

# ETSI TS 138 212 V15.6.0 (2019-07)



TECHNICAL SPECIFICATION

**5G;  
NR;**  
**Multiplexing and channel coding**  
**(3GPP TS 38.212 version 15.6.0 Release 15)**

*iTeh STANDARD PREVIEW  
(standards.iteh.ai)  
Full standards list: <https://standards.iteh.ai/catalog/standards/sist/502cd6a2-dcd0-44aa-b14a-8827/db9db35d/etsi-ts-138-212-v15-6-0-2019-07>*



---

**Reference**

RTS/TSGR-0138212vf60

---

**Keywords**

5G

**ETSI**

650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

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

Siret N° 348 623 562 00017 - NAF 742 C  
Association à but non lucratif enregistrée à la  
Sous-Préfecture de Grasse (06) N° 7803/88

---

**Important notice**

The present document can be downloaded from:  
<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at [www.etsi.org/deliver](http://www.etsi.org/deliver).

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at <https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:  
<https://portal.etsi.org/People/CommiteeSupportStaff.aspx>

---

**Copyright Notification**

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2019.  
All rights reserved.

**DECT™**, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members. **3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

**oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

**GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

---

# Intellectual Property Rights

## Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: "*Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards*", which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

---

# Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

---

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Contents

Intellectual Property Rights .....	2
Legal Notice .....	2
Modal verbs terminology.....	2
Foreword.....	6
1 Scope .....	7
2 References .....	7
3 Definitions, symbols and abbreviations .....	7
3.1 Definitions .....	7
3.2 Symbols.....	7
3.3 Abbreviations .....	7
4 Mapping to physical channels .....	8
4.1 Uplink.....	8
4.2 Downlink .....	9
5 General procedures.....	9
5.1 CRC calculation .....	9
5.2 Code block segmentation and code block CRC attachment .....	10
5.2.1 Polar coding .....	10
5.2.2 Low density parity check coding .....	11
5.3 Channel coding.....	12
5.3.1 Polar coding .....	13
5.3.1.1 Interleaving .....	13
5.3.1.2 Polar encoding.....	14
5.3.2 Low density parity check coding .....	18
5.3.3 Channel coding of small block lengths .....	25
5.3.3.1 Encoding of 1-bit information.....	25
5.3.3.2 Encoding of 2-bit information.....	25
5.3.3.3 Encoding of other small block lengths .....	26
5.4 Rate matching.....	26
5.4.1 Rate matching for Polar code.....	26
5.4.1.1 Sub-block interleaving .....	26
5.4.1.2 Bit selection.....	28
5.4.1.3 Interleaving of coded bits.....	28
5.4.2 Rate matching for LDPC code.....	29
5.4.2.1 Bit selection.....	29
5.4.2.2 Bit interleaving.....	32
5.4.3 Rate matching for channel coding of small block lengths .....	32
5.5 Code block concatenation .....	32
6 Uplink transport channels and control information.....	33
6.1 Random access channel.....	33
6.2 Uplink shared channel .....	33
6.2.1 Transport block CRC attachment.....	33
6.2.2 LDPC base graph selection.....	33
6.2.3 Code block segmentation and code block CRC attachment .....	33
6.2.4 Channel coding of UL-SCH.....	33
6.2.5 Rate matching .....	34
6.2.6 Code block concatenation.....	34
6.2.7 Data and control multiplexing .....	34
6.3 Uplink control information.....	44
6.3.1 Uplink control information on PUCCH.....	44
6.3.1.1 UCI bit sequence generation .....	44
6.3.1.1.1 HARQ-ACK/SR only .....	44
6.3.1.1.2 CSI only.....	44

6.3.1.1.3	HARQ-ACK/SR and CSI .....	52
6.3.1.2	Code block segmentation and CRC attachment .....	53
6.3.1.2.1	UCI encoded by Polar code .....	53
6.3.1.2.2	UCI encoded by channel coding of small block lengths .....	53
6.3.1.3	Channel coding of UCI .....	53
6.3.1.3.1	UCI encoded by Polar code .....	53
6.3.1.3.2	UCI encoded by channel coding of small block lengths .....	54
6.3.1.4	Rate matching .....	54
6.3.1.4.1	UCI encoded by Polar code .....	54
6.3.1.4.2	UCI encoded by channel coding of small block lengths .....	55
6.3.1.5	Code block concatenation .....	56
6.3.1.6	Multiplexing of coded UCI bits to PUCCH .....	56
6.3.2	Uplink control information on PUSCH .....	58
6.3.2.1	UCI bit sequence generation .....	58
6.3.2.1.1	HARQ-ACK .....	58
6.3.2.1.2	CSI .....	59
6.3.2.2	Code block segmentation and CRC attachment .....	62
6.3.2.2.1	UCI encoded by Polar code .....	62
6.3.2.2.2	UCI encoded by channel coding of small block lengths .....	62
6.3.2.3	Channel coding of UCI .....	62
6.3.2.3.1	UCI encoded by Polar code .....	62
6.3.2.3.2	UCI encoded by channel coding of small block lengths .....	62
6.3.2.4	Rate matching .....	63
6.3.2.4.1	UCI encoded by Polar code .....	63
6.3.2.4.1.1	HARQ-ACK .....	63
6.3.2.4.1.2	CSI part 1 .....	65
6.3.2.4.1.3	CSI part 2 .....	67
6.3.2.4.2	UCI encoded by channel coding of small block lengths .....	69
6.3.2.4.2.1	HARQ-ACK .....	69
6.3.2.4.2.2	CSI part 1 .....	69
6.3.2.4.2.3	CSI part 2 .....	69
6.3.2.5	Code block concatenation .....	69
6.3.2.6	Multiplexing of coded UCI bits to PUSCH .....	69
7	Downlink transport channels and control information .....	70
7.1	Broadcast channel .....	70
7.1.1	PBCH payload generation .....	70
7.1.2	Scrambling .....	71
7.1.3	Transport block CRC attachment .....	72
7.1.4	Channel coding .....	72
7.1.5	Rate matching .....	72
7.2	Downlink shared channel and paging channel .....	72
7.2.1	Transport block CRC attachment .....	72
7.2.2	LDPC base graph selection .....	73
7.2.3	Code block segmentation and code block CRC attachment .....	73
7.2.4	Channel coding .....	73
7.2.5	Rate matching .....	73
7.2.6	Code block concatenation .....	73
7.3	Downlink control information .....	74
7.3.1	DCI formats .....	74
7.3.1.0	DCI size alignment .....	74
7.3.1.1	DCI formats for scheduling of PUSCH .....	76
7.3.1.1.1	Format 0_0 .....	76
7.3.1.1.2	Format 0_1 .....	78
7.3.1.2	DCI formats for scheduling of PDSCH .....	91
7.3.1.2.1	Format 1_0 .....	91
7.3.1.2.2	Format 1_1 .....	94
7.3.1.3	DCI formats for other purposes .....	101
7.3.1.3.1	Format 2_0 .....	101
7.3.1.3.2	Format 2_1 .....	101
7.3.1.3.3	Format 2_2 .....	101
7.3.1.3.4	Format 2_3 .....	101

7.3.2 CRC attachment .....102  
7.3.3 Channel coding .....103  
7.3.4 Rate matching .....103  
**Annex <A> (informative): Change history .....104**  
History .....105

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**  
Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/502cd6a2-dd00-44aa-b14a-8827db9db35d/etsi-ts-138-212-v15.6.0-2019-07>

---

# 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.

**ITeH STANDARD PREVIEW**  
(standards.iteh.ai)  
Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/502cd6a2-dd00-44aa-b14a-8827db9db35d/etsi-ts-138-212-v15.6.0-2019-07>

---

# 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  $a_0, a_1, a_2, a_3, \dots, a_{A-1}$ , 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 Subclause 5.1 with a generator polynomial of length  $L$ .

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

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

end for

end for

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

iTech STANDARD PREVIEW  
(standards.iteh.ai)  
Full standard:  
<https://standards.iteh.ai/catalog/standards/sist/502cd6a2-dd00-44aa-b14a-8827db9db35d/etsi-ts-138-212-v15.6.0-2019-07>

## 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

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 Subclause 5.1 with the generator polynomial  $g_{\text{CRC24B}}(D)$ .

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

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

end for

end if

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

$c_{rk} = \langle \text{NULL} \rangle$ ;

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