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**iTeh STANDARD PREVIEW**  
(multiplexing and channel coding)  
**(3GPP TS 38.212 version 15.11.0 Release 15)**

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# 1 Scope

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

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## 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.
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- [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"

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## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

For the purposes of the present document, the terms and definitions given in 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 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 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 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                               |

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## 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.

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### 5.1 CRC calculation

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

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

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

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

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

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

$$b_k = a_k \quad \text{for } k = 0, 1, 2, \dots, A-1$$

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

## 5.2 Code block segmentation and code block CRC attachment

### 5.2.1 Polar coding

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

if  $I_{seg} = 1$

Number of code blocks:  $C = 2$ ;

else

Number of code blocks:  $C = 1$

end if

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

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

$$a'_i = 0;$$

end for

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

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

end for

$$s = 0;$$

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

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

$$c_{rk} = a'_s;$$

$$s = s + 1;$$

end for

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

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

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

end for

end for

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

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## 5.2.2 Low density parity check coding

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

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

$$K_{cb} = 8448.$$

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

$$K_{cb} = 3840.$$

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

if  $B \leq K_{cb}$

$$L = 0$$

Number of code blocks:  $C = 1$

$$B' = B$$

else

$$L = 24$$

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

$$B' = B + C \cdot L$$

end if

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

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

$$K' = B' / C ;$$

For LDPC base graph 1,

$$K_b = 22.$$

For LDPC base graph 2,

if  $B > 640$

$$K_b = 10 ;$$

elseif  $B > 560$

$$K_b = 9 ;$$

elseif  $B > 192$

$$K_b = 8 ;$$

else

$$K_b = 6 ;$$

end if

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

The bit sequence  $c_{rk}$  is calculated as:

$s = 0$ ;

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

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

$c_{rk} = b_s$ ;

$s = s + 1$ ;

end for

if  $C > 1$

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

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

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

end for

end if

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

$c_{rk} = \text{< NULL >}$ ;

end for

end for

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## 5.3 Channel coding

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

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

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

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

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

### 5.3.1 Polar coding

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

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

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

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

else

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

end if

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

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

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

where  $n_{\min} = 5$ .

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UE is not expected to be configured with  $K + n_{PC} > E$ , where  $n_{PC}$  is the number of parity check bits defined in Clause 5.3.1.2.

#### 5.3.1.1 Interleaving

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

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

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

if  $I_{IL} = 0$

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

else

$$k = 0;$$

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

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

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

$$k = k + 1;$$

end if

end for

end if

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

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

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

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### 5.3.1.2 Polar encoding

The Polar sequence  $\mathbf{Q}_0^{N_{\max}-1} = \{Q_0^{N_{\max}}, Q_1^{N_{\max}}, \dots, Q_{N_{\max}-1}^{N_{\max}}\}$  is given by Table 5.3.1.2-1, where  $0 \leq Q_i^{N_{\max}} \leq N_{\max} - 1$  denotes a bit index before Polar encoding for  $i = 0, 1, \dots, N_{\max} - 1$  and  $N_{\max} = 1024$ . The Polar sequence  $\mathbf{Q}_0^{N_{\max}-1}$  is in ascending order of reliability  $w(Q_0^{N_{\max}}) < w(Q_1^{N_{\max}}) < \dots < w(Q_{N_{\max}-1}^{N_{\max}})$ , where  $w(Q_i^{N_{\max}})$  denotes the reliability of bit index  $Q_i^{N_{\max}}$ .

For any code block encoded to  $N$  bits, a same Polar sequence  $\mathbf{Q}_0^{N-1} = \{Q_0^N, Q_1^N, Q_2^N, \dots, Q_{N-1}^N\}$  is used. The Polar sequence  $\mathbf{Q}_0^{N-1}$  is a subset of Polar sequence  $\mathbf{Q}_0^{N_{\max}-1}$  with all elements  $Q_i^{N_{\max}}$  of values less than  $N$ , ordered in ascending order of reliability  $w(Q_0^N) < w(Q_1^N) < w(Q_2^N) < \dots < w(Q_{N-1}^N)$ .

Denote  $\overline{\mathbf{Q}}_I^N$  as a set of bit indices in Polar sequence  $\mathbf{Q}_0^{N-1}$ , and  $\overline{\mathbf{Q}}_F^N$  as the set of other bit indices in Polar sequence  $\mathbf{Q}_0^{N-1}$ , where  $\overline{\mathbf{Q}}_I^N$  and  $\overline{\mathbf{Q}}_F^N$  are given in Clause 5.4.1.1,  $|\overline{\mathbf{Q}}_I^N| = K + n_{PC}$ ,  $|\overline{\mathbf{Q}}_F^N| = N - |\overline{\mathbf{Q}}_I^N|$ , and  $n_{PC}$  is the number of parity check bits.

Denote  $\mathbf{G}_N = (\mathbf{G}_2)^{\otimes n}$  as the  $n$ -th Kronecker power of matrix  $\mathbf{G}_2$ , where  $\mathbf{G}_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix}$ .

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