3GPP TS 38.212 V15.3.0 (2018-09)

Technical Specification

3rd Generation Partnership Project;

Technical Specification Group Radio Access Network;

NR;

Multiplexing and channel coding

(Release 15)

** 

The present document has been developed within the 3rd Generation Partnership Project (3GPP TM) and may be further elaborated for the purposes of 3GPP..  
The present document has not been subject to any approval process by the 3GPPOrganizational Partners and shall not be implemented.  
This Specification is provided for future development work within 3GPPonly. The Organizational Partners accept no liability for any use of this Specification.  
Specifications and Reports for implementation of the 3GPP TM system should be obtained via the 3GPP Organizational Partners' Publications Offices.

Keywords

3GPP, New Radio, Layer 1

***3GPP***

Postal address

3GPP support office address

650 Route des Lucioles - Sophia Antipolis

Valbonne - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

http://www.3gpp.org

***Copyright Notification***

No part may be reproduced except as authorized by written permission.  
The copyright and the foregoing restriction extend to reproduction in all media.

© 2018, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).

All rights reserved.

UMTS™ is a Trade Mark of ETSI registered for the benefit of its members

3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners  
LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners

GSM® and the GSM logo are registered and owned by the GSM Association

Contents

Foreword 5

1 Scope 6

2 References 6

3 Definitions, symbols and abbreviations 6

3.1 Definitions 6

3.2 Symbols 6

3.3 Abbreviations 6

4 Mapping to physical channels 7

4.1 Uplink 7

4.2 Downlink 8

5 General procedures 8

5.1 CRC calculation 8

5.2 Code block segmentation and code block CRC attachment 9

5.2.1 Polar coding 9

5.2.2 Low density parity check coding 10

5.3 Channel coding 11

5.3.1 Polar coding 12

5.3.1.1 Interleaving 12

5.3.1.2 Polar encoding 13

5.3.2 Low density parity check coding 17

5.3.3 Channel coding of small block lengths 24

5.3.3.1 Encoding of 1-bit information 24

5.3.3.2 Encoding of 2-bit information 24

5.3.3.3 Encoding of other small block lengths 24

5.4 Rate matching 25

5.4.1 Rate matching for Polar code 25

5.4.1.1 Sub-block interleaving 25

5.4.1.2 Bit selection 26

5.4.1.3 Interleaving of coded bits 27

5.4.2 Rate matching for LDPC code 28

5.4.2.1 Bit selection 28

5.4.2.2 Bit interleaving 30

5.4.3 Rate matching for channel coding of small block lengths 30

5.5 Code block concatenation 31

6 Uplink transport channels and control information 31

6.1 Random access channel 31

6.2 Uplink shared channel 31

6.2.1 Transport block CRC attachment 31

6.2.2 LDPC base graph selection 32

6.2.3 Code block segmentation and code block CRC attachment 32

6.2.4 Channel coding of UL-SCH 32

6.2.5 Rate matching 32

6.2.6 Code block concatenation 32

6.2.7 Data and control multiplexing 32

6.3 Uplink control information 42

6.3.1 Uplink control information on PUCCH 42

6.3.1.1 UCI bit sequence generation 43

6.3.1.1.1 HARQ-ACK/SR only 43

6.3.1.1.2 CSI only 43

6.3.1.1.3 HARQ-ACK/SR and CSI 50

6.3.1.2 Code block segmentation and CRC attachment 51

6.3.1.2.1 UCI encoded by Polar code 51

6.3.1.2.2 UCI encoded by channel coding of small block lengths 51

6.3.1.3 Channel coding of UCI 51

6.3.1.3.1 UCI encoded by Polar code 51

6.3.1.3.2 UCI encoded by channel coding of small block lengths 52

6.3.1.4 Rate matching 52

6.3.1.4.1 UCI encoded by Polar code 52

6.3.1.4.2 UCI encoded by channel coding of small block lengths 53

6.3.1.5 Code block concatenation 53

6.3.1.6 Multiplexing of coded UCI bits to PUCCH 53

6.3.2 Uplink control information on PUSCH 56

6.3.2.1 UCI bit sequence generation 56

6.3.2.1.1 HARQ-ACK 56

6.3.2.1.2 CSI 56

6.3.2.2 Code block segmentation and CRC attachment 59

6.3.2.2.1 UCI encoded by Polar code 59

6.3.2.2.2 UCI encoded by channel coding of small block lengths 59

6.3.2.3 Channel coding of UCI 59

6.3.2.3.1 UCI encoded by Polar code 59

6.3.2.3.2 UCI encoded by channel coding of small block lengths 59

6.3.2.4 Rate matching 60

6.3.2.4.1 UCI encoded by Polar code 60

6.3.2.4.1.1 HARQ-ACK 60

6.3.2.4.1.2 CSI part 1 61

6.3.2.4.1.3 CSI part 2 64

6.3.2.4.2 UCI encoded by channel coding of small block lengths 65

6.3.2.4.2.1 HARQ-ACK 65

6.3.2.4.2.2 CSI part 1 66

6.3.2.4.2.3 CSI part 2 66

6.3.2.5 Code block concatenation 66

6.3.2.6 Multiplexing of coded UCI bits to PUSCH 66

7 Downlink transport channels and control information 66

7.1 Broadcast channel 66

7.1.1 PBCH payload generation 67

7.1.2 Scrambling 68

7.1.3 Transport block CRC attachment 69

7.1.4 Channel coding 69

7.1.5 Rate matching 69

7.2 Downlink shared channel and paging channel 69

7.2.1 Transport block CRC attachment 69

7.2.2 LDPC base graph selection 70

7.2.3 Code block segmentation and code block CRC attachment 70

7.2.4 Channel coding 70

7.2.5 Rate matching 70

7.2.6 Code block concatenation 70

7.3 Downlink control information 70

7.3.1 DCI formats 71

7.3.1.1 DCI formats for scheduling of PUSCH 71

7.3.1.1.1 Format 0\_0 71

7.3.1.1.2 Format 0\_1 74

7.3.1.2 DCI formats for scheduling of PDSCH 86

7.3.1.2.1 Format 1\_0 86

7.3.1.2.2 Format 1\_1 89

7.3.1.3 DCI formats for other purposes 96

7.3.1.3.1 Format 2\_0 96

7.3.1.3.2 Format 2\_1 96

7.3.1.3.3 Format 2\_2 96

7.3.1.3.4 Format 2\_3 96

7.3.2 CRC attachment 97

7.3.3 Channel coding 97

7.3.4 Rate matching 98

Annex <A> (informative): Change history 99

# Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

z the third digit is incremented when editorial only changes have been incorporated in the document.

# 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"

[9] 3GPP TS 38.331: "NR; Radio Resource Control (RRC) 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

CORESET Control resource set

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

TrCH Transport channel

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 , and the parity bits by , where  is the size of the input sequence and  is the number of parity bits. The parity bits are generated by one of the following cyclic generator polynomials:

-  for a CRC length ;

-  for a CRC length ;

-  for a CRC length ;

-  for a CRC length ;

-  for a CRC length ;

-  for a CRC length .

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



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

The bits after CRC attachment are denoted by , where . The relation between  and  is:

 for 

 for .

## 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 , where .

if 

Number of code blocks: ;

else

Number of code blocks: 

end if

;

for  to 

;

end for

for  to 

;

end for

;

for  to 

for  to 

;

;

end for

The sequence  is used to calculate the CRC parity bits  according to Subclause 5.1 with a generator polynomial of length .

for  to 

;

end for

end for

The value of  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 , where . If  is larger than the maximum code block size , segmentation of the input bit sequence is performed and an additional CRC sequence of  bits is attached to each code block.

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

- .

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

- .

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

if 



Number of code blocks: 



else



Number of code blocks: .



end if

The bits output from code block segmentation are denoted by , where  is the code block number, and  is the number of bits for the code block number .

The number of bits  in each code block is calculated as:

;

For LDPC base graph 1,

.

For LDPC base graph 2,

if 

;

elseif 

;

elseif 

;

else

;

end if

find the minimum value of  in all sets of lifting sizes in Table 5.3.2-1, denoted as , such that , and set  for LDPC base graph 1 and  for LDPC base graph 2;

The bit sequence  is calculated as:

;

for  to 

for  to 

;

;

end for

if 

The sequence  is used to calculate the CRC parity bits  according to Subclause 5.1 with the generator polynomial .

for  to 

;

end for

end if

for  to  -- Insertion of filler bits

;

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, where  is the number of bits to encode. After encoding the bits are denoted by, where  and the value of  is determined by the following:

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

If  and 

;

else

;

end if

;

;



where .

UE is not expected to be configured with , where  is the number of parity check bits defined in Subclause 5.3.1.2.

#### 5.3.1.1 Interleaving

The bit sequence  is interleaved into bit sequence  as follows:

, 

where the interleaving pattern  is given by the following:

if 

, 

else

;

for  to 

if 

;

;

end if

end for

end if

where  is given by Table 5.3.1.1-1 and .

Table 5.3.1.1-1: Interleaving pattern 

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |
| 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  is given by Table 5.3.1.2-1, where  denotes a bit index before Polar encoding for  and . The Polar sequence  is in ascending order of reliability , where  denotes the reliability of bit index .

For any code block encoded to  bits, a same Polar sequence  is used. The Polar sequence  is a subset of Polar sequence  with all elements  of values less than , ordered in ascending order of reliability .

Denote  as a set of bit indices in Polar sequence , and  as the set of other bit indices in Polar sequence , where  and  are given in Subclause 5.4.1.1, , , and  is the number of parity check bits.

Denote  as the -th Kronecker power of matrix , where .

For a bit index  with , denote  as the -th row of  and  as the row weight of , where  is the number of ones in . Denote the set of bit indices for parity check bits as , where . A number of  parity check bits are placed in the  least reliable bit indices in . A number of  other parity check bits are placed in the bit indices of minimum row weight in , where  denotes the  most reliable bit indices in ; if there are more than  bit indices of the same minimum row weight in , the  other parity check bits are placed in the  bit indices of the highest reliability and the minimum row weight in .

Generate  according to the following:

;

if 

; ; ; ; ;

for  to 

; ; ; ; ; ;

if 

if 

;

else

;

;

;

end if

else

;

end if

end for

else

for  to 

if 

;

;

else

;

end if

end for

end if

The output after encoding  is obtained by . The encoding is performed in GF(2).

Table 5.3.1.2-1: Polar sequence  and its corresponding reliability 

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 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 , where  is the number of bits to encode as defined in Subclause 5.2.2. After encoding the bits are denoted by , where  for LDPC base graph 1 and  for LDPC base graph 2, and the value of  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  in Table 5.3.2-1 which contains .

2) for  to 

if 

;

else

;

;

end if

end for

3) Generate  parity bits  such that , where ;  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  has 46 rows with row indices and 68 columns with column indices . For LDPC base graph 2, a matrix of  has 42 rows with row indices and 52 columns with column indices . The elements in  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  are of value 0.

The matrix  is obtained by replacing each element of  with a  matrix, according to the following:

- Each element of value 0 in  is replaced by an all zero matrix of size ;

- Each element of value 1 in  is replaced by a circular permutation matrix  of size , where  and  are the row and column indices of the element, and  is obtained by circularly shifting the identity matrix of size  to the right  times. The value of  is given by . The value of  is given by Tables 5.3.2-2 and 5.3.2-3 according to the set index  and LDPC base graph.

4) for  to 

;

end for

Table 5.3.2-1: Sets of LDPC lifting size 

|  |  |
| --- | --- |
| *Set index (**)* | *Set of lifting sizes (**)* |
| 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 () and its parity check matrices ()

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | | | | | | | |  | |  | | | | | | | |
| Row  index | Column  index | Set index | | | | | | | | Row  index | Column  index | Set index | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 250 | 307 | 73 | 223 | 211 | 294 | 0 | 135 | 15 | 1 | 96 | 2 | 290 | 120 | 0 | 348 | 6 | 138 |
| 1 | 69 | 19 | 15 | 16 | 198 | 118 | 0 | 227 | 10 | 65 | 210 | 60 | 131 | 183 | 15 | 81 | 220 |
| 2 | 226 | 50 | 103 | 94 | 188 | 167 | 0 | 126 | 13 | 63 | 318 | 130 | 209 | 108 | 81 | 182 | 173 |
| 3 | 159 | 369 | 49 | 91 | 186 | 330 | 0 | 134 | 18 | 75 | 55 | 184 | 209 | 68 | 176 | 53 | 142 |
| 5 | 100 | 181 | 240 | 74 | 219 | 207 | 0 | 84 | 25 | 179 | 269 | 51 | 81 | 64 | 113 | 46 | 49 |
| 6 | 10 | 216 | 39 | 10 | 4 | 165 | 0 | 83 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 59 | 317 | 15 | 0 | 29 | 243 | 0 | 53 | 16 | 1 | 64 | 13 | 69 | 154 | 270 | 190 | 88 | 78 |
| 10 | 229 | 288 | 162 | 205 | 144 | 250 | 0 | 225 | 3 | 49 | 338 | 140 | 164 | 13 | 293 | 198 | 152 |
| 11 | 110 | 109 | 215 | 216 | 116 | 1 | 0 | 205 | 11 | 49 | 57 | 45 | 43 | 99 | 332 | 160 | 84 |
| 12 | 191 | 17 | 164 | 21 | 216 | 339 | 0 | 128 | 20 | 51 | 289 | 115 | 189 | 54 | 331 | 122 | 5 |
| 13 | 9 | 357 | 133 | 215 | 115 | 201 | 0 | 75 | 22 | 154 | 57 | 300 | 101 | 0 | 114 | 182 | 205 |
| 15 | 195 | 215 | 298 | 14 | 233 | 53 | 0 | 135 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 23 | 106 | 110 | 70 | 144 | 347 | 0 | 217 | 17 | 0 | 7 | 260 | 257 | 56 | 153 | 110 | 91 | 183 |
| 18 | 190 | 242 | 113 | 141 | 95 | 304 | 0 | 220 | 14 | 164 | 303 | 147 | 110 | 137 | 228 | 184 | 112 |
| 19 | 35 | 180 | 16 | 198 | 216 | 167 | 0 | 90 | 16 | 59 | 81 | 128 | 200 | 0 | 247 | 30 | 106 |
| 20 | 239 | 330 | 189 | 104 | 73 | 47 | 0 | 105 | 17 | 1 | 358 | 51 | 63 | 0 | 116 | 3 | 219 |
| 21 | 31 | 346 | 32 | 81 | 261 | 188 | 0 | 137 | 21 | 144 | 375 | 228 | 4 | 162 | 190 | 155 | 129 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 1 | 42 | 130 | 260 | 199 | 161 | 47 | 1 | 183 |
| 1 | 0 | 2 | 76 | 303 | 141 | 179 | 77 | 22 | 96 | 12 | 233 | 163 | 294 | 110 | 151 | 286 | 41 | 215 |
| 2 | 239 | 76 | 294 | 45 | 162 | 225 | 11 | 236 | 13 | 8 | 280 | 291 | 200 | 0 | 246 | 167 | 180 |
| 3 | 117 | 73 | 27 | 151 | 223 | 96 | 124 | 136 | 18 | 155 | 132 | 141 | 143 | 241 | 181 | 68 | 143 |
| 4 | 124 | 288 | 261 | 46 | 256 | 338 | 0 | 221 | 19 | 147 | 4 | 295 | 186 | 144 | 73 | 148 | 14 |
| 5 | 71 | 144 | 161 | 119 | 160 | 268 | 10 | 128 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 222 | 331 | 133 | 157 | 76 | 112 | 0 | 92 | 19 | 0 | 60 | 145 | 64 | 8 | 0 | 87 | 12 | 179 |
| 8 | 104 | 331 | 4 | 133 | 202 | 302 | 0 | 172 | 1 | 73 | 213 | 181 | 6 | 0 | 110 | 6 | 108 |
| 9 | 173 | 178 | 80 | 87 | 117 | 50 | 2 | 56 | 7 | 72 | 344 | 101 | 103 | 118 | 147 | 166 | 159 |
| 11 | 220 | 295 | 129 | 206 | 109 | 167 | 16 | 11 | 8 | 127 | 242 | 270 | 198 | 144 | 258 | 184 | 138 |
| 12 | 102 | 342 | 300 | 93 | 15 | 253 | 60 | 189 | 10 | 224 | 197 | 41 | 8 | 0 | 204 | 191 | 196 |
| 14 | 109 | 217 | 76 | 79 | 72 | 334 | 0 | 95 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 132 | 99 | 266 | 9 | 152 | 242 | 6 | 85 | 20 | 0 | 151 | 187 | 301 | 105 | 265 | 89 | 6 | 77 |
| 16 | 142 | 354 | 72 | 118 | 158 | 257 | 30 | 153 | 3 | 186 | 206 | 162 | 210 | 81 | 65 | 12 | 187 |
| 17 | 155 | 114 | 83 | 194 | 147 | 133 | 0 | 87 | 9 | 217 | 264 | 40 | 121 | 90 | 155 | 15 | 203 |
| 19 | 255 | 331 | 260 | 31 | 156 | 9 | 168 | 163 | 11 | 47 | 341 | 130 | 214 | 144 | 244 | 5 | 167 |
| 21 | 28 | 112 | 301 | 187 | 119 | 302 | 31 | 216 | 22 | 160 | 59 | 10 | 183 | 228 | 30 | 30 | 130 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 105 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 1 | 249 | 205 | 79 | 192 | 64 | 162 | 6 | 197 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 121 | 102 | 175 | 131 | 46 | 264 | 86 | 122 |
| 2 | 0 | 106 | 205 | 68 | 207 | 258 | 226 | 132 | 189 | 16 | 109 | 328 | 132 | 220 | 266 | 346 | 96 | 215 |
| 1 | 111 | 250 | 7 | 203 | 167 | 35 | 37 | 4 | 20 | 131 | 213 | 283 | 50 | 9 | 143 | 42 | 65 |
| 2 | 185 | 328 | 80 | 31 | 220 | 213 | 21 | 225 | 21 | 171 | 97 | 103 | 106 | 18 | 109 | 199 | 216 |
| 4 | 63 | 332 | 280 | 176 | 133 | 302 | 180 | 151 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 117 | 256 | 38 | 180 | 243 | 111 | 4 | 236 | 22 | 0 | 64 | 30 | 177 | 53 | 72 | 280 | 44 | 25 |
| 6 | 93 | 161 | 227 | 186 | 202 | 265 | 149 | 117 | 12 | 142 | 11 | 20 | 0 | 189 | 157 | 58 | 47 |
| 7 | 229 | 267 | 202 | 95 | 218 | 128 | 48 | 179 | 13 | 188 | 233 | 55 | 3 | 72 | 236 | 130 | 126 |
| 8 | 177 | 160 | 200 | 153 | 63 | 237 | 38 | 92 | 17 | 158 | 22 | 316 | 148 | 257 | 113 | 131 | 178 |
| 9 | 95 | 63 | 71 | 177 | 0 | 294 | 122 | 24 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 39 | 129 | 106 | 70 | 3 | 127 | 195 | 68 | 23 | 1 | 156 | 24 | 249 | 88 | 180 | 18 | 45 | 185 |
| 13 | 142 | 200 | 295 | 77 | 74 | 110 | 155 | 6 | 2 | 147 | 89 | 50 | 203 | 0 | 6 | 18 | 127 |
| 14 | 225 | 88 | 283 | 214 | 229 | 286 | 28 | 101 | 10 | 170 | 61 | 133 | 168 | 0 | 181 | 132 | 117 |
| 15 | 225 | 53 | 301 | 77 | 0 | 125 | 85 | 33 | 18 | 152 | 27 | 105 | 122 | 165 | 304 | 100 | 199 |
| 17 | 245 | 131 | 184 | 198 | 216 | 131 | 47 | 96 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 205 | 240 | 246 | 117 | 269 | 163 | 179 | 125 | 24 | 0 | 112 | 298 | 289 | 49 | 236 | 38 | 9 | 32 |
| 19 | 251 | 205 | 230 | 223 | 200 | 210 | 42 | 67 | 3 | 86 | 158 | 280 | 157 | 199 | 170 | 125 | 178 |
| 20 | 117 | 13 | 276 | 90 | 234 | 7 | 66 | 230 | 4 | 236 | 235 | 110 | 64 | 0 | 249 | 191 | 2 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 116 | 339 | 187 | 193 | 266 | 288 | 28 | 156 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 | 222 | 234 | 281 | 124 | 0 | 194 | 6 | 58 |
| 3 | 0 | 121 | 276 | 220 | 201 | 187 | 97 | 4 | 128 | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 89 | 87 | 208 | 18 | 145 | 94 | 6 | 23 | 25 | 1 | 23 | 72 | 172 | 1 | 205 | 279 | 4 | 27 |
| 3 | 84 | 0 | 30 | 165 | 166 | 49 | 33 | 162 | 6 | 136 | 17 | 295 | 166 | 0 | 255 | 74 | 141 |
| 4 | 20 | 275 | 197 | 5 | 108 | 279 | 113 | 220 | 7 | 116 | 383 | 96 | 65 | 0 | 111 | 16 | 11 |
| 6 | 150 | 199 | 61 | 45 | 82 | 139 | 49 | 43 | 14 | 182 | 312 | 46 | 81 | 183 | 54 | 28 | 181 |
| 7 | 131 | 153 | 175 | 142 | 132 | 166 | 21 | 186 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 243 | 56 | 79 | 16 | 197 | 91 | 6 | 96 | 26 | 0 | 195 | 71 | 270 | 107 | 0 | 325 | 21 | 163 |
| 10 | 136 | 132 | 281 | 34 | 41 | 106 | 151 | 1 | 2 | 243 | 81 | 110 | 176 | 0 | 326 | 142 | 131 |
| 11 | 86 | 305 | 303 | 155 | 162 | 246 | 83 | 216 | 4 | 215 | 76 | 318 | 212 | 0 | 226 | 192 | 169 |
| 12 | 246 | 231 | 253 | 213 | 57 | 345 | 154 | 22 | 15 | 61 | 136 | 67 | 127 | 277 | 99 | 197 | 98 |
| 13 | 219 | 341 | 164 | 147 | 36 | 269 | 87 | 24 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 211 | 212 | 53 | 69 | 115 | 185 | 5 | 167 | 27 | 1 | 25 | 194 | 210 | 208 | 45 | 91 | 98 | 165 |
| 16 | 240 | 304 | 44 | 96 | 242 | 249 | 92 | 200 | 6 | 104 | 194 | 29 | 141 | 36 | 326 | 140 | 232 |
| 17 | 76 | 300 | 28 | 74 | 165 | 215 | 173 | 32 | 8 | 194 | 101 | 304 | 174 | 72 | 268 | 22 | 9 |
| 18 | 244 | 271 | 77 | 99 | 0 | 143 | 120 | 235 | 49 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 144 | 39 | 319 | 30 | 113 | 121 | 2 | 172 | 28 | 0 | 128 | 222 | 11 | 146 | 275 | 102 | 4 | 32 |
| 21 | 12 | 357 | 68 | 158 | 108 | 121 | 142 | 219 | 4 | 165 | 19 | 293 | 153 | 0 | 1 | 1 | 43 |
| 22 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 19 | 181 | 244 | 50 | 217 | 155 | 40 | 40 | 200 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 63 | 274 | 234 | 114 | 62 | 167 | 93 | 205 |
| 4 | 0 | 157 | 332 | 233 | 170 | 246 | 42 | 24 | 64 | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 102 | 181 | 205 | 10 | 235 | 256 | 204 | 211 | 29 | 1 | 86 | 252 | 27 | 150 | 0 | 273 | 92 | 232 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 236 | 5 | 308 | 11 | 180 | 104 | 136 | 32 |
| 5 | 0 | 205 | 195 | 83 | 164 | 261 | 219 | 185 | 2 | 18 | 84 | 147 | 117 | 53 | 0 | 243 | 106 | 118 |
| 1 | 236 | 14 | 292 | 59 | 181 | 130 | 100 | 171 | 25 | 6 | 78 | 29 | 68 | 42 | 107 | 6 | 103 |
| 3 | 194 | 115 | 50 | 86 | 72 | 251 | 24 | 47 | 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 231 | 166 | 318 | 80 | 283 | 322 | 65 | 143 | 30 | 0 | 216 | 159 | 91 | 34 | 0 | 171 | 2 | 170 |
| 16 | 28 | 241 | 201 | 182 | 254 | 295 | 207 | 210 | 10 | 73 | 229 | 23 | 130 | 90 | 16 | 88 | 199 |
| 21 | 123 | 51 | 267 | 130 | 79 | 258 | 161 | 180 | 13 | 120 | 260 | 105 | 210 | 252 | 95 | 112 | 26 |
| 22 | 115 | 157 | 279 | 153 | 144 | 283 | 72 | 180 | 24 | 9 | 90 | 135 | 123 | 173 | 212 | 20 | 105 |
| 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 183 | 278 | 289 | 158 | 80 | 294 | 6 | 199 | 31 | 1 | 95 | 100 | 222 | 175 | 144 | 101 | 4 | 73 |
| 6 | 22 | 257 | 21 | 119 | 144 | 73 | 27 | 22 | 7 | 177 | 215 | 308 | 49 | 144 | 297 | 49 | 149 |
| 10 | 28 | 1 | 293 | 113 | 169 | 330 | 163 | 23 | 22 | 172 | 258 | 66 | 177 | 166 | 279 | 125 | 175 |
| 11 | 67 | 351 | 13 | 21 | 90 | 99 | 50 | 100 | 25 | 61 | 256 | 162 | 128 | 19 | 222 | 194 | 108 |
| 13 | 244 | 92 | 232 | 63 | 59 | 172 | 48 | 92 | 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 11 | 253 | 302 | 51 | 177 | 150 | 24 | 207 | 32 | 0 | 221 | 102 | 210 | 192 | 0 | 351 | 6 | 103 |
| 18 | 157 | 18 | 138 | 136 | 151 | 284 | 38 | 52 | 12 | 112 | 201 | 22 | 209 | 211 | 265 | 126 | 110 |
| 20 | 211 | 225 | 235 | 116 | 108 | 305 | 91 | 13 | 14 | 199 | 175 | 271 | 58 | 36 | 338 | 63 | 151 |
| 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 | 121 | 287 | 217 | 30 | 162 | 83 | 20 | 211 |
| 7 | 0 | 220 | 9 | 12 | 17 | 169 | 3 | 145 | 77 | 54 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 44 | 62 | 88 | 76 | 189 | 103 | 88 | 146 | 33 | 1 | 2 | 323 | 170 | 114 | 0 | 56 | 10 | 199 |
| 4 | 159 | 316 | 207 | 104 | 154 | 224 | 112 | 209 | 2 | 187 | 8 | 20 | 49 | 0 | 304 | 30 | 132 |
| 7 | 31 | 333 | 50 | 100 | 184 | 297 | 153 | 32 | 11 | 41 | 361 | 140 | 161 | 76 | 141 | 6 | 172 |
| 8 | 167 | 290 | 25 | 150 | 104 | 215 | 159 | 166 | 21 | 211 | 105 | 33 | 137 | 18 | 101 | 92 | 65 |
| 14 | 104 | 114 | 76 | 158 | 164 | 39 | 76 | 18 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 34 | 0 | 127 | 230 | 187 | 82 | 197 | 60 | 4 | 161 |
| 8 | 0 | 112 | 307 | 295 | 33 | 54 | 348 | 172 | 181 | 7 | 167 | 148 | 296 | 186 | 0 | 320 | 153 | 237 |
| 1 | 4 | 179 | 133 | 95 | 0 | 75 | 2 | 105 | 15 | 164 | 202 | 5 | 68 | 108 | 112 | 197 | 142 |
| 3 | 7 | 165 | 130 | 4 | 252 | 22 | 131 | 141 | 17 | 159 | 312 | 44 | 150 | 0 | 54 | 155 | 180 |
| 12 | 211 | 18 | 231 | 217 | 41 | 312 | 141 | 223 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 102 | 39 | 296 | 204 | 98 | 224 | 96 | 177 | 35 | 1 | 161 | 320 | 207 | 192 | 199 | 100 | 4 | 231 |
| 19 | 164 | 224 | 110 | 39 | 46 | 17 | 99 | 145 | 6 | 197 | 335 | 158 | 173 | 278 | 210 | 45 | 174 |
| 21 | 109 | 368 | 269 | 58 | 15 | 59 | 101 | 199 | 12 | 207 | 2 | 55 | 26 | 0 | 195 | 168 | 145 |
| 22 | 241 | 67 | 245 | 44 | 230 | 314 | 35 | 153 | 22 | 103 | 266 | 285 | 187 | 205 | 268 | 185 | 100 |
| 24 | 90 | 170 | 154 | 201 | 54 | 244 | 116 | 38 | 57 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 | 0 | 37 | 210 | 259 | 222 | 216 | 135 | 6 | 11 |
| 9 | 0 | 103 | 366 | 189 | 9 | 162 | 156 | 6 | 169 | 14 | 105 | 313 | 179 | 157 | 16 | 15 | 200 | 207 |
| 1 | 182 | 232 | 244 | 37 | 159 | 88 | 10 | 12 | 15 | 51 | 297 | 178 | 0 | 0 | 35 | 177 | 42 |
| 10 | 109 | 321 | 36 | 213 | 93 | 293 | 145 | 206 | 18 | 120 | 21 | 160 | 6 | 0 | 188 | 43 | 100 |
| 11 | 21 | 133 | 286 | 105 | 134 | 111 | 53 | 221 | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 142 | 57 | 151 | 89 | 45 | 92 | 201 | 17 | 37 | 1 | 198 | 269 | 298 | 81 | 72 | 319 | 82 | 59 |
| 17 | 14 | 303 | 267 | 185 | 132 | 152 | 4 | 212 | 13 | 220 | 82 | 15 | 195 | 144 | 236 | 2 | 204 |
| 18 | 61 | 63 | 135 | 109 | 76 | 23 | 164 | 92 | 23 | 122 | 115 | 115 | 138 | 0 | 85 | 135 | 161 |
| 20 | 216 | 82 | 209 | 218 | 209 | 337 | 173 | 205 | 59 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 167 | 185 | 151 | 123 | 190 | 164 | 91 | 121 |
| 10 | 1 | 98 | 101 | 14 | 82 | 178 | 175 | 126 | 116 | 9 | 151 | 177 | 179 | 90 | 0 | 196 | 64 | 90 |
| 2 | 149 | 339 | 80 | 165 | 1 | 253 | 77 | 151 | 10 | 157 | 289 | 64 | 73 | 0 | 209 | 198 | 26 |
| 4 | 167 | 274 | 211 | 174 | 28 | 27 | 156 | 70 | 12 | 163 | 214 | 181 | 10 | 0 | 246 | 100 | 140 |
| 7 | 160 | 111 | 75 | 19 | 267 | 231 | 16 | 230 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 49 | 383 | 161 | 194 | 234 | 49 | 12 | 115 | 39 | 1 | 173 | 258 | 102 | 12 | 153 | 236 | 4 | 115 |
| 14 | 58 | 354 | 311 | 103 | 201 | 267 | 70 | 84 | 3 | 139 | 93 | 77 | 77 | 0 | 264 | 28 | 188 |
| 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 149 | 346 | 192 | 49 | 165 | 37 | 109 | 168 |
| 11 | 0 | 77 | 48 | 16 | 52 | 55 | 25 | 184 | 45 | 19 | 0 | 297 | 208 | 114 | 117 | 272 | 188 | 52 |
| 1 | 41 | 102 | 147 | 11 | 23 | 322 | 194 | 115 | 61 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 83 | 8 | 290 | 2 | 274 | 200 | 123 | 134 | 40 | 0 | 157 | 175 | 32 | 67 | 216 | 304 | 10 | 4 |
| 16 | 182 | 47 | 289 | 35 | 181 | 351 | 16 | 1 | 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 () and its parity check matrices ()

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | | | | | | | |  | |  | | | | | | | |
| Row  index | Column  index | Set index | | | | | | | | Row  index | Column  index | Set index | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 0 | 9 | 174 | 0 | 72 | 3 | 156 | 143 | 145 | 16 | 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 117 | 97 | 0 | 110 | 26 | 143 | 19 | 131 | 17 | 1 | 254 | 158 | 0 | 48 | 120 | 134 | 57 | 196 |
| 2 | 204 | 166 | 0 | 23 | 53 | 14 | 176 | 71 | 5 | 124 | 23 | 24 | 132 | 43 | 23 | 201 | 173 |
| 3 | 26 | 66 | 0 | 181 | 35 | 3 | 165 | 21 | 11 | 114 | 9 | 109 | 206 | 65 | 62 | 142 | 195 |
| 6 | 189 | 71 | 0 | 95 | 115 | 40 | 196 | 23 | 12 | 64 | 6 | 18 | 2 | 42 | 163 | 35 | 218 |
| 9 | 205 | 172 | 0 | 8 | 127 | 123 | 13 | 112 | 27 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 18 | 0 | 220 | 186 | 0 | 68 | 17 | 173 | 129 | 128 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 194 | 6 | 18 | 16 | 106 | 31 | 203 | 211 |
| 1 | 0 | 167 | 27 | 137 | 53 | 19 | 17 | 18 | 142 | 7 | 50 | 46 | 86 | 156 | 142 | 22 | 140 | 210 |
| 3 | 166 | 36 | 124 | 156 | 94 | 65 | 27 | 174 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 253 | 48 | 0 | 115 | 104 | 63 | 3 | 183 | 19 | 0 | 87 | 58 | 0 | 35 | 79 | 13 | 110 | 39 |
| 5 | 125 | 92 | 0 | 156 | 66 | 1 | 102 | 27 | 1 | 20 | 42 | 158 | 138 | 28 | 135 | 124 | 84 |
| 6 | 226 | 31 | 88 | 115 | 84 | 55 | 185 | 96 | 10 | 185 | 156 | 154 | 86 | 41 | 145 | 52 | 88 |
| 7 | 156 | 187 | 0 | 200 | 98 | 37 | 17 | 23 | 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 224 | 185 | 0 | 29 | 69 | 171 | 14 | 9 | 20 | 1 | 26 | 76 | 0 | 6 | 2 | 128 | 196 | 117 |
| 9 | 252 | 3 | 55 | 31 | 50 | 133 | 180 | 167 | 4 | 105 | 61 | 148 | 20 | 103 | 52 | 35 | 227 |
| 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 29 | 153 | 104 | 141 | 78 | 173 | 114 | 6 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 81 | 25 | 20 | 152 | 95 | 98 | 126 | 74 | 21 | 0 | 76 | 157 | 0 | 80 | 91 | 156 | 10 | 238 |
| 1 | 114 | 114 | 94 | 131 | 106 | 168 | 163 | 31 | 8 | 42 | 175 | 17 | 43 | 75 | 166 | 122 | 13 |
| 3 | 44 | 117 | 99 | 46 | 92 | 107 | 47 | 3 | 13 | 210 | 67 | 33 | 81 | 81 | 40 | 23 | 11 |
| 4 | 52 | 110 | 9 | 191 | 110 | 82 | 183 | 53 | 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 240 | 114 | 108 | 91 | 111 | 142 | 132 | 155 | 22 | 1 | 222 | 20 | 0 | 49 | 54 | 18 | 202 | 195 |
| 10 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 2 | 63 | 52 | 4 | 1 | 132 | 163 | 126 | 44 |
| 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 | 0 | 23 | 106 | 0 | 156 | 68 | 110 | 52 | 5 |
| 3 | 1 | 8 | 136 | 38 | 185 | 120 | 53 | 36 | 239 | 3 | 235 | 86 | 75 | 54 | 115 | 132 | 170 | 94 |
| 2 | 58 | 175 | 15 | 6 | 121 | 174 | 48 | 171 | 5 | 238 | 95 | 158 | 134 | 56 | 150 | 13 | 111 |
| 4 | 158 | 113 | 102 | 36 | 22 | 174 | 18 | 95 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 104 | 72 | 146 | 124 | 4 | 127 | 111 | 110 | 24 | 1 | 46 | 182 | 0 | 153 | 30 | 113 | 113 | 81 |
| 6 | 209 | 123 | 12 | 124 | 73 | 17 | 203 | 159 | 2 | 139 | 153 | 69 | 88 | 42 | 108 | 161 | 19 |
| 7 | 54 | 118 | 57 | 110 | 49 | 89 | 3 | 199 | 9 | 8 | 64 | 87 | 63 | 101 | 61 | 88 | 130 |
| 8 | 18 | 28 | 53 | 156 | 128 | 17 | 191 | 43 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 128 | 186 | 46 | 133 | 79 | 105 | 160 | 75 | 25 | 0 | 228 | 45 | 0 | 211 | 128 | 72 | 197 | 66 |
| 10 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 5 | 156 | 21 | 65 | 94 | 63 | 136 | 194 | 95 |
| 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 179 | 72 | 0 | 200 | 42 | 86 | 43 | 29 | 26 | 2 | 29 | 67 | 0 | 90 | 142 | 36 | 164 | 146 |
| 1 | 214 | 74 | 136 | 16 | 24 | 67 | 27 | 140 | 7 | 143 | 137 | 100 | 6 | 28 | 38 | 172 | 66 |
| 11 | 71 | 29 | 157 | 101 | 51 | 83 | 117 | 180 | 12 | 160 | 55 | 13 | 221 | 100 | 53 | 49 | 190 |
| 14 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 122 | 85 | 7 | 6 | 133 | 145 | 161 | 86 |
| 5 | 0 | 231 | 10 | 0 | 185 | 40 | 79 | 136 | 121 | 36 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 41 | 44 | 131 | 138 | 140 | 84 | 49 | 41 | 27 | 0 | 8 | 103 | 0 | 27 | 13 | 42 | 168 | 64 |
| 5 | 194 | 121 | 142 | 170 | 84 | 35 | 36 | 169 | 6 | 151 | 50 | 32 | 118 | 10 | 104 | 193 | 181 |
| 7 | 159 | 80 | 141 | 219 | 137 | 103 | 132 | 88 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 103 | 48 | 64 | 193 | 71 | 60 | 62 | 207 | 28 | 1 | 98 | 70 | 0 | 216 | 106 | 64 | 14 | 7 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 101 | 111 | 126 | 212 | 77 | 24 | 186 | 144 |
| 6 | 0 | 155 | 129 | 0 | 123 | 109 | 47 | 7 | 137 | 5 | 135 | 168 | 110 | 193 | 43 | 149 | 46 | 16 |
| 5 | 228 | 92 | 124 | 55 | 87 | 154 | 34 | 72 | 38 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 45 | 100 | 99 | 31 | 107 | 10 | 198 | 172 | 29 | 0 | 18 | 110 | 0 | 108 | 133 | 139 | 50 | 25 |
| 9 | 28 | 49 | 45 | 222 | 133 | 155 | 168 | 124 | 4 | 28 | 17 | 154 | 61 | 25 | 161 | 27 | 57 |
| 11 | 158 | 184 | 148 | 209 | 139 | 29 | 12 | 56 | 39 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 2 | 71 | 120 | 0 | 106 | 87 | 84 | 70 | 37 |
| 7 | 1 | 129 | 80 | 0 | 103 | 97 | 48 | 163 | 86 | 5 | 240 | 154 | 35 | 44 | 56 | 173 | 17 | 139 |
| 5 | 147 | 186 | 45 | 13 | 135 | 125 | 78 | 186 | 7 | 9 | 52 | 51 | 185 | 104 | 93 | 50 | 221 |
| 7 | 140 | 16 | 148 | 105 | 35 | 24 | 143 | 87 | 9 | 84 | 56 | 134 | 176 | 70 | 29 | 6 | 17 |
| 11 | 3 | 102 | 96 | 150 | 108 | 47 | 107 | 172 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 116 | 143 | 78 | 181 | 65 | 55 | 58 | 154 | 31 | 1 | 106 | 3 | 0 | 147 | 80 | 117 | 115 | 201 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 1 | 170 | 20 | 182 | 139 | 148 | 189 | 46 |
| 8 | 0 | 142 | 118 | 0 | 147 | 70 | 53 | 101 | 176 | 41 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 94 | 70 | 65 | 43 | 69 | 31 | 177 | 169 | 32 | 0 | 242 | 84 | 0 | 108 | 32 | 116 | 110 | 179 |
| 12 | 230 | 152 | 87 | 152 | 88 | 161 | 22 | 225 | 5 | 44 | 8 | 20 | 21 | 89 | 73 | 0 | 14 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 166 | 17 | 122 | 110 | 71 | 142 | 163 | 116 |
| 9 | 1 | 203 | 28 | 0 | 2 | 97 | 104 | 186 | 167 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 205 | 132 | 97 | 30 | 40 | 142 | 27 | 238 | 33 | 2 | 132 | 165 | 0 | 71 | 135 | 105 | 163 | 46 |
| 10 | 61 | 185 | 51 | 184 | 24 | 99 | 205 | 48 | 7 | 164 | 179 | 88 | 12 | 6 | 137 | 173 | 2 |
| 11 | 247 | 178 | 85 | 83 | 49 | 64 | 81 | 68 | 10 | 235 | 124 | 13 | 109 | 2 | 29 | 179 | 106 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 11 | 59 | 0 | 174 | 46 | 111 | 125 | 38 | 34 | 0 | 147 | 173 | 0 | 29 | 37 | 11 | 197 | 184 |
| 1 | 185 | 104 | 17 | 150 | 41 | 25 | 60 | 217 | 12 | 85 | 177 | 19 | 201 | 25 | 41 | 191 | 135 |
| 6 | 0 | 22 | 156 | 8 | 101 | 174 | 177 | 208 | 13 | 36 | 12 | 78 | 69 | 114 | 162 | 193 | 141 |
| 7 | 117 | 52 | 20 | 56 | 96 | 23 | 51 | 232 | 44 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 | 1 | 57 | 77 | 0 | 91 | 60 | 126 | 157 | 85 |
| 11 | 0 | 11 | 32 | 0 | 99 | 28 | 91 | 39 | 178 | 5 | 40 | 184 | 157 | 165 | 137 | 152 | 167 | 225 |
| 7 | 236 | 92 | 7 | 138 | 30 | 175 | 29 | 214 | 11 | 63 | 18 | 6 | 55 | 93 | 172 | 181 | 175 |
| 9 | 210 | 174 | 4 | 110 | 116 | 24 | 35 | 168 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 56 | 154 | 2 | 99 | 64 | 141 | 8 | 51 | 36 | 0 | 140 | 25 | 0 | 1 | 121 | 73 | 197 | 178 |
| 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 38 | 151 | 63 | 175 | 129 | 154 | 167 | 112 |
| 12 | 1 | 63 | 39 | 0 | 46 | 33 | 122 | 18 | 124 | 7 | 154 | 170 | 82 | 83 | 26 | 129 | 179 | 106 |
| 3 | 111 | 93 | 113 | 217 | 122 | 11 | 155 | 122 | 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 11 | 14 | 11 | 48 | 109 | 131 | 4 | 49 | 72 | 37 | 10 | 219 | 37 | 0 | 40 | 97 | 167 | 181 | 154 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 151 | 31 | 144 | 12 | 56 | 38 | 193 | 114 |
| 13 | 0 | 83 | 49 | 0 | 37 | 76 | 29 | 32 | 48 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 2 | 125 | 112 | 113 | 37 | 91 | 53 | 57 | 38 | 1 | 31 | 84 | 0 | 37 | 1 | 112 | 157 | 42 |
| 8 | 38 | 35 | 102 | 143 | 62 | 27 | 95 | 167 | 5 | 66 | 151 | 93 | 97 | 70 | 7 | 173 | 41 |
| 13 | 222 | 166 | 26 | 140 | 47 | 127 | 186 | 219 | 11 | 38 | 190 | 19 | 46 | 1 | 19 | 191 | 105 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 1 | 115 | 19 | 0 | 36 | 143 | 11 | 91 | 82 | 39 | 0 | 239 | 93 | 0 | 106 | 119 | 109 | 181 | 167 |
| 6 | 145 | 118 | 138 | 95 | 51 | 145 | 20 | 232 | 7 | 172 | 132 | 24 | 181 | 32 | 6 | 157 | 45 |
| 11 | 3 | 21 | 57 | 40 | 130 | 8 | 52 | 204 | 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 , where  is the number of bits to encode. After encoding the bits are denoted by .

#### 5.3.3.1 Encoding of 1-bit information

For , the code block is encoded according to Table 5.3.3.1-1, where  and  is the modulation order for the code block.

Table 5.3.3.1-1: Encoding of 1-bit information

|  |  |
| --- | --- |
|  | Encoded bits |
| 1 |  |
| 2 |  |
| 4 |  |
| 6 |  |
| 8 |  |

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 , the code block is encoded according to Table 5.3.3-2, where , , and  is the modulation order for the code block.

Table 5.3.3.2-1: Encoding of 2-bit information

|  |  |
| --- | --- |
|  | Encoded bits |
| 1 |  |
| 2 |  |
| 4 |  |
| 6 |  |
| 8 |  |

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 , the code block is encoded by , where , , and  represents the basis sequences as defined in Table 5.3.3.3-1.

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

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| i | Mi,0 | Mi,1 | Mi,2 | Mi,3 | Mi,4 | Mi,5 | Mi,6 | Mi,7 | Mi,8 | Mi,9 | Mi,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 . The output bit sequence after rate matching is denoted as .

#### 5.4.1.1 Sub-block interleaving

The bits input to the sub-block interleaver are the coded bits . The coded bits  are divided into 32 sub-blocks. The bits output from the sub-block interleaver are denoted as , generated as follows:

for  to 

;

;

;

end for

where the sub-block interleaver pattern  is given by Table 5.4.1.1-1.

Table 5.4.1.1-1: Sub-block interleaver pattern 

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 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  and  are determined as follows, where , , and  are defined in Subclause 5.3.1



if 

if  -- puncturing

for  to 

;

end for

if 

;

else

;

end if

else -- shortening

for  to 

;

end for

end if

end if

;

 comprises  most reliable bit indices in ;

;

#### 5.4.1.2 Bit selection

The bit sequence after the sub-block interleaver  from Subclause 5.4.1.1 is written into a circular buffer of length .

Denoting by  the rate matching output sequence length, the bit selection output bit sequence , , is generated as follows:

if  -- repetition

for  to 

;

end for

else

if  -- puncturing

for  to 

;

end for

else -- shortening

for  to 

;

end for

end if

end if

#### 5.4.1.3 Interleaving of coded bits

The bit sequence  is interleaved into bit sequence , as follows:

If 

Denote  as the smallest integer such that ;

;

for  to 

for  to 

if 

;

else

;

end if

;

end for

end for

;

for  to 

for  to 

if 

;



end if

end for

end for

else

for  to 

;

end for

end if

The value of  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 . The output bit sequence after rate matching is denoted as .

#### 5.4.2.1 Bit selection

The bit sequence after encoding  from Subclause 5.3.2 is written into a circular buffer of length  for the -th coded block, where  is defined in Subclause 5.3.2.

For the -th code block, let  if  and  otherwise, where, ,  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, which for UL-SCH is according to higher layer parameter *ULmaxRank* if the parameter is configured;

- maximum modulation order configured for the serving cell, if configured by higher layers; otherwise a maximum modulation order  is assumed for DL-SCH ;

- maximum coding rate of 948/1024;

-  is given by Table 5.4.2.1-1, where the value of  for DL-SCH is determined according to the initial bandwidth part if there is no other bandwidth part configured to the UE;

- ;

-  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 

|  |  |
| --- | --- |
| Maximum number of PRBs across all configured BWPs of a carrier |  |
| 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  the rate matching output sequence length for the -th coded block, where the value of  is determined as follows:

Set 

for  to 

if the -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]

;

else

if 

;

else

;

end if

;

end if

end for

where

-  is the number of transmission layers that the transport block is mapped onto;

-  is the modulation order;

-  is the total number of coded bits available for transmission of the transport block;

-  if CBGTI is not present in the DCI scheduling the transport block and  is the number of scheduled code blocks of the transport block if CBGTI is present in the DCI scheduling the transport block.

Denote by  the redundancy version number for this transmission (= 0, 1, 2 or 3), the rate matching output bit sequence , , is generated as follows, where  is given by Table 5.4.2.1-2 according to the value of  and LDPC base graph:

;

;

while 

if 

;

;

end if

;

end while

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

|  |  |  |
| --- | --- | --- |
|  |  | |
| LDPC base graph 1 | LDPC base graph 2 |
| 0 |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |

#### 5.4.2.2 Bit interleaving

The bit sequence  is interleaved to bit sequence , according to the following, where the value of  is the modulation order.

for  to 

for  to 

;

end for

end for

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

The input bit sequence to rate matching is . The output bit sequence after rate matching is denoted as , where  is the rate matching output sequence length. The bit sequence  is obtained by the following:

for  to 

;

end for

## 5.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences , for  and , where  is the number of rate matched bits for the -th code block. The output bit sequence from the code block concatenation block is the sequence  for .

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

Set  and 

while 

Set 

while 







end while



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, and the parity bits by, where  is the payload size and  is the number of parity bits. The lowest order information bit  is mapped to the most significant bit of the transport block as defined in Subclause 6.1.1 of [TS38.321].

The parity bits are computed and attached to the UL-SCH transport block according to Subclause 5.1, by setting  to 24 bits and using the generator polynomial  if ; and by setting  to 16 bits and using the generator polynomial  otherwise.

The bits after CRC attachment are denoted by , where .

### 6.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate  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 , or if  and , or if , LDPC base graph 2 is used;

- otherwise, LDPC base graph 1 is used,

where  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  where  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, where  is the code block number and  is the number of bits for code block number  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 , where  is the code block number, and  is the number of bits in code block number . The total number of code blocks is denoted by  and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by , where the values of  is given in Subclause 5.3.2.

### 6.2.5 Rate matching

Coded bits for each code block, denoted as , are delivered to the rate match block, where  is the code block number, and  is the number of encoded bits in code block number . The total number of code blocks is denoted by  and each code block is individually rate matched according to Subclause 5.4.2 by setting  if higher layer parameter *rateMatching* is set to *limitedBufferRM* and by setting  otherwise.

After rate matching, the bits are denoted by, where is the number of rate matched bits for code block number .

### 6.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences , for  and where  is the number of rate matched bits for the -th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by, where  is the total number of coded bits for transmission.

### 6.2.7 Data and control multiplexing

Denote the coded bits for UL-SCH as .

Denote the coded bits for HARQ-ACK, if any, as .

Denote the coded bits for CSI part 1, if any, as .

Denote the coded bits for CSI part 2, if any, as .

Denote the multiplexed data and control coded bit sequence as .

Denote  as the OFDM symbol index of the scheduled PUSCH, starting from 0 to , where  is the total number of OFDM symbols of the PUSCH, including all OFDM symbols used for DMRS.

Denote  as the subcarrier index of the scheduled PUSCH, starting from 0 to , where  is expressed as a number of subcarriers.

Denote  as the set of resource elements, in ascending order of indices , available for transmission of data in OFDM symbol , for .

Denote  as the number of elements in set . Denote  as the -th element in .

Denote  as the set of resource elements, in ascending order of indices , available for transmission of UCI in OFDM symbol , for . Denote  as the number of elements in set . Denote  as the -th element in . For any OFDM symbol that carriers DMRS of the PUSCH, . For any OFDM symbol that does not carry DMRS of the PUSCH, .

If frequency hopping is configured for the PUSCH,

- denote  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  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  as the OFDM symbol index of the first OFDM symbol that does not carry DMRS in the first hop;

- denote  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

-  and ;

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

- ;

- ;

- ; and

- ;

- if only HARQ-ACK and CSI part 1 are present for transmission on the PUSCH without UL-SCH, let

- ;

- ;

- ; and

- ;

- if HARQ-ACK, CSI part 1 and CSI part 2 are present for transmission on the PUSCH without UL-SCH, let

- ;

- ;

- if the number of HARQ-ACK information bits is more than 2,; otherwise, 

- ;

-  if the number of HARQ-ACK information bits is no more than 2, and  otherwise; and

-  if the number of HARQ-ACK information bits is no more than 2, and  otherwise;

- if CSI part 1 and CSI part 2 are present for transmission on the PUSCH without UL-SCH, let

- ;

- ;

- ; and

- ;

- let , and denote ,  as the number of OFDM symbols of the PUSCH in the first and second hop, respectively;

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH;

- ;

- 

- .

If frequency hopping is not configured for the PUSCH,

- denote  as the OFDM symbol index of the first OFDM symbol after the first set of consecutive OFDM symbol(s) carrying DMRS;

- denote  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 ;

- if CSI is present for transmission on the PUSCH, let  and ;

- let  and .

The multiplexed data and control coded bit sequence  is obtained according to the following:

**Step 1:**

Set  for ;

Set  for ;

Set  for ;

Set  for ;

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 ;

denote  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  and ;

if frequency hopping is not configured for the PUSCH, let ;

denote  as the set of reserved resource elements for potential HARQ-ACK transmission, in OFDM symbol , for ;

Set ;

Set ;

 for ;

for  to 

;

while 

if 

if 

;

;

end if

if 

;

;

end if

for  to 



;

end for

end if

;

end while

end for

else

 for ;

end if

Denote  as the number of elements in .

**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 ;

Set ;

Set ;

for  to 

;

while 

if 

if 

;

;

end if

if 

;

;

end if

for  to 

;

for  to 

;

;

;

end for

end for

;

for  to 

;

end for

;

;

;

;

end if

;

end while

end for

end if

**Step 3:**

if CSI is present for transmission on the PUSCH,

Set ;

Set ;

Set ;

for  to 

;

while 

;

end while

while 

if 

if 

;

;

end if

if 

;

;

end if

;

for  to 

;

for  to 

;

;

;

end for

end for

;

for  to 

;

end for

;

;

;

;

end if

;

end while

end for

Set ;

Set ;

Set ;

for  to 

;

while 

;

end while

while 

if 

if 

;

;

end if

if 

;

;

end if

for  to 

;

for  to 

;

;

;

end for

end for

;

for  to 

;

end for

;

;

;

;

end if

;

end while

end for

end if

**Step 4:**

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

Set ;

for  to 

if 

for  to 

;

for  to 

;

;

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 ;

Set ;

Set ;

for  to 

;

while 

if 

if 

;

;

end if

if 

;

;

end if

for  to 

;

for  to 

;

;

;

end for

end for

end if

;

end while

end for

end if

**Step 6:**

Set ;

for  to 

for  to 

;

for  to 

;

;

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  is determined by setting  for  and , where the HARQ-ACK bit sequence  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  is determined by setting  for ,  for , and , where the HARQ-ACK bit sequence  is given by Subclause 9.1 of [5, TS 38.213], and the SR bit sequence  is given by Subclause 9.2.5.1 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 5.2.2.2.1 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 ****and **** 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  for wideband PMI | | | Information field  for wideband PMI or per subband PMI | |
| (,) | |  |  | |
| *codebookMode*=1 | *codebookMode*=2 | *codebookMode*=1 | *codebookMode*=2 |
| Rank = 1 with >2 CSI-RS ports, |  |  | N/A | 2 | 4 |
| Rank = 1 with >2 CSI-RS ports, |  |  | N/A | 2 | 4 |
| Rank=2 with 4 CSI-RS ports, |  |  | 1 | 1 | 3 |
| Rank=2 with >4 CSI-RS ports, |  |  | 2 | 1 | 3 |
| Rank=2 with >4 CSI-RS ports, |  |  | 2 | 1 | 3 |
| Rank=3 or 4, with 4 CSI-RS ports |  | | 0 | 1 | |
| Rank=3 or 4, with 8 or 12 CSI-RS ports |  | | 2 | 1 | |
| Rank=3 or 4 , with >=16 CSI-RS ports |  | | 2 | 1 | |
| Rank=5 or 6 |  | | N/A | 1 | |
| Rank=7 or 8, |  | | N/A | 1 | |
| Rank=7 or 8, |  | | N/A | 1 | |
| Rank=7 or 8, with  or or |  | | 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 and **** 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 for wideband | | | | | Information fields  for wideband  or per subband | | | |
| (,) |  |  |  |  |  |  |  |  |
| Rank=1 with  *codebookMode=1* |  | N/A | 2 | N/A | N/A | 2 | N/A | N/A | N/A |
| Rank=1 with  *codebookMode=1* |  | N/A | 2 | 2 | 2 | 2 | N/A | N/A | N/A |
| Rank=2 with ,  *codebookMode=1* |  | 1 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |
| Rank=3 or 4 with ,  *codebookMode=1* |  | 0 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |
| Rank=2 or 3 or 4 with ,  *codebookMode=1* |  | 2 | 2 | N/A | N/A | 1 | N/A | N/A | N/A |
| Rank=2 with ,  *codebookMode=1* |  | 1 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=3 or 4 with ,  *codebookMode=1* |  | 0 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=2 or 3 or 4 with ,  *codebookMode=1* |  | 2 | 2 | 2 | 2 | 1 | N/A | N/A | N/A |
| Rank=1 with  *codebookMode=2* |  | N/A | 2 | 2 | N/A | N/A | 2 | 1 | 1 |
| Rank=2 with ,  *codebookMode=2* |  | 1 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |
| Rank=3 or 4 with ,  *codebookMode=2* |  | 0 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |
| Rank=2 or 3 or 4 with ,  *codebookMode=2* |  | 2 | 2 | 2 | N/A | N/A | 1 | 1 | 1 |

The bitwidth for PMI with 1 CSI-RS port is 0.

The bitwidth for RI/LI/CQI/CRI of *codebookType=typeI-SinglePanel* is provided in Tables 6.3.1.1.2-3.

Table 6.3.1.1.2-3: RI, LI, CQI, and CRI of *codebookType=typeI-SinglePanel*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Field** | **Bitwidth** | | | | |
| **1 antenna port** | **2 antenna ports** | **4 antenna ports** | **>4 antenna ports** | |
| **Rank1~4** | **Rank5~8** |
| Rank Indicator | 0 |  |  |  |  |
| Layer Indicator | 0 |  |  |  |  |
| Wide-band CQI | 4 | 4 | 4 | 4 | 8 |
| Subband differential CQI | 2 | 2 | 2 | 2 | 4 |
| CRI |  |  |  |  |  |

 in Table 6.3.1.1.2-3 is the number of allowed rank indicator values according to Subclause 5.2.2.2.1 [6, TS 38.214].  is the value of the rank. The value of  is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI/CRI of *codebookType= typeI-MultiPanel* is provided in Table 6.3.1.1.2-4.

Table 6.3.1.1.2-4: RI, LI, CQI, and CRI of *codebookType=typeI-MultiPanel*

|  |  |
| --- | --- |
| Field | Bitwidth |
| Rank Indicator |  |
| Layer Indicator |  |
| Wide-band CQI | 4 |
| Subband differential CQI | 2 |
| CRI |  |

where  is the number of allowed rank indicator values according to Subclause 5.2.2.2.2 [6, TS 38.214],  is the value of the rank, and  is the number of CSI-RS resources in the corresponding resource set.

The bitwidth for RI/LI/CQI of *codebookType= typeII* or *codebookType=typeII-PortSelection* 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 |  |
| Layer Indicator |  |
| Wide-band CQI | 4 |
| Subband differential CQI | 2 |
| Indicator of the number of non-zero  wideband amplitude coefficients  for layer |  |

where  is the number of allowed rank indicator values according to Subclauses 5.2.2.2.3 and 5.2.2.2.4 [6, TS 38.214] and  is the value of the rank.

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

Table 6.3.1.1.2-6: CRI, SSBRI, and RSRP

|  |  |
| --- | --- |
| Field | Bitwidth |
| CRI |  |
| SSBRI |  |
| RSRP | 7 |
| Differential RSRP | 4 |

where  is the number of CSI-RS resources in the corresponding resource set, and  is the configured number of SS/PBCH blocks in the corresponding resource set for reporting 'ssb-Index-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, if reported |
| Rank Indicator as in Tables 6.3.1.1.2-3/4, if reported |
| Layer Indicator as in Tables 6.3.1.1.2-3/4, if reported |
| Zero padding bits , if needed |
| PMI wideband information fields , from left to right as in Tables 6.3.1.1.2-1/2, if reported |
| PMI wideband information fields , from left to right as in Tables 6.3.1.1.2-1/2, or codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214], if reported |
| Wideband CQI as in Tables 6.3.1.1.2-3/4, if reported |

The number of zero padding bits  in Table 6.3.1.1.2-7 is 0 for 1 CSI-RS port and  for more than 1 CSI-RS port, where

-  and  is the set of rank values  that are allowed to be reported;

- , where  is the reported rank;

- For 2 CSI-RS ports, ;

- For more than 2 CSI-RS ports, ;

- if PMI is reported,  and ; otherwise, ;

- if PMI  is reported,  is obtained according to Tables 6.3.1.1.2-1/2; otherwise, ;

- if PMI  is reported,  is obtained according to Tables 6.3.1.1.2-1/2; otherwise, ;

- if CQI is reported,  is obtained according to Tables 6.3.1.1.2-3/4; otherwise, ;

- if LI is reported,  is obtained according to Tables 6.3.1.1.2-3/4; otherwise, .

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

|  |  |
| --- | --- |
| CSI report number | CSI fields |
| CSI report #n | CRI or SSBRI #1 as in Table 6.3.1.1.2-6, if reported |
| CRI or SSBRI #2 as in Table 6.3.1.1.2-6, if reported |
| CRI or SSBRI #3 as in Table 6.3.1.1.2-6, if reported |
| CRI or SSBRI #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  CSI part 1 | CRI as in Tables 6.3.1.1.2-3/4, 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  for layer  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  CSI part 2 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 , from left to right as in Tables 6.3.1.1.2-1/2, if reported |
| PMI wideband information fields , from left to right as in Tables 6.3.1.1.2-1/2, or codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214], 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  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  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 codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214] of all even subbands with increasing order of subband number, 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  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 codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214] of all odd subbands with increasing order of subband number, 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  starting with .

Table 6.3.1.1.2-12: Mapping order of CSI reports to UCI bit sequence , without two-part CSI report(s)

|  |  |
| --- | --- |
| UCI bit sequence | CSI report number |
|  | CSI report #1  as in Table 6.3.1.1.2-7/8 |
| CSI report #2  as in Table 6.3.1.1.2-7/8 |
| … |
| CSI report #n  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,  and . 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  starting with . 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  starting with . If the length of UCI bit sequence  is less than 3 bits, zeros shall be appended to the UCI bit sequence until its length equals 3.

Table 6.3.1.1.2-13: Mapping order of CSI reports to UCI bit sequence ,   
with two-part CSI report(s)

|  |  |
| --- | --- |
| UCI bit sequence | CSI report number |
|  | CSI report #1 if CSI report #1 is not of two parts, or  CSI report #1, CSI part 1, if CSI report #1 is of two parts,  as in Table 6.3.1.1.2-7/8/9 |
| CSI report #2 if CSI report #2 is not of two parts, or  CSI report #2, CSI part 1, if CSI report #2 is of two parts,  as in Table 6.3.1.1.2-7/8/9 |
| … |
| CSI report #n if CSI report #n is not of two parts, or  CSI report #n, CSI part 1, if CSI report #n is of two parts,  as in Table 6.3.1.1.2-7/8/9 |

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.1.1.2-13 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

Table 6.3.1.1.2-14: Mapping order of CSI reports to UCI bit sequence ,   
with two-part CSI report(s)

|  |  |
| --- | --- |
| UCI bit sequence | CSI report number |
|  | 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 |

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.1.1.2-14 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

##### 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  is generated according to the following, where :

- if there is HARQ-ACK for transmission on the PUCCH, the HARQ-ACK bits are mapped to the UCI bit sequence , where  for , the HARQ-ACK bit sequence  is given by Subclause 9.1 of [5, TS38.213], and  is number of HARQ-ACK bits; if there is no HARQ-ACK for transmission on the PUCCH, set ;

- if there is SR for transmission on the PUCCH, set  for , where the SR bit sequence  is given by Subclause 9.2.5.1 of [5, TS 38.213]; if there is no SR for transmission on the PUCCH, set ;

- 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  starting with , where  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,  and , according to the following, where  and :

- if there is HARQ-ACK for transmission on the PUCCH, the HARQ-ACK bits are mapped to the UCI bit sequence , where  for , the HARQ-ACK bit sequence  is given by Subclause 9.1 of [5, TS38.213], and  is number of HARQ-ACK bits; if there is no HARQ-ACK for transmission on the PUCCH, set ;

- if there is SR for transmission on the PUCCH, set  for , where the SR bit sequence  is given by Subclause 9.2.5.1 of [5, TS 38.213]; if there is no SR for transmission on the PUCCH, set ;

- 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  starting with , where  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  starting with , where  is the number of CSI bits in CSI part 2 of all CSI reports. If the length of UCI bit sequence  is less than 3 bits, zeros shall be appended to the UCI bit sequence until its length equals 3.

#### 6.3.1.2 Code block segmentation and CRC attachment

The UCI bit sequence from subclause 6.3.1.1 is denoted by , where  is the payload size. The procedure in 6.3.1.2.1 applies for  and the procedure in Subclause 6.3.1.2.2 applies for .

##### 6.3.1.2.1 UCI encoded by Polar code

If the payload size , code block segmentation and CRC attachment is performed according to Subclause 5.2.1. If ( and ) or if , ; otherwise , where  is the rate matching output sequence length as given in Subclause 6.3.1.4.1.

If , the parity bits  in Subclause 5.2.1 are computed by setting  to 6 bits and using the generator polynomial  in Subclause 5.1, resulting in the sequence  where  is the code block number and  is the number of bits for code block number .

If , the parity bits  in Subclause 5.2.1 are computed by setting  to 11 bits and using the generator polynomial  in Subclause 5.1, resulting in the sequence  where  is the code block number and  is the number of bits for code block number .

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

If the payload size , CRC bits are not attached.

The output bit sequence is denoted by , where  for  and .

#### 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  , where  is the code block number, and  is the number of bits in code block number . The total number of code blocks is denoted by  and each code block is individually encoded by the following:

If , the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting , , ,  if  and  if , where  is the rate matching output sequence length as given in Subclause 6.3.1.4.1.

If , the information bits are encoded via Polar coding according to Subclause 5.3.1, by setting , , , and .

After encoding the bits are denoted by , where  is the number of coded bits in code block number .

##### 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 , where  is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by , where  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  is given by Table 6.3.1.4-1, where  , , and  are the number of symbols carrying UCI for PUCCH formats 2/3/4 respectively;  and  are the number of PRBs that are determined by the UE for PUCCH formats 2/3 transmission respectively according to Subclause 9.2 of [5, TS38.213]; and  is the spreading factor for PUCCH format 4.

Table 6.3.1.4-1: Total rate matching output sequence length 

|  |  |  |
| --- | --- | --- |
| *PUCCH format* | *Modulation order* | |
| QPSK | π/2-BPSK |
| PUCCH format 2 |  | N/A |
| PUCCH format 3 |  |  |
| PUCCH format 4 |  |  |

##### 6.3.1.4.1 UCI encoded by Polar code

The input bit sequence to rate matching is  where  is the code block number, and  is the number of coded bits in code block number .

Table 6.3.1.4.1-1: Rate matching output sequence length 

|  |  |  |
| --- | --- | --- |
| UCI(s) for transmission on a PUCCH | UCI for encoding | Value of |
| HARQ-ACK | HARQ-ACK |  |
| HARQ-ACK, SR | HARQ-ACK, SR |  |
| CSI  (CSI not of two parts) | CSI |  |
| HARQ-ACK, CSI  (CSI not of two parts) | HARQ-ACK, CSI |  |
| HARQ-ACK, SR, CSI  (CSI not of two parts) | HARQ-ACK, SR, CSI |  |
| CSI  (CSI of two parts) | CSI part 1 |  |
| CSI part 2 |  |
| HARQ-ACK, CSI  (CSI of two parts) | HARQ-ACK, CSI part 1 |  |
| CSI part 2 |  |
| HARQ-ACK, SR, CSI  (CSI of two parts) | HARQ-ACK, SR, CSI part 1 |  |
| CSI part 2 |  |

Rate matching is performed according to Subclause 5.4.1 by setting  and the rate matching output sequence length to , where  is the number of code blocks for UCI determined according to Subclause 6.3.1.2.1 and the value of  is given by Table 6.3.1.4.1-1:

-  is the number of bits for HARQ-ACK for transmission on the current PUCCH;

-  is the number of bits for SR for transmission on the current PUCCH;

-  is the number of bits for CSI part 1 for transmission on the current PUCCH;

-  is the number of bits for CSI part 2 for transmission on the current PUCCH;

- if ,  ; otherwise,  is the number of CRC bits determined according to subclause 6.3.1.2.1, where  equals  for "CSI (CSI of two parts)", equals  for "HARQ-ACK, CSI (CSI of two parts)", and equals  for "HARQ-ACK, SR, CSI (CSI of two parts)" respectively in Table 6.3.1.4.1-1;;

-  is the configured maximum PUCCH coding rate;

-  is given by Table 6.3.1.4-1.

The output bit sequence after rate matching is denoted as  where  is the length of rate matching output sequence in code block number .

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

The input bit sequence to rate matching is .

The value of  is determined according to Table 6.3.1.4.1-1 by setting .

Rate matching is performed according to Subclause 5.4.3 by setting the rate matching output sequence length .

The output bit sequence after rate matching is denoted as .

#### 6.3.1.5 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences, for  and where  is the number of rate matched bits for the -th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by, where  with the values of  and  given in Subclause 6.3.1.4.1. Let  be the total number of coded bits for transmission and . Set  for .

#### 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  is denoted by and the coded bits corresponding to UCI bit sequence  is denoted by . The coded bit sequence , where , 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 | 1st UCI symbol indices set | 2nd UCI symbol indices set | 3rd UCI symbol indices set |
| 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  as UCI OFDM symbol index. Denote  as the number of elements in UCI symbol indices set  for , where  and  are given by Table 6.3.1.6-1 according to the PUCCH duration and the PUCCH DMRS configuration. Denote  as the number of OFDM symbols carrying UCI in the PUCCH. Denote  as the modulation order of the PUCCH.

For PUCCH format 3, set  , where  is the number of PRBs that is determined by the UE for PUCCH format 3 transmission according to Subclause 9.2 of [5, TS 38.213].

For PUCCH format 4, set , where  is the spreading factor for PUCCH format 4.

Find the smallest such that .

Set ;

Set ;

Set ;

Set ;

for  to 

if 

for  to 

for  to 

;

;

end for

end for

elseif 

if 

;

else

;

end if

;

for  to 

for  to 

;

;

end for

end for

for  to 

for  to 

;

;

end for

end for

else

for  to 

for  to 

;

;

end for

end for

end if

end for

Set 

for  to 

for  to 

for  to 

;

;

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  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 , , and ;

- if there is only one HARQ-ACK bit  given by Subclause 9.1 of [5, TS 38.213], set , , and ;

- otherwise, ser  for  and , where the HARQ-ACK bit sequence  is given by Subclause 9.1 of [5, TS 38.213].

##### 6.3.2.1.2 CSI

The bitwidth for PMI of *codebookType=typeI-SinglePanel* and *codebookType=typeI-MultiPanel* is specified in Subclause 6.3.2.1.1.

The bitwidth for RI/LI/CQI/CRI of *codebookType=typeI-SinglePanel* and *codebookType=typeI-MultiPanel* is specified in Subclause 6.3.2.1.1.

The bitwidth for PMI of *codebookType=typeII* is provided in Tables 6.3.2.1.2-1, where the values of , , , , , , and  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 | | | |
|  |  |  |  |  |  |  |  |  |  |
| Rank=1  SBAmp off |  |  |  |  | N/A | N/A |  | N/A | N/A | N/A |
| Rank=2  SBAmp off |  |  |  |  |  |  |  |  | N/A | N/A |
| Rank=1  SBAmp on |  |  |  |  | N/A | N/A |  | N/A |  | N/A |
| Rank=2  SBAmp on |  |  |  |  |  |  |  |  |  |  |

The bitwidth for PMI of *codebookType= typeII-PortSelection* is provided in Tables 6.3.2.1.2-2, where the values of , , , , , , and  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 | | | |
|  |  |  |  |  |  |  |  |  |
| Rank=1  SBAmp off |  |  |  | N/A | N/A |  | N/A | N/A | N/A |
| Rank=2  SBAmp off |  |  |  |  |  |  |  | N/A | N/A |
| Rank=1  SBAmp on |  |  |  | N/A | N/A |  | N/A |  | N/A |
| Rank=2  SBAmp on |  |  |  |  |  |  |  |  |  |

For CSI on PUSCH, two UCI bit sequences are generated,  and . 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  starting with . 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  starting with .

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  CSI part 1 | CRI or SSBRI as in Tables 6.3.1.1.2-3/4/6, 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  for layer  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  CSI part 2 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 , 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 , from left to right as in Tables 6.3.1.1.2-1/2 or 6.3.2.1.2-1/2, or codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214], 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  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  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, or codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214] of all even subbands with increasing order of subband number, 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  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, or codebook index for 2 antenna ports according to Subclause 5.2.2.2.1 in [6, TS38.214] of all odd subbands with increasing order of subband number, if *pmi-FormatIndicator=* *subbandPMI* and if reported |

Table 6.3.2.1.2-6: Mapping order of CSI reports to UCI bit sequence ,   
with two-part CSI report(s)

|  |  |
| --- | --- |
| UCI bit sequence | CSI report number |
|  | 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 |

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.2.1.2-6 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

Table 6.3.2.1.2-7: Mapping order of CSI reports to UCI bit sequence ,   
with two-part CSI report(s)

|  |  |
| --- | --- |
| UCI bit sequence | CSI report number |
|  | CSI report #1, CSI part 2 wideband, as in Table 6.3.2.1.2-4 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 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 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 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  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  if CSI part 2 exists for CSI report #n |

where CSI report #1, CSI report #2, …, CSI report #n in Table 6.3.2.1.2-7 correspond to the CSI reports in increasing order of CSI report priority values according to Subclause 5.2.5 of [6, TS38.214].

#### 6.3.2.2 Code block segmentation and CRC attachment

Denote the bits of the payload by , where  is the payload size. The procedure in 6.3.2.2.1 applies for  and the procedure in Subclause 6.3.2.2.2 applies for .

##### 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, except that the rate matching output sequence length  is given in Subclause 6.3.2.4.1.

##### 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 , where  is the number of bits.

The information bits are encoded according to Subclause 5.3.3.

After encoding the bits are denoted by , where  is the number of coded bits.

#### 6.3.2.4 Rate matching

##### 6.3.2.4.1 UCI encoded by Polar code

###### 6.3.2.4.1.1 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 , is determined as follows:



where

-  is the number of HARQ-ACK bits;

- if , ; otherwise  is the number of CRC bits for HARQ-ACK determined according to Subclause 6.3.1.2.1;

- ;

-  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 -th code block, =0; otherwise,  is the -th code block size for UL-SCH of the PUSCH transmission;

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, ;

-  is configured by higher layer parameter *scaling*;

-  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 , is determined as follows:



where

-  is the number of HARQ-ACK bits;

- if , ; otherwise  is the number of CRC bits for HARQ-ACK defined according to Subclause 6.3.1.2.1;;

- ;

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, ;

-  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;

-  is the code rate of the PUSCH, determined according to Subclause 6.1.4.1 of [6, TS38.214];

-  is the modulation order of the PUSCH;

-  is configured by higher layer parameter *scaling*.

The input bit sequence to rate matching is  where  is the code block number, and  is the number of coded bits in code block number .

Rate matching is performed according to Subclause 5.4.1 by setting  and the rate matching output sequence length to , where

-  is the number of code blocks for UCI determined according to Subclause 5.2.1;

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH;

- .

The output bit sequence after rate matching is denoted as  where  is the length of rate matching output sequence in code block number .

###### 6.3.2.4.1.2 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 , is determined as follows:



where

-  is the number of bits for CSI part 1;

- if , ; otherwise  is the number of CRC bits for CSI part 1 determined according to Subclause 6.3.1.2.1;

- ;

-  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 -th code block, =0; otherwise, is the -th code block size for UL-SCH of the PUSCH transmission;

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  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  if the number of HARQ-ACK information bits is no more than 2 bits, where  is the number of reserved resource elements for potential HARQ-ACK transmission in OFDM symbol , for , in the PUSCH transmission, defined in Subclause 6.2.7;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, ;

-  is configured by higher layer parameter *scaling*.

For CSI part 1 transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as , is determined as follows:

if there is CSI part 2 to be transmitted on the PUSCH,



else



end if

where

-  is the number of bits for CSI part 1;

- if , ; otherwise  is the number of CRC bits for CSI part 1 determined according to Subclause 6.3.1.2.1;

- ;

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  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  if the number of HARQ-ACK information bits is no more than 2 bits, where  is the number of reserved resource elements for potential HARQ-ACK transmission in OFDM symbol , for , in the PUSCH transmission, defined in Subclause 6.2.7;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, ;

-  is the code rate of the PUSCH, determined according to Subclause 6.1.4.1 of [6, TS38.214];

-  is the modulation order of the PUSCH.

The input bit sequence to rate matching is  where  is the code block number, and  is the number of coded bits in code block number .

Rate matching is performed according to Subclause 5.4.1 by setting  and the rate matching output sequence length to , where

-  is the number of code blocks for UCI determined according to Subclause 5.2.1;

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH;

- .

The output bit sequence after rate matching is denoted as  where  is the length of rate matching output sequence in code block number .

###### 6.3.2.4.1.3 CSI 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 , is determined as follows:



where

-  is the number of bits for CSI part 2;

- if , ; otherwise  is the number of CRC bits for CSI part 2 determined according to Subclause 6.3.1.2.1;

- ;

-  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 -th code block, =0; otherwise, is the -th code block size for UL-SCH of the PUSCH transmission;

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  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  if the number of HARQ-ACK information bits is 1 or 2 bits;

-  is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, .

-  is configured by higher layer parameter *scaling*.

For CSI part 2 transmission on PUSCH without UL-SCH, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as , is determined as follows:



where

-  is the scheduled bandwidth of the PUSCH transmission, expressed as a number of subcarriers;

-  is the number of subcarriers in OFDM symbol  that carries PTRS, in the PUSCH transmission;

-  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  if the number of HARQ-ACK information bits is 1 or 2 bits;

-  is the number of coded modulation symbols per layer for CSI part 1 transmitted on the PUSCH;

-  is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission and  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, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH, .

The input bit sequence to rate matching is  where  is the code block number, and  is the number of coded bits in code block number .

Rate matching is performed according to Subclause 5.4.1 by setting  and the rate matching output sequence length to , where

-  is the number of code blocks for UCI determined according to Subclause 5.2.1;

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH;

- .

The output bit sequence after rate matching is denoted as  where  is the length of rate matching output sequence in code block number .

##### 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 , is determined according to Subclause 6.3.2.4.1.1, by setting the number of CRC bits .

The input bit sequence to rate matching is .

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length , where

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as .

###### 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 , is determined according to Subclause 6.3.2.4.1.2, by setting the number of CRC bits .

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length , where

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as .

###### 6.3.2.4.2.3 CSI 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 , is determined according to Subclause 6.3.2.4.1.3, by setting the number of CRC bits .

Rate matching is performed according to Subclause 5.4.3, by setting the rate matching output sequence length , where

-  is the number of transmission layers of the PUSCH;

-  is the modulation order of the PUSCH.

The output bit sequence after rate matching is denoted as .

#### 6.3.2.5 Code block concatenation

Code block concatenation is performed according to Subclause 6.3.1.5, except that the values of  and  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 , where  is the payload size generated by higher layers. The lowest order information bit  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 , where:

-  are the 4th, 3rd, 2nd, and 1st LSB of SFN, respectively;

-  is the half frame bit ;

- if 

 are the 6th, 5th, and 4th bits of SS/PBCH block index, respectively.

else

 is the MSB of  as defined in Subclause 7.4.3.1 of [4, TS 38.211].

 are reserved.

end if

Let ; ; ; ; ;

for  to 

if  is an SFN bit

;

;

elseif  is the half radio frame bit



elseif 

;

;

else

;

;

end if

end for

where  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  is given by Table 7.1.1-1.

Table 7.1.1-1: Value of PBCH payload interleaver pattern 

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 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  is scrambled into a bit sequence , where  for  and  is generated according to the following:

;

;

while 

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

;

else

;

;

end if

;

end while

The scrambling sequence  is given by Subclause 5.2.1of [4, TS38.211] and initialized with  at the start of each SFN satisfying ;  for  or , and  for , where  is the number of candidate SS/PBCH blocks in a half frame according to Subclause 4.1 of [5, TS38.213]; and  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  for PBCH scrambling

|  |  |
| --- | --- |
| *(3rd LSB of SFN, 2nd LSB of SFN)* | *Value of* |
| (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 , and the parity bits by, where  is the payload size and  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  to 24 bits and using the generator polynomial , resulting in the sequence, where .

The bit sequence  is the input bit sequence  to the channel encoder, where  for  and .

### 7.1.4 Channel coding

Information bits are delivered to the channel coding block. They are denoted by  , where  is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting , , , and .

After encoding the bits are denoted by , where  is the number of coded bits.

### 7.1.5 Rate matching

The input bit sequence to rate matching is .

The rate matching output sequence length .

Rate matching is performed according to Subclause 5.4.1 by setting .

The output bit sequence after rate matching is denoted as .

## 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, and the parity bits by, where  is the payload size and  is the number of parity bits. The lowest order information bit  is mapped to the most significant bit of the transport block as defined in Subclause 6.1.1 of [TS38.321].

The parity bits are computed and attached to the DL-SCH transport block according to Subclause 5.1, by setting  to 24 bits and using the generator polynomial  if ; and by setting  to 16 bits and using the generator polynomial  otherwise.

The bits after CRC attachment are denoted by , where .

### 7.2.2 LDPC base graph selection

For initial transmission of a transport block with coding rate  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 , or if  and , or if , LDPC base graph 2 is used;

- otherwise, LDPC base graph 1 is used,

where  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  where  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, where  is the code block number and  is the number of bits for code block number  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  , where  is the code block number, and  is the number of bits in code block number . The total number of code blocks is denoted by  and each code block is individually LDPC encoded according to Subclause 5.3.2.

After encoding the bits are denoted by , where the values of  is given in Subclause 5.3.2.

### 7.2.5 Rate matching

Coded bits for each code block, denoted as , are delivered to the rate match block, where  is the code block number, and  is the number of encoded bits in code block number . The total number of code blocks is denoted by  and each code block is individually rate matched according to Subclause 5.4.2 by setting .

After rate matching, the bits are denoted by, where is the number of rate matched bits for code block number .

### 7.2.6 Code block concatenation

The input bit sequence for the code block concatenation block are the sequences , for  and where  is the number of rate matched bits for the -th code block.

Code block concatenation is performed according to Subclause 5.5.

The bits after code block concatenation are denoted by, where  is the total number of coded bits for transmission.

## 7.3 Downlink control information

A DCI transports downlink control information for one or more cells with 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  to  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  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 .

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 or CS-RNTI or MCS-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 –  bits where

-  is the size of the active UL 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 configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

- otherwise,  is the size of the initial UL bandwidth part.

- For PUSCH hopping with resource allocation type 1:

-  MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where  if the higher layer parameter *frequencyHoppingOffsetLists* contains two offset values and  if the higher layer parameter *frequencyHoppingOffsetLists* contains four offset values

-  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:

-  bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – 4 bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]

- Frequency hopping flag – 1 bit according to Table 7.3.1.1.1-3, as defined in Subclause 6.3 of [6, TS 38.214]

- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.4.1 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 7.1.1 of [5, TS 38.213]

- Padding bits, if required.

- 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. The UL/SUL indicator, if present, locates in the last bit position of DCI format 0\_0, after the padding bit(s).

- If the UL/SUL indicator is present in DCI format 0\_0 and the higher layer parameter *pusch-Config* is not configured on both UL and SUL 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 UL or SUL for which high layer parameter *pucch-Config* is configured;

- 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 UL or SUL for which high layer parameter *pucch-Config* is configured.

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 –bits where

-  is the size of the initial UL bandwidth part.

- For PUSCH hopping with resource allocation type 1:

-  MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where  if  and  otherwise

-  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:

-  bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

- Time domain resource assignment – 4 bits as defined in Subclause 6.1.2.1 of [6, TS 38.214]

- Frequency hopping flag – 1 bit according to Table 7.3.1.1.1-3, as defined in Subclause 6.3 of [6, TS 38.214]

- Modulation and coding scheme – 5 bits as defined in Subclause 6.1.4.1 of [6, TS 38.214]

- 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 7.1.1 of [5, TS 38.213]

- Padding bits, if required.

- 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. The UL/SUL indicator, if present, locates in the last bit position of DCI format 0\_0, after the padding bit(s).

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

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 by truncating the first few most significant bits such that the size of DCI format 0\_0 equals to the size of the DCI format 1\_0.

If DCI format 0\_0 is monitored in UE specific search space but does not satisfy at least one of the following

- the total number of different DCI sizes configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

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 UE specific search space but does not satisfy at least one of the following

- the total number of different DCI sizes configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

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 by truncating the first few most significant bits such that the size of DCI format 0\_0 equals to the size of the DCI format 1\_0.

If DCI format 0\_0 is monitored in UE specific search space and satisfies both of the following

- the total number of different DCI sizes configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

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 UE specific 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.

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  to be applied |
| 00 | 0 |
| 01 | 1 |
| 10 | 2 |
| 11 | 3 |

Table 7.3.1.1.1-3: Frequency hopping indication

|  |  |
| --- | --- |
| **Bit field mapped to index** | **PUSCH frequency hopping** |
| 0 | Disabled |
| 1 | Enabled |

##### 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 or CS-RNTI or SP-CSI-RNTI or MCS-C-RNTI:

- Identifier for DCI formats – 1 bit

- The value of this bit field is always set to 0, indicating an UL DCI format

- Carrier indicator – 0 or 3 bits, as defined in Subclause 10.1 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.

- Bandwidth part indicator – 0, 1 or 2 bits as determined by the number of UL BWPs  configured by higher layers, excluding the initial UL bandwidth part. The bitwidth for this field is determined as bits, where

-  if , in which case the bandwidth part indicator is equivalent to the higher layer parameter *BWP-Id*;

- otherwise , in which case the bandwidth part indicator is defined in Table 7.3.1.1.2-1;

If a UE does not support active BWP change via DCI, the UE ignores this bit field.

- Frequency domain resource assignment – number of bits determined by the following, where  is the size of the active UL bandwidth part:

-  bits if only resource allocation type 0 is configured, where  is defined in Subclause 6.1.2.2.1 of [6, TS 38.214],

- bits if only resource allocation type 1 is configured, or  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  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  LSBs provide the resource allocation as follows:

- For PUSCH hopping with resource allocation type 1:

-  MSB bits are used to indicate the frequency offset according to Subclause 6.3 of [6, TS 38.214], where  if the higher layer parameter *frequencyHoppingOffsetLists* contains two offset values and  if the higher layer parameter *frequencyHoppingOffsetLists* contains four offset values

-  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:

-  bits provides the frequency domain resource allocation according to Subclause 6.1.2.2.2 of [6, TS 38.214]

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and if both resource allocation type 0 and 1 are configured for the indicated bandwidth part, the UE assumes resource allocation type 0 for the indicated bandwidth part if the bitwidth of the "Frequency domain resource assignment" field of the active bandwidth part is smaller than the bitwidth of the "Frequency domain resource assignment" field of the indicated bandwidth part.

- 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 bits, where *I* is the number of entries in the higher layer parameter *pusch-TimeDomainAllocationList.*

- Frequency hopping flag – 0 or 1 bit:

- 0 bit if only resource allocation type 0 is configured or if the higher layer parameter *frequencyHopping* is not configured;

- 1 bit according to Table 7.3.1.1.1-3 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 6.1.4.1 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.

- 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 – or  bits, where  is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*codeBook*' or '*nonCodeBook*', and  is the maximum number of supported layers for the PUSCH.

-  bits according to Tables 7.3.1.1.2-28/29/30/31 if the higher layer parameter *txConfig = nonCodebook*, where  is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*nonCodeBook*';

-  bits according to Tables 7.3.1.1.2-32 if the higher layer parameter *txConfig = codebook*, where  is the number of configured SRS resources in the SRS resource set associated with the higher layer parameter *usage* of value '*codeBook*'.

- Precoding information and number of layers – number of bits determined by the following:

- 0 bits if the higher layer parameter *txConfig = nonCodeBook*;

- 0 bits for 1 antenna port and if the higher layer parameter *txConfig = codebook*;

- 4, 5, or 6 bits according to Table 7.3.1.1.2-2 for 4 antenna ports, if *txConfig = codebook,* and according to whether transform precoder is enabled or disabled, and the values of higher layer parameters *maxRank*, and *codebookSubset*;

- 2, 4, or 5 bits according to Table 7.3.1.1.2-3 for 4 antenna ports, if *txConfig = codebook,* and according to whether transform precoder is enabled or disabled, and the values of higher layer parameters *maxRank*, and *codebookSubset*;

- 2 or 4 bits according to Table7.3.1.1.2-4 for 2 antenna ports, if *txConfig = codebook,* and according to whether transform precoder is enabled or disabled, and the values of higher layer parameters *maxRank* and *codebookSubset*;

- 1 or 3 bits according to Table7.3.1.1.2-5 for 2 antenna ports, if *txConfig = codebook,* and according to whether transform precoder is enabled or disabled, and the values of higher layer parameters *maxRank* and *codebookSubset*.

- Antenna ports – number of bits determined by the following

- 2 bits as defined by Tables 7.3.1.1.2-6, if transform precoder is enabled, *dmrs-Type*=1, and *maxLength*=1;

- 4 bits as defined by Tables 7.3.1.1.2-7, if transform precoder is enabled, *dmrs-Type*=1, and *maxLength*=2;

- 3 bits as defined by Tables 7.3.1.1.2-8/9/10/11, if transform precoder is disabled, *dmrs-Type*=1, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;

- 4 bits as defined by Tables 7.3.1.1.2-12/13/14/15, if transform precoder is disabled, *dmrs-Type*=1, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;

- 4 bits as defined by Tables 7.3.1.1.2-16/17/18/19, if transform precoder is disabled, *dmrs-Type*=2, and *maxLength*=1, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = codebook*;

- 5 bits as defined by Tables 7.3.1.1.2-20/21/22/23, if transform precoder is disabled, *dmrs-Type*=2, and *maxLength*=2, and the value of rank is determined according to the SRS resource indicator field if the higher layer parameter *txConfig = nonCodebook* and according to the Precoding information and number of layers field if the higher layer parameter *txConfig = 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.

If a UE is configured with both *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*, the bitwidth of this field equals , where  is the "Antenna ports" bitwidth derived according to *dmrs-UplinkForPUSCH-MappingTypeA* and  is the "Antenna ports" bitwidthderived according to *dmrs-UplinkForPUSCH-MappingTypeB*. A number of  zeros are padded in the MSB of this field, if the mapping type of the PUSCH corresponds to the smaller value of  and .

- 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 *PTRS-UplinkConfi*g is not configured and transform precoder is disabled, or if transform precoder is enabled, or if *maxRank=1*;

- 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 transmission of one PT-RS port and two PT-RS ports respectively, and the DMRS ports are indicated by the Antenna ports field.

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "PTRS-DMRS association" field is present for the indicated bandwidth part but not present for the active bandwidth part, the UE assumes the "PTRS-DMRS association" field is not present for the indicated bandwidth part.

- beta\_offset indicator – 0 if the higher layer parameter *betaOffsets = semiStatic*; otherwise 2 bits as defined by Table 9.3-3 in [5, TS 38.213].

- DMRS sequence initialization – 0 bit if the higher layer parameter transform precoder is enabled; 1 bit if the higher layer parameter transform precoder is disabled.

- UL-SCH indicator – 1 bit. A value of "1" indicates UL-SCH shall be transmitted on the PUSCH and a value of "0" indicates UL-SCH shall not be transmitted on the PUSCH. A UE is not expected to received a DCI format 0\_1 with UL-SCH indicator of "0" and CSI request of all zero(s).

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 |
| 2 bits |
| 00 | First bandwidth part configured by higher layers |
| 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 transform precoder is disabled and *maxRank* = 2 or 3 or 4

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | *codebookSubset* = *fullyAndPartialAndNonCoherent* | Bit field mapped to index | *codebookSubset* = *partialAndNonCoherent* | Bit field mapped to index | *codebookSubset*= *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 transform precoder is enabled, or if transform precoder is disabled and *maxRank* = 1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | *codebookSubset* = *fullyAndPartialAndNonCoherent* | Bit field mapped to index | *codebookSubset*= *partialAndNonCoherent* | Bit field mapped to index | *codebookSubset*= *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 transform precoder is disabledand *maxRank* = 2

|  |  |  |  |
| --- | --- | --- | --- |
| Bit field mapped to index | *codebookSubset* = *fullyAndPartialAndNonCoherent* | Bit field mapped to index | *codebookSubset* = *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 transform precoder is enabled, or if transform precoder is disabledand *maxRank* = 1

|  |  |  |  |
| --- | --- | --- | --- |
| Bit field mapped to index | *codebookSubset* = *fullyAndPartialAndNonCoherent* | Bit field mapped to index | *codebookSubset* = *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), transform precoder is enabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is enabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=1, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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), transform precoder is disabled, *dmrs-Type*=2, *maxLength*=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 | Triggered aperiodic SRS resource set(s) |
| 00 | No aperiodic SRS resource set triggered |
| 01 | SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 1 |
| 10 | SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 2 |
| 11 | SRS resource set(s) configured with higher layer parameter *aperiodicSRS-ResourceTrigger* set to 3 |

Table 7.3.1.1.2-25: PTRS-DMRS association for UL PTRS port 0

|  |  |
| --- | --- |
| **Value** | **DMRS port** |
| 0 | 1st scheduled DMRS port |
| 1 | 2nd scheduled DMRS port |
| 2 | 3rd scheduled DMRS port |
| 3 | 4th scheduled DMRS port |

Table 7.3.1.1.2-26: PTRS-DMRS association for UL PTRS ports 0 and 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Value of MSB** | **DMRS port** |  | **Value of LSB** | **DMRS port** |
| 0 | 1st DMRS port which shares PTRS port 0 |  | 0 | 1st DMRS port which shares PRTS port 1 |
| 1 | 2nd DMRS port which shares PTRS port 0 |  | 1 | 2nd DMRS port which shares PTRS port 1 |

Table 7.3.1.1.2-27: void

Table 7.3.1.1.2-28: SRI indication for non-codebook based PUSCH transmission, 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), |
| 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, 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), |
| 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, 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), |
| 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, 

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), | Bit field mapped to index | SRI(s), |
| 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), |
| 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 or CS-RNTI or MCS-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 –  bits

-  is the size of the active DL 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 configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

otherwise,  is the size of CORESET 0.

If the CRC of the DCI format 1\_0 is scrambled by C-RNTI and the "Frequency domain resource assignment" field are of all ones, the DCI format 1\_0 is for random access procedure initiated by a PDCCH order, with all remaining fields set as follows:

- Random Access Preamble index – 6 bits according to *ra-PreambleIndex* in Subclause 5.1.2 of [8, TS38.321]

- UL/SUL indicator – 1 bit. If the value of the "Random Access Preamble index" is not all zeros and if the UE is configured with SUL in the cell, this field indicates which UL carrier in the cell to transmit the PRACH according to Table 7.3.1.1.1-1; otherwise, this field is reserved

- SS/PBCH index – 6 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the SS/PBCH that shall be used to determine the RACH occasion for the PRACH transmission; otherwise, this field is reserved.

- PRACH Mask index – 4 bits. If the value of the "Random Access Preamble index" is not all zeros, this field indicates the RACH occasion associated with the SS/PBCH indicated by "SS/PBCH index" for the PRACH transmission, according to Subclause 5.1.1 of [8, TS38.321]; otherwise, this field is reserved

- Reserved bits – 10 bits

Otherwise, all remaining fields are set as follows:

- Time domain resource assignment – 4 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 9.2.3 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 – 2 bits according to Table 7.3.1.2.1-1.

- Short Messages – 8 bits, according to Subclause x.x of [9, TS38.331]. If only the scheduling information for Paging is carried, this bit field is reserved.

- Frequency domain resource assignment – bits. If only the short message is carried, this bit field is reserved.

-  is the size of CORESET 0

- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]. If only the short message is carried, this bit field is reserved.

- VRB-to-PRB mapping – 1 bit according to Table 7.3.1.1.2-33. If only the short message is carried, this bit field is reserved.

- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3 of [6, TS38.214], using Table 5.1.3.1-1. If only the short message is carried, this bit field is reserved.

- TB scaling – 2 bits as defined in Subclause 5.1.3.2 of [6, TS38.214]. If only the short message is carried, this bit field is reserved.

- Reserved bits – 6 bits

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

- Frequency domain resource assignment – bits

-  is the size of CORESET 0

- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]

- 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, TS38.214], using Table 5.1.3.1-1

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

- System information indicator – 1 bit as defined in Table 7.3.1.2.1-2

- Reserved bits – [15] bits

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

- Frequency domain resource assignment – bits

-  is the size of CORESET 0

- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]

- 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, TS38.214], using Table 5.1.3.1-1

- TB scaling – 2 bits as defined in Subclause 5.1.3.2 of [6, TS38.214]

- Reserved bits – 16 bits

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 – bits

-  is the size of CORESET 0

- Time domain resource assignment – 4 bits as defined in Subclause 5.1.2.1 of [6, TS38.214]

- 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, 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 9.2.3 of [5, TS38.213]

If DCI format 1\_0 is monitored in UE specific search space and satisfies both of the following

- the total number of different DCI sizes configured to monitor is no more than 4 for the cell, and

- the total number of different DCI sizes with C-RNTI configured to monitor is no more than 3 for the cell

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

Table 7.3.1.2.1-1: Short Message indicator

|  |  |
| --- | --- |
| Bit field | Short Message indicator |
| 00 | Reserved |
| 01 | Only scheduling information for Paging is present in the DCI |
| 10 | Only short message is present in the DCI |
| 11 | Both scheduling information for Paging and short message are present in the DCI |

Table 7.3.1.2.1-2: System information indicator

|  |  |
| --- | --- |
| Bit field | System information indicator |
| 0 | SIB1 [9, TS38.331, Subclause 5.2.1] |
| 1 | SI message [9, TS38.331, Subclause 5.2.1] |

##### 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 or CS-RNTI or MCS-C-RNTI:

- Identifier for DCI formats – 1 bits

- The value of this bit field is always set to 1, indicating a DL DCI format

- Carrier indicator – 0 or 3 bits as defined in Subclause 10.1 of [5, TS 38.213].

- Bandwidth part indicator – 0, 1 or 2 bits as determined by the number of DL BWPs  configured by higher layers, excluding the initial DL bandwidth part. The bitwidth for this field is determined as bits, where

-  if , in which case the bandwidth part indicator is equivalent to the higher layer parameter *BWP-Id*;

- otherwise , in which case the bandwidth part indicator is defined in Table 7.3.1.1.2-1;

If a UE does not support active BWP change via DCI, the UE ignores this bit field.

- Frequency domain resource assignment – number of bits determined by the following, where  is the size of the active DL bandwidth part:

-  bits if only resource allocation type 0 is configured, where  is defined in Subclause 5.1.2.2.1 of [6, TS38.214],

- bits if only resource allocation type 1 is configured, or

-  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 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  LSBs provide the resource allocation as defined in Subclause 5.1.2.2.2 of [6, TS 38.214]

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and if both resource allocation type 0 and 1 are configured for the indicated bandwidth part, the UE assumes resource allocation type 0 for the indicated bandwidth part if the bitwidth of the "Frequency domain resource assignment" field of the active bandwidth part is smaller than the bitwidth of the "Frequency domain resource assignment" field of the indicated bandwidth part.

- 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 bits, where *I* is the number of entries in the higher layer parameter *pdsch-TimeDomainAllocationList*.

- VRB-to-PRB mapping – 0 or 1 bit:

- 0 bit if only resource allocation type 0 is configured or if interleaved VRB-to-PRB mapping is not configured by high layers;

- 1 bit according to Table 7.3.1.1.2-33 otherwise, only applicable to resource allocation type 1, as defined in Subclause 7.3.1.6 of [4, TS 38.211].

- PRB bundling size indicator – 0 bit if the higher layer parameter *prb-BundlingType* is not configured or is set to 'static', or 1 bit if the higher layer parameter *prb-BundlingType* 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 parameters *rateMatchPatternGroup1* and *rateMatchPatternGroup2*.

- ZP CSI-RS trigger – 0, 1, or 2 bits as defined in Subclause 5.1.4.2 of [6, TS 38.214]. The bitwidth for this field is determined as bits, where is the number of ZP CSI-RS resource sets in the higher layer parameter *zp-CSI-RS-Resource*.

For transport block 1:

- Modulation and coding scheme – 5 bits as defined in Subclause 5.1.3.1 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 *maxNrofCodeWordsScheduledByDCI* equals 2):

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

- New data indicator – 1 bit

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

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the value of *maxNrofCodeWordsScheduledByDCI* for the indicated bandwidth part equals 2 and the value of *maxNrofCodeWordsScheduledByDCI* for the active bandwidth part equals 1, the UE assumes zeros are padded when interpreting the "Modulation and coding scheme", "New data indicator", and "Redundancy version" fields of transport block 2 according to Subclause 12 of [5, TS38.213], and the UE ignores the "Modulation and coding scheme", "New data indicator", and "Redundancy version" fields of transport block 2 for the indicated bandwidth part.

- 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 *pdsch-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 *pdsch-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 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 – 0, 1, 2, or 3 bits as defined in Subclause 9.2.3 of [5, TS 38.213]. The bitwidth for this field is determined as bits, where *I* is the number of entries in the higher layer parameter *dl-DataToUL-ACK.*

- 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. The antenna ports  shall be determined according to the ordering of DMRS port(s) given by Tables 7.3.1.2.2-1/2/3/4.

If a UE is configured with both *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB*, the bitwidth of this field equals , where  is the "Antenna ports" bitwidth derived according to *dmrs-DownlinkForPDSCH-MappingTypeA* and  is the "Antenna ports" bitwidthderived according to *dmrs-DownlinkForPDSCH-MappingTypeB*. A number of  zeros are padded in the MSB of this field, if the mapping type of the PDSCH corresponds to the smaller value of  and .

- Transmission configuration indication – 0 bit if higher layer parameter *tci-PresentInDCI* is not enabled; otherwise 3 bits as defined in Subclause 5.1.5 of [6, TS38.214].

If "Bandwidth part indicator" field indicates a bandwidth part other than the active bandwidth part and the "Transmission configuration indication" field is not present in the DCI format 1\_1, the UE assumes *tci-PresentInDCI* is not enabled for the indicated bandwidth part.

- 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].

- CBG transmission information (CBGTI) – 0, 2, 4, 6, or 8 bits as defined in Subclause 5.1.7 of [6, TS38.214], determined by the higher layer parameters *maxCodeBlockGroupsPerTransportBlock* and *Number-MCS-HARQ-DL-DCI* for the PDSCH.

- CBG flushing out information (CBGFI) – 0 or 1 bit as defined in Subclause 5.1.7 of [6, TS38.214], determined by higher layer parameter *codeBlockGroupFlushIndicator*.

- DMRS sequence initialization – 1 bit.

If DCI formats 1\_1 are monitored in multiple search spaces associated with multiple CORESETs in a BWP, zeros shall be appended until the payload size of the DCI formats 1\_1 monitored in the multiple search spaces equal to the maximum payload size of the DCI format 1\_1 monitored in the multiple search spaces.

Table 7.3.1.2.2-1: Antenna port(s) (1000 + DMRS port), *dmrs-Type*=1, *maxLength*=1

|  |  |  |
| --- | --- | --- |
| **One Codeword:**  **Codeword 0 enabled,**  **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), *dmrs-Type*=1, *maxLength*=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), *dmrs-Type*=2, *maxLength*=1

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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)** | **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), *dmrs-Type*=2, *maxLength*=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:

- 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:

- 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:

- block number 1, block number 2,…, block number *N*

The parameter *tpc-PUSCH* or *tpc-PUCCH*  provided by higher layers determines the index to the block number for an UL of a cell, with the following fields defined for each block:

- Closed loop indicator – 0 or 1 bit.

- For DCI format 2\_2 with TPC-PUSCH-RNTI, 0 bit if the UE is not configured with high layer parameter *twoPUSCH-PC-AdjustmentStates*, in which case UE assumes each block in the DCI format 2\_2 is of 2 bits; 1 bit otherwise, in which case UE assumes each block in the DCI format 2\_2 is of 3 bits;

- For DCI format 2\_2 with TPC-PUCCH-RNTI, 0 bit if the UE is not configured with high layer parameter *twoPUCCH-PC-AdjustmentStates*, in which case UE assumes each block in the DCI format 2\_2 is of 2 bits; 1 bit otherwise, in which case UE assumes each block in the DCI format 2\_2 is of 3 bits;

- TPC command –2 bits

If the number of information bits in format 2\_2 is less than the payload size of format 1\_0 monitored in common search space in the same serving cell, zeros shall be appended to format 2\_2 until the payload size equals that of format 1\_0 monitored in common search space 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:

- block number 1, block number 2, …, block number 

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.

If the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* = *typeA* 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 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.

- TPC command number 1, TPC command number 2, ..., TPC command number *N*, where each TPC command applies to a respective UL carrier provided by higher layer parameter *cc-IndexInOneCC-Set*

If the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* = *typeB* 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 or more blocks is configured for the UE by higher layers where each block applies to an UL carrier, with the following fields defined for each block:

- SRS request – 0 or 2 bits. The presence of this field is according to the definition in Subclause 11.4 of [5, TS38.213]. If present, this field is interpreted as defined by Table 7.3.1.1.2-24.

- TPC command –2 bits

If the number of information bits in format 2\_3 is less than the payload size of format 1\_0 monitored in common search space in the same serving cell, zeros shall be appended to format 2\_3 until the payload size equals that of format 1\_0 monitored in common search space 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, and the parity bits by, where  is the payload size and  is the number of parity bits. Let  be a bit sequence such that  for  and  for . The parity bits are computed with input bit sequence  and attached according to Subclause 5.1 by setting  to 24 bits and using the generator polynomial . The output bit  is

 for 

 for ,

where .

After attachment, the CRC parity bits are scrambled with the corresponding RNTI  , where  corresponds to the MSB of the RNTI, to form the sequence of bits . The relation between *ck* and *bk* is:

 for *k* = 0, 1, 2, …, 

 for *k* = , ,,..., .

### 7.3.3 Channel coding

Information bits are delivered to the channel coding block. They are denoted by  , where  is the number of bits, and they are encoded via Polar coding according to Subclause 5.3.1, by setting , , , and .

After encoding the bits are denoted by , where  is the number of coded bits.

### 7.3.4 Rate matching

The input bit sequence to rate matching is .

Rate matching is performed according to Subclause 5.4.1 by setting .

The output bit sequence after rate matching is denoted as .

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 |
| 2018-06 | RAN#80 | RP-181172 | 0002 | 1 | F | CR to 38.212 capturing the RAN1#92bis and RAN1#93 meeting agreements | 15.2.0 |
| 2018-06 | RAN#80 | RP-181257 | 0003 | - | B | CR to 38.212 capturing the RAN1#92bis and RAN1#93 meeting agreements related to URLLC | 15.2.0 |
| 2018-09 | RAN#81 | RP-181789 | 0004 | - | F | CR to 38.212 capturing the RAN1#94 meeting agreements | 15.3.0 |