end if

end for

else

for $n = 0$ to $N-1$

if $n \in \bar{Q}_I^N$

$u_n = c'_k$ ;

$k = k+1$ ;

else

$u_n = 0$ ;

end if

end for

end if

The output after encoding $d = [d_0 d_1 d_2 \ldots d_{N-1}]$ is obtained by $d = \mathbf{u}\mathbf{G}_N$ . The encoding is performed in GF(2).

**Table 5.3.1.2-1: Polar sequence $Q_0^{N_{max}-1}$ and its corresponding reliability $W(Q_i^{N_{max}})$**

| $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ | $W(Q_i^N)$ | $Q_i^N$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 128 | 518 | 256 | 94 | 384 | 214 | 512 | 364 | 640 | 414 | 768 | 819 | 896 | 966 |
| 1 | 1 | 129 | 54 | 257 | 204 | 385 | 309 | 513 | 654 | 641 | 223 | 769 | 814 | 897 | 755 |
| 2 | 2 | 130 | 83 | 258 | 298 | 386 | 188 | 514 | 659 | 642 | 663 | 770 | 439 | 898 | 859 |
| 3 | 4 | 131 | 57 | 259 | 400 | 387 | 449 | 515 | 335 | 643 | 692 | 771 | 929 | 899 | 940 |
| 4 | 8 | 132 | 521 | 260 | 608 | 388 | 217 | 516 | 480 | 644 | 835 | 772 | 490 | 900 | 830 |
| 5 | 16 | 133 | 112 | 261 | 352 | 389 | 408 | 517 | 315 | 645 | 619 | 773 | 623 | 901 | 911 |
| 6 | 32 | 134 | 135 | 262 | 325 | 390 | 609 | 518 | 221 | 646 | 472 | 774 | 671 | 902 | 871 |
| 7 | 3 | 135 | 78 | 263 | 533 | 391 | 596 | 519 | 370 | 647 | 455 | 775 | 739 | 903 | 639 |
| 8 | 5 | 136 | 289 | 264 | 155 | 392 | 551 | 520 | 613 | 648 | 796 | 776 | 916 | 904 | 888 |
| 9 | 64 | 137 | 194 | 265 | 210 | 393 | 650 | 521 | 422 | 649 | 809 | 777 | 463 | 905 | 479 |
| 10 | 9 | 138 | 85 | 266 | 305 | 394 | 229 | 522 | 425 | 650 | 714 | 778 | 843 | 906 | 946 |
| 11 | 6 | 139 | 276 | 267 | 547 | 395 | 159 | 523 | 451 | 651 | 721 | 779 | 381 | 907 | 750 |
| 12 | 17 | 140 | 522 | 268 | 300 | 396 | 420 | 524 | 614 | 652 | 837 | 780 | 497 | 908 | 969 |
| 13 | 10 | 141 | 58 | 269 | 109 | 397 | 310 | 525 | 543 | 653 | 716 | 781 | 930 | 909 | 508 |
| 14 | 18 | 142 | 168 | 270 | 184 | 398 | 541 | 526 | 235 | 654 | 864 | 782 | 821 | 910 | 861 |
| 15 | 128 | 143 | 139 | 271 | 534 | 399 | 773 | 527 | 412 | 655 | 810 | 783 | 726 | 911 | 757 |
| 16 | 12 | 144 | 99 | 272 | 537 | 400 | 610 | 528 | 343 | 656 | 606 | 784 | 961 | 912 | 970 |
| 17 | 33 | 145 | 86 | 273 | 115 | 401 | 657 | 529 | 372 | 657 | 912 | 785 | 872 | 913 | 919 |
| 18 | 65 | 146 | 60 | 274 | 167 | 402 | 333 | 530 | 775 | 658 | 722 | 786 | 492 | 914 | 875 |
| 19 | 20 | 147 | 280 | 275 | 225 | 403 | 119 | 531 | 317 | 659 | 696 | 787 | 631 | 915 | 862 |
| 20 | 256 | 148 | 89 | 276 | 326 | 404 | 600 | 532 | 222 | 660 | 377 | 788 | 729 | 916 | 758 |
| 21 | 34 | 149 | 290 | 277 | 306 | 405 | 339 | 533 | 426 | 661 | 435 | 789 | 700 | 917 | 948 |
| 22 | 24 | 150 | 529 | 278 | 772 | 406 | 218 | 534 | 453 | 662 | 817 | 790 | 443 | 918 | 977 |
| 23 | 36 | 151 | 524 | 279 | 157 | 407 | 368 | 535 | 237 | 663 | 319 | 791 | 741 | 919 | 923 |
| 24 | 7 | 152 | 196 | 280 | 656 | 408 | 652 | 536 | 559 | 664 | 621 | 792 | 845 | 920 | 972 |
| 25 | 129 | 153 | 141 | 281 | 329 | 409 | 230 | 537 | 833 | 665 | 812 | 793 | 920 | 921 | 761 |
| 26 | 66 | 154 | 101 | 282 | 110 | 410 | 391 | 538 | 804 | 666 | 484 | 794 | 382 | 922 | 877 |
| 27 | 512 | 155 | 147 | 283 | 117 | 411 | 313 | 539 | 712 | 667 | 430 | 795 | 822 | 923 | 952 |
| 28 | 11 | 156 | 176 | 284 | 212 | 412 | 450 | 540 | 834 | 668 | 838 | 796 | 851 | 924 | 495 |
| 29 | 40 | 157 | 142 | 285 | 171 | 413 | 542 | 541 | 661 | 669 | 667 | 797 | 730 | 925 | 703 |
| 30 | 68 | 158 | 530 | 286 | 776 | 414 | 334 | 542 | 808 | 670 | 488 | 798 | 498 | 926 | 935 |
| 31 | 130 | 159 | 321 | 287 | 330 | 415 | 233 | 543 | 779 | 671 | 239 | 799 | 880 | 927 | 978 |
| 32 | 19 | 160 | 31 | 288 | 226 | 416 | 555 | 544 | 617 | 672 | 378 | 800 | 742 | 928 | 883 |
| 33 | 13 | 161 | 200 | 289 | 549 | 417 | 774 | 545 | 604 | 673 | 459 | 801 | 445 | 929 | 762 |
| 34 | 48 | 162 | 90 | 290 | 538 | 418 | 175 | 546 | 433 | 674 | 622 | 802 | 471 | 930 | 503 |
| 35 | 14 | 163 | 545 | 291 | 387 | 419 | 123 | 547 | 720 | 675 | 627 | 803 | 635 | 931 | 925 |
| 36 | 72 | 164 | 292 | 292 | 308 | 420 | 658 | 548 | 816 | 676 | 437 | 804 | 932 | 932 | 878 |
| 37 | 257 | 165 | 322 | 293 | 216 | 421 | 612 | 549 | 836 | 677 | 380 | 805 | 687 | 933 | 735 |
| 38 | 21 | 166 | 532 | 294 | 416 | 422 | 341 | 550 | 347 | 678 | 818 | 806 | 903 | 934 | 993 |
| 39 | 132 | 167 | 263 | 295 | 271 | 423 | 777 | 551 | 897 | 679 | 461 | 807 | 825 | 935 | 885 |
| 40 | 35 | 168 | 149 | 296 | 279 | 424 | 220 | 552 | 243 | 680 | 496 | 808 | 500 | 936 | 939 |
| 41 | 258 | 169 | 102 | 297 | 158 | 425 | 314 | 553 | 662 | 681 | 669 | 809 | 846 | 937 | 994 |
| 42 | 26 | 170 | 105 | 298 | 337 | 426 | 424 | 554 | 454 | 682 | 679 | 810 | 745 | 938 | 980 |
| 43 | 513 | 171 | 304 | 299 | 550 | 427 | 395 | 555 | 318 | 683 | 724 | 811 | 826 | 939 | 926 |
| 44 | 80 | 172 | 296 | 300 | 672 | 428 | 673 | 556 | 675 | 684 | 841 | 812 | 732 | 940 | 764 |
| 45 | 37 | 173 | 163 | 301 | 118 | 429 | 583 | 557 | 618 | 685 | 629 | 813 | 446 | 941 | 941 |
| 46 | 25 | 174 | 92 | 302 | 332 | 430 | 355 | 558 | 898 | 686 | 351 | 814 | 962 | 942 | 967 |
| 47 | 22 | 175 | 47 | 303 | 579 | 431 | 287 | 559 | 781 | 687 | 467 | 815 | 936 | 943 | 886 |
| 48 | 136 | 176 | 267 | 304 | 540 | 432 | 183 | 560 | 376 | 688 | 438 | 816 | 475 | 944 | 831 |
| 49 | 260 | 177 | 385 | 305 | 389 | 433 | 234 | 561 | 428 | 689 | 737 | 817 | 853 | 945 | 947 |
| 50 | 264 | 178 | 546 | 306 | 173 | 434 | 125 | 562 | 665 | 690 | 251 | 818 | 867 | 946 | 507 |
| 51 | 38 | 179 | 324 | 307 | 121 | 435 | 557 | 563 | 736 | 691 | 462 | 819 | 637 | 947 | 889 |
| 52 | 514 | 180 | 208 | 308 | 553 | 436 | 660 | 564 | 567 | 692 | 442 | 820 | 907 | 948 | 984 |
| 53 | 96 | 181 | 386 | 309 | 199 | 437 | 616 | 565 | 840 | 693 | 441 | 821 | 487 | 949 | 751 |
| 54 | 67 | 182 | 150 | 310 | 784 | 438 | 342 | 566 | 625 | 694 | 469 | 822 | 695 | 950 | 942 |
| 55 | 41 | 183 | 153 | 311 | 179 | 439 | 316 | 567 | 238 | 695 | 247 | 823 | 746 | 951 | 996 |
| 56 | 144 | 184 | 165 | 312 | 228 | 440 | 241 | 568 | 359 | 696 | 683 | 824 | 828 | 952 | 971 |
| 57 | 28 | 185 | 106 | 313 | 338 | 441 | 778 | 569 | 457 | 697 | 842 | 825 | 753 | 953 | 890 |
| 58 | 69 | 186 | 55 | 314 | 312 | 442 | 563 | 570 | 399 | 698 | 738 | 826 | 854 | 954 | 509 |
| 59 | 42 | 187 | 328 | 315 | 704 | 443 | 345 | 571 | 787 | 699 | 899 | 827 | 857 | 955 | 949 |
| 60 | 516 | 188 | 536 | 316 | 390 | 444 | 452 | 572 | 591 | 700 | 670 | 828 | 504 | 956 | 973 |
| 61 | 49 | 189 | 577 | 317 | 174 | 445 | 397 | 573 | 678 | 701 | 783 | 829 | 799 | 957 | 1000 |
| 62 | 74 | 190 | 548 | 318 | 554 | 446 | 403 | 574 | 434 | 702 | 849 | 830 | 255 | 958 | 892 |
| 63 | 272 | 191 | 113 | 319 | 581 | 447 | 207 | 575 | 677 | 703 | 820 | 831 | 964 | 959 | 950 |
| 64 | 160 | 192 | 154 | 320 | 393 | 448 | 674 | 576 | 349 | 704 | 728 | 832 | 909 | 960 | 863 |
| 65 | 520 | 193 | 79 | 321 | 283 | 449 | 558 | 577 | 245 | 705 | 928 | 833 | 719 | 961 | 759 |
| 66 | 288 | 194 | 269 | 322 | 122 | 450 | 785 | 578 | 458 | 706 | 791 | 834 | 477 | 962 | 1008 |
| 67 | 528 | 195 | 108 | 323 | 448 | 451 | 432 | 579 | 666 | 707 | 367 | 835 | 915 | 963 | 510 |
| 68 | 192 | 196 | 578 | 324 | 353 | 452 | 357 | 580 | 620 | 708 | 901 | 836 | 638 | 964 | 979 |
| 69 | 544 | 197 | 224 | 325 | 561 | 453 | 187 | 581 | 363 | 709 | 630 | 837 | 748 | 965 | 953 |
| 70 | 70 | 198 | 166 | 326 | 203 | 454 | 236 | 582 | 127 | 710 | 685 | 838 | 944 | 966 | 763 |
| 71 | 44 | 199 | 519 | 327 | 63 | 455 | 664 | 583 | 191 | 711 | 844 | 839 | 869 | 967 | 974 |
| 72 | 131 | 200 | 552 | 328 | 340 | 456 | 624 | 584 | 782 | 712 | 633 | 840 | 491 | 968 | 954 |
| 73 | 81 | 201 | 195 | 329 | 394 | 457 | 587 | 585 | 407 | 713 | 711 | 841 | 699 | 969 | 879 |
| 74 | 50 | 202 | 270 | 330 | 527 | 458 | 780 | 586 | 436 | 714 | 253 | 842 | 754 | 970 | 981 |
| 75 | 73 | 203 | 641 | 331 | 582 | 459 | 705 | 587 | 626 | 715 | 691 | 843 | 858 | 971 | 982 |
| 76 | 15 | 204 | 523 | 332 | 556 | 460 | 126 | 588 | 571 | 716 | 824 | 844 | 478 | 972 | 927 |
| 77 | 320 | 205 | 275 | 333 | 181 | 461 | 242 | 589 | 465 | 717 | 902 | 845 | 968 | 973 | 995 |
| 78 | 133 | 206 | 580 | 334 | 295 | 462 | 565 | 590 | 681 | 718 | 686 | 846 | 383 | 974 | 765 |
| 79 | 52 | 207 | 291 | 335 | 285 | 463 | 398 | 591 | 246 | 719 | 740 | 847 | 910 | 975 | 956 |
| 80 | 23 | 208 | 59 | 336 | 232 | 464 | 346 | 592 | 707 | 720 | 850 | 848 | 815 | 976 | 887 |
| 81 | 134 | 209 | 169 | 337 | 124 | 465 | 456 | 593 | 350 | 721 | 375 | 849 | 976 | 977 | 985 |
| 82 | 384 | 210 | 560 | 338 | 205 | 466 | 358 | 594 | 599 | 722 | 444 | 850 | 870 | 978 | 997 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 83 | 76 | 211 | 114 | 339 | 182 | 467 | 405 | 595 | 668 | 723 | 470 | 851 | 917 | 979 | 986 |
| 84 | 137 | 212 | 277 | 340 | 643 | 468 | 303 | 596 | 790 | 724 | 483 | 852 | 727 | 980 | 943 |
| 85 | 82 | 213 | 156 | 341 | 562 | 469 | 569 | 597 | 460 | 725 | 415 | 853 | 493 | 981 | 891 |
| 86 | 56 | 214 | 87 | 342 | 286 | 470 | 244 | 598 | 249 | 726 | 485 | 854 | 873 | 982 | 998 |
| 87 | 27 | 215 | 197 | 343 | 585 | 471 | 595 | 599 | 682 | 727 | 905 | 855 | 701 | 983 | 766 |
| 88 | 97 | 216 | 116 | 344 | 299 | 472 | 189 | 600 | 573 | 728 | 795 | 856 | 931 | 984 | 511 |
| 89 | 39 | 217 | 170 | 345 | 354 | 473 | 566 | 601 | 411 | 729 | 473 | 857 | 756 | 985 | 988 |
| 90 | 259 | 218 | 61 | 346 | 211 | 474 | 676 | 602 | 803 | 730 | 634 | 858 | 860 | 986 | 1001 |
| 91 | 84 | 219 | 531 | 347 | 401 | 475 | 361 | 603 | 789 | 731 | 744 | 859 | 499 | 987 | 951 |
| 92 | 138 | 220 | 525 | 348 | 185 | 476 | 706 | 604 | 709 | 732 | 852 | 860 | 731 | 988 | 1002 |
| 93 | 145 | 221 | 642 | 349 | 396 | 477 | 589 | 605 | 365 | 733 | 960 | 861 | 823 | 989 | 893 |
| 94 | 261 | 222 | 281 | 350 | 344 | 478 | 215 | 606 | 440 | 734 | 865 | 862 | 922 | 990 | 975 |
| 95 | 29 | 223 | 278 | 351 | 586 | 479 | 786 | 607 | 628 | 735 | 693 | 863 | 874 | 991 | 894 |
| 96 | 43 | 224 | 526 | 352 | 645 | 480 | 647 | 608 | 689 | 736 | 797 | 864 | 918 | 992 | 1009 |
| 97 | 98 | 225 | 177 | 353 | 593 | 481 | 348 | 609 | 374 | 737 | 906 | 865 | 502 | 993 | 955 |
| 98 | 515 | 226 | 293 | 354 | 535 | 482 | 419 | 610 | 423 | 738 | 715 | 866 | 933 | 994 | 1004 |
| 99 | 88 | 227 | 388 | 355 | 240 | 483 | 406 | 611 | 466 | 739 | 807 | 867 | 743 | 995 | 1010 |
| 100 | 140 | 228 | 91 | 356 | 206 | 484 | 464 | 612 | 793 | 740 | 474 | 868 | 760 | 996 | 957 |
| 101 | 30 | 229 | 584 | 357 | 95 | 485 | 680 | 613 | 250 | 741 | 636 | 869 | 881 | 997 | 983 |
| 102 | 146 | 230 | 769 | 358 | 327 | 486 | 801 | 614 | 371 | 742 | 694 | 870 | 494 | 998 | 958 |
| 103 | 71 | 231 | 198 | 359 | 564 | 487 | 362 | 615 | 481 | 743 | 254 | 871 | 702 | 999 | 987 |
| 104 | 262 | 232 | 172 | 360 | 800 | 488 | 590 | 616 | 574 | 744 | 717 | 872 | 921 | 1000 | 1012 |
| 105 | 265 | 233 | 120 | 361 | 402 | 489 | 409 | 617 | 413 | 745 | 575 | 873 | 501 | 1001 | 999 |
| 106 | 161 | 234 | 201 | 362 | 356 | 490 | 570 | 618 | 603 | 746 | 913 | 874 | 876 | 1002 | 1016 |
| 107 | 576 | 235 | 336 | 363 | 307 | 491 | 788 | 619 | 366 | 747 | 798 | 875 | 847 | 1003 | 767 |
| 108 | 45 | 236 | 62 | 364 | 301 | 492 | 597 | 620 | 468 | 748 | 811 | 876 | 992 | 1004 | 989 |
| 109 | 100 | 237 | 282 | 365 | 417 | 493 | 572 | 621 | 655 | 749 | 379 | 877 | 447 | 1005 | 1003 |
| 110 | 640 | 238 | 143 | 366 | 213 | 494 | 219 | 622 | 900 | 750 | 697 | 878 | 733 | 1006 | 990 |
| 111 | 51 | 239 | 103 | 367 | 568 | 495 | 311 | 623 | 805 | 751 | 431 | 879 | 827 | 1007 | 1005 |
| 112 | 148 | 240 | 178 | 368 | 832 | 496 | 708 | 624 | 615 | 752 | 607 | 880 | 934 | 1008 | 959 |
| 113 | 46 | 241 | 294 | 369 | 588 | 497 | 598 | 625 | 684 | 753 | 489 | 881 | 882 | 1009 | 1011 |
| 114 | 75 | 242 | 93 | 370 | 186 | 498 | 601 | 626 | 710 | 754 | 866 | 882 | 937 | 1010 | 1013 |
| 115 | 266 | 243 | 644 | 371 | 646 | 499 | 651 | 627 | 429 | 755 | 723 | 883 | 963 | 1011 | 895 |
| 116 | 273 | 244 | 202 | 372 | 404 | 500 | 421 | 628 | 794 | 756 | 486 | 884 | 747 | 1012 | 1006 |
| 117 | 517 | 245 | 592 | 373 | 227 | 501 | 792 | 629 | 252 | 757 | 908 | 885 | 505 | 1013 | 1014 |
| 118 | 104 | 246 | 323 | 374 | 896 | 502 | 802 | 630 | 373 | 758 | 718 | 886 | 855 | 1014 | 1017 |
| 119 | 162 | 247 | 392 | 375 | 594 | 503 | 611 | 631 | 605 | 759 | 813 | 887 | 924 | 1015 | 1018 |
| 120 | 53 | 248 | 297 | 376 | 418 | 504 | 602 | 632 | 848 | 760 | 476 | 888 | 734 | 1016 | 991 |
| 121 | 193 | 249 | 770 | 377 | 302 | 505 | 410 | 633 | 690 | 761 | 856 | 889 | 829 | 1017 | 1020 |
| 122 | 152 | 250 | 107 | 378 | 649 | 506 | 231 | 634 | 713 | 762 | 839 | 890 | 965 | 1018 | 1007 |
| 123 | 77 | 251 | 180 | 379 | 771 | 507 | 688 | 635 | 632 | 763 | 725 | 891 | 938 | 1019 | 1015 |
| 124 | 164 | 252 | 151 | 380 | 360 | 508 | 653 | 636 | 482 | 764 | 698 | 892 | 884 | 1020 | 1019 |
| 125 | 768 | 253 | 209 | 381 | 539 | 509 | 248 | 637 | 806 | 765 | 914 | 893 | 506 | 1021 | 1021 |
| 126 | 268 | 254 | 284 | 382 | 111 | 510 | 369 | 638 | 427 | 766 | 752 | 894 | 749 | 1022 | 1022 |
| 127 | 274 | 255 | 648 | 383 | 331 | 511 | 190 | 639 | 904 | 767 | 868 | 895 | 945 | 1023 | 1023 |

## 5.3.2 Low density parity check coding

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits to encode as defined in Subclause 5.2.2. After encoding the bits are denoted by $d_0, d_1, d_2, \ldots, d_{N-1}$, where $N = 66 Z_c$ for LDPC base graph 1 and $N = 50 Z_c$ for LDPC base graph 2, and the value of $Z_c$ is given in Subclause 5.2.2.

For a code block encoded by LDPC, the following encoding procedure applies:

1) Find the set with index $i_{LS}$ in Table 5.3.2-1 which contains $Z_c$.

2) for $k = 2Z_c$ to $K-1$

if $c_k \neq <NULL>$

$d_{k-2Z_c} = c_k$ ;

else

$c_k = 0$ ;

$d_{k-2Z_c} = <NULL>$ ;

end if

end for

3) Generate $N+2Z_c-K$ parity bits $w = [w_0, w_1, w_2, \ldots, w_{N+2Z_c-K-1}]^T$ such that $H \times \begin{bmatrix} c \\ w \end{bmatrix} = 0$ , where $c = [c_0, c_1, c_2, \ldots, c_{K-1}]^T$ ; $0$ is a column vector of all elements equal to 0. The encoding is performed in GF(2).

For LDPC base graph 1, a matrix of $H_{BG}$ has 46 rows with row indices $i = 0,1,2,\ldots,45$ and 68 columns with column indices $j = 0,1,2,\ldots,67$ . For LDPC base graph 2, a matrix of $H_{BG}$ has 42 rows with row indices $i = 0,1,2,\ldots,41$ and 52 columns with column indices $j = 0,1,2,\ldots,51$ . The elements in $H_{BG}$ with row and column indices given in Table 5.3.2-2 (for LDPC base graph 1) and Table 5.3.2-3 (for LDPC base graph 2) are of value 1, and all other elements in $H_{BG}$ are of value 0.

The matrix $H$ is obtained by replacing each element of $H_{BG}$ with a $Z_c \times Z_c$ matrix, according to the following:

- Each element of value 0 in $H_{BG}$ is replaced by an all zero matrix $0$ of size $Z_c \times Z_c$ ;
- Each element of value 1 in $H_{BG}$ is replaced by a circular permutation matrix $I(P_{i,j})$ of size $Z_c \times Z_c$ , where $i$ and $j$ are the row and column indices of the element, and $I(P_{i,j})$ is obtained by circularly shifting the identity matrix $I$ of size $Z_c \times Z_c$ to the right $P_{i,j}$ times. The value of $P_{i,j}$ is given by $P_{i,j} = \text{mod}(V_{i,j}, Z_c)$ . The value of $V_{i,j}$ is given by Tables 5.3.2-2 and 5.3.2-3 according to the set index $i_{LS}$ and LDPC base graph.

4) for $k = K$ to $N+2Z_c-1$

$d_{k-2Z_c} = w_{k-K}$ ;

end for

**Table 5.3.2-1: Sets of LDPC lifting size $Z$**

| ***Set index ( $i_{LS}$ )*** | ***Set of lifting sizes ( $Z$ )*** |
|---|---|
| 0 | {2, 4, 8, 16, 32, 64, 128, 256} |
| 1 | {3, 6, 12, 24, 48, 96, 192, 384} |
| 2 | {5, 10, 20, 40, 80, 160, 320} |
| 3 | {7, 14, 28, 56, 112, 224} |
| 4 | {9, 18, 36, 72, 144, 288} |
| 5 | {11, 22, 44, 88, 176, 352} |
| 6 | {13, 26, 52, 104, 208} |
| 7 | {15, 30, 60, 120, 240} |

### Table 5.3.2-2: LDPC base graph 1 ( $H_{BG}$ ) and its parity check matrices ( $V_{i,j}$ )

| $H_{BG}$ | | $V_{i,j}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Row index $i$ | Column index $j$ | Set index $i_{LS}$ | | | | | | | |
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 250 | 307 | 73 | 223 | 211 | 294 | 0 | 135 |
| | 1 | 69 | 19 | 15 | 16 | 198 | 118 | 0 | 227 |
| | 2 | 226 | 50 | 103 | 94 | 188 | 167 | 0 | 126 |
| | 3 | 159 | 369 | 49 | 91 | 186 | 330 | 0 | 134 |
| | 5 | 100 | 181 | 240 | 74 | 219 | 207 | 0 | 84 |
| | 6 | 10 | 216 | 39 | 10 | 4 | 165 | 0 | 83 |
| | 9 | 59 | 317 | 15 | 0 | 29 | 243 | 0 | 53 |
| | 10 | 229 | 288 | 162 | 205 | 144 | 250 | 0 | 225 |
| | 11 | 110 | 109 | 215 | 216 | 116 | 1 | 0 | 205 |
| | 12 | 191 | 17 | 164 | 21 | 216 | 339 | 0 | 128 |
| | 13 | 9 | 357 | 133 | 215 | 115 | 201 | 0 | 75 |
| | 15 | 195 | 215 | 298 | 14 | 233 | 53 | 0 | 135 |
| | 16 | 23 | 106 | 110 | 70 | 144 | 347 | 0 | 217 |
| | 18 | 190 | 242 | 113 | 141 | 95 | 304 | 0 | 220 |
| | 19 | 35 | 180 | 16 | 198 | 216 | 167 | 0 | 90 |
| | 20 | 239 | 330 | 189 | 104 | 73 | 47 | 0 | 105 |
| | 21 | 31 | 346 | 32 | 81 | 261 | 188 | 0 | 137 |
| | 22 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 2 | 76 | 303 | 141 | 179 | 77 | 22 | 96 |
| | 2 | 239 | 76 | 294 | 45 | 162 | 225 | 11 | 236 |
| | 3 | 117 | 73 | 27 | 151 | 223 | 96 | 124 | 136 |
| | 4 | 124 | 288 | 261 | 46 | 256 | 338 | 0 | 221 |
| | 5 | 71 | 144 | 161 | 119 | 160 | 268 | 10 | 128 |
| | 7 | 222 | 331 | 133 | 157 | 76 | 112 | 0 | 92 |
| | 8 | 104 | 331 | 4 | 133 | 202 | 302 | 0 | 172 |
| | 9 | 173 | 178 | 80 | 87 | 117 | 50 | 2 | 56 |
| | 11 | 220 | 295 | 129 | 206 | 109 | 167 | 16 | 11 |
| | 12 | 102 | 342 | 300 | 93 | 15 | 253 | 60 | 189 |
| | 14 | 109 | 217 | 76 | 79 | 72 | 334 | 0 | 95 |
| | 15 | 132 | 99 | 266 | 9 | 152 | 242 | 6 | 85 |
| | 16 | 142 | 354 | 72 | 118 | 158 | 257 | 30 | 153 |
| | 17 | 155 | 114 | 83 | 194 | 147 | 133 | 0 | 87 |
| | 19 | 255 | 331 | 260 | 31 | 156 | 9 | 168 | 163 |
| | 21 | 28 | 112 | 301 | 187 | 119 | 302 | 31 | 216 |
| | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 0 |
| | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 106 | 205 | 68 | 207 | 258 | 226 | 132 | 189 |
| | 1 | 111 | 250 | 7 | 203 | 167 | 35 | 37 | 4 |
| | 2 | 185 | 328 | 80 | 31 | 220 | 213 | 21 | 225 |
| 15 | 1 | 96 | 2 | 290 | 120 | 0 | 348 | 6 | 138 |
| | 10 | 65 | 210 | 60 | 131 | 183 | 15 | 81 | 220 |
| | 13 | 63 | 318 | 130 | 209 | 108 | 81 | 182 | 173 |
| | 18 | 75 | 55 | 184 | 209 | 68 | 176 | 53 | 142 |
| | 25 | 179 | 269 | 51 | 81 | 64 | 113 | 46 | 49 |
| | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 1 | 64 | 13 | 69 | 154 | 270 | 190 | 88 | 78 |
| | 3 | 49 | 338 | 140 | 164 | 13 | 293 | 198 | 152 |
| | 11 | 49 | 57 | 45 | 43 | 99 | 332 | 160 | 84 |
| | 20 | 51 | 289 | 115 | 189 | 54 | 331 | 122 | 5 |
| | 22 | 154 | 57 | 300 | 101 | 0 | 114 | 182 | 205 |
| | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 7 | 260 | 257 | 56 | 153 | 110 | 91 | 183 |
| | 14 | 164 | 303 | 147 | 110 | 137 | 228 | 184 | 112 |
| | 16 | 59 | 81 | 128 | 200 | 0 | 247 | 30 | 106 |
| | 17 | 1 | 358 | 51 | 63 | 0 | 116 | 3 | 219 |
| | 21 | 144 | 375 | 228 | 4 | 162 | 190 | 155 | 129 |
| | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 1 | 42 | 130 | 260 | 199 | 161 | 47 | 1 | 183 |
| | 12 | 233 | 163 | 294 | 110 | 151 | 286 | 41 | 215 |
| | 13 | 8 | 280 | 291 | 200 | 0 | 246 | 167 | 180 |
| | 18 | 155 | 132 | 141 | 143 | 241 | 181 | 68 | 143 |
| | 19 | 147 | 4 | 295 | 186 | 144 | 73 | 148 | 14 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 60 | 145 | 64 | 8 | 0 | 87 | 12 | 179 |
| | 1 | 73 | 213 | 181 | 6 | 0 | 110 | 6 | 108 |
| | 7 | 72 | 344 | 101 | 103 | 118 | 147 | 166 | 159 |
| | 8 | 127 | 242 | 270 | 198 | 144 | 258 | 184 | 138 |
| | 10 | 224 | 197 | 41 | 8 | 0 | 204 | 191 | 196 |
| | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 151 | 187 | 301 | 105 | 265 | 89 | 6 | 77 |
| | 3 | 186 | 206 | 162 | 210 | 81 | 65 | 12 | 187 |
| | 9 | 217 | 264 | 40 | 121 | 90 | 155 | 15 | 203 |
| | 11 | 47 | 341 | 130 | 214 | 144 | 244 | 5 | 167 |
| | 22 | 160 | 59 | 10 | 183 | 228 | 30 | 30 | 130 |
| | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 1 | 249 | 205 | 79 | 192 | 64 | 162 | 6 | 197 |
| | 5 | 121 | 102 | 175 | 131 | 46 | 264 | 86 | 122 |
| | 16 | 109 | 328 | 132 | 220 | 266 | 346 | 96 | 215 |
| | 20 | 131 | 213 | 283 | 50 | 9 | 143 | 42 | 65 |
| | 21 | 171 | 97 | 103 | 106 | 18 | 109 | 199 | 216 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 63 | 332 | 280 | 176 | 133 | 302 | 180 | 151 |
| | 5 | 117 | 256 | 38 | 180 | 243 | 111 | 4 | 236 |
| | 6 | 93 | 161 | 227 | 186 | 202 | 265 | 149 | 117 |
| | 7 | 229 | 267 | 202 | 95 | 218 | 128 | 48 | 179 |
| | 8 | 177 | 160 | 200 | 153 | 63 | 237 | 38 | 92 |
| | 9 | 95 | 63 | 71 | 177 | 0 | 294 | 122 | 24 |
| | 10 | 39 | 129 | 106 | 70 | 3 | 127 | 195 | 68 |
| | 13 | 142 | 200 | 295 | 77 | 74 | 110 | 155 | 6 |
| | 14 | 225 | 88 | 283 | 214 | 229 | 286 | 28 | 101 |
| | 15 | 225 | 53 | 301 | 77 | 0 | 125 | 85 | 33 |
| | 17 | 245 | 131 | 184 | 198 | 216 | 131 | 47 | 96 |
| | 18 | 205 | 240 | 246 | 117 | 269 | 163 | 179 | 125 |
| | 19 | 251 | 205 | 230 | 223 | 200 | 210 | 42 | 67 |
| | 20 | 117 | 13 | 276 | 90 | 234 | 7 | 66 | 230 |
| | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 121 | 276 | 220 | 201 | 187 | 97 | 4 | 128 |
| | 1 | 89 | 87 | 208 | 18 | 145 | 94 | 6 | 23 |
| | 3 | 84 | 0 | 30 | 165 | 166 | 49 | 33 | 162 |
| | 4 | 20 | 275 | 197 | 5 | 108 | 279 | 113 | 220 |
| | 6 | 150 | 199 | 61 | 45 | 82 | 139 | 49 | 43 |
| | 7 | 131 | 153 | 175 | 142 | 132 | 166 | 21 | 186 |
| | 8 | 243 | 56 | 79 | 16 | 197 | 91 | 6 | 96 |
| | 10 | 136 | 132 | 281 | 34 | 41 | 106 | 151 | 1 |
| | 11 | 86 | 305 | 303 | 155 | 162 | 246 | 83 | 216 |
| | 12 | 246 | 231 | 253 | 213 | 57 | 345 | 154 | 22 |
| | 13 | 219 | 341 | 164 | 147 | 36 | 269 | 87 | 24 |
| | 14 | 211 | 212 | 53 | 69 | 115 | 185 | 5 | 167 |
| | 16 | 240 | 304 | 44 | 96 | 242 | 249 | 92 | 200 |
| | 17 | 76 | 300 | 28 | 74 | 165 | 215 | 173 | 32 |
| | 18 | 244 | 271 | 77 | 99 | 0 | 143 | 120 | 235 |
| | 20 | 144 | 39 | 319 | 30 | 113 | 121 | 2 | 172 |
| | 21 | 12 | 357 | 68 | 158 | 108 | 121 | 142 | 219 |
| | 22 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 157 | 332 | 233 | 170 | 246 | 42 | 24 | 64 |
| | 1 | 102 | 181 | 205 | 10 | 235 | 256 | 204 | 211 |
| | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 205 | 195 | 83 | 164 | 261 | 219 | 185 | 2 |
| | 1 | 236 | 14 | 292 | 59 | 181 | 130 | 100 | 171 |
| | 3 | 194 | 115 | 50 | 86 | 72 | 251 | 24 | 47 |
| | 12 | 231 | 166 | 318 | 80 | 283 | 322 | 65 | 143 |
| | 16 | 28 | 241 | 201 | 182 | 254 | 295 | 207 | 210 |
| | 21 | 123 | 51 | 267 | 130 | 79 | 258 | 161 | 180 |
| | 22 | 115 | 157 | 279 | 153 | 144 | 283 | 72 | 180 |
| | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 0 | 64 | 30 | 177 | 53 | 72 | 280 | 44 | 25 |
| | 12 | 142 | 11 | 20 | 0 | 189 | 157 | 58 | 47 |
| | 13 | 188 | 233 | 55 | 3 | 72 | 236 | 130 | 126 |
| | 17 | 158 | 22 | 316 | 148 | 257 | 113 | 131 | 178 |
| | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 1 | 156 | 24 | 249 | 88 | 180 | 18 | 45 | 185 |
| | 2 | 147 | 89 | 50 | 203 | 0 | 6 | 18 | 127 |
| | 10 | 170 | 61 | 133 | 168 | 0 | 181 | 132 | 117 |
| | 18 | 152 | 27 | 105 | 122 | 165 | 304 | 100 | 199 |
| | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 112 | 298 | 289 | 49 | 236 | 38 | 9 | 32 |
| | 3 | 86 | 158 | 280 | 157 | 199 | 170 | 125 | 178 |
| | 4 | 236 | 235 | 110 | 64 | 0 | 249 | 191 | 2 |
| | 11 | 116 | 339 | 187 | 193 | 266 | 288 | 28 | 156 |
| | 22 | 222 | 234 | 281 | 124 | 0 | 194 | 6 | 58 |
| | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 1 | 23 | 72 | 172 | 1 | 205 | 279 | 4 | 27 |
| | 6 | 136 | 17 | 295 | 166 | 0 | 255 | 74 | 141 |
| | 7 | 116 | 383 | 96 | 65 | 0 | 111 | 16 | 11 |
| | 14 | 182 | 312 | 46 | 81 | 183 | 54 | 28 | 181 |
| | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 195 | 71 | 270 | 107 | 0 | 325 | 21 | 163 |
| | 2 | 243 | 81 | 110 | 176 | 0 | 326 | 142 | 131 |
| | 4 | 215 | 76 | 318 | 212 | 0 | 226 | 192 | 169 |
| | 15 | 61 | 136 | 67 | 127 | 277 | 99 | 197 | 98 |
| | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 1 | 25 | 194 | 210 | 208 | 45 | 91 | 98 | 165 |
| | 6 | 104 | 194 | 29 | 141 | 36 | 326 | 140 | 232 |
| | 8 | 194 | 101 | 304 | 174 | 72 | 268 | 22 | 9 |
| | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 0 | 128 | 222 | 11 | 146 | 275 | 102 | 4 | 32 |
| | 4 | 165 | 19 | 293 | 153 | 0 | 1 | 1 | 43 |
| | 19 | 181 | 244 | 50 | 217 | 155 | 40 | 40 | 200 |
| | 21 | 63 | 274 | 234 | 114 | 62 | 167 | 93 | 205 |
| | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 1 | 86 | 252 | 27 | 150 | 0 | 273 | 92 | 232 |
| | 14 | 236 | 5 | 308 | 11 | 180 | 104 | 136 | 32 |
| | 18 | 84 | 147 | 117 | 53 | 0 | 243 | 106 | 118 |
| | 25 | 6 | 78 | 29 | 68 | 42 | 107 | 6 | 103 |
| | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 216 | 159 | 91 | 34 | 0 | 171 | 2 | 170 |
| | 10 | 73 | 229 | 23 | 130 | 90 | 16 | 88 | 199 |
| | 13 | 120 | 260 | 105 | 210 | 252 | 95 | 112 | 26 |
| | 24 | 9 | 90 | 135 | 123 | 173 | 212 | 20 | 105 |
| | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 0 | 183 | 278 | 289 | 158 | 80 | 294 | 6 | 199 |
| | 6 | 22 | 257 | 21 | 119 | 144 | 73 | 27 | 22 |
| | 10 | 28 | 1 | 293 | 113 | 169 | 330 | 163 | 23 |
| | 11 | 67 | 351 | 13 | 21 | 90 | 99 | 50 | 100 |
| | 13 | 244 | 92 | 232 | 63 | 59 | 172 | 48 | 92 |
| | 17 | 11 | 253 | 302 | 51 | 177 | 150 | 24 | 207 |
| | 18 | 157 | 18 | 138 | 136 | 151 | 284 | 38 | 52 |
| | 20 | 211 | 225 | 235 | 116 | 108 | 305 | 91 | 13 |
| | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 220 | 9 | 12 | 17 | 169 | 3 | 145 | 77 |
| | 1 | 44 | 62 | 88 | 76 | 189 | 103 | 88 | 146 |
| | 4 | 159 | 316 | 207 | 104 | 154 | 224 | 112 | 209 |
| | 7 | 31 | 333 | 50 | 100 | 184 | 297 | 153 | 32 |
| | 8 | 167 | 290 | 25 | 150 | 104 | 215 | 159 | 166 |
| | 14 | 104 | 114 | 76 | 158 | 164 | 39 | 76 | 18 |
| | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 112 | 307 | 295 | 33 | 54 | 348 | 172 | 181 |
| | 1 | 4 | 179 | 133 | 95 | 0 | 75 | 2 | 105 |
| | 3 | 7 | 165 | 130 | 4 | 252 | 22 | 131 | 141 |
| | 12 | 211 | 18 | 231 | 217 | 41 | 312 | 141 | 223 |
| | 16 | 102 | 39 | 296 | 204 | 98 | 224 | 96 | 177 |
| | 19 | 164 | 224 | 110 | 39 | 46 | 17 | 99 | 145 |
| | 21 | 109 | 368 | 269 | 58 | 15 | 59 | 101 | 199 |
| | 22 | 241 | 67 | 245 | 44 | 230 | 314 | 35 | 153 |
| | 24 | 90 | 170 | 154 | 201 | 54 | 244 | 116 | 38 |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 103 | 366 | 189 | 9 | 162 | 156 | 6 | 169 |
| | 1 | 182 | 232 | 244 | 37 | 159 | 88 | 10 | 12 |
| | 10 | 109 | 321 | 36 | 213 | 93 | 293 | 145 | 206 |
| | 11 | 21 | 133 | 286 | 105 | 134 | 111 | 53 | 221 |
| | 13 | 142 | 57 | 151 | 89 | 45 | 92 | 201 | 17 |
| | 17 | 14 | 303 | 267 | 185 | 132 | 152 | 4 | 212 |
| | 18 | 61 | 63 | 135 | 109 | 76 | 23 | 164 | 92 |
| | 20 | 216 | 82 | 209 | 218 | 209 | 337 | 173 | 205 |
| | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 1 | 98 | 101 | 14 | 82 | 178 | 175 | 126 | 116 |
| | 2 | 149 | 339 | 80 | 165 | 1 | 253 | 77 | 151 |
| | 4 | 167 | 274 | 211 | 174 | 28 | 27 | 156 | 70 |
| | 7 | 160 | 111 | 75 | 19 | 267 | 231 | 16 | 230 |
| | 8 | 49 | 383 | 161 | 194 | 234 | 49 | 12 | 115 |
| | 14 | 58 | 354 | 311 | 103 | 201 | 267 | 70 | 84 |
| | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 77 | 48 | 16 | 52 | 55 | 25 | 184 | 45 |
| | 1 | 41 | 102 | 147 | 11 | 23 | 322 | 194 | 115 |
| | 12 | 83 | 8 | 290 | 2 | 274 | 200 | 123 | 134 |
| | 16 | 182 | 47 | 289 | 35 | 181 | 351 | 16 | 1 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 31 | 1 | 95 | 100 | 222 | 175 | 144 | 101 | 4 | 73 |
| | 7 | 177 | 215 | 308 | 49 | 144 | 297 | 49 | 149 |
| | 22 | 172 | 258 | 66 | 177 | 166 | 279 | 125 | 175 |
| | 25 | 61 | 256 | 162 | 128 | 19 | 222 | 194 | 108 |
| | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 0 | 221 | 102 | 210 | 192 | 0 | 351 | 6 | 103 |
| | 12 | 112 | 201 | 22 | 209 | 211 | 265 | 126 | 110 |
| | 14 | 199 | 175 | 271 | 58 | 36 | 338 | 63 | 151 |
| | 24 | 121 | 287 | 217 | 30 | 162 | 83 | 20 | 211 |
| | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 1 | 2 | 323 | 170 | 114 | 0 | 56 | 10 | 199 |
| | 2 | 187 | 8 | 20 | 49 | 0 | 304 | 30 | 132 |
| | 11 | 41 | 361 | 140 | 161 | 76 | 141 | 6 | 172 |
| | 21 | 211 | 105 | 33 | 137 | 18 | 101 | 92 | 65 |
| | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | 0 | 127 | 230 | 187 | 82 | 197 | 60 | 4 | 161 |
| | 7 | 167 | 148 | 296 | 186 | 0 | 320 | 153 | 237 |
| | 15 | 164 | 202 | 5 | 68 | 108 | 112 | 197 | 142 |
| | 17 | 159 | 312 | 44 | 150 | 0 | 54 | 155 | 180 |
| | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | 1 | 161 | 320 | 207 | 192 | 199 | 100 | 4 | 231 |
| | 6 | 197 | 335 | 158 | 173 | 278 | 210 | 45 | 174 |
| | 12 | 207 | 2 | 55 | 26 | 0 | 195 | 168 | 145 |
| | 22 | 103 | 266 | 285 | 187 | 205 | 268 | 185 | 100 |
| | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0 | 37 | 210 | 259 | 222 | 216 | 135 | 6 | 11 |
| | 14 | 105 | 313 | 179 | 157 | 16 | 15 | 200 | 207 |
| | 15 | 51 | 297 | 178 | 0 | 0 | 35 | 177 | 42 |
| | 18 | 120 | 21 | 160 | 6 | 0 | 188 | 43 | 100 |
| | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 1 | 198 | 269 | 298 | 81 | 72 | 319 | 82 | 59 |
| | 13 | 220 | 82 | 15 | 195 | 144 | 236 | 2 | 204 |
| | 23 | 122 | 115 | 115 | 138 | 0 | 85 | 135 | 161 |
| | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 0 | 167 | 185 | 151 | 123 | 190 | 164 | 91 | 121 |
| | 9 | 151 | 177 | 179 | 90 | 0 | 196 | 64 | 90 |
| | 10 | 157 | 289 | 64 | 73 | 0 | 209 | 198 | 26 |
| | 12 | 163 | 214 | 181 | 10 | 0 | 246 | 100 | 140 |
| | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 1 | 173 | 258 | 102 | 12 | 153 | 236 | 4 | 115 |
| | 3 | 139 | 93 | 77 | 77 | 0 | 264 | 28 | 188 |
| | 7 | 149 | 346 | 192 | 49 | 165 | 37 | 109 | 168 |
| | 19 | 0 | 297 | 208 | 114 | 117 | 272 | 188 | 52 |
| | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | 0 | 157 | 175 | 32 | 67 | 216 | 304 | 10 | 4 |
| | 8 | 137 | 37 | 80 | 45 | 144 | 237 | 84 | 103 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 21 | 78 | 188 | 177 | 32 | 273 | 166 | 104 | 152 | | 17 | 149 | 312 | 197 | 96 | 2 | 135 | 12 | 30 |
| | 22 | 252 | 334 | 43 | 84 | 39 | 338 | 109 | 165 | | 62 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 23 | 22 | 115 | 280 | 201 | 26 | 192 | 124 | 107 | 41 | 1 | 167 | 52 | 154 | 23 | 0 | 123 | 2 | 53 |
| | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 3 | 173 | 314 | 47 | 215 | 0 | 77 | 75 | 189 |
| 12 | 0 | 160 | 77 | 229 | 142 | 225 | 123 | 6 | 186 | | 9 | 139 | 139 | 124 | 60 | 0 | 25 | 142 | 215 |
| | 1 | 42 | 186 | 235 | 175 | 162 | 217 | 20 | 215 | | 18 | 151 | 288 | 207 | 167 | 183 | 272 | 128 | 24 |
| | 10 | 21 | 174 | 169 | 136 | 244 | 142 | 203 | 124 | | 63 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 11 | 32 | 232 | 48 | 3 | 151 | 110 | 153 | 180 | 42 | 0 | 149 | 113 | 226 | 114 | 27 | 288 | 163 | 222 |
| | 13 | 234 | 50 | 105 | 28 | 238 | 176 | 104 | 98 | | 4 | 157 | 14 | 65 | 91 | 0 | 83 | 10 | 170 |
| | 18 | 7 | 74 | 52 | 182 | 243 | 76 | 207 | 80 | | 24 | 137 | 218 | 126 | 78 | 35 | 17 | 162 | 71 |
| | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 177 | 313 | 39 | 81 | 231 | 311 | 52 | 220 | 43 | 1 | 151 | 113 | 228 | 206 | 52 | 210 | 1 | 22 |
| | 3 | 248 | 177 | 302 | 56 | 0 | 251 | 147 | 185 | | 16 | 163 | 132 | 69 | 22 | 243 | 3 | 163 | 127 |
| | 7 | 151 | 266 | 303 | 72 | 216 | 265 | 1 | 154 | | 18 | 173 | 114 | 176 | 134 | 0 | 53 | 99 | 49 |
| | 20 | 185 | 115 | 160 | 217 | 47 | 94 | 16 | 178 | | 25 | 139 | 168 | 102 | 161 | 270 | 167 | 98 | 125 |
| | 23 | 62 | 370 | 37 | 78 | 36 | 81 | 46 | 150 | | 65 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 | 0 | 139 | 80 | 234 | 84 | 18 | 79 | 4 | 191 |
| 14 | 0 | 206 | 142 | 78 | 14 | 0 | 22 | 1 | 124 | | 7 | 157 | 78 | 227 | 4 | 0 | 244 | 6 | 211 |
| | 12 | 55 | 248 | 299 | 175 | 186 | 322 | 202 | 144 | | 9 | 163 | 163 | 259 | 9 | 0 | 293 | 142 | 187 |
| | 15 | 206 | 137 | 54 | 211 | 253 | 277 | 118 | 182 | | 22 | 173 | 274 | 260 | 12 | 57 | 272 | 3 | 148 |
| | 16 | 127 | 89 | 61 | 191 | 16 | 156 | 130 | 95 | | 66 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 17 | 16 | 347 | 179 | 51 | 0 | 66 | 1 | 72 | 45 | 1 | 149 | 135 | 101 | 184 | 168 | 82 | 181 | 177 |
| | 21 | 229 | 12 | 258 | 43 | 79 | 78 | 2 | 76 | | 6 | 151 | 149 | 228 | 121 | 0 | 67 | 45 | 114 |
| | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 10 | 167 | 15 | 126 | 29 | 144 | 235 | 153 | 93 |
| 15 | 0 | 40 | 241 | 229 | 90 | 170 | 176 | 173 | 39 | | 67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Table 5.3.2-3: LDPC base graph 2 ( $H_{BG}$ ) and its parity check matrices ( $V_{i,j}$ )

| $H_{BG}$ Row index $i$ | $H_{BG}$ Column index $j$ | $V_{i,j}$ Set index $i_{LS}$ 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 9 | 174 | 0 | 72 | 3 | 156 | 143 | 145 |
| | 1 | 117 | 97 | 0 | 110 | 26 | 143 | 19 | 131 |
| | 2 | 204 | 166 | 0 | 23 | 53 | 14 | 176 | 71 |
| | 3 | 26 | 66 | 0 | 181 | 35 | 3 | 165 | 21 |
| | 6 | 189 | 71 | 0 | 95 | 115 | 40 | 196 | 23 |
| | 9 | 205 | 172 | 0 | 8 | 127 | 123 | 13 | 112 |
| | 10 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 167 | 27 | 137 | 53 | 19 | 17 | 18 | 142 |
| | 3 | 166 | 36 | 124 | 156 | 94 | 65 | 27 | 174 |
| | 4 | 253 | 48 | 0 | 115 | 104 | 63 | 3 | 183 |
| | 5 | 125 | 92 | 0 | 156 | 66 | 1 | 102 | 27 |
| | 6 | 226 | 31 | 88 | 115 | 84 | 55 | 185 | 96 |
| | 7 | 156 | 187 | 0 | 200 | 98 | 37 | 17 | 23 |
| | 8 | 224 | 185 | 0 | 29 | 69 | 171 | 14 | 9 |
| | 9 | 252 | 3 | 55 | 31 | 50 | 133 | 180 | 167 |
| | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 81 | 25 | 20 | 152 | 95 | 98 | 126 | 74 |
| | 1 | 114 | 114 | 94 | 131 | 106 | 168 | 163 | 31 |
| | 3 | 44 | 117 | 99 | 46 | 92 | 107 | 47 | 3 |
| | 4 | 52 | 110 | 9 | 191 | 110 | 82 | 183 | 53 |
| | 8 | 240 | 114 | 108 | 91 | 111 | 142 | 132 | 155 |
| | 10 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 1 | 8 | 136 | 38 | 185 | 120 | 53 | 36 | 239 |
| | 2 | 58 | 175 | 15 | 6 | 121 | 174 | 48 | 171 |
| | 4 | 158 | 113 | 102 | 36 | 22 | 174 | 18 | 95 |
| | 5 | 104 | 72 | 146 | 124 | 4 | 127 | 111 | 110 |
| | 6 | 209 | 123 | 12 | 124 | 73 | 17 | 203 | 159 |
| | 7 | 54 | 118 | 57 | 110 | 49 | 89 | 3 | 199 |
| | 8 | 18 | 28 | 53 | 156 | 128 | 17 | 191 | 43 |
| | 9 | 128 | 186 | 46 | 133 | 79 | 105 | 160 | 75 |
| | 10 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 179 | 72 | 0 | 200 | 42 | 86 | 43 | 29 |
| | 1 | 214 | 74 | 136 | 16 | 24 | 67 | 27 | 140 |
| | 11 | 71 | 29 | 157 | 101 | 51 | 83 | 117 | 180 |
| | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 0 | 231 | 10 | 0 | 185 | 40 | 79 | 136 | 121 |
| | 1 | 41 | 44 | 131 | 138 | 140 | 84 | 49 | 41 |

| $H_{BG}$ Row index $i$ | $H_{BG}$ Column index $j$ | $V_{i,j}$ Set index $i_{LS}$ 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|
| 16 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 1 | 254 | 158 | 0 | 48 | 120 | 134 | 57 | 196 |
| | 5 | 124 | 23 | 24 | 132 | 43 | 23 | 201 | 173 |
| | 11 | 114 | 9 | 109 | 206 | 65 | 62 | 142 | 195 |
| | 12 | 64 | 6 | 18 | 2 | 42 | 163 | 35 | 218 |
| | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 220 | 186 | 0 | 68 | 17 | 173 | 129 | 128 |
| | 6 | 194 | 6 | 18 | 16 | 106 | 31 | 203 | 211 |
| | 7 | 50 | 46 | 86 | 156 | 142 | 22 | 140 | 210 |
| | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 87 | 58 | 0 | 35 | 79 | 13 | 110 | 39 |
| | 1 | 20 | 42 | 158 | 138 | 28 | 135 | 124 | 84 |
| | 10 | 185 | 156 | 154 | 86 | 41 | 145 | 52 | 88 |
| | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 1 | 26 | 76 | 0 | 6 | 2 | 128 | 196 | 117 |
| | 4 | 105 | 61 | 148 | 20 | 103 | 52 | 35 | 227 |
| | 11 | 29 | 153 | 104 | 141 | 78 | 173 | 114 | 6 |
| | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 76 | 157 | 0 | 80 | 91 | 156 | 10 | 238 |
| | 8 | 42 | 175 | 17 | 43 | 75 | 166 | 122 | 13 |
| | 13 | 210 | 67 | 33 | 81 | 81 | 40 | 23 | 11 |
| | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 1 | 222 | 20 | 0 | 49 | 54 | 18 | 202 | 195 |
| | 2 | 63 | 52 | 4 | 1 | 132 | 163 | 126 | 44 |
| | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 23 | 106 | 0 | 156 | 68 | 110 | 52 | 5 |
| | 3 | 235 | 86 | 75 | 54 | 115 | 132 | 170 | 94 |
| | 5 | 238 | 95 | 158 | 134 | 56 | 150 | 13 | 111 |
| | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 1 | 46 | 182 | 0 | 153 | 30 | 113 | 113 | 81 |
| | 2 | 139 | 153 | 69 | 88 | 42 | 108 | 161 | 19 |
| | 9 | 8 | 64 | 87 | 63 | 101 | 61 | 88 | 130 |
| | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 228 | 45 | 0 | 211 | 128 | 72 | 197 | 66 |
| | 5 | 156 | 21 | 65 | 94 | 63 | 136 | 194 | 95 |
| | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 2 | 29 | 67 | 0 | 90 | 142 | 36 | 164 | 146 |
| | 7 | 143 | 137 | 100 | 6 | 28 | 38 | 172 | 66 |
| | 12 | 160 | 55 | 13 | 221 | 100 | 53 | 49 | 190 |
| | 13 | 122 | 85 | 7 | 6 | 133 | 145 | 161 | 86 |
| | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0 | 8 | 103 | 0 | 27 | 13 | 42 | 168 | 64 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5 | 194 | 121 | 142 | 170 | 84 | 35 | 36 | 169 |
| | 7 | 159 | 80 | 141 | 219 | 137 | 103 | 132 | 88 |
| | 11 | 103 | 48 | 64 | 193 | 71 | 60 | 62 | 207 |
| | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 155 | 129 | 0 | 123 | 109 | 47 | 7 | 137 |
| | 5 | 228 | 92 | 124 | 55 | 87 | 154 | 34 | 72 |
| | 7 | 45 | 100 | 99 | 31 | 107 | 10 | 198 | 172 |
| | 9 | 28 | 49 | 45 | 222 | 133 | 155 | 168 | 124 |
| | 11 | 158 | 184 | 148 | 209 | 139 | 29 | 12 | 56 |
| | 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 1 | 129 | 80 | 0 | 103 | 97 | 48 | 163 | 86 |
| | 5 | 147 | 186 | 45 | 13 | 135 | 125 | 78 | 186 |
| | 7 | 140 | 16 | 148 | 105 | 35 | 24 | 143 | 87 |
| | 11 | 3 | 102 | 96 | 150 | 108 | 47 | 107 | 172 |
| | 13 | 116 | 143 | 78 | 181 | 65 | 55 | 58 | 154 |
| | 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 142 | 118 | 0 | 147 | 70 | 53 | 101 | 176 |
| | 1 | 94 | 70 | 65 | 43 | 69 | 31 | 177 | 169 |
| | 12 | 230 | 152 | 87 | 152 | 88 | 161 | 22 | 225 |
| | 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 1 | 203 | 28 | 0 | 2 | 97 | 104 | 186 | 167 |
| | 8 | 205 | 132 | 97 | 30 | 40 | 142 | 27 | 238 |
| | 10 | 61 | 185 | 51 | 184 | 24 | 99 | 205 | 48 |
| | 11 | 247 | 178 | 85 | 83 | 49 | 64 | 81 | 68 |
| | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 11 | 59 | 0 | 174 | 46 | 111 | 125 | 38 |
| | 1 | 185 | 104 | 17 | 150 | 41 | 25 | 60 | 217 |
| | 6 | 0 | 22 | 156 | 8 | 101 | 174 | 177 | 208 |
| | 7 | 117 | 52 | 20 | 56 | 96 | 23 | 51 | 232 |
| | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 0 | 11 | 32 | 0 | 99 | 28 | 91 | 39 | 178 |
| | 7 | 236 | 92 | 7 | 138 | 30 | 175 | 29 | 214 |
| | 9 | 210 | 174 | 4 | 110 | 116 | 24 | 35 | 168 |
| | 13 | 56 | 154 | 2 | 99 | 64 | 141 | 8 | 51 |
| | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 1 | 63 | 39 | 0 | 46 | 33 | 122 | 18 | 124 |
| | 3 | 111 | 93 | 113 | 217 | 122 | 11 | 155 | 122 |
| | 11 | 14 | 11 | 48 | 109 | 131 | 4 | 49 | 72 |
| | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 83 | 49 | 0 | 37 | 76 | 29 | 32 | 48 |
| | 1 | 2 | 125 | 112 | 113 | 37 | 91 | 53 | 57 |
| | 8 | 38 | 35 | 102 | 143 | 62 | 27 | 95 | 167 |
| | 13 | 222 | 166 | 26 | 140 | 47 | 127 | 186 | 219 |
| | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 1 | 115 | 19 | 0 | 36 | 143 | 11 | 91 | 82 |
| | 6 | 145 | 118 | 138 | 95 | 51 | 145 | 20 | 232 |
| | 11 | 3 | 21 | 57 | 40 | 130 | 8 | 52 | 204 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 6 | 151 | 50 | 32 | 118 | 10 | 104 | 193 | 181 |
| | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | 1 | 98 | 70 | 0 | 216 | 106 | 64 | 14 | 7 |
| | 2 | 101 | 111 | 126 | 212 | 77 | 24 | 186 | 144 |
| | 5 | 135 | 168 | 110 | 193 | 43 | 149 | 46 | 16 |
| | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 0 | 18 | 110 | 0 | 108 | 133 | 139 | 50 | 25 |
| | 4 | 28 | 17 | 154 | 61 | 25 | 161 | 27 | 57 |
| | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 2 | 71 | 120 | 0 | 106 | 87 | 84 | 70 | 37 |
| | 5 | 240 | 154 | 35 | 44 | 56 | 173 | 17 | 139 |
| | 7 | 9 | 52 | 51 | 185 | 104 | 93 | 50 | 221 |
| | 9 | 84 | 56 | 134 | 176 | 70 | 29 | 6 | 17 |
| | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 1 | 106 | 3 | 0 | 147 | 80 | 117 | 115 | 201 |
| | 13 | 1 | 170 | 20 | 182 | 139 | 148 | 189 | 46 |
| | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 32 | 0 | 242 | 84 | 0 | 108 | 32 | 116 | 110 | 179 |
| | 5 | 44 | 8 | 20 | 21 | 89 | 73 | 0 | 14 |
| | 12 | 166 | 17 | 122 | 110 | 71 | 142 | 163 | 116 |
| | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 2 | 132 | 165 | 0 | 71 | 135 | 105 | 163 | 46 |
| | 7 | 164 | 179 | 88 | 12 | 6 | 137 | 173 | 2 |
| | 10 | 235 | 124 | 13 | 109 | 2 | 29 | 179 | 106 |
| | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | 0 | 147 | 173 | 0 | 29 | 37 | 11 | 197 | 184 |
| | 12 | 85 | 177 | 19 | 201 | 25 | 41 | 191 | 135 |
| | 13 | 36 | 12 | 78 | 69 | 114 | 162 | 193 | 141 |
| | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | 1 | 57 | 77 | 0 | 91 | 60 | 126 | 157 | 85 |
| | 5 | 40 | 184 | 157 | 165 | 137 | 152 | 167 | 225 |
| | 11 | 63 | 18 | 6 | 55 | 93 | 172 | 181 | 175 |
| | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0 | 140 | 25 | 0 | 1 | 121 | 73 | 197 | 178 |
| | 2 | 38 | 151 | 63 | 175 | 129 | 154 | 167 | 112 |
| | 7 | 154 | 170 | 82 | 83 | 26 | 129 | 179 | 106 |
| | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | 10 | 219 | 37 | 0 | 40 | 97 | 167 | 181 | 154 |
| | 13 | 151 | 31 | 144 | 12 | 56 | 38 | 193 | 114 |
| | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | 1 | 31 | 84 | 0 | 37 | 1 | 112 | 157 | 42 |
| | 5 | 66 | 151 | 93 | 97 | 70 | 7 | 173 | 41 |
| | 11 | 38 | 190 | 19 | 46 | 1 | 19 | 191 | 105 |
| | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 0 | 239 | 93 | 0 | 106 | 119 | 109 | 181 | 167 |
| | 7 | 172 | 132 | 24 | 181 | 32 | 6 | 157 | 45 |
| | 12 | 34 | 57 | 138 | 154 | 142 | 105 | 173 | 189 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 232 | 163 | 27 | 116 | 97 | 166 | 109 | 162 | | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 40 | 2 | 0 | 103 | 0 | 98 | 6 | 160 | 193 | 78 |
| 15 | 0 | 51 | 68 | 0 | 116 | 139 | 137 | 174 | 38 | | 10 | 75 | 107 | 36 | 35 | 73 | 156 | 163 | 67 |
| | 10 | 175 | 63 | 73 | 200 | 96 | 103 | 108 | 217 | | 13 | 120 | 163 | 143 | 36 | 102 | 82 | 179 | 180 |
| | 11 | 213 | 81 | 99 | 110 | 128 | 40 | 102 | 157 | | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 1 | 129 | 147 | 0 | 120 | 48 | 132 | 191 | 53 |
| 16 | 1 | 203 | 87 | 0 | 75 | 48 | 78 | 125 | 170 | | 5 | 229 | 7 | 2 | 101 | 47 | 6 | 197 | 215 |
| | 9 | 142 | 177 | 79 | 158 | 9 | 158 | 31 | 23 | | 11 | 118 | 60 | 55 | 81 | 19 | 8 | 167 | 230 |
| | 11 | 8 | 135 | 111 | 134 | 28 | 17 | 54 | 175 | | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | 12 | 242 | 64 | 143 | 97 | 8 | 165 | 176 | 202 | | | | | | | | | | |

## 5.3.3 Channel coding of small block lengths

The bit sequence input for a given code block to channel coding is denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits to encode. After encoding the bits are denoted by $d_0, d_1, d_2, \ldots, d_{N-1}$.

### 5.3.3.1 Encoding of 1-bit information

For $K=1$, the code block is encoded according to Table 5.3.3.1-1, where $N=Q_m$ and $Q_m$ is the modulation order for the code block.

**Table 5.3.3.1-1: Encoding of 1-bit information**

| $Q_m$ | **Encoded bits** $d_0, d_1, d_2, \ldots, d_{N-1}$ |
|---|---|
| **1** | $[c_0]$ |
| 2 | $[c_0\ \mathrm{y}]$ |
| 4 | $[c_0\ \mathrm{y}\ \mathrm{x}\ \mathrm{x}]$ |
| 6 | $[c_0\ \mathrm{y}\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}]$ |
| 8 | $[c_0\ \mathrm{y}\ x\ x\ x\ x\ x\ \mathrm{x}]$ |

The "x" and "y" in Table 5.3.3.1-1 are placeholders for Subclause 6.3.1.1 of [4, TS 38.211] to scramble the information bits in a way that maximizes the Euclidean distance of the modulation symbols carrying the information bits.

### 5.3.3.2 Encoding of 2-bit information

For $K=2$, the code block is encoded according to Table 5.3.3-2, where $c_2=(c_0+c_1)\bmod 2$, $N=3Q_m$, and $Q_m$ is the modulation order for the code block.

**Table 5.3.3.2-1: Encoding of 2-bit information**

| $Q_m$ | **Encoded bits** $d_0, d_1, d_2, \ldots, d_{N-1}$ |
|---|---|
| **1** | $[c_0 c_1 c_2]$ |
| 2 | $[c_0 c_1 c_2 c_0 c_1 c_2]$ |
| 4 | $[c_0 c_1\ \mathrm{x}\ \mathrm{x}\ \ c_2 c_0\ \mathrm{x}\ \mathrm{x}\ c_1 c_2\ \mathrm{x}\ \mathrm{x}]$ |
| 6 | $[c_0 c_1\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \ c_2 c_0\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \ c_1 c_2\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}\ \mathrm{x}]$ |
| 8 | $[c_0 c_1\ \mathrm{x}\ x\ x\ x\ x\ \mathrm{x}\ \ c_2 c_0\ \mathrm{x}\ x\ x\ x\ x\ \mathrm{x}\ \ c_1 c_2\ \mathrm{x}\ x\ x\ x\ x\ x]$ |

The "x" in Table 5.3.3.2-1 are placeholders for Subclause 6.3.1.1 of [4, TS 38.211] to scramble the information bits in a way that maximizes the Euclidean distance of the modulation symbols carrying the information bits.

### 5.3.3.3 Encoding of other small block lengths

For $3 \le K \le 11$, the code block is encoded by $d_i = \left( \sum_{k=0}^{K-1} c_k \cdot M_{i,k} \right) \bmod 2$, where $i = 0, 1, \cdots, N-1$, $N = 32$, and $M_{i,k}$ represents the basis sequences as defined in Table 5.3.3.3-1.

**Table 5.3.3.3-1: Basis sequences for (32, $K$) code**

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

# 5.4 Rate matching

## 5.4.1 Rate matching for Polar code

The rate matching for Polar code is defined per coded block and consists of sub-block interleaving, bit collection, and bit interleaving. The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

### 5.4.1.1 Sub-block interleaving

The bits input to the sub-block interleaver are the coded bits $d_0, d_1, d_2, ..., d_{N-1}$. The coded bits $d_0, d_1, d_2, ..., d_{N-1}$ are divided into 32 sub-blocks. The bits output from the sub-block interleaver are denoted as $y_0, y_1, y_2, ..., y_{N-1}$, generated as follows:

for $n=0$ to $N-1$

$i = \lfloor 32n/N \rfloor$;

$J(n) = P(i) \times (N/32) + \text{mod}(n, N/32)$;

$y_n = d_{J(n)}$;

end for

where the sub-block interleaver pattern $P(i)$ is given by Table 5.4.1.1-1.

**Table 5.4.1.1-1: Sub-block interleaver pattern $P(i)$**

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

The sets of bit indices $\bar{Q}_I^N$ and $\bar{Q}_F^N$ are determined as follows, where $K$, $n_{PC}$, and $Q_0^{N-1}$ are defined in Subclause 5.3.1

$\bar{Q}_{F,tmp}^N = \emptyset$

if $E < N$

if $K/E \leq 7/16$ -- puncturing

for $n=0$ to $N-E-1$

$\bar{Q}_{F,tmp}^N = \bar{Q}_{F,tmp}^N \cup \{J(n)\}$;

end for

if $E \geq 3N/4$

$\bar{Q}_{F,tmp}^N = \bar{Q}_{F,tmp}^N \cup \{0, 1, ..., \lceil 3N/4 - E/2 \rceil - 1\}$;

else

$\bar{Q}_{F,tmp}^N = \bar{Q}_{F,tmp}^N \cup \{0, 1, ..., \lceil 9N/16 - E/4 \rceil - 1\}$;

end if

else -- shortening

for $n = E$ to $N-1$

$\bar{Q}_{F,tmp}^N = \bar{Q}_{F,tmp}^N \cup \{J(n)\}$ ;

end for

end if

end if

$\bar{Q}_{I,tmp}^N = Q_0^{N-1} \backslash \bar{Q}_{F,tmp}^N$ ;

$\bar{Q}_I^N$ comprises $(K + n_{PC})$ most reliable bit indices in $\bar{Q}_{I,tmp}^N$ ;

$\bar{Q}_F^N = Q_0^{N-1} \backslash \bar{Q}_I^N$ ;

### 5.4.1.2 Bit selection

The bit sequence after the sub-block interleaver $y_0, y_1, y_2, \ldots, y_{N-1}$ from Subclause 5.4.1.1 is written into a circular buffer of length $N$ .

Denoting by $E$ the rate matching output sequence length, the bit selection output bit sequence $e_k$ , $k = 0,1,2,\ldots,E-1$ , is generated as follows:

if $E \geq N$ -- repetition

for $k = 0$ to $E-1$

$e_k = y_{\mathrm{mod}(k,N)}$ ;

end for

else

if $K/E \leq 7/16$ -- puncturing

for $k = 0$ to $E-1$

$e_k = y_{k+N-E}$ ;

end for

else -- shortening

for $k = 0$ to $E-1$

$e_k = y_k$ ;

end for

end if

end if

### 5.4.1.3 Interleaving of coded bits

The bit sequence $e_0, e_1, e_2, \ldots, e_{E-1}$ is interleaved into bit sequence $f_0, f_1, f_2, \ldots, f_{E-1}$ , as follows:

If $I_{BIL}=1$

Denote $T$ as the smallest integer such that $T(T+1)/2 \geq E$;

$k=0$;

for $i=0$ to $T-1$

for $j=0$ to $T-1-i$

if $k<E$

$v_{i,j}=e_k$;

else

$v_{i,j}=<NULL>$;

end if

$k=k+1$;

end for

end for

$k=0$;

for $j=0$ to $T-1$

for $i=0$ to $T-1-j$

if $v_{i,j} \neq <NULL>$

$f_k=v_{i,j}$;

$k=k+1$

end if

end for

end for

else

for $i=0$ to $E-1$

$f_i=e_i$;

end for

end if

The value of $E$ is no larger than 8192.

## 5.4.2 Rate matching for LDPC code

The rate matching for LDPC code is defined per coded block and consists of bit selection and bit interleaving. The input bit sequence to rate matching is $d_0, d_1, d_2, ..., d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, ..., f_{E-1}$.

### 5.4.2.1 Bit selection

The bit sequence after encoding $d_0, d_1, d_2, ..., d_{N-1}$ from Subclause 5.3.2 is written into a circular buffer of length $N_{cb}$ for the $r$-th coded block, where $N$ is defined in Subclause 5.3.2.

For the $r$-th code block, let $N_{cb} = N$ if $I_{LBRM} = 0$ and $N_{cb} = \min(N, N_{ref})$ otherwise, where $N_{ref} = \left\lfloor \frac{TBS_{LBRM}}{C \cdot R_{\mathrm{LBRM}}} \right\rfloor$, $R_{\mathrm{LBRM}} = 2/3$, $TBS_{LBRM}$ is determined according to Subclause 6.1.4.2 in [6, TS 38.214] for UL-SCH and Subclause 5.1.3.2 in [6, TS 38.214] for DL-SCH/PCH, assuming the following:

- maximum number of layers for one TB supported by the UE for the serving cell, if the UE has reported its corresponding capability; otherwise a maximum of 2 layers is assumed for DL-SCH;
- maximum modulation order configured for the serving cell, if configured by higher layers; otherwise a maximum modulation order $Q_m = 6$ is assumed for DL-SCH ;
- maximum coding rate of 948/1024;
- $n_{PRB} = n_{PRB,LBRM}$ is given by Table 5.4.2.1-1, where the value of $n_{PRB,LBRM}$ for DL-SCH is determined according to the initial bandwidth part if there is no other bandwidth part configured to the UE;
- $N_{RE} = 156 \cdot n_{PRB}$ ;
- $C$ is the number of code blocks of the transport block determined according to Subclause 5.2.2.

**Table 5.4.2.1-1: Value of $n_{PRB,LBRM}$**

| Maximum number of PRBs across all configured BWPs of a carrier | $n_{PRB,LBRM}$ |
|---|---|
| Less than 33 | 32 |
| 33 to 66 | 66 |
| 67 to 107 | 107 |
| 108 to 135 | 135 |
| 136 to 162 | 162 |
| 163 to 217 | 217 |
| Larger than 217 | 273 |

Denoting by $E_r$ the rate matching output sequence length for the $r$-th coded block, where the value of $E_r$ is determined as follows:

Set $j = 0$

for $r = 0$ to $C - 1$

if the $r$-th coded block is not scheduled for transmission as indicated by CBGTI according to Subclause 5.1.7.2 for DL-SCH and 6.1.5.2 for UL-SCH in [6, TS 38.214]

$E_r = 0$ ;

else

if $j \le C' - \mathrm{mod}\left(G/\left(N_L \cdot Q_m\right), C'\right) - 1$

$$E_r = N_L \cdot Q_m \cdot \left\lfloor \frac{G}{N_L \cdot Q_m \cdot C'} \right\rfloor;$$

else

$$E_r = N_L \cdot Q_m \cdot \left\lceil \frac{G}{N_L \cdot Q_m \cdot C'} \right\rceil;$$

end if

$j = j + 1$;

end if

end for

where

- $N_L$ is the number of transmission layers that the transport block is mapped onto;
- $Q_m$ is the modulation order;
- $G$ is the total number of coded bits available for transmission of the transport block;
- $C' = C$ if CBGTI is not present in the DCI scheduling the transport block and $C'$ is the number of scheduled code blocks of the transport block if CBGTI is present in the DCI scheduling the transport block.

Denote by $rv_{id}$ the redundancy version number for this transmission ($rv_{id}$ = 0, 1, 2 or 3), the rate matching output bit sequence $e_k$, $k = 0,1,2,\ldots,E-1$, is generated as follows, where $k_0$ is given by Table 5.4.2.1-2 according to the value of $rv_{id}$ and LDPC base graph:

$k = 0$;

$j = 0$;

while $k < E$

if $d_{(k_0 + j) \bmod N_{cb}} \neq \langle NULL \rangle$

$e_k = d_{(k_0 + j) \bmod N_{cb}}$;

$k = k + 1$;

end if

$j = j + 1$;

end while

**Table 5.4.2.1-2: Starting position of different redundancy versions, $k_0$**

| $rv_{id}$ | $k_0$ | |
|---|---|---|
| | LDPC base graph 1 | LDPC base graph 2 |
| 0 | 0 | 0 |
| 1 | $\left\lfloor \frac{17 N_{cb}}{66 Z_c} \right\rfloor Z_c$ | $\left\lfloor \frac{13 N_{cb}}{50 Z_c} \right\rfloor Z_c$ |
| 2 | $\left\lfloor \frac{33 N_{cb}}{66 Z_c} \right\rfloor Z_c$ | $\left\lfloor \frac{25 N_{cb}}{50 Z_c} \right\rfloor Z_c$ |
| 3 | $\left\lfloor \frac{56 N_{cb}}{66 Z_c} \right\rfloor Z_c$ | $\left\lfloor \frac{43 N_{cb}}{50 Z_c} \right\rfloor Z_c$ |

### 5.4.2.2 Bit interleaving

The bit sequence $e_0, e_1, e_2, \ldots, e_{E-1}$ is interleaved to bit sequence $f_0, f_1, f_2, \ldots, f_{E-1}$, according to the following, where the value of $Q_m$ is the modulation order.

for $j = 0$ to $E/Q_m - 1$

for $i = 0$ to $Q_m - 1$

$f_{i+j\cdot Q_m} = e_{i\cdot E/Q_m + j}$ ;

end for

end for

## 5.4.3 Rate matching for channel coding of small block lengths

The input bit sequence to rate matching is $d_0, d_1, d_2, \ldots, d_{N-1}$. The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, \ldots, f_{E-1}$, where $E$ is the rate matching output sequence length. The bit sequence $f_0, f_1, f_2, \ldots, f_{E-1}$ is obtained by the following:

for $k = 0$ to $E - 1$

$f_k = d_{k \bmod N}$ ;

end for

# 5.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{rk}$, for $r = 0, \ldots, C-1$ and $k = 0, \ldots, E_r - 1$, where $E_r$ is the number of rate matched bits for the $r$ -th code block. The output bit sequence from the code block concatenation block is the sequence $g_k$ for $k = 0, \ldots, G-1$ .

The code block concatenation consists of sequentially concatenating the rate matching outputs for the different code blocks. Therefore,

Set $k = 0$ and $r = 0$

while $r < C$

Set $j = 0$

while $j < E_r$

$g_k = f_{rj}$

$k = k + 1$

$j = j + 1$

end while

$r = r + 1$

end while

# 6 Uplink transport channels and control information

## 6.1 Random access channel

The sequence index for the random access channel is received from higher layers and is processed according to [4, TS 38.211].

## 6.2 Uplink shared channel

### 6.2.1 Transport block CRC attachment

Error detection is provided on each UL-SCH transport block through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. Denote the bits in a transport block delivered to layer 1 by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, \ldots, p_{L-1}$, where $A$ is the payload size and $L$ is the number of parity bits. The lowest order information bit $a_0$ is mapped to the most significant bit of the transport block as defined in Subclause x.x of [TS38.321].

The parity bits are computed and attached to the UL-SCH transport block according to Subclause 5.1, by setting $L$ to 24 bits and using the generator polynomial $g_{\mathrm{CRC24A}}(D)$ if $A > 3824$; and by setting $L$ to 16 bits and using the generator polynomial $g_{\mathrm{CRC16}}(D)$ otherwise.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$, where $B = A + L$.

### 6.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate $R$ indicated by the MCS index according to Subclause 6.1.4.1 in [6, TS 38.214] and subsequent re-transmission of the same transport block, each code block of the transport block is encoded with either LDPC base graph 1 or 2 according to the following:

- if $A \leq 292$, or if $A \leq 3824$ and $R \leq 0.67$, or if $R \leq 0.25$, LDPC base graph 2 is used;
- otherwise, LDPC base graph 1 is used,

where $A$ is the payload size as described in Subclause 6.2.1.

### 6.2.3 Code block segmentation and code block CRC attachment

The bits input to the code block segmentation are denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$ where $B$ is the number of bits in the transport block (including CRC).

Code block segmentation and code block CRC attachment are performed according to Subclause 5.2.2.

The bits after code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $r$ is the code block number and $K_r$ is the number of bits for code block number $r$ according to Subclause 5.2.2.

### 6.2.4 Channel coding of UL-SCH

Code blocks are delivered to the channel coding block. The bits in a code block are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $r$ is the code block number, and $K_r$ is the number of bits in code block number $r$. The total number of code blocks is denoted by $C$ and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$, where the values of $N_r$ is given in Subclause 5.3.2.

### 6.2.5 Rate matching

Coded bits for each code block, denoted as $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$, are delivered to the rate match block, where $r$ is the code block number, and $N_r$ is the number of encoded bits in code block number $r$. The total number of code blocks is denoted by $C$ and each code block is individually rate matched according to Subclause 5.4.2 by setting $I_{LBRM}=1$ if higher layer parameter *LBRM-FBRM-selection* = *LBRM* and by setting $I_{LBRM}=0$ if higher layer parameter *LBRM-FBRM-selection* = *FBRM* or if higher layer parameter *LBRM-FBRM-selection* is not configured.

After rate matching, the bits are denoted by $f_{r0}, f_{r1}, f_{r2}, f_{r3}, \ldots, f_{r(E_r-1)}$, where $E_r$ is the number of rate matched bits for code block number $r$.

### 6.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0}, f_{r1}, f_{r2}, f_{r3}, \ldots, f_{r(E_r-1)}$, for $r=0,\ldots,C-1$ and where $E_r$ is the number of rate matched bits for the $r$-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0, g_1, g_2, g_3, \ldots, g_{G-1}$, where $G$ is the total number of coded bits for transmission.

### 6.2.7 Data and control multiplexing

Denote the coded bits for UL-SCH as $g_0^{\text{UL-SCH}}, g_1^{\text{UL-SCH}}, g_2^{\text{UL-SCH}}, g_3^{\text{UL-SCH}}, \ldots, g_{G^{\text{UL-SCH}}-1}^{\text{UL-SCH}}$.

Denote the coded bits for HARQ-ACK, if any, as $g_0^{\text{ACK}}, g_1^{\text{ACK}}, g_2^{\text{ACK}}, g_3^{\text{ACK}}, \ldots, g_{G^{\text{ACK}}-1}^{\text{ACK}}$.

Denote the coded bits for CSI part 1, if any, as $g_0^{\text{CSI-part1}}, g_1^{\text{CSI-part1}}, g_2^{\text{CSI-part1}}, g_3^{\text{CSI-part1}}, \ldots, g_{G^{\text{CSI-part1}}-1}^{\text{CSI-part1}}$.

Denote the coded bits for CSI part 2, if any, as $g_0^{\text{CSI-part2}}, g_1^{\text{CSI-part2}}, g_2^{\text{CSI-part2}}, g_3^{\text{CSI-part2}}, \ldots, g_{G^{\text{CSI-part2}}-1}^{\text{CSI-part2}}$.

Denote the multiplexed data and control coded bit sequence as $g_0, g_1, g_2, g_3, \ldots, g_{G-1}$.

Denote $l$ as the OFDM symbol index of the scheduled PUSCH, starting from 0 to $N_{\text{symb,all}}^{\text{PUSCH}} - 1$, where $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS.

Denote $k$ as the subcarrier index of the scheduled PUSCH, starting from 0 to $M_{\text{sc}}^{\text{PUSCH}} - 1$, where $M_{\text{sc}}^{\text{PUSCH}}$ is expressed as a number of subcarriers.

Denote $\Phi_l^{\text{UL-SCH}}$ as the set of resource elements, in ascending order of indices $k$, available for transmission of data in OFDM symbol $l$, for $l = 0, 1, 2, \ldots, N_{\text{symb,all}}^{\text{PUSCH}} - 1$.

Denote $M_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\Phi_l^{\text{UL-SCH}}\right|$ as the number of elements in set $\Phi_l^{\text{UL-SCH}}$. Denote $\Phi_l^{\text{UL-SCH}}(j)$ as the $j$-th element in $\Phi_l^{\text{UL-SCH}}$.

Denote $\Phi_l^{\text{UCI}}$ as the set of resource elements, in ascending order of indices $k$, available for transmission of UCI in OFDM symbol $l$, for $l = 0, 1, 2, \ldots, N_{\text{symb,all}}^{\text{PUSCH}} - 1$. Denote $M_{\text{sc}}^{\text{UCI}}(l) = \left|\Phi_l^{\text{UCI}}\right|$ as the number of elements in set $\Phi_l^{\text{UCI}}$. Denote $\Phi_l^{\text{UCI}}(j)$ as the $j$-th element in $\Phi_l^{\text{UCI}}$. For any OFDM symbol that carries DMRS of the PUSCH, $\Phi_l^{\text{UCI}} =$ �. For any OFDM symbol that does not carry DMRS of the PUSCH, $\Phi_l^{\text{UCI}} = \Phi_l^{\text{UL-SCH}}$.

If frequency hopping is configured for the PUSCH,

- denote $l^{(1)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS in the first hop;
- denote $l^{(2)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS in the second hop.
- denote $l_{\text{CSI}}^{(1)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS in the first hop;
- denote $l_{\text{CSI}}^{(2)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS in the second hop;
- if HARQ-ACK is present for transmission on the PUSCH with UL-SCH, let
  - $G^{\text{ACK}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$ and $G^{\text{ACK}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
- if CSI is present for transmission on the PUSCH with UL-SCH, let
  - $G^{\text{CSI-part1}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part1}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$;
  - $G^{\text{CSI-part1}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{CSI-part1}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
  - $G^{\text{CSI-part2}}(1) = N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part2}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$; and
  - $G^{\text{CSI-part2}}(2) = N_L \cdot Q_m \cdot \left\lceil G^{\text{CSI-part2}} / (2 \cdot N_L \cdot Q_m) \right\rceil$;
- if only HARQ-ACK and CSI part 1 are present for transmission on the PUSCH without UL-SCH, let
  - $G^{\text{ACK}}(1) = \min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor, M_1 \cdot N_L \cdot Q_m\right)$;
  - $G^{\text{ACK}}(2) = G^{\text{ACK}} - G^{\text{ACK}}(1)$;

- $G^{\text{CSI-part1}}(1)=M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1)$ ; and
- $G^{\text{CSI-part1}}(2)=G^{\text{CSI-part1}} - G^{\text{CSI-part1}}(1)$ ;

- if HARQ-ACK, CSI part 1 and CSI part 2 are present for transmission on the PUSCH without UL-SCH, let
  - $G^{\text{ACK}}(1)=\min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{ACK}}/(2 \cdot N_L \cdot Q_m)\right\rfloor, M_1 \cdot N_L \cdot Q_m\right)$ ;
  - $G^{\text{ACK}}(2)=G^{\text{ACK}} - G^{\text{ACK}}(1)$ ;
  - $G^{\text{CSI-part1}}(1)=\min\left(N_L \cdot Q_m \cdot \left\lfloor G^{\text{CSI-part1}}/(2 \cdot N_L \cdot Q_m)\right\rfloor, M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1)\right)$ ;
  - $G^{\text{CSI-part1}}(2)=G^{\text{CSI-part1}} - G^{\text{CSI-part1}}(1)$ ;
  - $G^{\text{CSI-part2}}(1)=M_1 \cdot N_L \cdot Q_m - G^{\text{CSI-part1}}(1)$ if the number of HARQ-ACK information bits is no more than 2, and $G^{\text{CSI-part2}}(1)=M_1 \cdot N_L \cdot Q_m - G^{\text{ACK}}(1) - G^{\text{CSI-part1}}(1)$ otherwise; and
  - $G^{\text{CSI-part2}}(2)=M_2 \cdot N_L \cdot Q_m - G^{\text{CSI-part1}}(2)$ if the number of HARQ-ACK information bits is no more than 2, and $G^{\text{CSI-part2}}(2)=M_2 \cdot N_L \cdot Q_m - G^{\text{ACK}}(2) - G^{\text{CSI-part1}}(2)$ otherwise;
- let $N_{\text{hop}}^{\text{PUSCH}}=2$ , and denote $N_{\text{symb,hop}}^{\text{PUSCH}}(1)$ , $N_{\text{symb,hop}}^{\text{PUSCH}}(2)$ as the number of OFDM symbols of the PUSCH in the first and second hop, respectively;
- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH;
- $M_1=\sum_{l=0}^{N_{\text{symb,hop}}^{\text{PUSCH}}(1)-1} M_{\text{SC}}^{\text{UCI}}(l)$ ;
- $M_2=\sum_{l=N_{\text{symb,hop}}^{\text{PUSCH}}(1)}^{N_{\text{symb,hop}}^{\text{PUSCH}}(1)+N_{\text{symb,hop}}^{\text{PUSCH}}(2)-1} M_{\text{SC}}^{\text{UCI}}(l)$ .

If frequency hopping is not configured for the PUSCH,

- denote $l^{(1)}$ as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS;
- denote $l_{\text{CSI}}^{(1)}$ as the OFDM symbol index of the first OFDM symbol that does not carry DMRS;
- if HARQ-ACK is present for transmission on the PUSCH, let $G^{\text{ACK}}(1)=G^{\text{ACK}}$ ;
- if CSI is present for transmission on the PUSCH, let $G^{\text{CSI-part1}}(1)=G^{\text{CSI-part1}}$ and $G^{\text{CSI-part2}}(1)=G^{\text{CSI-part2}}$ ;
- let $N_{\text{hop}}^{\text{PUSCH}}=1$ and $N_{\text{symb,hop}}^{\text{PUSCH}}(1)=N_{\text{symb,all}}^{\text{PUSCH}}$ .

The multiplexed data and control coded bit sequence $g_0, g_1, g_2, g_3, \ldots, g_{G-1}$ is obtained according to the following:

**Step 1:**

Set $\bar{\Phi}_l^{\text{UL-SCH}} = \Phi_l^{\text{UL-SCH}}$ for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

Set $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_l^{\text{UL-SCH}}\right|$ for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

Set $\bar{\Phi}_l^{\text{UCI}} = \Phi_l^{\text{UCI}}$ for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

Set $\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_l^{\text{UCI}}\right|$ for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

if the number of HARQ-ACK information bits to be transmitted on PUSCH is 0, 1 or 2 bits

the number of reserved resource elements for potential HARQ-ACK transmission is calculated according to Subclause 6.3.2.4.1.1, by setting $O_{\text{ACK}} = 2$ ;

denote $G_{\text{rvd}}^{\text{ACK}}$ as the number of coded bits for potential HARQ-ACK transmission using the reserved resource elements;

if frequency hopping is configured for the PUSCH, let $G_{\text{rvd}}^{\text{ACK}}(1) = N_L \cdot Q_m \cdot \left\lfloor G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rfloor$ and $G_{\text{rvd}}^{\text{ACK}}(2) = N_L \cdot Q_m \cdot \left\lceil G_{\text{rvd}}^{\text{ACK}} / (2 \cdot N_L \cdot Q_m) \right\rceil$ ;

if frequency hopping is not configured for the PUSCH, let $G_{\text{rvd}}^{\text{ACK}}(1) = G_{\text{rvd}}^{\text{ACK}}$ ;

denote $\bar{\Phi}_l^{\text{rvd}}$ as the set of reserved resource elements for potential HARQ-ACK transmission, in OFDM symbol $l$ , for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

Set $m_{\text{count}}^{\text{ACK}}(1)=0$ ;

Set $m_{\text{count}}^{\text{ACK}}(2)=0$ ;

$\bar{\Phi}_l^{\text{rvd}}=\emptyset$ for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ ;

for $i=1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l=l^{(i)}$ ;

while $m_{\text{count}}^{\text{ACK}}(i) < G_{\text{rvd}}^{\text{ACK}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d=1$ ;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UL-SCH}}(l)$ ;

end if

if $G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m \Big/ \left( G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \right) \right\rfloor$ ;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left( G_{\text{rvd}}^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \right) / \left( N_L \cdot Q_m \right) \right\rceil$ ;

end if

for $j=0$ to $m_{\text{count}}^{\text{RE}}-1$

$\bar{\Phi}_l^{\text{rvd}} = \bar{\Phi}_l^{\text{rvd}} \cup \{ \bar{\Phi}_l^{\text{UL-SCH}}(j \cdot d) \}$

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + N_L \cdot Q_m$ ;

end for

end if

$l = l + 1$ ;

end while

end for

else

$\bar{\Phi}_l^{\text{rvd}} = \varnothing$ for $l = 0, 1, 2, \ldots, N_{\text{symb,all}}^{\text{PUSCH}} - 1$ ;

end if

Denote $\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) = |\bar{\Phi}_l^{\text{rvd}}|$ as the number of elements in $\bar{\Phi}_l^{\text{rvd}}$ .

**Step 2:**

if HARQ-ACK is present for transmission on the PUSCH and the number of HARQ-ACK information bits is more than 2,

Set $m_{\text{count}}^{\text{ACK}}(1) = 0$ ;

Set $m_{\text{count}}^{\text{ACK}}(2) = 0$ ;

Set $m_{\text{count,all}}^{\text{ACK}} = 0$ ;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l^{(i)}$ ;

while $m_{\text{count}}^{\text{ACK}}(i) < G^{\text{ACK}}(i)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}(l) > 0$

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \geq \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = 1$ ;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UCI}}(l)$ ;

end if

if $G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}(l) \cdot N_L \cdot Q_m / \left( G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \right) \right\rfloor$ ;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left( G^{\text{ACK}}(i) - m_{\text{count}}^{\text{ACK}}(i) \right) / \left( N_L \cdot Q_m \right) \right\rceil$ ;

end if

for $j=0$ to $m_{\text{count}}^{\text{RE}}-1$

$k = \bar{\Phi}_l^{\text{UCI}}(j \cdot d)$ ;

for $v=0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count, all}}^{\text{ACK}}}^{\text{ACK}}$ ;

$m_{\text{count,all}}^{\text{ACK}} = m_{\text{count,all}}^{\text{ACK}} + 1$ ;

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + 1$ ;

end for

end for

for $j=0$ to $m_{\text{count}}^{\text{RE}}-1$

$\bar{\Phi}_l^{\text{UCI}} = \bar{\Phi}_l^{\text{UCI}} \setminus \left\{ \bar{\Phi}_l^{\text{UCI}}(j \cdot d) \right\}$ ;

$\bar{\Phi}_l^{\text{UL-SCH}} = \bar{\Phi}_l^{\text{UL-SCH}} \setminus \left\{ \bar{\Phi}_l^{\text{UCI}}(j \cdot d) \right\}$ ;

end for

$\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left| \bar{\Phi}_l^{\text{UCI}} \right|$ ;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left| \bar{\Phi}_l^{\text{UL-SCH}} \right|$ ;

end if

$l = l + 1$ ;

end while

end for

end if

**Step 3:**

if CSI is present for transmission on the PUSCH,

Set $m_{\text{count}}^{\text{CSI-part1}}(1) = 0$ ;

Set $m_{\text{count}}^{\text{CSI-part1}}(2) = 0$ ;

Set $m_{\text{count,all}}^{\text{CSI-part1}} = 0$ ;

for $i=1$ to $N_{\text{hop}}^{\text{PUSCH}}$

  $l=l_{\text{CSI}}^{(i)}$ ;

  while $\bar{M}_{\text{sc}}^{\text{UCI}}(l)-\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l) \le 0$

    $l=l+1$ ;

  end while

  while $m_{\text{count}}^{\text{CSI-part1}}(i)<G^{\text{CSI-part1}}(i)$

    if $\bar{M}_{\text{sc}}^{\text{UCI}}(l)-\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)>0$

      if $G^{\text{CSI-part1}}(i)-m_{\text{count}}^{\text{CSI-part1}}(i) \ge \left(\bar{M}_{\text{sc}}^{\text{UCI}}(l)-\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right)\cdot N_L\cdot Q_m$

        $d=1$ ;

        $m_{\text{count}}^{\text{RE}}=\bar{M}_{\text{sc}}^{\text{UCI}}(l)-\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)$ ;

      end if

      if $G^{\text{CSI-part1}}(i)-m_{\text{count}}^{\text{CSI-part1}}(i)<\left(\bar{M}_{\text{sc}}^{\text{UCI}}(l)-\bar{M}_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right)\cdot N_L\cdot Q_m$

        $d=\left\lfloor \left(\bar{M}_{\text{sc}}^{\text{UCI}}(l)-M_{\text{sc, rvd}}^{\bar{\Phi}}(l)\right)\cdot N_L\cdot Q_m \Big/ \left(G^{\text{CSI-part1}}(i)-m_{\text{count}}^{\text{CSI-part1}}(i)\right)\right\rfloor$ ;

        $m_{\text{count}}^{\text{RE}}=\left\lceil \left(G^{\text{CSI-part1}}(i)-m_{\text{count}}^{\text{CSI-part1}}(i)\right)/\left(N_L\cdot Q_m\right)\right\rceil$ ;

      end if

      $\bar{\Phi}_l^{\text{temp}}=\bar{\Phi}_l^{\text{UCI}}\setminus\bar{\Phi}_l^{\text{rvd}}$ ;

      for $j=0$ to $m_{\text{count}}^{\text{RE}}-1$

        $k=\bar{\Phi}_l^{\text{temp}}(j\cdot d)$ ;

        for $v=0$ to $N_L\cdot Q_m-1$

          $\bar{g}_{l,k,v}=g_{m_{\text{count, all}}^{\text{CSI-part1}}}^{\text{CSI-part1}}$ ;

          $m_{\text{count,all}}^{\text{CSI-part1}}=m_{\text{count,all}}^{\text{CSI-part1}}+1$ ;

          $m_{\text{count}}^{\text{CSI-part1}}(i)=m_{\text{count}}^{\text{CSI-part1}}(i)+1$ ;

        end for

      end for

      for $j=0$ to $m_{\text{count}}^{\text{RE}}-1$

        $\bar{\Phi}_l^{\text{UCI}}=\bar{\Phi}_l^{\text{UCI}}\setminus\left\{\bar{\Phi}_l^{\text{temp}}(j\cdot d)\right\}$ ;

$\bar{\Phi}_l^{\text{UL-SCH}} = \bar{\Phi}_l^{\text{UL-SCH}} \setminus \left\{ \bar{\Phi}_l^{\text{temp}}\left( j \cdot d \right) \right\}$

end for

$\bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) = \left| \bar{\Phi}_l^{\text{UCI}} \right|$ ;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}\left( l \right) = \left| \bar{\Phi}_l^{\text{UL-SCH}} \right|$ ;

end if $l = l + 1$ ;

end while

end for

Set $m_{\text{count}}^{\text{CSI-part2}}\left(1\right) = 0$ ;

Set $m_{\text{count}}^{\text{CSI-part2}}\left(2\right) = 0$ ;

Set $m_{\text{count,all}}^{\text{CSI-part2}} = 0$ ;

for $i = 1$ to $N_{\text{hop}}^{\text{PUSCH}}$

$l = l_{\text{CSI}}^{(i)}$ ;

while $\bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) = 0$

$l = l + 1$ ;

end while

while $m_{\text{count}}^{\text{CSI-part2}}\left( i \right) < G^{\text{CSI-part2}}\left( i \right)$

if $\bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) > 0$

if $G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i) \geq \bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) \cdot N_L \cdot Q_m$

$d = 1$ ;

$m_{\text{count}}^{\text{RE}} = \bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right)$ ;

end if

if $G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i) < \bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}_{\text{sc}}^{\text{UCI}}\left( l \right) \cdot N_L \cdot Q_m \Big/ \left( G^{\text{CSI-part2}}(i) - m_{\text{count}}^{\text{CSI-part2}}(i) \right) \right\rfloor$ ;

$m_{\text{count}}^{\text{RE}} = \left\lceil \left( G^{\text{CSI-part2}}\left( i \right) - m_{\text{count}}^{\text{CSI-part2}}\left( i \right) \right) / \left( N_L \cdot Q_m \right) \right\rceil$ ;

end if

for $j = 0$ to $m_{\text{count}}^{\text{RE}} - 1$

$k = \bar{\Phi}_l^{\text{UCI}}(j)$ ;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g^{\text{CSI-part2}}_{m^{\text{CSI-part2}}_{\text{count, all}}}$ ;

$m^{\text{CSI-part2}}_{\text{count,all}} = m^{\text{CSI-part2}}_{\text{count,all}} + 1$ ;

$m^{\text{CSI-part2}}_{\text{count}}(i) = m^{\text{CSI-part2}}_{\text{count}}(i) + 1$ ;

end for

end for

for $j = 0$ to $m^{\text{RE}}_{\text{count}} - 1$

$\bar{\Phi}_l^{\text{UCI}} = \bar{\Phi}_l^{\text{UCI}} \setminus \{\bar{\Phi}_l^{\text{UCI}}(j)\}$ ;

$\bar{\Phi}_l^{\text{UL-SCH}} = \bar{\Phi}_l^{\text{UL-SCH}} \setminus \{\bar{\Phi}_l^{\text{UCI}}(j)\}$ ;

end for

$\bar{M}_{\text{sc}}^{\text{UCI}}(l) = \left|\bar{\Phi}_l^{\text{UCI}}\right|$ ;

$\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) = \left|\bar{\Phi}_l^{\text{UL-SCH}}\right|$ ;

end if

$l = l + 1$ ;

end while

end for

end if

**Step 4:**

if UL-SCH is present for transmission on the PUSCH,

Set $m^{\text{UL-SCH}}_{\text{count}} = 0$ ;

for $l = 0$ to $N^{\text{PUSCH}}_{\text{symb,all}} - 1$

if $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) > 0$

for $j = 0$ to $\bar{M}_{\text{sc}}^{\text{UL-SCH}}(l) - 1$

$k = \bar{\Phi}_l^{\text{UL-SCH}}(j)$ ;

for $v = 0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m^{\mathrm{UL-SCH}}_{\mathrm{count}}}^{\mathrm{UL-SCH}}$ ;

$m^{\mathrm{UL-SCH}}_{\mathrm{count}} = m^{\mathrm{UL-SCH}}_{\mathrm{count}} + 1$ ;

end for

end for

end if

end for

end if

**Step 5:**

if HARQ-ACK is present for transmission on the PUSCH and the number of HARQ-ACK information bits is no more than 2,

Set $m^{\mathrm{ACK}}_{\mathrm{count}}(1) = 0$ ;

Set $m^{\mathrm{ACK}}_{\mathrm{count}}(2) = 0$ ;

Set $m^{\mathrm{ACK}}_{\mathrm{count,all}} = 0$ ;

for $i=1$ to $N^{\mathrm{PUSCH}}_{\mathrm{hop}}$

$l = l^{(i)}$ ;

while $m^{\mathrm{ACK}}_{\mathrm{count}}(i) < G^{\mathrm{ACK}}(i)$

if $\bar{M}^{\Phi}_{\mathrm{sc,\,rvd}}(l) > 0$

if $G^{\mathrm{ACK}}(i) - m^{\mathrm{ACK}}_{\mathrm{count}}(i) \geq \bar{M}^{\Phi}_{\mathrm{sc,\,rvd}}(l) \cdot N_L \cdot Q_m$

$d = 1$ ;

$m^{\mathrm{RE}}_{\mathrm{count}} = \bar{M}^{\Phi}_{\mathrm{sc,\,rvd}}(l)$ ;

end if

if $G^{\mathrm{ACK}}(i) - m^{\mathrm{ACK}}_{\mathrm{count}}(i) < \bar{M}^{\Phi}_{\mathrm{sc,\,rvd}}(l) \cdot N_L \cdot Q_m$

$d = \left\lfloor \bar{M}^{\Phi}_{\mathrm{sc,\,rvd}}(l) \cdot N_L \cdot Q_m / \left( G^{\mathrm{ACK}}(i) - m^{\mathrm{ACK}}_{\mathrm{count}}(i) \right) \right\rfloor$ ;

$m^{\mathrm{RE}}_{\mathrm{count}} = \left\lceil \left( G^{\mathrm{ACK}}(i) - m^{\mathrm{ACK}}_{\mathrm{count}}(i) \right) / \left( N_L \cdot Q_m \right) \right\rceil$ ;

end if

for $j=0$ to $m^{\mathrm{RE}}_{\mathrm{count}} - 1$

$k = \bar{\Phi}^{\mathrm{rvd}}_{l}(j \cdot d)$ ;

for $v=0$ to $N_L \cdot Q_m - 1$

$\bar{g}_{l,k,v} = g_{m_{\text{count, all}}^{\text{ACK}}}^{\text{ACK}}$ ;

$m_{\text{count,all}}^{\text{ACK}} = m_{\text{count,all}}^{\text{ACK}} + 1$ ;

$m_{\text{count}}^{\text{ACK}}(i) = m_{\text{count}}^{\text{ACK}}(i) + 1$ ;

end for

end for

end if

$l = l + 1$ ;

end while

end for

end if

**Step 6:**

Set $t=0$ ;

for $l=0$ to $N_{\text{symb,all}}^{\text{PUSCH}} - 1$

for $j=0$ to $M_{\text{sc}}^{\text{UL-SCH}}(l) - 1$

$k = \Phi_l^{\text{UL-SCH}}(j)$ ;

for $v=0$ to $N_L \cdot Q_m - 1$

$g_t = \bar{g}_{l,k,v}$ ;

$t = t + 1$ ;

end for

end for

end for

# 6.3 Uplink control information

## 6.3.1 Uplink control information on PUCCH

The procedure in this subclause applies to PUCCH formats 2/3/4.

#### 6.3.1.1 UCI bit sequence generation

##### 6.3.1.1.1 HARQ-ACK/SR only

If only HARQ-ACK bits are transmitted on a PUCCH, the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ is determined by setting $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, \ldots, O^{\mathrm{ACK}} - 1$ and $A = O^{\mathrm{ACK}}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \{\tilde{o}_1^{ACK}, \ldots, \tilde{o}_{O^{ACK}-1}^{ACK}¿$ is given by Subclause 9.1 of [5, TS38.213].

If only HARQ-ACK and SR bits are transmitted on a PUCCH, the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ is determined by setting $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, \ldots, O^{\mathrm{ACK}} - 1$, $a_i = \tilde{o}_i^{SR}$ for $i = O^{\mathrm{ACK}}, O^{\mathrm{ACK}} + 1, \ldots, O^{\mathrm{ACK}} + O^{\mathrm{SR}} - 1$, and $A = O^{\mathrm{ACK}} + O^{\mathrm{SR}}$, where the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}, \{\tilde{o}_1^{ACK}, \ldots, \tilde{o}_{O^{ACK}-1}^{ACK}¿$ is given by Subclause 9.1 of [5, TS 38.213], and the SR bit sequence $\tilde{o}_0^{SR}, \{\tilde{o}_1^{SR}, \ldots, \tilde{o}_{O^{SR}-1}^{SR}¿$ is given by Subclause x.x of [5, TS 38.213].

##### 6.3.1.1.2 CSI only

The bitwidth for PMI of *CodebookType=TypeI-SinglePanel* with 2 CSI-RS ports is 2 for Rank=1 and 1 for Rank=2, according to Subclause 5.2.2.2 in [6, TS 38.214].

The bitwidth for PMI of *CodebookType=TypeI-SinglePanel* with more than 2 CSI-RS ports is provided in Tables 6.3.1.1.2-1, where the values of $(N_1, N_2)$ and $(O_1, O_2)$ are given by Subclause 5.2.2.2.1 in [6, TS 38.214].

**Table 6.3.1.1.2-1: PMI of *CodebookType=TypeI-SinglePanel***

| | Information field $X_1$ for wideband PMI | | | Information field $X_2$ for wideband PMI or per subband PMI | |
|---|---|---|---|---|---|
| | ( $i_{1,1}$ , $i_{1,2}$ ) | | $i_{1,3}$ | $i_2$ | |
| | CodebookMode=1 | CodebookMode=2 | | CodebookMode=1 | CodebookMode=2 |
| Rank = 1 with >2 CSI-RS ports, $N_2>1$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | $\lceil \log_2\left(\frac{N_1 O_1}{2} \cdot \frac{N_2 O_2}{2}\right) \rceil$ | N/A | 2 | 4 |
| Rank = 1 with >2 CSI-RS ports, $N_2=1$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | $\lceil \log_2\left(\frac{N_1 O_1}{2}\right) \rceil$ | N/A | 2 | 4 |
| Rank=2 with 4 CSI-RS ports, $N_2=1$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | $\lceil \log_2\left(\frac{N_1 O_1}{2}\right) \rceil$ | 1 | 1 | 3 |
| Rank=2 with >4 CSI-RS ports, $N_2>1$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | $\lceil \log_2\left(\frac{N_1 O_1}{2} \cdot \frac{N_2 O_2}{2}\right) \rceil$ | 2 | 1 | 3 |
| Rank=2 with >4 CSI-RS ports, $N_2=1$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | $\lceil \log_2\left(\frac{N_1 O_1}{2}\right) \rceil$ | 2 | 1 | 3 |

| | | | |
|---|---|---|---|
| Rank=3 or 4, with 4 CSI-RS ports | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | 0 | 1 |
| Rank=3 or 4, with 8 or 12 CSI-RS ports | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | 2 | 1 |
| Rank=3 or 4 , with >=16 CSI-RS ports | $\lceil \log_2\left(\frac{N_1 O_1}{2} \cdot N_2 O_2\right) \rceil$ | 2 | 1 |
| Rank=5 or 6 | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | N/A | 1 |
| Rank=7 or 8, $N_1 = 4, N_2 = 1$ | $\lceil \log_2\left(\frac{N_1 O_1}{2} \cdot N_2 O_2\right) \rceil$ | N/A | 1 |
| Rank=7 or 8, $N_1 > 2, N_2 = 2$ | $\lceil \log_2\left(N_1 O_1 \cdot \frac{N_2 O_2}{2}\right) \rceil$ | N/A | 1 |
| Rank=7 or 8, with $N_1 > 4, N_2 = 1$ or $N_1 = 2, N_2 = 2$ or $N_1 > 2, N_2 > 2$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | N/A | 1 |

The bitwidth for PMI of *CodebookType= TypeI-MultiPanel* is provided in Tables 6.3.1.1.2-2, where the values of $(N_g, N_1, N_2)$ and $(O_1, O_2)$ are given by Subclause 5.2.2.2.2 in [6, TS 38.214].

**Table 6.3.1.1.2-2: PMI of *CodebookType= TypeI-MultiPanel***

| | Information fields $X_1$ for wideband | | | | | Information fields $X_2$ for wideband or per subband | | | |
|---|---|---|---|---|---|---|---|---|---|
| | ( $i_{1,1}$ , $i_{1,2}$ ) | $i_{1,3}$ | $i_{1,4,1}$ | $i_{1,4,2}$ | $i_{1,4,3}$ | $i_2$ | $i_{2,0}$ | $i_{2,1}$ | $i_{2,2}$ |
| Rank=1 with $N_g=2$ *CodebookMode=1* | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | N/A | 2 | N/A | N/A | 2 | N/A | N/A | N/A |
| Rank=1 with $N_g=4$ *CodebookMode=1* | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | N/A | 2 | 2 | 2 | 2 | N/A | N/A | N/A |
| Rank=2 with $N_g=2$ , $N_1 N_2 = 2$ *CodebookMode=1* | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | 1 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |
| Rank=3 or 4 with $N_g=2$ , $N_1 N_2 = 2$ | $\lceil \log_2(N_1 O_1 \cdot N_2 O_2) \rceil$ | 0 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *CodebookMode=1* | | | | | | | | | |
| Rank=2 or 3 or 4 with $N_g=2$, $N_1N_2>2$ *CodebookMode=1* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 2 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |
| Rank=2 with $N_g=4$, $N_1N_2=2$ *CodebookMode=1* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 1 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=3 or 4 with $N_g=4$, $N_1N_2=2$ *CodebookMode=1* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 0 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=2 or 3 or 4 with $N_g=4$, $N_1N_2>2$ *CodebookMode=1* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 2 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=1 with $N_g=2$ *CodebookMode=2* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | N/A | 2 | 2 | N/A | N/A | 2 | 1 | 1 |
| Rank=2 with $N_g=2$, $N_1N_2=2$ *CodebookMode=2* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 1 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |
| Rank=3 or 4 with $N_g=2$, $N_1N_2=2$ *CodebookMode=2* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 0 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |
| Rank=2 or 3 or 4 with $N_g=2$, $N_1N_2>2$ *CodebookMode=2* | $\lceil\log_2(N_1O_1\cdot N_2O_2)\rceil$ | 2 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |

The bitwidth for RI/LI/CQI of *CodebookType=TypeI-SinglePanel* is provided in Tables 6.3.1.1.2-3.

**Table 6.3.1.1.2-3: RI, LI, and CQI of *CodebookType=TypeI-SinglePanel***

| Field | Bitwidth | | | |
|---|---|---|---|---|
| | 2 antenna ports | 4 antenna ports | >4 antenna ports | |
| | | | Rank1~4 | Rank5~8 |
| Rank Indicator | $\min\left(1,\lceil\log_2 n_{\mathrm{RI}}\rceil\right)$ | $\min\left(2,\lceil\log_2 n_{\mathrm{RI}}\rceil\right)$ | $\lceil\log_2 n_{\mathrm{RI}}\rceil$ | $\lceil\log_2 n_{\mathrm{RI}}\rceil$ |
| Layer Indicator | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ |
| Wide-band CQI | 4 | 4 | 4 | 8 |
| Subband differential CQI | 2 | 2 | 2 | 4 |
| CRI | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ |

If the higher layer parameter *Number_CQI* is not configured or *Number_CQI*=1, $n_{\mathrm{RI}}$ in Table 6.3.1.1.2-3 is the number of allowed rank indicator values in the 4 LSBs of the higher layer parameter *TypeI-SinglePanel-RI-Restriction* according to Subclause X.X [6, TS 38.214]; otherwise $n_{\mathrm{RI}}$ in Table 6.3.1.1.2-3 is the number of allowed rank indicator values according to Subclause X.X [6, TS 38.214]. The value of $K_s^{\mathrm{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI of *CodebookType= TypeI-MultiPanel* is provided in Table 6.3.1.1.2-4.

**Table 6.3.1.1.2-4: RI, LI, and CQI of *CodebookType=TypeI-MultiPanel***

| Field | Bitwidth |
|---|---|
| Rank Indicator | $\min\left(2,\lceil\log_2 n_{\mathrm{RI}}\rceil\right)$ |
| Layer Indicator | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ |
| Wide-band CQI | 4 |
| Subband differential CQI | 2 |
| CRI | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ |

Where $n_{\mathrm{RI}}$ is the number of allowed rank indicator values according to Subclause X.X [6, TS 38.214], and $K_s^{\mathrm{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI of *CodebookType= TypeII* is provided in Table 6.3.1.1.2-5.

**Table 6.3.1.1.2-5: RI, LI, and CQI of *CodebookType=TypeII or TypeII-PortSelection***

| Field | Bitwidth |
|---|---|
| Rank Indicator | $\min\left(1,\lceil\log_2 n_{\mathrm{RI}}\rceil\right)$ |
| Layer Indicator | $\min\left(2,\lceil\log_2 \mathrm{RI}\rceil\right)$ |
| Wide-band CQI | 4 |
| Subband differential CQI | 2 |
| Indicator of the number of non-zero wideband amplitude coefficients $M_l$ for layer $l$ | $\lceil\log_2\left(2L-1\right)\rceil$ |
| CRI | $\lceil\log_2\left(K_s^{\mathrm{CSI-RS}}\right)\rceil$ |

Where $n_{\mathrm{RI}}$ is the number of allowed rank indicator values according to Subclause X.X [6, TS 38.214], and $K_s^{\mathrm{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for CRI, SSB index, RSRP, and differential RSRP are provided in Table 6.3.1.1.2-6.

**Table 6.3.1.1.2-6: CRI, SSB index, and RSRP**

| Field | Bitwidth |
|---|---|
| CRI | $\lceil \log_2(K_s^{\text{CSI-RS}}) \rceil$ |
| SSB index | $\lceil \log_2(K_s^{\text{SSB}}) \rceil$ |
| RSRP | 7 |
| Differential RSRP | 4 |

where $K_s^{\text{CSI-RS}}$ is the number of CSI-RS resources in the corresponding resource set, and $K_s^{\text{SSB}}$ is the configured number of SS/PBCH blocks in the corresponding resource set for reporting 'SSBRI/RSRP'.

**Table 6.3.1.1.2-7: Mapping order of CSI fields of one CSI report, *PMI-FormatIndicator=widebandPMI* and *CQI-FormatIndicator=widebandCQI***

| CSI report number | CSI fields |
|---|---|
| CSI report #n | CRI as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Rank Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Layer Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Zero padding bits $O_P$, if needed |
| | PMI wideband information fields $X_1$, from left to right as in Tables 6.3.1.1.2-1/2, if reported |
| | PMI wideband information fields $X_2$, from left to right as in Tables 6.3.1.1.2-1/2, if reported |
| | Wideband CQI as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Indicator of the number of non-zero wideband amplitude coefficients $M_l$ for layer $l$ as in Table 6.3.1.1.2-5, if reported |

The number of zero padding bits $O_P$ in Table 6.3.1.1.2-7 is $O_P = N_{\max} - N_{\text{reported}}$, where

- $N_{\max} = \max_{r \in S_{\text{Rank}}} B(r)$ and $S_{\text{Rank}}$ is the set of rank values $r$ that are allowed to be reported;
- $N_{\text{reported}} = B(R)$, where $R$ is the reported rank;
- For 2 CSI-RS ports, $B(r) = N_{\text{PMI}}(r) + N_{\text{CQI}}(r) + N_{\text{LI}}(r)$;
- For more than 2 CSI-RS ports, $B(r) = N_{\text{PMI,i1}}(r) + N_{\text{PMI,i2}}(r) + N_{\text{CQI}}(r) + N_{\text{LI}}(r)$;
- if PMI is reported, $N_{\text{PMI}}(1) = 2$ and $N_{\text{PMI}}(2) = 1$; otherwise, $N_{\text{PMI}}(r) = 0$;
- if PMI $i1$ is reported, $N_{\text{PMI,i1}}(r)$ is obtained according to Tables 6.3.1.1.2-1/2; otherwise, $N_{\text{PMI,i1}}(r) = 0$;
- if PMI $i2$ is reported, $N_{\text{PMI,i2}}(r)$ is obtained according to Tables 6.3.1.1.2-1/2; otherwise, $N_{\text{PMI,i2}}(r) = 0$;
- if CQI is reported, $N_{\text{CQI}}(r)$ is obtained according to Tables 6.3.1.1.2-3/4; otherwise, $N_{\text{CQI}}(r) = 0$;
- if LI is reported, $N_{\text{LI}}(r)$ is obtained according to Tables 6.3.1.1.2-3/4; otherwise, $N_{\text{LI}}(r) = 0$.

**Table 6.3.1.1.2-8: Mapping order of CSI fields of one report for CRI/RSRP or SSB/RSRP reporting**

| CSI report number | CSI fields |
|---|---|
| CSI report #n | CRI or SSB index #1 as in Table 6.3.1.1.2-6, if reported |
| | CRI or SSB index #2 as in Table 6.3.1.1.2-6, if reported |
| | CRI or SSB index #3 as in Table 6.3.1.1.2-6, if reported |
| | CRI or SSB index #4 as in Table 6.3.1.1.2-6, if reported |
| | RSRP #1 as in Table 6.3.1.1.2-6, if reported |
| | Differential RSRP #2 as in Table 6.3.1.1.2-6, if reported |
| | Differential RSRP #3 as in Table 6.3.1.1.2-6, if reported |
| | Differential RSRP #4 as in Table 6.3.1.1.2-6, if reported |

**Table 6.3.1.1.2-9: Mapping order of CSI fields of one CSI report, CSI part 1, *PMI-FormatIndicator= subbandPMI* or *CQI-FormatIndicator=subbandCQI***

| CSI report number | CSI fields |
|---|---|
| CSI report #n<br>CSI part 1 | CRI as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Rank Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Wideband CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Subband differential CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Indicator of the number of non-zero wideband amplitude coefficients $M_l$ for layer $l$ as in Table 6.3.1.1.2-5, if reported |

**Table 6.3.1.1.2-10: Mapping order of CSI fields of one CSI report, CSI part 2 wideband, *PMI-FormatIndicator= subbandPMI* or *CQI-FormatIndicator=subbandCQI***

| CSI report number | CSI fields |
|---|---|
| CSI report #n<br>CSI part 2<br>wideband | Wideband CQI for the second TB as in Tables 6.3.1.1.2-3/4/5, if present and reported |
| | Layer Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | PMI wideband information fields $X_1$, from left to right as in Tables 6.3.1.1.2-1/2, if reported |
| | PMI wideband information fields $X_2$, from left to right as in Tables 6.3.1.1.2-1/2, if *PMI-FormatIndicator= widebandPMI* and if reported |

**Table 6.3.1.1.2-11: Mapping order of CSI fields of one CSI report, CSI part 2 subband, *PMI-FormatIndicator= subbandPMI* or *CQI-FormatIndicator=subbandCQI***

| | |
|---|---|
| CSI report #n<br>Part 2 subband | Subband differential CQI for the second TB of all even subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *CQI-FormatIndicator=subbandCQI* and if reported |
| | PMI subband information fields $X_2$ of all even subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2, if *PMI-FormatIndicator= subbandPMI* and if reported |
| | Subband differential CQI for the second TB of all odd subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *CQI-FormatIndicator=subbandCQI* and if reported |
| | PMI subband information fields $X_2$ of all odd subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2, if *PMI-FormatIndicator= subbandPMI* and if reported |

If none of the CSI reports for transmission on a PUCCH is of two parts, the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-12, are mapped to the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ starting with $a_0$ .

**Table 6.3.1.1.2-12: Mapping order of CSI reports to UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ , without two-part CSI report(s)**

| UCI bit sequence | CSI report number |
|---|---|
| $a_0$<br>$a_1$<br>$a_2$<br>$a_3$<br>$\vdots$<br>$a_{A-1}$ | CSI report #1<br>as in Table 6.3.1.1.2-7/8 |
| | CSI report #2<br>as in Table 6.3.1.1.2-7/8 |
| | … |
| | CSI report #n<br>as in Table 6.3.1.1.2-7/8 |

If at least one of the CSI reports for transmission on a PUCCH is of two parts, two UCI bit sequences are generated, $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$ . The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-13, are mapped to the UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ starting with $a_0^{(1)}$ . The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-14, are mapped to the UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$ starting with $a_0^{(2)}$ .

**Table 6.3.1.1.2-13: Mapping order of CSI reports to UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ , with two-part CSI report(s)**

| UCI bit sequence | CSI report number |
|---|---|
| $a_0^{(1)}$<br>$a_1^{(1)}$<br>$a_2^{(1)}$<br>$a_3^{(1)}$<br>$\vdots$<br>$a_{A^{(1)}-1}^{(1)}$ | CSI report #1 if CSI report #1 is not of two parts, or<br>CSI report #1, CSI part 1, if CSI report #1 is of two parts,<br>as in Table 6.3.1.1.2-7/8/9 |
| | CSI report #2 if CSI report #2 is not of two parts, or<br>CSI report #2, CSI part 1, if CSI report #2 is of two parts,<br>as in Table 6.3.1.1.2-7/8/9 |
| | … |
| | CSI report #n if CSI report #n is not of two parts, or<br>CSI report #n, CSI part 1, if CSI report #n is of two parts,<br>as in Table 6.3.1.1.2-7/8/9 |

**Table 6.3.1.1.2-14: Mapping order of CSI reports to UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$, with two-part CSI report(s)**

| UCI bit sequence | CSI report number |
|---|---|
| $a_0^{(2)}$ $a_1^{(2)}$ $a_2^{(2)}$ $a_3^{(2)}$ $\vdots$ $a_{A^{(2)}-1}^{(2)}$ | CSI report #1, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #1 |
| | CSI report #2, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #2 |
| | … |
| | CSI report #n, CSI part 2 wideband, as in Table 6.3.1.1.2-10 if CSI part 2 exists for CSI report #n |
| | CSI report #1, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #1 |
| | CSI report #2, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #2 |
| | … |
| | CSI report #n, CSI part 2 subband, as in Table 6.3.1.1.2-11 if CSI part 2 exists for CSI report #n |

### 6.3.1.1.3 HARQ-ACK/SR and CSI

If none of the CSI reports for transmission on a PUCCH is of two parts, the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ is generated according to the following, where $A = O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI}}$ :

- the HARQ-ACK bits are mapped to the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{O^{\text{ACK}}-1}$, where $a_i = \tilde{o}_i^{ACK}$ for $i = 0, 1, \ldots, O^{\text{ACK}} - 1$, the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}$, $\{\tilde{o}_1^{ACK}, \ldots, \tilde{o}_{O^{ACK}-1}^{ACK}$¿ is given by Subclause 9.1 of [5, TS38.213], and $O^{\text{ACK}}$ is number of HARQ-ACK bits;

- if SR is transmitted on the PUCCH, set $a_i = \tilde{o}_i^{SR}$ for $i = O^{\text{ACK}}, O^{\text{ACK}} + 1, \ldots, O^{\text{ACK}} + O^{\text{SR}} - 1$, where the SR bit sequence $\tilde{o}_0^{SR}$, $\{\tilde{o}_1^{SR}, \ldots, \tilde{o}_{O^{\text{SR}}-1}^{SR}$¿ is given by Subclause x.x of [5, TS 38.213];

- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-12, are mapped to the UCI bit sequence $a_{O^{\text{ACK}}+O^{\text{SR}}}, a_{O^{\text{ACK}}+O^{\text{SR}}+1}, \ldots, a_{O^{\text{ACK}}+O^{\text{SR}}+O^{\text{CSI}}-1}$ starting with $a_{O^{\text{ACK}}+O^{\text{SR}}}$, where $O^{\text{CSI}}$ is the number of CSI bits.

If at least one of the CSI reports for transmission on a PUCCH is of two parts, two UCI bit sequences are generated, $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$, according to the following, where $A^{(1)} = O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}}$ and $A^{(2)} = O^{\text{CSI-part2}}$ :

- the HARQ-ACK bits are mapped to the UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{O^{\text{ACK}}-1}^{(1)}$, where $a_i^{(1)} = \tilde{o}_i^{ACK}$ for $i = 0, 1, \ldots, O^{\text{ACK}} - 1$, the HARQ-ACK bit sequence $\tilde{o}_0^{ACK}$, $\{\tilde{o}_1^{ACK}, \ldots, \tilde{o}_{O^{ACK}-1}^{ACK}$¿ is given by Subclause 9.1 of [5, TS38.213], and $O^{\text{ACK}}$ is number of HARQ-ACK bits;

- if SR is transmitted on the PUCCH, set $a_i = \tilde{o}_i^{SR}$ for $i = O^{\text{ACK}}, O^{\text{ACK}} + 1, \ldots, O^{\text{ACK}} + O^{\text{SR}} - 1$, where the SR bit sequence $\tilde{o}_0^{SR}$, $\{\tilde{o}_1^{SR}, \ldots, \tilde{o}_{O^{\text{SR}}-1}^{SR}$¿ is given by Subclause x.x of [5, TS 38.213];

- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-13, are mapped to the UCI bit sequence $a^{(1)}_{O^{\text{ACK}}+O^{\text{SR}}}, a^{(1)}_{O^{\text{ACK}}+O^{\text{SR}}+1}, \ldots, a^{(1)}_{O^{\text{ACK}}+O^{\text{SR}}+O^{\text{CSI-part1}}-1}$ starting with $a^{(1)}_{O^{\text{ACK}}+O^{\text{SR}}}$, where $O^{\text{CSI-part1}}$ is the number of CSI bits in CSI part 1 of all CSI reports;
- the CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.1.1.2-14, are mapped to the UCI bit sequence $a^{(2)}_0, a^{(2)}_1, a^{(2)}_2, a^{(2)}_3, \ldots, a^{(2)}_{A^{(2)}-1}$ starting with $a^{(2)}_0$, where $O^{\text{CSI-part2}}$ is the number of CSI bits in CSI part 2 of all CSI reports.

#### 6.3.1.2 Code block segmentation and CRC attachment

The UCI bit sequence from subclause 6.3.1.1 is denoted by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$, where $A$ is the payload size. The procedure in 6.3.1.2.1 applies for $A \geq 12$ and the procedure in Subclause 6.3.1.2.2 applies for $A \leq 11$.

##### 6.3.1.2.1 UCI encoded by Polar code

If the payload size $A \geq 12$, code block segmentation and CRC attachment is performed according to Subclause 5.2.1. If $A \geq 360$ and $E \geq 1088$, $I_{seg} = 1$; otherwise $I_{seg} = 0$, where $E$ is the rate matching output sequence length as given in Subclause 6.3.1.4.

If $12 \leq A \leq 19$, the parity bits $p_{r0}, p_{r1}, p_{r2}, \ldots, p_{r(L-1)}$ in Subclause 5.2.1 are computed by setting $L$ to 6 bits and using the generator polynomial $g_{\text{CRC6}}(D)$ in Subclause 5.1, resulting in the sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$ where $r$ is the code block number and $K_r$ is the number of bits for code block number $r$.

If $A \geq 20$, the parity bits $p_{r0}, p_{r1}, p_{r2}, \ldots, p_{r(L-1)}$ in Subclause 5.2.1 are computed by setting $L$ to 11 bits and using the generator polynomial $g_{\text{CRC11}}(D)$ in Subclause 5.1, resulting in the sequence $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$ where $r$ is the code block number and $K_r$ is the number of bits for code block number $r$.

##### 6.3.1.2.2 UCI encoded by channel coding of small block lengths

If the payload size $A \leq 11$, CRC bits are not attached.

The output bit sequence is denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $c_i = a_i$ for $i = 0, 1, \ldots, A-1$ and $K = A$.

#### 6.3.1.3 Channel coding of UCI

##### 6.3.1.3.1 UCI encoded by Polar code

Information bits are delivered to the channel coding block. They are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $r$ is the code block number, and $K_r$ is the number of bits in code block number $r$. The total number of code blocks is denoted by $C$ and each code block is individually encoded by the following:

If $18 \leq K_r \leq 25$, the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 10$, $I_{IL} = 0$, $n_{PC} = 3$, $n^{wm}_{PC} = 1$ if $E_r - K_r + 3 > 192$ and $n^{wm}_{PC} = 0$ if $E_r - K_r + 3 \leq 192$, where $E_r$ is the rate matching output sequence length as given in Subclause 6.3.1.4.1.

If $K_r > 30$, the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 10$, $I_{IL} = 0$, $n_{PC} = 0$, and $n^{wm}_{PC} = 0$.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$, where $N_r$ is the number of coded bits in code block number $r$.

#### 6.3.1.3.2 UCI encoded by channel coding of small block lengths

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, \ldots, d_{N-1}$, where $N$ is the number of coded bits.

### 6.3.1.4 Rate matching

For PUCCH formats 2/3/4, the total rate matching output sequence length $E_{\text{tot}}$ is given by Table 6.3.1.4-1, where $N_{\text{symb, UCI}}^{\text{PUCCH, 2}}$, $N_{\text{symb, UCI}}^{\text{PUCCH, 3}}$, and $N_{\text{symb, UCI}}^{\text{PUCCH, 4}}$ are the number of symbols carrying UCI for PUCCH formats 2/3/4 respectively; $N_{\text{PRB}}^{\text{PUCCH, 2}}$ and $N_{\text{PRB}}^{\text{PUCCH, 3}}$ are the number of PRBs that are determined by the UE for PUCCH formats 2/3 transmission respectively according to Subclause x.x of [5, TS38.213]; and $N_{\text{SF}}^{\text{PUCCH, 4}}$ is the spreading factor for PUCCH format 4.

**Table 6.3.1.4-1: Total rate matching output sequence length $E_{\text{tot}}$**

| ***PUCCH format*** | ***Modulation order*** | |
|---|---|---|
| | QPSK | π/2-BPSK |
| PUCCH format 2 | $16 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 2}} \cdot N_{\text{PRB}}^{\text{PUCCH, 2}}$ | N/A |
| PUCCH format 3 | $24 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 3}} \cdot N_{\text{PRB}}^{\text{PUCCH, 3}}$ | $12 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 3}} \cdot N_{\text{PRB}}^{\text{PUCCH, 3}}$ |
| PUCCH format 4 | $24 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 4}} / N_{\text{SF}}^{\text{PUCCH, 4}}$ | $12 \cdot N_{\text{symb, UCI}}^{\text{PUCCH, 4}} / N_{\text{SF}}^{\text{PUCCH, 4}}$ |

#### 6.3.1.4.1 UCI encoded by Polar code

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$ where $r$ is the code block number, and $N_r$ is the number of coded bits in code block number $r$.

**Table 6.3.1.4.1-1: Rate matching output sequence length $E_{\text{UCI}}$**

| **UCI(s) for transmission on a PUCCH** | **UCI for encoding** | **Value of $E_{\text{UCI}}$** |
|---|---|---|
| HARQ-ACK | HARQ-ACK | $E_{\text{UCI}} = E_{\text{tot}}$ |
| HARQ-ACK, SR | HARQ-ACK, SR | $E_{\text{UCI}} = E_{\text{tot}}$ |
| CSI<br>(CSI not of two parts) | CSI | $E_{\text{UCI}} = E_{\text{tot}}$ |
| HARQ-ACK, CSI<br>(CSI not of two parts) | HARQ-ACK, CSI | $E_{\text{UCI}} = E_{\text{tot}}$ |
| HARQ-ACK, SR, CSI<br>(CSI not of two parts) | HARQ-ACK, SR, CSI | $E_{\text{UCI}} = E_{\text{tot}}$ |
| CSI<br>(CSI of two parts) | CSI part 1 | $E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |
| | CSI part 2 | $E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |
| HARQ-ACK, CSI<br>(CSI of two parts) | HARQ-ACK, CSI part 1 | $E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |
| | CSI part 2 | $E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |
| HARQ-ACK, SR, CSI<br>(CSI of two parts) | HARQ-ACK, SR, CSI part 1 | $E_{\text{UCI}} = \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |
| | CSI part 2 | $E_{\text{UCI}} = E_{\text{tot}} - \min\left(E_{\text{tot}}, \left\lceil \left(O^{\text{ACK}} + O^{\text{SR}} + O^{\text{CSI-part1}} + L\right) / R_{\text{UCI}}^{\max} / Q_m \right\rceil \cdot Q_m\right)$ |

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL}=1$ and the rate matching output sequence length to $E_r=\lfloor E_{\text{UCI}}/C_{\text{UCI}}\rfloor$, where $C_{\text{UCI}}$ is the number of code blocks for UCI determined according to Subclause 6.3.1.2.1 and the value of $E_{\text{UCI}}$ is given by Table 6.3.1.4.1-1:

- $O^{\text{ACK}}$ is the number of bits for HARQ-ACK for transmission on the current PUCCH;
- $O^{\text{SR}}$ is the number of bits for SR for transmission on the current PUCCH;
- $O^{\text{CSI-part1}}$ is the number of bits for CSI part 1 for transmission on the current PUCCH;
- $O^{\text{CSI-part2}}$ is the number of bits for CSI part 2 for transmission on the current PUCCH;
- $L$ is the number of CRC bits;
- $R_{\text{UCI}}^{\max}$ is the configured maximum PUCCH coding rate;
- $E_{\text{tot}}$ is given by Table 6.3.1.4-1.

The output bit sequence after rate matching is denoted as $f_{r0},f_{r1},f_{r2},\ldots,f_{r(E_r-1)}$ where $E_r$ is the length of rate matching output sequence in code block number $r$.

#### 6.3.1.4.2 UCI encoded by channel coding of small block lengths

The input bit sequence to rate matching is $d_0,d_1,d_2,\ldots,d_{N-1}$.

The value of $E_{\text{UCI}}$ is determined according to Table 6.3.1.4.1-1 by setting $L=0$.

Rate matching is performed according to Subclause 5.4.3 by setting the rate matching output sequence length $E=E_{\text{UCI}}$.

The output bit sequence after rate matching is denoted as $f_0,f_1,f_2,\ldots,f_{E-1}$.

### 6.3.1.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0},f_{r1},f_{r2},\ldots,f_{r(E_r-1)}$, for $r=0,\ldots,C-1$ and where $E_r$ is the number of rate matched bits for the $r$-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0,g_1,g_2,g_3,\ldots,g_{G'-1}$, where $G'=\lfloor E_{\text{UCI}}/C_{\text{UCI}}\rfloor\cdot C_{\text{UCI}}$ with the values of $E_{\text{UCI}}$ and $C_{\text{UCI}}$ given in Subclause 6.3.1.4.1. Let $G$ be the total number of coded bits for transmission and $G=G'+\text{mod}(E_{\text{UCI}},C_{\text{UCI}})$. Set $g_i=0$ for $i=G',G'+1,\ldots,G-1$.

### 6.3.1.6 Multiplexing of coded UCI bits to PUCCH

If CSI of two parts are transmitted on a PUCCH, the coded bits corresponding to UCI bit sequence $a_0^{(1)},a_1^{(1)},a_2^{(1)},a_3^{(1)},\ldots,a_{A^{(1)}-1}^{(1)}$ is denoted by $g_0^{(1)},g_1^{(1)},g_2^{(1)},g_3^{(1)},\ldots,g_{G^{(1)}-1}^{(1)}$ and the coded bits corresponding to UCI bit sequence $a_0^{(2)},a_1^{(2)},a_2^{(2)},a_3^{(2)},\ldots,a_{A^{(2)}-1}^{(2)}$ is denoted by $g_0^{(2)},g_1^{(2)},g_2^{(2)},g_3^{(2)},\ldots,g_{G^{(2)}-1}^{(2)}$. The coded bit sequence $g_0,g_1,g_2,g_3,\ldots,g_{G-1}$, where $G=G^{(1)}+G^{(2)}$, is generated according to the following.

**Table 6.3.1.6-1: PUCCH DMRS and UCI symbols**

| PUCCH duration (symbols) | PUCCH DMRS symbol indices | Number of UCI symbol indices sets $N_{\text{UCI}}^{\text{set}}$ | 1st UCI symbol indices set $S_{\text{UCI}}^{(1)}$ | 2nd UCI symbol indices set $S_{\text{UCI}}^{(2)}$ | 3rd UCI symbol indices set $S_{\text{UCI}}^{(3)}$ |
|---|---|---|---|---|---|
| 4 | {1} | 2 | {0,2} | {3} | - |
| 4 | {0,2} | 1 | {1,3} | - | - |
| 5 | {0, 3} | 1 | {1, 2, 4} | - | - |
| 6 | {1, 4} | 1 | {0, 2, 3, 5} | - | - |
| 7 | {1, 4} | 2 | {0, 2, 3, 5} | {6} | - |
| 8 | {1, 5} | 2 | {0, 2, 4, 6} | {3, 7} | - |
| 9 | {1, 6} | 2 | {0, 2, 5, 7} | {3, 4, 8} | - |
| 10 | {2, 7} | 2 | {1, 3, 6, 8} | {0, 4, 5, 9} | - |
| 10 | {1, 3, 6, 8} | 1 | {0,2,4,5,7,9} | - | - |
| 11 | {2, 7} | 3 | {1,3,6,8} | {0,4,5,9} | {10} |
| 11 | {1,3,6,9} | 1 | {0,2,4,5,7,8,10} | - | - |
| 12 | {2, 8} | 3 | {1,3,7,9} | {0,4,6,10} | {5, 11} |
| 12 | {1,4,7,10} | 1 | {0,2,3,5,6,8,9,11} | - | - |
| 13 | {2, 9} | 3 | {1,3,8,10} | {0,4,7,11} | {5,6,12} |
| 13 | {1,4,7,11} | 2 | {0,2,3,5,6,8,10,12} | {9} | - |
| 14 | {3, 10} | 3 | {2,4,9,11} | {1,5,8,12} | {0,6,7,13} |
| 14 | {1,5,8,12} | 2 | {0,2,4,6,7,9,11,13} | {3, 10} | - |

Denote $s_l$ as UCI OFDM symbol index. Denote $N_{\text{UCI}}^{(i)}$ as the number of elements in UCI symbol indices set $S_{\text{UCI}}^{(i)}$ for $i=1,\ldots,N_{\text{UCI}}^{\text{set}}$, where $S_{\text{UCI}}^{(i)}$ and $N_{\text{UCI}}^{\text{set}}$ are given by Table 6.3.1.6-1 according to the PUCCH duration and the PUCCH DMRS configuration. Denote $N_{\text{symb, UCI}}^{\text{PUCCH,}}=\sum_{i=1}^{N_{\text{UCI}}^{\text{set}}} N_{\text{UCI}}^{(i)}$ as the number of OFDM symbols carrying UCI in the PUCCH. Denote $Q_m$ as the modulation order of the PUCCH.

For PUCCH format 3, set $N_{\text{UCI}}^{\text{symbol}}=12\cdot N_{\text{PRB}}^{\text{PUCCH,3}}$, where $N_{\text{PRB}}^{\text{PUCCH,3}}$ is the number of PRBs that is determined by the UE for PUCCH format 3 transmission according to Subclause x.x of [5, TS 38.213].

For PUCCH format 4, set $N_{\text{UCI}}^{\text{symbol}}=12/N_{\text{SF}}^{\text{PUCCH, 4}}$, where $N_{\text{SF}}^{\text{PUCCH, 4}}$ is the spreading factor for PUCCH format 4.

Find the smallest $j>0$ such that $\left(\sum_{i=1}^{j} N_{\text{UCI}}^{(i)}\right)\cdot N_{\text{UCI}}^{\text{symbol}}\cdot Q_m \geq G^{(1)}$.

Set $n_1=0$ ;

Set $n_2=0$ ;

Set $\bar{N}_{\text{UCI}}^{\text{symbol}}=\left\lfloor\left(G^{(1)}-\left(\sum_{i=1}^{j-1} N_{\text{UCI}}^{(i)}\right)\cdot N_{\text{UCI}}^{\text{symbol}}\cdot Q_m\right)/\left(N_{\text{UCI}}^{(j)}\cdot Q_m\right)\right\rfloor$ ;

Set $M=\text{mod}\left(\left(G^{(1)}-\left(\sum_{i=1}^{j-1} N_{\text{UCI}}^{(i)}\right)\cdot N_{\text{UCI}}^{\text{symbol}}\cdot Q_m\right)/Q_m, N_{\text{UCI}}^{(j)}\right)$ ;

for $l=0$ to $N_{\text{symb, UCI}}^{\text{PUCCH,}}-1$

if $s_l \in ¿_{i=1}^{j-1} S_{\text{UCI}}^{(i)}$

for $k=0$ to $N_{\text{UCI}}^{\text{symbol}}-1$

for $v=0$ to $Q_m-1$

$\bar{g}_{l,k,v}=g_{n_1}^{(1)}$ ;

$n_1=n_1+1$ ;

end for

end for

elseif $s_l \in S_{\text{UCI}}^{(j)}$

if $M>0$

$\gamma=1$ ;

else

$\gamma=0$ ;

end if

$M=M-1$ ;

for $k=0$ to $\bar{N}_{\text{UCI}}^{\text{symbol}}+\gamma-1$

for $v=0$ to $Q_m-1$

$\bar{g}_{l,k,v}=g_{n_1}^{(1)}$ ;

$n_1=n_1+1$ ;

end for

end for

for $k=\bar{N}_{\text{UCI}}^{\text{symbol}}+\gamma$ to $N_{\text{UCI}}^{\text{symbol}}-1$

for $v=0$ to $Q_m-1$

$\bar{g}_{l,k,v}=g_{n_2}^{(2)}$ ;

$n_2=n_2+1$ ;

end for

end for

else

for $k=0$ to $N_{\text{UCI}}^{\text{symbol}}-1$

for $v=0$ to $Q_m-1$

$\bar{g}_{l,k,v} = g^{(2)}_{n_2}$ ;

$n_2 = n_2 + 1$ ;

end for

end for

end if

end for

Set $n = 0$

for $l = 0$ to $N^{\text{PUCCH,}}_{\text{symb, UCI}} - 1$

for $k = 0$ to $N^{\text{symbol}}_{\text{UCI}} - 1$

for $v = 0$ to $Q_m - 1$

$g_n = \bar{g}_{l,k,v}$ ;

$n = n + 1$ ;

end for

end for

end for

## 6.3.2 Uplink control information on PUSCH

### 6.3.2.1 UCI bit sequence generation

#### 6.3.2.1.1 HARQ-ACK

If HARQ-ACK bits are transmitted on a PUSCH, the UCI bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ is determined as follows:

- If UCI is transmitted on PUSCH without UL-SCH and the UCI includes CSI part 1 without CSI part 2,
  - if there is no HARQ-ACK bit given by Subclause 9.1 of [5, TS 38.213], set $a_0 = 0$ , $a_1 = 0$ , and $A = 2$ ;
  - if there is only one HARQ-ACK bit $\tilde{o}^{ACK}_0$ given by Subclause 9.1 of [5, TS 38.213], set $a_0 = \tilde{o}^{ACK}_0$ , $a_1 = 0$ , and $A = 2$ ;
- otherwise, ser $a_i = \tilde{o}^{ACK}_i$ for $i = 0, 1, \ldots, O^{\text{ACK}} - 1$ and $A = O^{\text{ACK}}$ , where the HARQ-ACK bit sequence $\tilde{o}^{ACK}_0$, $\{\tilde{o}^{ACK}_1, \ldots, \tilde{o}^{ACK}_{O^{ACK}-1}¿$ is given by Subclause 9.1 of [5, TS 38.213].

#### 6.3.2.1.2 CSI

The bitwidth for PMI of *CodebookType=TypeII* is provided in Tables 6.3.2.1.2-1, where the values of $(N_1, N_2)$ , $(O_1, O_2)$ , $L$ , $N_{\text{PSK}}$ , $M_1$ , $M_2$ , and $K^{(2)}$ are given by Subclause 5.2.2.2.3 in [6, TS 38.214].

**Table 6.3.2.1.2-1: PMI of *CodebookType= TypeII***

| | Information fields for wideband PMI | | | | | | Information fields per subband PMI | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $i_{1,1}$ | $i_{1,2}$ | $i_{1,3,1}$ | $i_{1,4,1}$ | $i_{1,3,2}$ | $i_{1,4,2}$ | $i_{2,1,1}$ | $i_{2,1,2}$ | $i_{2,2,1}$ | $i_{2,2,2}$ |
| Rank=1<br>SBAmp off | $\lceil \log_2 (O_1 O_2)$ | $\lceil \log_2 \binom{N_1 N_2}{L}$ | $\lceil \log_2 (2L)$ | $3(2L-$ | N/A | N/A | $(M_1-1)\cdot \log_2 N_{\text{PSK}}$ | N/A | N/A | N/A |
| Rank=2<br>SBAmp off | $\lceil \log_2 (O_1 O_2)$ | $\lceil \log_2 \binom{N_1 N_2}{L}$ | $\lceil \log_2 (2L)$ | $3(2L-$ | $\lceil \log_2 (2L)$ | $3(2L-$ | $(M_1-1)\cdot \log_2 N_{\text{PSK}}$ | $(M_2-1)\cdot \log_2 N_{\text{PSK}}$ | N/A | N/A |
| Rank=1<br>SBAmp on | $\lceil \log_2 (O_1 O_2)$ | $\lceil \log_2 \binom{N_1 N_2}{L}$ | $\lceil \log_2 (2L)$ | $3(2L-$ | N/A | N/A | $\min(M_1, K^{(2)})\cdot \log_2 N_{\text{PSK}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_1-\min(M_1, K^{(2)}))$ | N/A | $\min(M_1, K^{(2)})-$ | N/A |
| Rank=2<br>SBAmp on | $\lceil \log_2 (O_1 O_2)$ | $\lceil \log_2 \binom{N_1 N_2}{L}$ | $\lceil \log_2 (2L)$ | $3(2L-$ | $\lceil \log_2 (2L)$ | $3(2L-$ | $\min(M_1, K^{(2)})\cdot \log_2 N_{\text{PSK}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_1-\min(M_1, K^{(2)}))$ | $\min(M_2, K^{(2)})\cdot \log_2 N_{\text{PS}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_2-\min(M_2, K^{(2}$ | $\min(M_1, K^{(2)})-$ | $\min(M_2, K^{(2)})-1$ |

The bitwidth for PMI of *CodebookType= TypeII-PortSelection* is provided in Tables 6.3.2.1.2-2, where the values of $P_{CSI-RS}$ , $d$ , $L$ , $N_{\text{PSK}}$ , $M_1$ , $M_2$ , and $K^{(2)}$ are given by Subclause 5.2.2.2.4 in [6, TS 38.214].

**Table 6.3.2.1.2-2: PMI of *CodebookType= TypeII-PortSelection***

| | Information fields for wideband PMI | | | | | Information fields per subband PMI | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $i_{1,1}$ | $i_{1,3,1}$ | $i_{1,4,1}$ | $i_{1,3,2}$ | $i_{1,4,2}$ | $i_{2,1,1}$ | $i_{2,1,2}$ | $i_{2,2,1}$ | $i_{2,2,2}$ |
| Rank=1<br>SBAmp off | $\lceil \log_2 \lceil \frac{P_{CSI-RS}}{2d} \rceil \rceil$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | N/A | N/A | $(M_1-1)\cdot \log_2 N_{\text{PSK}}$ | N/A | N/A | N/A |
| Rank=2<br>SBAmp off | $\lceil \log_2 \lceil \frac{P_{CSI-RS}}{2d} \rceil \rceil$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | $(M_1-1)\cdot \log_2 N_{\text{PSK}}$ | $(M_2-1)\cdot \log_2 N_{\text{PSK}}$ | N/A | N/A |
| Rank=1<br>SBAmp on | $\lceil \log_2 \lceil \frac{P_{CSI-RS}}{2d} \rceil \rceil$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | N/A | N/A | $\min(M_1, K^{(2)})\cdot \log_2 N_{\text{PSK}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_1-\min(M_1, K^{(2)}))$ | N/A | $\min(M_1, K^{(2)})-$ | N/A |
| Rank=2<br>SBAmp on | $\lceil \log_2 \lceil \frac{P_{CSI-RS}}{2d} \rceil \rceil$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | $\lceil \log_2 (2L) \rceil$ | $3(2L-1)$ | $\min(M_1, K^{(2)})\cdot \log_2 N_{\text{PSK}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_1-\min(M_1, K^{(2)}))$ | $\min(M_2, K^{(2)})\cdot \log_2 N_{\text{PS}}$ $-\log_2 N_{\text{PSK}}$ $+2\cdot(M_2-\min(M_2, K^{(2}$ | $\min(M_1, K^{(2)})-$ | $\min(M_2, K^{(2)})-1$ |

For CSI on PUSCH, two UCI bit sequences are generated, $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ and $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$ . The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.2.1.2-6, are mapped to the UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$ starting with $a_0^{(1)}$ . The CSI fields of all CSI reports, in the order from upper part to lower part in Table 6.3.2.1.2-7, are mapped to the UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$ starting with $a_0^{(2)}$ .

**Table 6.3.2.1.2-3: Mapping order of CSI fields of one CSI report, CSI part 1**

| CSI report number | CSI fields |
|---|---|
| CSI report #n<br>CSI part 1 | CRI or SSB index as in Tables 6.3.1.1.2-6, if reported |
| | Rank Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Wideband CQI as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Subband differential CQI for the first TB as in Tables 6.3.1.1.2-3/4/5, if reported |
| | Indicator of the number of non-zero wideband amplitude coefficients $M_l$ for layer $l$ as in Table 6.3.1.1.2-5, if reported |
| | RSRP as in Table 6.3.1.1.2-6, if reported |
| | Differential RSRP as in Table 6.3.1.1.2-6, if reported |

**Table 6.3.2.1.2-4: Mapping order of CSI fields of one CSI report, CSI part 2 wideband**

| CSI report number | CSI fields |
|---|---|
| CSI report #n<br>CSI part 2<br>wideband | Wideband CQI for the second TB as in Tables 6.3.1.1.2-3/4/5, if present and reported |
| | Layer Indicator as in Tables 6.3.1.1.2-3/4/5, if reported |
| | PMI wideband information fields $X_1$, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if reported |
| | PMI wideband information fields $X_2$, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *PMI-FormatIndicator= widebandPMI* and if reported |

**Table 6.3.2.1.2-5: Mapping order of CSI fields of one CSI report, CSI part 2 subband**

| | |
|---|---|
| CSI report #n<br>Part 2 subband | Subband differential CQI for the second TB of all even subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *CQI-FormatIndicator=subbandCQI* and if reported |
| | PMI subband information fields $X_2$ of all even subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *PMI-FormatIndicator= subbandPMI* and if reported |
| | Subband differential CQI for the second TB of all odd subbands with increasing order of subband number, as in Tables 6.3.1.1.2-3/4/5, if *CQI-FormatIndicator=subbandCQI* and if reported |
| | PMI subband information fields $X_2$ of all odd subbands with increasing order of subband number, from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, if *PMI-FormatIndicator= subbandPMI* and if reported |

**Table 6.3.2.1.2-6: Mapping order of CSI reports to UCI bit sequence $a_0^{(1)}, a_1^{(1)}, a_2^{(1)}, a_3^{(1)}, \ldots, a_{A^{(1)}-1}^{(1)}$, with two-part CSI report(s)**

| UCI bit sequence | CSI report number |
|---|---|
| $a_0^{(1)}$<br>$a_1^{(1)}$<br>$a_2^{(1)}$<br>$a_3^{(1)}$<br>$\vdots$<br>$a_{A^{(1)}-1}^{(1)}$ | CSI part 1 of CSI report #1 as in Table 6.3.2.1.2-3 |
| | CSI part 1 of CSI report #2 as in Table 6.3.2.1.2-3 |
| | … |
| | CSI part 1 of CSI report #n as in Table 6.3.2.1.2-3 |

**Table 6.3.2.1.2-7: Mapping order of CSI reports to UCI bit sequence $a_0^{(2)}, a_1^{(2)}, a_2^{(2)}, a_3^{(2)}, \ldots, a_{A^{(2)}-1}^{(2)}$, with two-part CSI report(s)**

| UCI bit sequence | CSI report number |
|---|---|
| $a_0^{(2)}$<br>$a_1^{(2)}$<br>$a_2^{(2)}$<br>$a_3^{(2)}$<br>$\vdots$<br>$a_{A^{(2)}-1}^{(2)}$ | CSI report #1, CSI part 2 wideband, as in Table 6.3.2.1.2-4<br>if CSI part 2 exists for CSI report #1 |
| | CSI report #2, CSI part 2 wideband, as in Table 6.3.2.1.2-4<br>if CSI part 2 exists for CSI report #2 |
| | … |
| | CSI report #n, CSI part 2 wideband, as in Table 6.3.2.1.2-4<br>if CSI part 2 exists for CSI report #n |
| | CSI report #1, CSI part 2 subband, as in Table 6.3.2.1.2-5<br>if CSI part 2 exists for CSI report #1 |
| | CSI report #2, CSI part 2 subband, as in Table 6.3.2.1.2-5<br>if CSI part 2 exists for CSI report #2 |
| | … |
| | CSI report #n, CSI part 2 subband, as in Table 6.3.2.1.2-5<br>if CSI part 2 exists for CSI report #n |

## 6.3.2.2 Code block segmentation and CRC attachment

Denote the bits of the payload by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$, where $A$ is the payload size. The procedure in 6.3.2.2.1 applies for $A \geq 12$ and the procedure in Subclause 6.3.2.2.2 applies for $A \leq 11$.

### 6.3.2.2.1 UCI encoded by Polar code

Code block segmentation and CRC attachment is performed according to Subclause 6.3.1.2.1.

### 6.3.2.2.2 UCI encoded by channel coding of small block lengths

The procedure in Subclause 6.3.1.2.2 applies.

## 6.3.2.3 Channel coding of UCI

### 6.3.2.3.1 UCI encoded by Polar code

Channel coding is performed according to Subclause 6.3.1.3.1.

### 6.3.2.3.2 UCI encoded by channel coding of small block lengths

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, \ldots, d_{N-1}$, where $N$ is the number of coded bits.

## 6.3.2.4 Rate matching

### 6.3.2.4.1 UCI encoded by Polar code

6.3.2.4.1.1HARQ-ACK

For HARQ-ACK transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as $Q'_{\mathrm{ACK}}$, is determined as follows:

$$Q'_{\mathrm{ACK}} = \min\left\{ \left\lceil \frac{\left(O_{\mathrm{ACK}} + L_{\mathrm{ACK}}\right) \cdot \beta_{\mathrm{offset}}^{\mathrm{PUSCH}} \cdot \sum_{l=0}^{N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}-1} M_{\mathrm{sc}}^{\mathrm{UCI}}(l)}{\sum_{r=0}^{C_{\mathrm{UL-SCH}}-1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=l_0}^{N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}-1} M_{\mathrm{sc}}^{\mathrm{UCI}}(l) \right\rceil \right\}$$

where

- $O_{\mathrm{ACK}}$ is the number of HARQ-ACK bits;
- $L_{\mathrm{ACK}}$ is the number of CRC bits for HARQ-ACK;
- $\beta_{\mathrm{offset}}^{\mathrm{PUSCH}} = \beta_{\mathrm{offset}}^{\mathrm{HARQ-ACK}}$ ;
- $C_{\mathrm{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the $r$ -th code block, $K_r$ =0; otherwise, $K_r$ is the $r$ -th code block size for UL-SCH of the PUSCH transmission;
- $M_{\mathrm{sc}}^{\mathrm{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\mathrm{sc}}^{\mathrm{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol $l$ that carries PTRS, in the PUSCH transmission;
- $M_{\mathrm{sc}}^{\mathrm{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol $l$ , for $l = 0,1,2,\ldots,N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}-1$ , in the PUSCH transmission and $N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\mathrm{sc}}^{\mathrm{UCI}}(l) = 0$ ;
  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{\mathrm{sc}}^{\mathrm{UCI}}(l) = M_{\mathrm{sc}}^{\mathrm{PUSCH}} - M_{\mathrm{sc}}^{\mathrm{PT-RS}}(l)$ ;
- $\alpha \in \{0.5,\ 0.65,\ 0.8,\ 1\}$ is configured by higher layer parameter *uci-on-pusch-scaling*;
- $l_0$ is the symbol index of the first OFDM symbol that does not carry DMRS of the PUSCH, after the first DMRS symbol(s), in the PUSCH transmission.

For HARQ-ACK transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as $Q'_{\mathrm{ACK}}$, is determined as follows:

$$Q'_{\mathrm{ACK}} = \min\left\{ \left\lceil \frac{\left(O_{\mathrm{ACK}} + L_{\mathrm{ACK}}\right) \cdot \beta_{\mathrm{offset}}^{\mathrm{PUSCH}} \cdot \sum_{l=0}^{N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}-1} M_{\mathrm{sc}}^{\mathrm{UCI}}(l)}{O_{\mathrm{CSI}}} \right\rceil, \sum_{l=l_0}^{N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}-1} M_{\mathrm{sc}}^{\mathrm{UCI}}(l) \right\}$$

where

- $O_{\mathrm{ACK}}$ is the number of HARQ-ACK bits;
- $L_{\mathrm{ACK}}$ is the number of CRC bits for HARQ-ACK bits;
- $O_{\mathrm{CSI}}$ is the number of bits for CSI part 1;
- $\beta_{\mathrm{offset}}^{\mathrm{PUSCH}} = \beta_{\mathrm{offset}}^{\mathrm{HARQ-ACK}} / \beta_{\mathrm{offset}}^{\mathrm{CSI-part1}}$ ;
- $M_{\mathrm{sc}}^{\mathrm{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\mathrm{sc}}^{\mathrm{PT\text{-}RS}}(l)$ is the number of subcarriers in OFDM symbol $l$ that carries PTRS, in the PUSCH transmission;
- $M_{\mathrm{sc}}^{\mathrm{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol $l$, for $l = 0,1,2,\ldots,N_{\mathrm{symb,all}}^{\mathrm{PUSCH}} - 1$, in the PUSCH transmission and $N_{\mathrm{symb,all}}^{\mathrm{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\mathrm{sc}}^{\mathrm{UCI}}(l) = 0$ ;
  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{\mathrm{sc}}^{\mathrm{UCI}}(l) = M_{\mathrm{sc}}^{\mathrm{PUSCH}} - M_{\mathrm{sc}}^{\mathrm{PT\text{-}RS}}(l)$ ;
- $l_0$ is the symbol index of the first OFDM symbol that does not carry DMRS of the PUSCH, after the first DMRS symbol(s), in the PUSCH transmission.

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$ where $r$ is the code block number, and $N_r$ is the number of coded bits in code block number $r$ .

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 1$ and the rate matching output sequence length to $E_r = \lfloor E_{\mathrm{UCI}} / C_{\mathrm{UCI}} \rfloor$ , where

- $C_{\mathrm{UCI}}$ is the number of code blocks for UCI determined according to Subclause 5.2.1;
- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH;
- $E_{\mathrm{UCI}} = N_L \cdot Q'_{\mathrm{ACK}} \cdot Q_m$ .

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, \ldots, f_{r(E_r-1)}$ where $E_r$ is the length of rate matching output sequence in code block number $r$ .

6.3.2.4.1.2CSI part 1

For CSI part 1 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as $Q'_{\mathrm{CSI\text{-}part1}}$ , is determined as follows:

$$Q'_{\text{CSI-1}} = \min\left\{ \left\lceil \frac{(O_{\text{CSI-1}} + L_{\text{CSI-1}}) \cdot \beta_{\text{offset}}^{\text{PUSCH}} \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}}-1} K_r} \right\rceil, \left\lceil \alpha \cdot \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l) \right\rceil - Q'_{\text{ACK}} \right\}$$

where

- $O_{\text{CSI-1}}$ is the number of bits for CSI part 1;
- $L_{\text{CSI-1}}$ is the number of CRC bits for CSI part 1;
- $\beta_{\text{offset}}^{\text{PUSCH}} = \beta_{\text{offset}}^{\text{CSI-part1}}$ ;
- $C_{\text{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the $r$ -th code block, $K_r$ =0; otherwise, $K_r$ is the $r$ -th code block size for UL-SCH of the PUSCH transmission;
- $M_{\text{sc}}^{\text{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\text{sc}}^{\text{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol $l$ that carries PTRS, in the PUSCH transmission;
- $Q'_{\text{ACK}}$ is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{\text{ACK}} = \sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} \bar{M}_{\text{sc, rvd}}^{\text{ACK}}(l)$ if the number of HARQ-ACK information bits is no more than 2 bits, where $\bar{M}_{\text{sc, rvd}}^{\text{ACK}}(l)$ is the number of reserved resource elements for potential HARQ-ACK transmission in OFDM symbol $l$ , for $l = 0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ , in the PUSCH transmission, defined in Subclause 6.2.7;
- $M_{\text{sc}}^{\text{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol $l$ , for $l = 0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$ , in the PUSCH transmission and $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
    - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l) = 0$ ;
    - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l) = M_{\text{sc}}^{\text{PUSCH}} - M_{\text{sc}}^{\text{PT-RS}}(l)$ ;
- $\alpha \in \{0.5,\ 0.65,\ 0.8,\ 1\}$ is configured by higher layer parameter *uci-on-pusch-scaling*.

The input bit sequence to rate matching is $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$ where $r$ is the code block number, and $N_r$ is the number of coded bits in code block number $r$ .

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL}=1$ and the rate matching output sequence length to $E_r=\lfloor E_{\text{UCI}}/C_{\text{UCI}} \rfloor$, where

- $C_{\text{UCI}}$ is the number of code blocks for UCI determined according to Subclause 5.2.1;
- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH;
- $E_{\text{UCI}}=N_L \cdot Q'_{\text{CSI,1}} \cdot Q_m$ .

The output bit sequence after rate matching is denoted as $f_{r0}, f_{r1}, f_{r2}, \ldots, f_{r(E_r-1)}$ where $E_r$ is the length of rate matching output sequence in code block number $r$ .

6.3.2.4.1.3CSI part 2

For CSI part 2 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as $Q'_{\text{CSI-part2}}$, is determined as follows:

$$Q'_{\text{CSI-2}}=\min\left\{\left\lceil \frac{(O_{\text{CSI-2}}+L_{\text{CSI-2}})\cdot\beta_{\text{offset}}^{\text{PUSCH}}\cdot\sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)}{\sum_{r=0}^{C_{\text{UL-SCH}}-1} K_r}\right\rceil, \left\lceil \alpha\cdot\sum_{l=0}^{N_{\text{symb,all}}^{\text{PUSCH}}-1} M_{\text{sc}}^{\text{UCI}}(l)\right\rceil - Q'_{\text{ACK}} - Q'_{\text{CSI-1}}\right\}$$

where

- $O_{\text{CSI-2}}$ is the number of bits for CSI part 2;
- $L_{\text{CSI-2}}$ is the number of CRC bits for CSI part 2;
- $\beta_{\text{offset}}^{\text{PUSCH}}=\beta_{\text{offset}}^{\text{CSI-part2}}$ ;
- $C_{\text{UL-SCH}}$ is the number of code blocks for UL-SCH of the PUSCH transmission;
- if the DCI format scheduling the PUSCH transmission includes a CBGTI field indicating that the UE shall not transmit the $r$ -th code block, $K_r$ =0; otherwise, $K_r$ is the $r$ -th code block size for UL-SCH of the PUSCH transmission;
- $M_{\text{sc}}^{\text{PUSCH}}$ is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;
- $M_{\text{sc}}^{\text{PT-RS}}(l)$ is the number of subcarriers in OFDM symbol $l$ that carries PTRS, in the PUSCH transmission;
- $Q'_{\text{ACK}}$ is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH if number of HARQ-ACK information bits is more than 2, and $Q'_{\text{ACK}}=0$ if the number of HARQ-ACK information bits is 1 or 2 bits;
- $Q'_{\text{CSI-1}}$ is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH;

- $M_{\text{sc}}^{\text{UCI}}(l)$ is the number of resource elements that can be used for transmission of UCI in OFDM symbol $l$, for $l=0,1,2,\ldots,N_{\text{symb,all}}^{\text{PUSCH}}-1$, in the PUSCH transmission and $N_{\text{symb,all}}^{\text{PUSCH}}$ is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS;
  - for any OFDM symbol that carries DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l)=0$;
  - for any OFDM symbol that does not carry DMRS of the PUSCH, $M_{\text{sc}}^{\text{UCI}}(l)=M_{\text{sc}}^{\text{PUSCH}}-M_{\text{sc}}^{\text{PT-RS}}(l)$.
- $\alpha \in \{0.5,\ 0.65,\ 0.8,\ 1\}$ is configured by higher layer parameter *uci-on-pusch-scaling*.

The input bit sequence to rate matching is $d_{r0},d_{r1},d_{r2},d_{r3},\ldots,d_{r(N_r-1)}$ where $r$ is the code block number, and $N_r$ is the number of coded bits in code block number $r$.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL}=1$ and the rate matching output sequence length to $E_r=\lfloor E_{\text{UCI}}/C_{\text{UCI}}\rfloor$, where

- $C_{\text{UCI}}$ is the number of code blocks for UCI determined according to Subclause 5.2.1;
- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH;
- $E_{\text{UCI}}=N_L\cdot Q'_{\text{CSI,2}}\cdot Q_m$.

The output bit sequence after rate matching is denoted as $f_{r0},f_{r1},f_{r2},\ldots,f_{r(E_r-1)}$ where $E_r$ is the length of rate matching output sequence in code block number $r$.

### 6.3.2.4.2 UCI encoded by channel coding of small block lengths

#### 6.3.2.4.2.1 HARQ-ACK

For HARQ-ACK transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as $Q'_{\text{ACK}}$, is determined according to Subclause 6.3.2.4.1.1, by setting the number of CRC bits $L=0$.

The input bit sequence to rate matching is $d_0,d_1,d_2,\ldots,d_{N-1}$.

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E=N_L\cdot Q'_{\text{ACK}}\cdot Q_m$, where

- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0,f_1,f_2,\ldots,f_{E-1}$.

#### 6.3.2.4.2.2 CSI part 1

For CSI part 1 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as $Q'_{\text{CSI,1}}$, is determined according to Subclause 6.3.2.4.1.2, by setting the number of CRC bits $L=0$.

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E=N_L \cdot Q'_{\mathrm{CSI},1} \cdot Q_m$ , where

- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, \ldots, f_{E-1}$ .

6.3.2.4.2.3CSI part 2

For CSI part 2 transmission on PUSCH with UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as $Q'_{\mathrm{CSI},2}$ , is determined according to Subclause 6.3.2.4.1.3, by setting the number of CRC bits $L=0$ .

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length $E=N_L \cdot Q'_{\mathrm{CSI},2} \cdot Q_m$ , where

- $N_L$ is the number of transmission layers of the PUSCH;
- $Q_m$ is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, \ldots, f_{E-1}$ .

#### 6.3.2.5 Code block concatenation

Code block concatenation is performed according to Subclause 6.3.1.5, except that the values of $E_{\mathrm{UCI}}$ and $C_{\mathrm{UCI}}$ given in Subclause 6.3.2.4.1.

#### 6.3.2.6 Multiplexing of coded UCI bits to PUSCH

The coded UCI bits are multiplexed onto PUSCH according to the procedures in Subclause 6.2.7.

# 7 Downlink transport channels and control information

## 7.1 Broadcast channel

Data arrives to the coding unit in the form of a maximum of one transport block every 80ms. The following coding steps can be identified:

- Payload generation
- Scrambling
- Transport block CRC attachment
- Channel coding
- Rate matching

### 7.1.1 PBCH payload generation

Denote the bits in a transport block delivered to layer 1 by $\bar{a}_0, \bar{a}_1, \bar{a}_2, \bar{a}_3, \ldots, \bar{a}_{\bar{A}-1}$ , where $\bar{A}$ is the payload size generated by higher layers. The lowest order information bit $\bar{a}_0$ is mapped to the most significant bit of the transport block as defined in Subclause [6.1.4] of [8, TS 38.321].

Generate the following additional timing related PBCH payload bits $\bar{a}_{\bar{A}}, \bar{a}_{\bar{A}+1}, \bar{a}_{\bar{A}+2}, \bar{a}_{\bar{A}+3}, \ldots, \bar{a}_{\bar{A}+7}$ , where:

- $\bar{a}_{\bar{A}}, \bar{a}_{\bar{A}+1}, \bar{a}_{\bar{A}+2}, \bar{a}_{\bar{A}+3}$ are the 4th, 3rd, 2nd, and 1st LSB of SFN, respectively;
- $\bar{a}_{\bar{A}+4}$ is the half radio frame bit $\bar{a}_{\mathrm{HRF}}$ ;
- if $L_{\mathrm{SSB}} = 64$

    $\bar{a}_{\bar{A}+5}, \bar{a}_{\bar{A}+6}, \bar{a}_{\bar{A}+7}$ are the 6th, 5th, and 4th bits of SS/PBCH block index, respectively.

  else

    $\bar{a}_{\bar{A}+5}$ is the MSB of $k_0$ as defined in Subclause 7.4.3.1 of [4, TS 38.211].

    $\bar{a}_{\bar{A}+6}, \bar{a}_{\bar{A}+7}$ are reserved.

  end if

Let $A = \bar{A} + 8$ ; $j_{\mathrm{SFN}} = 0$ ; $j_{\mathrm{HRF}} = 10$ ; $j_{\mathrm{SSB}} = 11$ ; $j_{\mathrm{other}} = 14$ ;

for $i = 0$ to $A - 1$

  if $\bar{a}_i$ is an SFN bit

    $a_{G(j_{\mathrm{SFN}})} = \bar{a}_i$ ;

    $j_{\mathrm{SFN}} = j_{\mathrm{SFN}} + 1$ ;

  elseif $\bar{a}_i$ is the half radio frame bit

    $a_{G(j_{\mathrm{HRF}})} = \bar{a}_i$

  elseif $\bar{A} + 5 \le i \le \bar{A} + 7$

    $a_{G(j_{\mathrm{SSB}})} = \bar{a}_i$ ;

    $j_{\mathrm{SSB}} = j_{\mathrm{SSB}} + 1$ ;

  else

    $a_{G(j_{\mathrm{Other}})} = \bar{a}_i$ ;

    $j_{\mathrm{Other}} = j_{\mathrm{Other}} + 1$ ;

  end if

end for

where $L_{\mathrm{SSB}}$ is the number of candidate SS/PBCH blocks in a half frame according to Subclause 4.1 of [5, TS38.213], and the value of $G(j)$ is given by Table 7.1.1-1.

**Table 7.1.1-1: Value of PBCH payload interleaver pattern $G(j)$**

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

## 7.1.2 Scrambling

For PBCH transmission in a frame, the bit sequence $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$ is scrambled into a bit sequence $a'_0, a'_1, a'_2, a'_3, \ldots, a'_{A-1}$, where $a'_i = (a_i + s_i) \bmod 2$ for $i = 0, 1, \ldots, A-1$ and $s_0, s_1, s_2, s_3, \ldots, s_{A-1}$ is generated according to the following:

$i = 0$ ;

$j = 0$ ;

while $i < A$

if $a_i$ corresponds to any one of the bits belonging to the SS/PBCH block index, the half radio frame index, and 2nd and 3rd least significant bits of the system frame number

$s_i = 0$ ;

else

$s_i = c(j + vM)$ ;

$j = j + 1$ ;

end if

$i = i + 1$ ;

end while

The scrambling sequence $c(i)$ is given by Subclause 5.2.1of [4, TS38.211] and initialized with $c_{\text{init}} = N_{ID}^{cell}$ at the start of each SFN satisfying $\operatorname{mod}(SFN, 8) = 0$ ; $M = A - 3$ for $L = 4$ or $L = 8$ , and $M = A - 6$ for $L = 64$ , where $L$ is the number of candidate SS/PBCH blocks in a half frame according to Subclause 4.1 of [5, TS38.213]; and $v$ is determined according to Table 7.1.2-1 using the 3rd and 2nd LSB of the SFN in which the PBCH is transmitted.

**Table 7.1.2-1: Value of $v$ for PBCH scrambling**

| *(3rd LSB of SFN, 2nd LSB of SFN)* | *Value of $v$* |
|---|---|
| (0, 0) | 0 |
| (0, 1) | 1 |
| (1, 0) | 2 |
| (1, 1) | 3 |

## 7.1.3 Transport block CRC attachment

Error detection is provided on BCH transport blocks through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. The input bit sequence is denoted by $a'_0, a'_1, a'_2, a'_3, \ldots, a'_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, \ldots, p_{L-1}$, where $A$ is the payload size and $L$ is the number of parity bits.

The parity bits are computed and attached to the BCH transport block according to Subclause 5.1 by setting $L$ to 24 bits and using the generator polynomial $g_{\mathrm{CRC24C}}(D)$, resulting in the sequence $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$, where $B = A + L$.

The bit sequence $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$ is the input bit sequence $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$ to the channel encoder, where $c_i = b_i$ for $i = 0, 1, \ldots, B-1$ and $K = B$.

### 7.1.4 Channel coding

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 9$, $I_{IL} = 1$, $n_{PC} = 0$, and $n_{PC}^{wm} = 0$.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, \ldots, d_{N-1}$, where $N$ is the number of coded bits.

### 7.1.5 Rate matching

The input bit sequence to rate matching is $d_0, d_1, d_2, \ldots, d_{N-1}$.

The rate matching output sequence length $E = 864$.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 0$.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, \ldots, f_{E-1}$.

## 7.2 Downlink shared channel and paging channel

### 7.2.1 Transport block CRC attachment

Error detection is provided on each transport block through a Cyclic Redundancy Check (CRC).

The entire transport block is used to calculate the CRC parity bits. Denote the bits in a transport block delivered to layer 1 by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, \ldots, p_{L-1}$, where $A$ is the payload size and $L$ is the number of parity bits. The lowest order information bit $a_0$ is mapped to the most significant bit of the transport block as defined in Subclause x.x of [TS38.321].

The parity bits are computed and attached to the DL-SCH transport block according to Subclause 5.1, by setting $L$ to 24 bits and using the generator polynomial $g_{\mathrm{CRC24A}}(D)$ if $A > 3824$; and by setting $L$ to 16 bits and using the generator polynomial $g_{\mathrm{CRC16}}(D)$ otherwise.

The bits after CRC attachment are denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$, where $B = A + L$.

### 7.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate $R$ indicated by the MCS index according to Subclause 5.1.3.1 in [6, TS 38.214] and subsequent re-transmission of the same transport block, each code block of the transport block is encoded with either LDPC base graph 1 or 2 according to the following:

- if $A \le 292$, or if $A \le 3824$ and $R \le 0.67$, or if $R \le 0.25$, LDPC base graph 2 is used;

- otherwise, LDPC base graph 1 is used,

where $A$ is the payload size in Subclause 7.2.1.

### 7.2.3 Code block segmentation and code block CRC attachment

The bits input to the code block segmentation are denoted by $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$ where $B$ is the number of bits in the transport block (including CRC).

Code block segmentation and code block CRC attachment are performed according to Subclause 5.2.2.

The bits after code block segmentation are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $r$ is the code block number and $K_r$ is the number of bits for code block number $r$ according to Subclause 5.2.2.

### 7.2.4 Channel coding

Code blocks are delivered to the channel coding block. The bits in a code block are denoted by $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \ldots, c_{r(K_r-1)}$, where $r$ is the code block number, and $K_r$ is the number of bits in code block number $r$. The total number of code blocks is denoted by $C$ and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$, where the values of $N_r$ is given in Subclause 5.3.2.

### 7.2.5 Rate matching

Coded bits for each code block, denoted as $d_{r0}, d_{r1}, d_{r2}, d_{r3}, \ldots, d_{r(N_r-1)}$, are delivered to the rate match block, where $r$ is the code block number, and $N_r$ is the number of encoded bits in code block number $r$. The total number of code blocks is denoted by $C$ and each code block is individually rate matched according to Subclause 5.4.2 by setting $I_{LBRM}=1$.

After rate matching, the bits are denoted by $f_{r0}, f_{r1}, f_{r2}, f_{r3}, \ldots, f_{r(E_r-1)}$, where $E_r$ is the number of rate matched bits for code block number $r$.

### 7.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences $f_{r0}, f_{r1}, f_{r2}, f_{r3}, \ldots, f_{r(E_r-1)}$, for $r=0,\ldots,C-1$ and where $E_r$ is the number of rate matched bits for the $r$-th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by $g_0, g_1, g_2, g_3, \ldots, g_{G-1}$, where $G$ is the total number of coded bits for transmission.

## 7.3 Downlink control information

A DCI transports downlink and uplink scheduling information, requests for aperiodic CQI reports, or uplink power control commands for one cell and one RNTI.

The following coding steps can be identified:

- Information element multiplexing
- CRC attachment
- Channel coding

- Rate matching

## 7.3.1 DCI formats

The DCI formats defined in table 7.3.1-1 are supported.

**Table 7.3.1-1: DCI formats**

| DCI format | Usage |
|---|---|
| 0_0 | Scheduling of PUSCH in one cell |
| 0_1 | Scheduling of PUSCH in one cell |
| 1_0 | Scheduling of PDSCH in one cell |
| 1_1 | Scheduling of PDSCH in one cell |
| 2_0 | Notifying a group of UEs of the slot format |
| 2_1 | Notifying a group of UEs of the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE |
| 2_2 | Transmission of TPC commands for PUCCH and PUSCH |
| 2_3 | Transmission of a group of TPC commands for SRS transmissions by one or more UEs |

The fields defined in the DCI formats below are mapped to the information bits $a_0$ to $a_{A-1}$ as follows.

Each field is mapped in the order in which it appears in the description, including the zero-padding bit(s), if any, with the first field mapped to the lowest order information bit $a_0$ and each successive field mapped to higher order information bits. The most significant bit of each field is mapped to the lowest order information bit for that field, e.g. the most significant bit of the first field is mapped to $a_0$ .

If the number of information bits in a DCI format is less than 12 bits, zeros shall be appended to the DCI format until the payload size equals 12.

### 7.3.1.1 DCI formats for scheduling of PUSCH

#### 7.3.1.1.1 Format 0_0

DCI format 0_0 is used for the scheduling of PUSCH in one cell.

The following information is transmitted by means of the DCI format 0_0 with CRC scrambled by C-RNTI:

- Identifier for DCI formats – 1 bit
- The value of this bit field is always set to 0, indicating an UL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits where
  - $N_{RB}^{UL,BWP}$ is the size of the initial bandwidth part in case DCI format 0_0 is monitored in the common search space
  - $N_{RB}^{UL,BWP}$ is the size of the active bandwidth part in case DCI format 0_0 is monitored in the UE specific search space and satisfying
    - the total number of different DCI sizes monitored per slot is no more than 4, and
    - the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3
  - For PUSCH hopping with resource allocation type 1:
    - $N_{UL\_hop}$ MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{UL\_hop}=1$ if the higher layer parameter *Frequency-hopping-offsets-set* contains two

offset values and $N_{\text{UL\_hop}} = 2$ if the higher layer parameter *Frequency-hopping-offsets-set* contains four offset values

- $\lceil \log_2(N_{\text{RB}}^{\text{UL,BWP}}(N_{\text{RB}}^{\text{UL,BWP}}+1)/2) \rceil - N_{\text{UL\_hop}}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- For non-PUSCH hopping with resource allocation type 1:
  - $\lceil \log_2(N_{\text{RB}}^{\text{UL,BWP}}(N_{\text{RB}}^{\text{UL,BWP}}+1)/2) \rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – X bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]
- Frequency hopping flag – 1 bit.
- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.3 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- TPC command for scheduled PUSCH – [2] bits as defined in Subclause x.x of [5, TS 38.213]
- UL/SUL indicator – 1 bit for UEs configured with SUL in the cell as defined in Table 7.3.1.1.1-1 and the number of bits for DCI format 1_0 before padding is larger than the number of bits for DCI format 0_0 before padding; 0 bit otherwise.
  - If the UL/SUL indicator is present in DCI format 0_0 and the higher layer parameter *dynamicPUSCHSUL* is set to *Disabled*, the UE ignores the UL/SUL indicator field in DCI format 0_0, and the corresponding PUSCH scheduled by the DCI format 0_0 is for the carrier indicated by the higher layer parameter *pucchCarrierSUL*;
  - If the UL/SUL indicator is not present in DCI format 0_0, the corresponding PUSCH scheduled by the DCI format 0_0 is for the carrier indicated by the higher layer parameter *pucchCarrierSUL*.

The following information is transmitted by means of the DCI format 0_0 with CRC scrambled by TC-RNTI:

- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 0, indicating an UL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{\text{RB}}^{\text{UL,BWP}}(N_{\text{RB}}^{\text{UL,BWP}}+1)/2) \rceil$ bits where
  - $N_{\text{RB}}^{\text{UL,BWP}}$ is the size of the initial bandwidth part in case DCI format 0_0 is monitored in the common search space in CORESET 0
  - $N_{\text{RB}}^{\text{UL,BWP}}$ is the size of the active bandwidth part in case DCI format 0_0 is monitored in the UE specific search space and satisfying
    - the total number of different DCI sizes monitored per slot is no more than 4, and
    - the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3
  - For PUSCH hopping with resource allocation type 1:
    - $N_{\text{UL\_hop}}$ MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{\text{UL\_hop}} = 1$ if $N_{\text{RB}}^{\text{UL,BWP}} < 50$ and $N_{\text{UL\_hop}} = 2$ otherwise

- $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil - N_{UL\_hop}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- For non-PUSCH hopping with resource allocation type 1:

- $\lceil \log_2(N_{RB}^{UL,BWP}(N_{RB}^{UL,BWP}+1)/2) \rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – X bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]

- Frequency hopping flag – 1 bit.

- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.3 of [6, TS 38.214], using Table 5.1.3.1-1

- New data indicator – 1 bit, reserved

- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

- HARQ process number – 4 bits, reserved

- TPC command for scheduled PUSCH – [2] bits as defined in Subclause x.x of [5, TS 38.213]

- UL/SUL indicator – 1 bit if the cell has two ULs and the number of bits for DCI format 1_0 before padding is larger than the number of bits for DCI format 0_0 before padding; 0 bit otherwise.

  - If 1 bit, reserved, and the corresponding PUSCH is always on the same UL carrier as the previous transmission of the same TB

The following information is transmitted by means of the DCI format 0_0 with CRC scrambled by CS-RNTI:

- XXX – x bit

If DCI format 0_0 is monitored in common search space and if the number of information bits in the DCI format 0_0 prior to padding is less than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, zeros shall be appended to the DCI format 0_0 until the payload size equals that of the DCI format 1_0.

If DCI format 0_0 is monitored in common search space and if the number of information bits in the DCI format 0_0 prior to padding is larger than the payload size of the DCI format 1_0 monitored in common search space for scheduling the same serving cell, the bitwidth of the frequency domain resource allocation field in the DCI format 0_0 is reduced such that the size of DCI format 0_0 equals to the size of the DCI format 1_0..

**Table 7.3.1.1.1-1: UL/SUL indicator**

| Value of UL/SUL indicator | Uplink |
|---|---|
| 0 | The non-supplementary uplink |
| 1 | The supplementary uplink |

**Table 7.3.1.1.1-2: Redundancy version**

| Value of the Redundancy version field | Value of $rv_{id}$ to be applied |
|---|---|
| 00 | 0 |
| 01 | 1 |
| 10 | 2 |
| 11 | 3 |

#### 7.3.1.1.2 Format 0_1

DCI format 0_1 is used for the scheduling of PUSCH in one cell.

The following information is transmitted by means of the DCI format 0_1 with CRC scrambled by C-RNTI:

- Carrier indicator – 0 or 3 bits, as defined in Subclause x.x of [5, TS38.213].
- UL/SUL indicator – 0 bit for UEs not configured with SUL in the cell or UEs configured with SUL in the cell but only PUCCH carrier in the cell is configured for PUSCH transmission; 1 bit for UEs configured with SUL in the cell as defined in Table 7.3.1.1.1-1.
- Identifier for DCI formats – 1 bit
  - The value of this bit field is always set to 0, indicating an UL DCI format
- Bandwidth part indicator – 0, 1 or 2 bits as defined in Table 7.3.1.1.2-1. The bitwidth for this field is determined as $\lceil \log_2(n_{\mathrm{BWP}}) \rceil$ bits, where
  - $n_{\mathrm{BWP}} = n_{\mathrm{BWP,RRC}} + 1$ if the higher layer parameter *BandwidthPart-Config* configures up to 3 bandwidth parts and the initial bandwidth part is not included in higher layer parameter *BandwidthPart-Config*;
  - otherwise $n_{\mathrm{BWP}} = n_{\mathrm{BWP,RRC}}$ ;
  - $n_{\mathrm{BWP,RRC}}$ is the number of configured bandwidth parts according to higher layer parameter *BandwidthPart-Config*.
- Frequency domain resource assignment – number of bits determined by the following, where $N_{\mathrm{RB}}^{\mathrm{UL,BWP}}$ is the size of the active bandwidth part:
  - $N_{\mathrm{RBG}}$ bits if only resource allocation type 0 is configured, where $N_{\mathrm{RBG}}$ is defined in Subclause 6.1.2.2.1 of [6, TS 38.214],
  - $\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}+1)/2) \rceil$ bits if only resource allocation type 1 is configured, or $\max\left(\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}+1)/2) \rceil, N_{\mathrm{RBG}}\right)+1$ bits if both resource allocation type 0 and 1 are configured.
- If both resource allocation type 0 and 1 are configured, the MSB bit is used to indicate resource allocation type 0 or resource allocation type 1, where the bit value of 0 indicates resource allocation type 0 and the bit value of 1 indicates resource allocation type 1.
- For resource allocation type 0, the $N_{\mathrm{RBG}}$ LSBs provide the resource allocation as defined in Subclause 6.1.2.2.1 of [6, TS 38.214].
- For resource allocation type 1, the $\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}+1)/2) \rceil$ LSBs provide the resource allocation as follows:
  - For PUSCH hopping with resource allocation type 1:
    - $N_{\mathrm{UL\_hop}}$ MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where $N_{\mathrm{UL\_hop}} = 1$ if the higher layer parameter *Frequency-hopping-offsets-set* contains two offset values and $N_{\mathrm{UL\_hop}} = 2$ if the higher layer parameter *Frequency-hopping-offsets-set* contains four offset values
    - $\lceil \log_2(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}(N_{\mathrm{RB}}^{\mathrm{UL,BWP}}+1)/2) \rceil - N_{\mathrm{UL\_hop}}$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]
  - For non-PUSCH hopping with resource allocation type 1:

- $\lceil \log_2 ( N_{\mathrm{RB}}^{\mathrm{UL,BWP}} ( N_{\mathrm{RB}}^{\mathrm{UL,BWP}} + 1 ) / 2 ) \rceil$ bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – 0, 1, 2, 3, or 4 bits as defined in Subclause 6.1.2.1 of [6, TS38.214]. The bitwidth for this field is determined as $\lceil \log_2 ( I ) \rceil$ bits, where *I* the number of entries in the higher layer parameter *pusch-AllocationList.*

- VRB-to-PRB mapping – 0 or 1 bit:
  - 0 bit if only resource allocation type 0 is configured or if *PUSCH-tp=Enabled*;
  - 1 bit according to Table 7.3.1.1.2-33 otherwise, only applicable to resource allocation type 1, as defined in Subclause 6.3.1.7 of [4, TS 38.211].

- Frequency hopping flag – 0 or 1 bit:
  - 0 bit if only resource allocation type 0 is configured;
  - 1 bit otherwise, only applicable to resource allocation type 1, as defined in Subclause 6.3 of [6, TS 38.214].

- Modulation and coding scheme – 5 bits as defined in Subclause x.x of [6, TS 38.214]

- New data indicator – 1 bit

- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

- HARQ process number – 4 bits

- 1st downlink assignment index – 1 or 2 bits:
  - 1 bit for semi-static HARQ-ACK codebook;
  - 2 bits for dynamic HARQ-ACK codebook with single HARQ-ACK codebook.

- 2nd downlink assignment index – 0 or 2 bits:
  - 2 bits for dynamic HARQ-ACK codebook with two HARQ-ACK sub-codebooks;
  - 0 bit otherwise.

- TPC command for scheduled PUSCH – 2 bits as defined in Subclause 7.1.1 of [5, TS38.213]

- SRS resource indicator – $\left\lceil \log_2 \left( \sum_{k=1}^{\min\{L_{\max}, N_{\mathrm{SRS}}\}} \binom{N_{\mathrm{SRS}}}{k} \right) \right\rceil$ or $\lceil \log_2 ( N_{\mathrm{SRS}} ) \rceil$ bits, where $N_{\mathrm{SRS}}$ is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *SRS-SetUse* of value '*CodeBook*' or '*NonCodeBook*', and $L_{\max}$ is the maximum number of supported layers for the PUSCH.
  - $\left\lceil \log_2 \left( \sum_{k=1}^{\min\{L_{\max}, N_{\mathrm{SRS}}\}} \binom{N_{\mathrm{SRS}}}{k} \right) \right\rceil$ bits for non-codebook based PUSCH transmission according to Tables 7.3.1.1.2-28/29/30/31, where $N_{\mathrm{SRS}}$ is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *SRS-SetUse* of value '*NonCodeBook*';
  - $\lceil \log_2 ( N_{\mathrm{SRS}} ) \rceil$ bits for codebook based PUSCH transmission according to Tables 7.3.1.1.2-32, where $N_{\mathrm{SRS}}$ is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *SRS-SetUse* of value '*CodeBook*'.

- Precoding information and number of layers – number of bits determined by the following:
  - 0 bits if the higher layer parameter *ulTxConfig = NonCodeBook*;

  - 0 bits for 1 antenna port and if the higher layer parameter *ulTxConfig = Codebook*;
  - 4, 5, or 6 bits according to Table 7.3.1.1.2-2 for 4 antenna ports, if *ulTxConfig = Codebook*, and according to the values of higher layer parameters *PUSCH-tp*, *ULmaxRank*, and *ULCodebookSubset*;
  - 2, 4, or 5 bits according to Table 7.3.1.1.2-3 for 4 antenna ports, if *ulTxConfig = Codebook,* and according to the values of higher layer parameters *PUSCH-tp, ULmaxRank*, and *ULCodebookSubset*;
  - 2 or 4 bits according to Table7.3.1.1.2-4 for 2 antenna ports, if *ulTxConfig = Codebook,* and according to the values of higher layer parameters *ULmaxRank* and *ULCodebookSubset*;
  - 1 or 3 bits according to Table7.3.1.1.2-5 for 2 antenna ports, if *ulTxConfig = Codebook,* and according to the values of higher layer parameters *ULmaxRank* and *ULCodebookSubset*.
- Antenna ports – number of bits determined by the following
  - 2 bits as defined by Tables 7.3.1.1.2-6, if *PUSCH-tp=Enabled*, *UL-DMRS-config-type*=1, and *UL-DMRS-max-len*=1;
  - 4 bits as defined by Tables 7.3.1.1.2-7, if *PUSCH-tp=Enabled*, *UL-DMRS-config-type*=1, and *UL-DMRS-max-len*=2;
  - 3 bits as defined by Tables 7.3.1.1.2-8/9/10/11, if *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, and *UL-DMRS-max-len*=1, and the value of rank is determined according to the SRS resource indicator field if *SRS-SetUse = NonCodeBook* and according to the Precoding information and number of layers field if *SRS-SetUse = CodeBook*;
  - 4 bits as defined by Tables 7.3.1.1.2-12/13/14/15, if *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, and *UL-DMRS-max-len*=2, and the value of rank is determined according to the SRS resource indicator field if *SRS-SetUse = NonCodeBook* and according to the Precoding information and number of layers field if *SRS-SetUse = CodeBook*;
  - 4 bits as defined by Tables 7.3.1.1.2-16/17/18/19, if *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, and *UL-DMRS-max-len*=1, and the value of rank is determined according to the SRS resource indicator field if *SRS-SetUse = NonCodeBook* and according to the Precoding information and number of layers field if *SRS-SetUse = CodeBook*;
  - 5 bits as defined by Tables 7.3.1.1.2-20/21/22/23, if *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, and *UL-DMRS-max-len*=2, and the value of rank is determined according to the SRS resource indicator field if *SRS-SetUse = NonCodeBook* and according to the Precoding information and number of layers field if *SRS-SetUse = CodeBook*.

  where the number of CDM groups without data of values 1, 2, and 3 in Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 refers to CDM groups {0}, {0,1}, and {0, 1,2} respectively.

- SRS request – 2 bits as defined by Table 7.3.1.1.2-24 for UEs not configured with SUL in the cell; 3 bits for UEs configured SUL in the cell where the first bit is the non-SUL/SUL indicator as defined in Table 7.3.1.1.1-1 and the second and third bits are defined by Table 7.3.1.1.2-24. This bit field may also indicate the associated CSI-RS according to Subclause 6.1.1.2 of [6, TS 38.214].
- CSI request – 0, 1, 2, 3, 4, 5, or 6 bits determined by higher layer parameter *ReportTriggerSize*.
- CBG transmission information (CBGTI) – 0, 2, 4, 6, or 8 bits determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for PUSCH.
- PTRS-DMRS association – number of bits determined as follows
  - 0 bit if UL-PTRS-present=OFF and PUSCH-tp=Disabled, or if PUSCH-tp=Enabled;
  - 2 bits otherwise, where Table 7.3.1.1.2-25 and 7.3.1.1.2-26 are used to indicate the association between PTRS port(s) and DMRS port(s) for UL-PTRS-ports = 1 and UL-PTRS-ports = 2 respectively, and the DMRS ports are indicated by the Antenna ports field.
- beta_offset indicator – 0 if the higher layer parameter *dynamic* in *uci-on-PUSCH* is not configured; otherwise 2 bits as defined by Table 9.3-3 in [5, TS 38.213].

- DMRS sequence initialization – 0 if the higher layer parameter *PUSCH-tp=Enabled* or 1 bit if the higher layer parameter *PUSCH-tp=Disabled* for $n_{\mathrm{SCID}}$ selection defined in Subclause 7.4.1.1.1 of [4, TS 38.211].

The following information is transmitted by means of the DCI format 0_1 with CRC scrambled by CS-RNTI:

- XXX – x bit

The following information is transmitted by means of the DCI format 0_1 with CRC scrambled by SP-CSI-RNTI:

- XXX – x bit

For a UE configured with SUL in a cell, if PUSCH is configured to be transmitted on both the SUL and the non-SUL of the cell and if the number of information bits in format 0_1 for the SUL is not equal to the number of information bits in format 0_1 for the non-SUL, zeros shall be appended to smaller format 0_1 until the payload size equals that of the larger format 0_1.

**Table 7.3.1.1.2-1: Bandwidth part indicator**

| Value of BWP indicator field | | Bandwidth part |
|---|---|---|
| 1 bit | 2 bits | |
| 0 | 00 | First bandwidth part configured by higher layers |
| 1 | 01 | Second bandwidth part configured by higher layers |
| | 10 | Third bandwidth part configured by higher layers |
| | 11 | Fourth bandwidth part configured by higher layers |

**Table 7.3.1.1.2-2: Precoding information and number of layers, for 4 antenna ports, if *PUSCH-tp=Disabled* and *ULmaxRank* = 2 or 3 or 4**

| Bit field mapped to index | *ULCodebookSubset = fullAndPartialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = partialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = nonCoherent* |
|---|---|---|---|---|---|
| 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 |
| 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 |
| … | … | … | … | … | … |
| 3 | 1 layer: TPMI=3 | 3 | 1 layer: TPMI=3 | 3 | 1 layer: TPMI=3 |
| 4 | 2 layers: TPMI=0 | 4 | 2 layers: TPMI=0 | 4 | 2 layers: TPMI=0 |
| … | … | … | … | … | … |
| 9 | 2 layers: TPMI=5 | 9 | 2 layers: TPMI=5 | 9 | 2 layers: TPMI=5 |
| 10 | 3 layers: TPMI=0 | 10 | 3 layers: TPMI=0 | 10 | 3 layers: TPMI=0 |
| 11 | 4 layers: TPMI=0 | 11 | 4 layers: TPMI=0 | 11 | 4 layers: TPMI=0 |
| 12 | 1 layer: TPMI=4 | 12 | 1 layer: TPMI=4 | 12-15 | reserved |
| … | … | … | … | | |
| 19 | 1 layer: TPMI=11 | 19 | 1 layer: TPMI=11 | | |
| 20 | 2 layers: TPMI=6 | 20 | 2 layers: TPMI=6 | | |
| … | … | … | … | | |
| 27 | 2 layers: TPMI=13 | 27 | 2 layers: TPMI=13 | | |
| 28 | 3 layers: TPMI=1 | 28 | 3 layers: TPMI=1 | | |
| 29 | 3 layers: TPMI=2 | 29 | 3 layers: TPMI=2 | | |
| 30 | 4 layers: TPMI=1 | 30 | 4 layers: TPMI=1 | | |
| 31 | 4 layers: TPMI=2 | 31 | 4 layers: TPMI=2 | | |
| 32 | 1 layers: TPMI=12 | | | | |
| … | … | | | | |
| 47 | 1 layers: TPMI=27 | | | | |
| 48 | 2 layers: TPMI=14 | | | | |
| … | … | | | | |
| 55 | 2 layers: TPMI=21 | | | | |
| 56 | 3 layers: TPMI=3 | | | | |
| … | … | | | | |
| 59 | 3 layers: TPMI=6 | | | | |
| 60 | 4 layers: TPMI=3 | | | | |
| 61 | 4 layers: TPMI=4 | | | | |
| 62-63 | reserved | | | | |

**Table 7.3.1.1.2-3: Precoding information and number of layers for 4 antenna ports, if *PUSCH-tp=Enabled*, or if *PUSCH-tp=Disabled* and *ULmaxRank* = 1**

| Bit field mapped to index | *ULCodebookSubset = fullAndPartialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = partialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = nonCoherent* |
|---|---|---|---|---|---|
| 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 |
| 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 |
| … | … | … | … | … | … |
| 3 | 1 layer: TPMI=3 | 3 | 1 layer: TPMI=3 | 3 | 1 layer: TPMI=3 |
| 4 | 1 layer: TPMI=4 | 4 | 1 layer: TPMI=4 | | |
| … | … | … | … | | |
| 11 | 1 layer: TPMI=11 | 11 | 1 layer: TPMI=11 | | |
| 12 | 1 layers: TPMI=12 | 12-15 | reserved | | |
| … | … | | | | |
| 27 | 1 layers: TPMI=27 | | | | |
| 28-31 | reserved | | | | |

**Table 7.3.1.1.2-4: Precoding information and number of layers, for 2 antenna ports, if *PUSCH-tp=Disabled* and *ULmaxRank* = 2**

| Bit field mapped to index | *ULCodebookSubset = fullAndPartialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = nonCoherent* |
|---|---|---|---|
| 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 |
| 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 |
| 2 | 2 layers: TPMI=0 | 2 | 2 layers: TPMI=0 |
| 3 | 1 layer: TPMI=2 | 3 | reserved |
| 4 | 1 layer: TPMI=3 | | |
| 5 | 1 layer: TPMI=4 | | |
| 6 | 1 layer: TPMI=5 | | |
| 7 | 2 layers: TPMI=1 | | |
| 8 | 2 layers: TPMI=2 | | |
| 9-15 | reserved | | |

**Table 7.3.1.1.2-5: Precoding information and number of layers, for 2 antenna ports, if *PUSCH-tp= Enabled*, or if *PUSCH-tp= Disabled* and *ULmaxRank* = 1**

| Bit field mapped to index | *ULCodebookSubset = fullAndPartialAndNonCoherent* | Bit field mapped to index | *ULCodebookSubset = nonCoherent* |
|---|---|---|---|
| 0 | 1 layer: TPMI=0 | 0 | 1 layer: TPMI=0 |
| 1 | 1 layer: TPMI=1 | 1 | 1 layer: TPMI=1 |
| 2 | 1 layer: TPMI=2 | | |
| 3 | 1 layer: TPMI=3 | | |
| 4 | 1 layer: TPMI=4 | | |
| 5 | 1 layer: TPMI=5 | | |
| 6-7 | reserved | | |

**Table 7.3.1.1.2-6: Antenna port(s), *PUSCH-tp=Enabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=1**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 2 | 0 |
| 1 | 2 | 1 |
| 2 | 2 | 2 |
| 3 | 2 | 3 |

Table 7.3.1.1.2-7: Antenna port(s), *PUSCH-tp=Enabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=2

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 2 | 0 | 1 |
| 1 | 2 | 1 | 1 |
| 2 | 2 | 2 | 1 |
| 3 | 2 | 3 | 1 |
| 4 | 2 | 0 | 2 |
| 5 | 2 | 1 | 2 |
| 6 | 2 | 2 | 2 |
| 7 | 2 | 3 | 2 |
| 8 | 2 | 4 | 2 |
| 9 | 2 | 5 | 2 |
| 10 | 2 | 6 | 2 |
| 11 | 2 | 7 | 2 |
| 12-15 | Reserved | Reserved | Reserved |

Table 7.3.1.1.2-8: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=1, rank = 1

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 2 | 2 | 0 |
| 3 | 2 | 1 |
| 4 | 2 | 2 |
| 5 | 2 | 3 |
| 6-7 | Reserved | Reserved |

Table 7.3.1.1.2-9: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=1, rank = 2

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 1 | 0,1 |
| 1 | 2 | 0,1 |
| 2 | 2 | 2,3 |
| 3 | 2 | 0,2 |
| 4-7 | Reserved | Reserved |

Table 7.3.1.1.2-10: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=1, rank = 3

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 2 | 0-2 |
| 2-7 | Reserved | Reserved |

Table 7.3.1.1.2-11: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=1, rank = 4

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 2 | 0-3 |
| 2-7 | Reserved | Reserved |

**Table 7.3.1.1.2-12: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=2, rank = 1**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 0 | 1 |
| 3 | 2 | 1 | 1 |
| 4 | 2 | 2 | 1 |
| 5 | 2 | 3 | 1 |
| 6 | 2 | 0 | 2 |
| 7 | 2 | 1 | 2 |
| 8 | 2 | 2 | 2 |
| 9 | 2 | 3 | 2 |
| 10 | 2 | 4 | 2 |
| 11 | 2 | 5 | 2 |
| 12 | 2 | 6 | 2 |
| 13 | 2 | 7 | 2 |
| 14-15 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-13: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=2, rank = 2**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 1 | 0,1 | 1 |
| 1 | 2 | 0,1 | 1 |
| 2 | 2 | 2,3 | 1 |
| 3 | 2 | 0,2 | 1 |
| 4 | 2 | 0,1 | 2 |
| 5 | 2 | 2,3 | 2 |
| 6 | 2 | 4,5 | 2 |
| 7 | 2 | 6,7 | 2 |
| 8 | 2 | 0,4 | 2 |
| 9 | 2 | 2,6 | 2 |
| 10-15 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-14: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=2, rank = 3**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 2 | 0-2 | 1 |
| 1 | 2 | 0,1,4 | 2 |
| 2 | 2 | 2,3,6 | 2 |
| 3-15 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-15: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=1, *UL-DMRS-max-len*=2, rank = 4**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 2 | 0-3 | 1 |
| 1 | 2 | 0,1,4,5 | 2 |
| 2 | 2 | 2,3,6,7 | 2 |
| 3 | 2 | 0,2,4,6 | 2 |
| 4-15 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-16: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=1, rank=1**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 2 | 2 | 0 |
| 3 | 2 | 1 |
| 4 | 2 | 2 |
| 5 | 2 | 3 |
| 6 | 3 | 0 |
| 7 | 3 | 1 |
| 8 | 3 | 2 |
| 9 | 3 | 3 |
| 10 | 3 | 4 |
| 11 | 3 | 5 |
| 12-15 | Reserved | Reserved |

**Table 7.3.1.1.2-17: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *DL-DMRS-max-len*=1, rank=2**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 1 | 0,1 |
| 1 | 2 | 0,1 |
| 2 | 2 | 2,3 |
| 3 | 3 | 0,1 |
| 4 | 3 | 2,3 |
| 5 | 3 | 4,5 |
| 6 | 2 | 0,2 |
| 7-15 | Reserved | Reserved |

**Table 7.3.1.1.2-18: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *DL-DMRS-max-len*=1, rank =3**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 2 | 0-2 |
| 1 | 3 | 0-2 |
| 2 | 3 | 3-5 |
| 3-15 | Reserved | Reserved |

**Table 7.3.1.1.2-19: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=1, rank =4**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) |
|---|---|---|
| 0 | 2 | 0-3 |
| 1 | 3 | 0-3 |
| 2-15 | Reserved | Reserved |

**Table 7.3.1.1.2-20: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=2, rank=1**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |
| 2 | 2 | 0 | 1 |
| 3 | 2 | 1 | 1 |
| 4 | 2 | 2 | 1 |
| 5 | 2 | 3 | 1 |
| 6 | 3 | 0 | 1 |
| 7 | 3 | 1 | 1 |
| 8 | 3 | 2 | 1 |
| 9 | 3 | 3 | 1 |
| 10 | 3 | 4 | 1 |
| 11 | 3 | 5 | 1 |
| 12 | 3 | 0 | 2 |
| 13 | 3 | 1 | 2 |
| 14 | 3 | 2 | 2 |
| 15 | 3 | 3 | 2 |
| 16 | 3 | 4 | 2 |
| 17 | 3 | 5 | 2 |
| 18 | 3 | 6 | 2 |
| 19 | 3 | 7 | 2 |
| 20 | 3 | 8 | 2 |
| 21 | 3 | 9 | 2 |
| 22 | 3 | 10 | 2 |
| 23 | 3 | 11 | 2 |
| 24 | 1 | 0 | 2 |
| 25 | 1 | 1 | 2 |
| 26 | 1 | 6 | 2 |
| 27 | 1 | 7 | 2 |
| 28-31 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-21: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=2, rank=2**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 1 | 0,1 | 1 |
| 1 | 2 | 0,1 | 1 |
| 2 | 2 | 2,3 | 1 |
| 3 | 3 | 0,1 | 1 |
| 4 | 3 | 2,3 | 1 |
| 5 | 3 | 4,5 | 1 |
| 6 | 2 | 0,2 | 1 |
| 7 | 3 | 0,1 | 2 |
| 8 | 3 | 2,3 | 2 |
| 9 | 3 | 4,5 | 2 |
| 10 | 3 | 6,7 | 2 |
| 11 | 3 | 8,9 | 2 |
| 12 | 3 | 10,11 | 2 |
| 13 | 1 | 0,1 | 2 |
| 14 | 1 | 6,7 | 2 |
| 15 | 2 | 0,1 | 2 |
| 16 | 2 | 2,3 | 2 |
| 17 | 2 | 6,7 | 2 |
| 18 | 2 | 8,9 | 2 |
| 19-31 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-22: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=2, rank=3**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 2 | 0-2 | 1 |
| 1 | 3 | 0-2 | 1 |
| 2 | 3 | 3-5 | 1 |
| 3 | 3 | 0,1,6 | 2 |
| 4 | 3 | 2,3,8 | 2 |
| 5 | 3 | 4,5,10 | 2 |
| 6-31 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-23: Antenna port(s), *PUSCH-tp=Disabled*, *UL-DMRS-config-type*=2, *UL-DMRS-max-len*=2, rank=4**

| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
|---|---|---|---|
| 0 | 2 | 0-3 | 1 |
| 1 | 3 | 0-3 | 1 |
| 2 | 3 | 0,1,6,7 | 2 |
| 3 | 3 | 2,3,8,9 | 2 |
| 4 | 3 | 4,5,10,11 | 2 |
| 5-31 | Reserved | Reserved | Reserved |

**Table 7.3.1.1.2-24: SRS request**

| Value of SRS request field | SRS resource set |
|---|---|
| 00 | |
| 01 | |
| 10 | |
| 11 | |

**Table 7.3.1.1.2-25: PTRS-DMRS association for UL PTRS port 0, *UL-PTRS-ports* = 1**

| Value | DMRS port |
|---|---|
| 0 | 0 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |

**Table 7.3.1.1.2-26: PTRS-DMRS association for UL PTRS ports 0 and 1, *UL-PTRS-ports* = 2**

| Value of MSB | DMRS port | | Value of LSB | DMRS port |
|---|---|---|---|---|
| 0 | 1st DMRS port transmitting layers corresponding to SRS port 0 and 2 | | 0 | 1st DMRS port transmitting layers corresponding to SRS port 1 and 3 |
| 1 | 2nd DMRS port transmitting layers corresponding to SRS port 0 and 2 | | 1 | 2nd DMRS port transmitting layers corresponding to SRS port 1 and 3 |

**Table 7.3.1.1.2-27: void**

**Table 7.3.1.1.2-28: SRI indication for non-codebook based PUSCH transmission, $L_{max}=1$**

| Bit field mapped to index | SRI(s), $N_{SRS}=2$ | Bit field mapped to index | SRI(s), $N_{SRS}=3$ | Bit field mapped to index | SRI(s), $N_{SRS}=4$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| | | 2 | 2 | 2 | 2 |
| | | 3 | reserved | 3 | 3 |

**Table 7.3.1.1.2-29: SRI indication for non-codebook based PUSCH transmission, $L_{max}=2$**

| Bit field mapped to index | SRI(s), $N_{SRS}=2$ | Bit field mapped to index | SRI(s), $N_{SRS}=3$ | Bit field mapped to index | SRI(s), $N_{SRS}=4$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0,1 | 2 | 2 | 2 | 2 |
| 3 | reserved | 3 | 0,1 | 3 | 3 |
| | | 4 | 0,2 | 4 | 0,1 |
| | | 5 | 1,2 | 5 | 0,2 |
| | | 6-7 | reserved | 6 | 0,3 |
| | | | | 7 | 1,2 |
| | | | | 8 | 1,3 |
| | | | | 9 | 2,3 |
| | | | | 10-15 | reserved |

**Table 7.3.1.1.2-30: SRI indication for non-codebook based PUSCH transmission, $L_{max}=3$**

| Bit field mapped to index | SRI(s), $N_{SRS}=2$ | Bit field mapped to index | SRI(s), $N_{SRS}=3$ | Bit field mapped to index | SRI(s), $N_{SRS}=4$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0,1 | 2 | 2 | 2 | 2 |
| 3 | reserved | 3 | 0,1 | 3 | 3 |
| | | 4 | 0,2 | 4 | 0,1 |
| | | 5 | 1,2 | 5 | 0,2 |
| | | 6 | 0,1,2 | 6 | 0,3 |
| | | 7 | reserved | 7 | 1,2 |
| | | | | 8 | 1,3 |
| | | | | 9 | 2,3 |
| | | | | 10 | 0,1,2 |
| | | | | 11 | 0,1,3 |
| | | | | 12 | 0,2,3 |
| | | | | 13 | 1,2,3 |
| | | | | 14-15 | reserved |

**Table 7.3.1.1.2-31: SRI indication for non-codebook based PUSCH transmission, $L_{max}=4$**

| Bit field mapped to index | SRI(s), $N_{SRS}=2$ | Bit field mapped to index | SRI(s), $N_{SRS}=3$ | Bit field mapped to index | SRI(s), $N_{SRS}=4$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 | 1 | 1 |
| 2 | 0,1 | 2 | 2 | 2 | 2 |
| 3 | reserved | 3 | 0,1 | 3 | 3 |
| | | 4 | 0,2 | 4 | 0,1 |
| | | 5 | 1,2 | 5 | 0,2 |
| | | 6 | 0,1,2 | 6 | 0,3 |
| | | 7 | reserved | 7 | 1,2 |
| | | | | 8 | 1,3 |
| | | | | 9 | 2,3 |
| | | | | 10 | 0,1,2 |
| | | | | 11 | 0,1,3 |
| | | | | 12 | 0,2,3 |
| | | | | 13 | 1,2,3 |
| | | | | 14 | 0,1,2,3 |
| | | | | 15 | reserved |

**Table 7.3.1.1.2-32: SRI indication for codebook based PUSCH transmission**

| Bit field mapped to index | SRI(s), $N_{SRS}=2$ |
|---|---|
| 0 | 0 |
| 1 | 1 |

**Table 7.3.1.1.2-33: VRB-to-PRB mapping**

| Bit field mapped to index | VRB-to-PRB mapping |
|---|---|
| 0 | Non-interleaved |
| 1 | Interleaved |

### 7.3.1.2 DCI formats for scheduling of PDSCH

#### 7.3.1.2.1 Format 1_0

DCI format 1_0 is used for the scheduling of PDSCH in one DL cell.

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by C-RNTI:

- Identifier for DCI formats – 1 bits
  - The value of this bit field is always set to 1, indicating a DL DCI format
- Frequency domain resource assignment – $\lceil \log_2(N_{RB}^{DL,BWP}(N_{RB}^{DL,BWP}+1)/2) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial bandwidth part in case DCI format 1_0 is monitored in the common search space
  - $N_{RB}^{DL,BWP}$ is the size of the active bandwidth part in case DCI format 1_0 is monitored in the UE specific search space and satisfying
    - the total number of different DCI sizes monitored per slot is no more than 4, and
    - the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3
- Time domain resource assignment – X bits as defined in Subclause 5.1.2.1 of [6, TS 38.214]

- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- Downlink assignment index – 2 bits as defined in Subclause 9.1.3 of [5, TS 38.213], as counter DAI
- TPC command for scheduled PUCCH – [2] bits as defined in Subclause 7.2.1 of [5, TS 38.213]
- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]
- PDSCH-to-HARQ_feedback timing indicator – [3] bits as defined in Subclause x.x of [5, TS38.213]

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by P-RNTI:

- Short Messages Indicator – 1 bit. This bit is used to indicate whether the short message only or scheduling information only is carried in the Paging DCI.

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by SI-RNTI:

- XXX – x bit

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by RA-RNTI:

- Identifier for DCI formats – 1 bit, reserved
- Frequency domain resource assignment – $\lceil \log_2 ( N_{RB}^{DL,BWP} ( N_{RB}^{DL,BWP} + 1 ) / 2 ) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial bandwidth part in case DCI format 1_0 is monitored in the common search space in CORESET 0
  - $N_{RB}^{DL,BWP}$ is the size of the active bandwidth part in case DCI format 1_0 is monitored in the UE specific search space and satisfying
    - the total number of different DCI sizes monitored per slot is no more than 4, and
    - the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3
- Time domain resource assignment – X bits as defined in Subclause 5.1.2.1 of [6, TS38.214]
- VRB-to-PRB mapping – 1 bit
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1
- New data indicator – 1 bit, reserved
- Redundancy version – 2 bits, reserved
- HARQ process number – 4 bits, reserved
- Downlink assignment index – 2 bits, reserved
- TPC command for scheduled PUCCH – 2 bits, reserved
- PUCCH resource indicator – 3 bits, reserved
- PDSCH-to-HARQ_feedback timing indicator – 3 bits, reserved

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by TC-RNTI:

- Identifier for DCI formats – 1 bit

  - The value of this bit field is always set to 1, indicating a DL DCI format
- Frequency domain resource assignment – $\lceil \log_2 ( N_{RB}^{DL,BWP} ( N_{RB}^{DL,BWP} + 1 ) / 2 ) \rceil$ bits
  - $N_{RB}^{DL,BWP}$ is the size of the initial bandwidth part in case DCI format 1_0 is monitored in the common search space in CORESET 0
  - $N_{RB}^{DL,BWP}$ is the size of the active bandwidth part in case DCI format 0_0 is monitored in the UE specific search space and satisfying
    - the total number of different DCI sizes monitored per slot is no more than 4, and
    - the total number of different DCI sizes with C-RNTI monitored per slot is no more than 3
- Time domain resource assignment – X bits as defined in Subclause 5.1.2.1 of [6, TS38.214]
- VRB-to-PRB mapping – 1 bit
- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2
- HARQ process number – 4 bits
- Downlink assignment index – 2 bits, reserved
- TPC command for scheduled PUCCH – 2 bits as defined in Subclause 7.2.1 of [5, TS38.213]
- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS38.213]
- PDSCH-to-HARQ_feedback timing indicator – 3 bits as defined in Subclause x.x of [5, TS38.213]

The following information is transmitted by means of the DCI format 1_0 with CRC scrambled by CS-RNTI:

- XXX – x bit

#### 7.3.1.2.2 Format 1_1

DCI format 1_1 is used for the scheduling of PDSCH in one cell.

The following information is transmitted by means of the DCI format 1_1 with CRC scrambled by C-RNTI:

- Carrier indicator – 0 or 3 bits as defined in Subclause x.x of [5, TS 38.213].
- Identifier for DCI formats – 1 bits
  - The value of this bit field is always set to 1, indicating a DL DCI format
- Bandwidth part indicator – 0, 1 or 2 bits as defined in Table 7.3.1.1.2-1. The bitwidth for this field is determined as $\lceil \log_2 ( n_{BWP} ) \rceil$ bits, where
  - $n_{BWP} = n_{BWP,RRC} + 1$ if the higher layer parameter *BandwidthPart-Config* configures up to 3 bandwidth parts and the initial bandwidth part is not included in higher layer parameter *BandwidthPart-Config*;
  - otherwise $n_{BWP} = n_{BWP,RRC}$ ;
  - $n_{BWP,RRC}$ is the number of configured bandwidth parts according to higher layer parameter *BandwidthPart-Config*.

- Frequency domain resource assignment – number of bits determined by the following, where $N_{\text{RB}}^{\text{DL,BWP}}$ is the size of the active bandwidth part:
  - $N_{\text{RBG}}$ bits if only resource allocation type 0 is configured, where $N_{\text{RBG}}$ is defined in Subclause 5.1.2.2.1 of [6, TS38.214],
  - $\lceil \log_2 ( N_{\text{RB}}^{\text{DL,BWP}} ( N_{\text{RB}}^{\text{DL,BWP}} + 1 ) / 2 ) \rceil$ bits if only resource allocation type 1 is configured, or
  - $\max \left( \lceil \log_2 ( N_{\text{RB}}^{\text{DL,BWP}} ( N_{\text{RB}}^{\text{DL,BWP}} + 1 ) / 2 ) \rceil , N_{\text{RBG}} \right) + 1$ bits if both resource allocation type 0 and 1 are configured.
  - If both resource allocation type 0 and 1 are configured, the MSB bit is used to indicate resource allocation type 0 or resource allocation type 1, where the bit value of 0 indicates resource allocation type 0 and the bit value of 1 indicates resource allocation type 1.
  - For resource allocation type 0, the $N_{\text{RBG}}$ LSBs provide the resource allocation as defined in Subclause 5.1.2.2.1 of [6, TS 38.214].
  - For resource allocation type 1, the $\lceil \log_2 ( N_{\text{RB}}^{\text{DL,BWP}} ( N_{\text{RB}}^{\text{DL,BWP}} + 1 ) / 2 ) \rceil$ LSBs provide the resource allocation as defined in Subclause 5.1.2.2.2 of [6, TS 38.214]
- Time domain resource assignment – 0, 1, 2, 3, or 4 bits as defined in Subclause 5.1.2.1 of [6, TS 38.214]. The bitwidth for this field is determined as $\lceil \log_2 ( I ) \rceil$ bits, where *I* is the number of entries in the higher layer parameter *pdsch-AllocationList*.
- VRB-to-PRB mapping – 0 or 1 bit:
  - 0 bit if only resource allocation type 0 is configured;
  - 1 bit according to Table 7.3.1.1.2-33 otherwise, only applicable to resource allocation type 1, as defined in Subclause xxx of [4, TS 38.211].
- PRB bundling size indicator – 0 bit if the higher layer parameter *PRB_bundling* is not configured or is set to 'static', or 1 bit if the higher layer parameter *PRB_bundling* is set to 'dynamic' according to Subclause 5.1.2.3 of [6, TS 38.214].
- Rate matching indicator – 0, 1, or 2 bits according to higher layer parameter *rate-match-PDSCH-resource-set*.
- ZP CSI-RS trigger – 0, 1, or 2 bits as defined in Subclause x.x of [6, TS 38.214]. The bitwidth for this field is determined as $\lceil \log_2 ( n_{ZP} + 1 ) \rceil$ bits, where $n_{ZP}$ is the number of ZP CSI-RS resource sets in the higher layer parameter [*ZP-CSI-RS-ResourceConfigList*].

For transport block 1:

- Modulation and coding scheme – 5 bits as defined in Subclause x.x of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

For transport block 2 (only present if *Number-MCS-HARQ-DL-DCI* equals 2):

- Modulation and coding scheme – 5 bits as defined in Subclause x.x of [6, TS 38.214]
- New data indicator – 1 bit
- Redundancy version – 2 bits as defined in Table 7.3.1.1.1-2

- HARQ process number – 4 bits
- Downlink assignment index – number of bits as defined in the following

- 4 bits if more than one serving cell are configured in the DL and the higher layer parameter *HARQ-ACK-codebook=dynamic*, where the 2 MSB bits are the counter DAI and the 2 LSB bits are the total DAI;

- 2 bits if only one serving cell is configured in the DL and the higher layer parameter *HARQ-ACK-codebook=dynamic*, where the 2 bits are the counter DAI;

- 0 bits otherwise.

- TPC command for scheduled PUCCH – 2 bits as defined in Subclause x.x of [5, TS 38.213]

- PUCCH resource indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]

- PDSCH-to-HARQ_feedback timing indicator – 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]

- Antenna port(s) – 4, 5, or 6 bits as defined by Tables 7.3.1.2.2-1/2/3/4, where the number of CDM groups without data of values 1, 2, and 3 refers to CDM groups {0}, {0,1}, and {0, 1,2} respectively.

- Transmission configuration indication – 0 bit if higher layer parameter *tci-PresentInDCI* is not enabled; otherwise 3 bits as defined in Subclause x.x of [6, TS38.214].

- SRS request – 2 bits as defined by Table 7.3.1.1.2-24 for UEs not configured with SUL in the cell; 3 bits for UEs configured SUL in the cell where the first bit is the non-SUL/SUL indicator as defined in Table 7.3.1.1.1-1 and the second and third bits are defined by Table 7.3.1.1.2-24.

- CBG transmission information (CBGTI) – 0, 2, 4, 6, or 8 bits as defined in Subclause x.x of [6, TS38.214], determined by higher layer parameter *maxCodeBlockGroupsPerTransportBlock* for the PDSCH.

- CBG flushing out information (CBGFI) – 0 or 1 bit as defined in Subclause x.x of [6, TS38.214], determined by higher layer parameter *codeBlockGroupFlushIndicator*.

- DMRS sequence initialization – 1 bit for $n_{\mathrm{SCID}}$ selection defined in Subclause 7.4.1.1.1 of [4, TS 38.211].

The following information is transmitted by means of the DCI format 1_1 with CRC scrambled by CS-RNTI:

- XXX – x bit

**Table 7.3.1.2.2-1: Antenna port(s) (1000 + DMRS port), *DL-DMRS-config-type*=1, *DL-DMRS-max-len*=1**

| One Codeword:<br>Codeword 0 enabled,<br>Codeword 1 disabled | | |
|---|---|---|
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 1 | 0 |
| 1 | 1 | 1 |
| 2 | 1 | 0,1 |
| 3 | 2 | 0 |
| 4 | 2 | 1 |
| 5 | 2 | 2 |
| 6 | 2 | 3 |
| 7 | 2 | 0,1 |
| 8 | 2 | 2,3 |
| 9 | 2 | 0-2 |
| 10 | 2 | 0-3 |
| 11 | 2 | 0,2 |
| 12-15 | Reserved | Reserved |

**Table 7.3.1.2.2-2: Antenna port(s) (1000 + DMRS port), *DL-DMRS-config-type*=1, *DL-DMRS-max-len*=2**

| One Codeword: Codeword 0 enabled, Codeword 1 disabled | | | | Two Codewords: Codeword 0 enabled, Codeword 1 enabled | | | |
|---|---|---|---|---|---|---|---|
| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols | Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
| 0 | 1 | 0 | 1 | 0 | 2 | 0-4 | 2 |
| 1 | 1 | 1 | 1 | 1 | 2 | 0,1,2,3,4,6 | 2 |
| 2 | 1 | 0,1 | 1 | 2 | 2 | 0,1,2,3,4,5,6 | 2 |
| 3 | 2 | 0 | 1 | 3 | 2 | 0,1,2,3,4,5,6,7 | 2 |
| 4 | 2 | 1 | 1 | 4-31 | reserved | reserved | reserved |
| 5 | 2 | 2 | 1 | | | | |
| 6 | 2 | 3 | 1 | | | | |
| 7 | 2 | 0,1 | 1 | | | | |
| 8 | 2 | 2,3 | 1 | | | | |
| 9 | 2 | 0-2 | 1 | | | | |
| 10 | 2 | 0-3 | 1 | | | | |
| 11 | 2 | 0,2 | 1 | | | | |
| 12 | 2 | 0 | 2 | | | | |
| 13 | 2 | 1 | 2 | | | | |
| 14 | 2 | 2 | 2 | | | | |
| 15 | 2 | 3 | 2 | | | | |
| 16 | 2 | 4 | 2 | | | | |
| 17 | 2 | 5 | 2 | | | | |
| 18 | 2 | 6 | 2 | | | | |
| 19 | 2 | 7 | 2 | | | | |
| 20 | 2 | 0,1 | 2 | | | | |
| 21 | 2 | 2,3 | 2 | | | | |
| 22 | 2 | 4,5 | 2 | | | | |
| 23 | 2 | 6,7 | 2 | | | | |
| 24 | 2 | 0,4 | 2 | | | | |
| 25 | 2 | 2,6 | 2 | | | | |
| 26 | 2 | 0,1,4 | 2 | | | | |
| 27 | 2 | 2,3,6 | 2 | | | | |
| 28 | 2 | 0,1,4,5 | 2 | | | | |
| 29 | 2 | 2,3,6,7 | 2 | | | | |
| 30 | 2 | 0,2,4,6 | 2 | | | | |
| 31 | Reserved | Reserved | Reserved | | | | |

**Table 7.3.1.2.2-3: Antenna port(s) (1000 + DMRS port), *DL-DMRS-config-type*=2, *DL-DMRS-max-len*=1**

| One codeword:<br>Codeword 0 enabled,<br>Codeword 1 disabled | | | Two codewords:<br>Codeword 0 enabled,<br>Codeword 1 enabled | | |
|---|---|---|---|---|---|
| **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** | **Value** | **Number of DMRS CDM group(s) without data** | **DMRS port(s)** |
| 0 | 1 | 0 | 0 | 3 | 0-4 |
| 1 | 1 | 1 | 1 | 3 | 0-5 |
| 2 | 1 | 0,1 | 2-31 | reserved | reserved |
| 3 | 2 | 0 | | | |
| 4 | 2 | 1 | | | |
| 5 | 2 | 2 | | | |
| 6 | 2 | 3 | | | |
| 7 | 2 | 0,1 | | | |
| 8 | 2 | 2,3 | | | |
| 9 | 2 | 0-2 | | | |
| 10 | 2 | 0-3 | | | |
| 11 | 3 | 0 | | | |
| 12 | 3 | 1 | | | |
| 13 | 3 | 2 | | | |
| 14 | 3 | 3 | | | |
| 15 | 3 | 4 | | | |
| 16 | 3 | 5 | | | |
| 17 | 3 | 0,1 | | | |
| 18 | 3 | 2,3 | | | |
| 19 | 3 | 4,5 | | | |
| 20 | 3 | 0-2 | | | |
| 21 | 3 | 3-5 | | | |
| 22 | 3 | 0-3 | | | |
| 23 | 2 | 0,2 | | | |
| 24-31 | Reserved | Reserved | | | |

**Table 7.3.1.2.2-4: Antenna port(s) (1000 + DMRS port), *DL-DMRS-config-type*=2, *DL-DMRS-max-len*=2**

| One codeword: Codeword 0 enabled, Codeword 1 disabled | | | | Two Codewords: Codeword 0 enabled, Codeword 1 enabled | | | |
|---|---|---|---|---|---|---|---|
| Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols | Value | Number of DMRS CDM group(s) without data | DMRS port(s) | Number of front-load symbols |
| 0 | 1 | 0 | 1 | 0 | 3 | 0-4 | 1 |
| 1 | 1 | 1 | 1 | 1 | 3 | 0-5 | 1 |
| 2 | 1 | 0,1 | 1 | 2 | 2 | 0,1,2,3,6 | 2 |
| 3 | 2 | 0 | 1 | 3 | 2 | 0,1,2,3,6,8 | 2 |
| 4 | 2 | 1 | 1 | 4 | 2 | 0,1,2,3,6,7,8 | 2 |
| 5 | 2 | 2 | 1 | 5 | 2 | 0,1,2,3,6,7,8,9 | 2 |
| 6 | 2 | 3 | 1 | 6-63 | Reserved | Reserved | Reserved |
| 7 | 2 | 0,1 | 1 | | | | |
| 8 | 2 | 2,3 | 1 | | | | |
| 9 | 2 | 0-2 | 1 | | | | |
| 10 | 2 | 0-3 | 1 | | | | |
| 11 | 3 | 0 | 1 | | | | |
| 12 | 3 | 1 | 1 | | | | |
| 13 | 3 | 2 | 1 | | | | |
| 14 | 3 | 3 | 1 | | | | |
| 15 | 3 | 4 | 1 | | | | |
| 16 | 3 | 5 | 1 | | | | |
| 17 | 3 | 0,1 | 1 | | | | |
| 18 | 3 | 2,3 | 1 | | | | |
| 19 | 3 | 4,5 | 1 | | | | |
| 20 | 3 | 0-2 | 1 | | | | |
| 21 | 3 | 3-5 | 1 | | | | |
| 22 | 3 | 0-3 | 1 | | | | |
| 23 | 2 | 0,2 | 1 | | | | |
| 24 | 3 | 0 | 2 | | | | |
| 25 | 3 | 1 | 2 | | | | |
| 26 | 3 | 2 | 2 | | | | |
| 27 | 3 | 3 | 2 | | | | |
| 28 | 3 | 4 | 2 | | | | |
| 29 | 3 | 5 | 2 | | | | |
| 30 | 3 | 6 | 2 | | | | |
| 31 | 3 | 7 | 2 | | | | |
| 32 | 3 | 8 | 2 | | | | |
| 33 | 3 | 9 | 2 | | | | |
| 34 | 3 | 10 | 2 | | | | |
| 35 | 3 | 11 | 2 | | | | |
| 36 | 3 | 0,1 | 2 | | | | |
| 37 | 3 | 2,3 | 2 | | | | |
| 38 | 3 | 4,5 | 2 | | | | |
| 39 | 3 | 6,7 | 2 | | | | |
| 40 | 3 | 8,9 | 2 | | | | |
| 41 | 3 | 10,11 | 2 | | | | |
| 42 | 3 | 0,1,6 | 2 | | | | |
| 43 | 3 | 2,3,8 | 2 | | | | |
| 44 | 3 | 4,5,10 | 2 | | | | |
| 45 | 3 | 0,1,6,7 | 2 | | | | |
| 46 | 3 | 2,3,8,9 | 2 | | | | |
| 47 | 3 | 4,5,10,11 | 2 | | | | |
| 48 | 1 | 0 | 2 | | | | |
| 49 | 1 | 1 | 2 | | | | |
| 50 | 1 | 6 | 2 | | | | |
| 51 | 1 | 7 | 2 | | | | |
| 52 | 1 | 0,1 | 2 | | | | |
| 53 | 1 | 6,7 | 2 | | | | |
| 54 | 2 | 0,1 | 2 | | | | |
| 55 | 2 | 2,3 | 2 | | | | |
| 56 | 2 | 6,7 | 2 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 57 | 2 | 8,9 | 2 | | | | |
| 58-63 | Reserved | Reserved | Reserved | | | | |

#### 7.3.1.3 DCI formats for other purposes

##### 7.3.1.3.1 Format 2_0

DCI format 2_0 is used for notifying the slot format.

The following information is transmitted by means of the DCI format 2_0 with CRC scrambled by SFI-RNTI:

- Identifier for DCI formats – [1] bits
- Slot format indicator 1, Slot format indicator 2, …, Slot format indicator $N$.

The size of DCI format 2_0 is configurable by higher layers up to 128 bits, according to Subclause 11.1.1 of [5, TS 38.213].

##### 7.3.1.3.2 Format 2_1

DCI format 2_1 is used for notifying the PRB(s) and OFDM symbol(s) where UE may assume no transmission is intended for the UE.

The following information is transmitted by means of the DCI format 2_1 with CRC scrambled by INT-RNTI:

- Identifier for DCI formats – [1] bits
- Pre-emption indication 1, Pre-emption indication 2, …, Pre-emption indication $N$.

The size of DCI format 2_1 is configurable by higher layers up to 126 bits, according to Subclause 11.2 of [5, TS 38.213]. Each pre-emption indication is 14 bits.

##### 7.3.1.3.3 Format 2_2

DCI format 2_2 is used for the transmission of TPC commands for PUCCH and PUSCH.

The following information is transmitted by means of the DCI format 2_2 with CRC scrambled by TPC-PUSCH-RNTI or TPC-PUCCH-RNTI:

- Identifier for DCI formats – [1] bits
- TPC command number 1, TPC command number 2,…, TPC command number $N$

The parameter *xxx* provided by higher layers determines the index to the TPC command number for an UL of a cell. Each TPC command number is 2 bits.

If the number of information bits in format 2_2 is less than the payload size of format 0_0 as defined in the initial bandwidth part in the same serving cell, zeros shall be appended to format 2_2 until the payload size equals that of format 0_0 as defined in the initial bandwidth part in the same serving cell.

##### 7.3.1.3.4 Format 2_3

DCI format 2_3 is used for the transmission of a group of TPC commands for SRS transmissions by one or more UEs. Along with a TPC command, a SRS request may also be transmitted.

The following information is transmitted by means of the DCI format 2_3 with CRC scrambled by TPC-SRS-RNTI:

- Identifier for DCI formats – [1] bits
- block number 1, block number 2, …, block number $B$

  where the starting position of a block is determined by the parameter *startingBitOfFormat2_3* provided by higher layers for the UE configured with the block.

For an UL without PUCCH and PUSCH or an UL on which the SRS power control is not tied with PUSCH power control, one block is configured for the UE by higher layers, with the following fields defined for the block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Subclause x.x of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-5.

- TPC command number –2 bits

If the number of information bits in format 2_3 is less than the payload size of format 0_0 as defined in the initial bandwidth part in the same serving cell, zeros shall be appended to format 2_3 until the payload size equals that of format 0_0 as defined in the initial bandwidth part in the same serving cell.

## 7.3.2 CRC attachment

Error detection is provided on DCI transmissions through a Cyclic Redundancy Check (CRC).

The entire payload is used to calculate the CRC parity bits. Denote the bits of the payload by $a_0, a_1, a_2, a_3, \ldots, a_{A-1}$, and the parity bits by $p_0, p_1, p_2, p_3, \ldots, p_{L-1}$, where $A$ is the payload size and $L$ is the number of parity bits. Let $a'_0, a'_1, a'_2, a'_3, \ldots, a'_{A+L-1}$ be a bit sequence such that $a'_i = 1$ for $i = 0, 1, \ldots, L-1$ and $a'_i = a_{i-L}$ for $i = L, L+1, \ldots, A+L-1$. The parity bits are computed with input bit sequence $a'_0, a'_1, a'_2, a'_3, \ldots, a'_{A+L-1}$ and attached according to Subclause 5.1 by setting $L$ to 24 bits and using the generator polynomial $g_{\mathrm{CRC24C}}(D)$. The output bit $b_0, b_1, b_2, b_3, \ldots, b_{B-1}$ is

$b_k = a_k$ for $k = 0, 1, 2, \ldots, A-1$

$b_k = p_{k-A}$ for $k = A, A+1, A+2, \ldots, A+L-1$,

where $K = A + L$.

After attachment, the CRC parity bits are scrambled with the corresponding RNTI $x_{rnti,0}, x_{rnti,1}, \ldots, x_{rnti,15}$, where $x_{rnti,0}$ corresponds to the MSB of the RNTI, to form the sequence of bits $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$. The relation between $c_k$ and $b_k$ is:

$c_k = b_k$ for $k$ = 0, 1, 2, …, $A+7$

$c_k = \left(b_k + x_{rnti,k-A-8}\right) \bmod 2$ for $k$ = $A+8$, $A+9$, $A+10$,..., $A+23$.

## 7.3.3 Channel coding

Information bits are delivered to the channel coding block. They are denoted by $c_0, c_1, c_2, c_3, \ldots, c_{K-1}$, where $K$ is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting $n_{\max} = 9$, $I_{IL} = 1$, $n_{PC} = 0$, and $n_{PC}^{wm} = 0$.

After encoding the bits are denoted by $d_0, d_1, d_2, d_3, \ldots, d_{N-1}$, where $N$ is the number of coded bits.

## 7.3.4 Rate matching

The input bit sequence to rate matching is $d_0, d_1, d_2, \ldots, d_{N-1}$.

Rate matching is performed according to Subclause 5.4.1 by setting $I_{BIL} = 0$.

The output bit sequence after rate matching is denoted as $f_0, f_1, f_2, \ldots, f_{E-1}$.

# Annex <A> (informative): Change history

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2017-05 | RAN1#89 | R1-1707082 | | | | Draft skeleton | 0.0.0 |
| 2017-07 | AH_NR2 | R1-1712014 | | | | Inclusion of LDPC related agreements | 0.0.1 |
| 2017-08 | RAN1#90 | R1-1714564 | | | | Inclusion of Polar coding related agreements | 0.0.2 |
| 2017-08 | RAN1#90 | R1-1714659 | | | | Endorsed version by RAN1#90 as basis for further updates | 0.1.0 |
| 2017-09 | RAN1#90 | R1-1715322 | | | | Capturing additional agreements on LDPC and Polar code from RAN1 #90 | 0.1.1 |
| 2017-09 | RAN#77 | RP-171991 | | | | For information to plenary | 1.0.0 |
| 2017-09 | RAN1#90b | R1-1716928 | | | | Capturing additional agreements on LDPC and Polar code from RAN1 NR AH#3 | 1.0.1 |
| 2017-10 | RAN1#90b | R1-1719106 | | | | Endorsed as v1.1.0 | 1.1.0 |
| 2017-11 | RAN1#91 | R1-1719225 | | | | Capturing additional agreements on channel coding, etc. | 1.1.1 |
| 2017-11 | RAN1#91 | R1-1719245 | | | | Capturing additional agreements on DCI format, channel coding, etc. | 1.1.2 |
| 2017-11 | RAN1#91 | R1-1721049 | | | | Endorsed as v1.2.0 | 1.2.0 |
| 2017-12 | RAN1#91 | R1-1721342 | | | | Capturing additional agreements on UCI, DCI, channel coding, etc. | 1.2.1 |
| 2017-12 | RAN#78 | RP-172668 | | | | Endorsed version for approval by plenary. | 2.0.0 |
| 2017-12 | RAN#78 | | | | | Approved by plenary – Rel-15 spec under change control | 15.0.0 |
| 2018-03 | RAN#79 | RP-180200 | 0001 | - | F | CR capturing the Jan18 ad-hoc and RAN1#92 meeting agreements | 15.1.0 |
| 2018-04 | RAN#79 | | | | | MCC: correction of typo in DCI format 0_1 (time domain resource assignment) – higher layer parameter should be *pusch-AllocationList* | 15.1.1 |