

# ETSI TS 136 212 V15.7.0 (2019-10)



**LTE;**  
**Evolved Universal Terrestrial Radio Access (E-UTRA);**  
**Multiplexing and channel coding**  
**(3GPP TS 36.212 version 15.7.0 Release 15)**

*Standard PREVIEW*  
*(standard.it) Full standard: <https://standards.iteh.ai/catalog/standards/sist/5a3275c-b5df-4a8a-9c7c-6abb1197b5c5/etsi-ts-136-212-v15-7-0-2019-10>*



---

**Reference**RTS/TSGR-0136212vf70

---

---

**Keywords**LTE

---

**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 .....	8
4 Mapping to physical channels .....	9
4.1 Uplink.....	9
4.2 Downlink.....	9
4.3 Sidelink .....	10
5 Channel coding, multiplexing and interleaving.....	10
5.1 Generic procedures.....	10
5.1.1 CRC calculation.....	10
5.1.2 Code block segmentation and code block CRC attachment .....	11
5.1.3 Channel coding .....	12
5.1.3.1 Tail biting convolutional coding .....	13
5.1.3.2 Turbo coding .....	14
5.1.3.2.1 Turbo encoder.....	14
5.1.3.2.2 Trellis termination for turbo encoder.....	15
5.1.3.2.3 Turbo code internal interleaver.....	15
5.1.4 Rate matching .....	17
5.1.4.1 Rate matching for turbo coded transport channels .....	17
5.1.4.1.1 Sub-block interleaver.....	17
5.1.4.1.2 Bit collection, selection and transmission.....	18
5.1.4.2 Rate matching for convolutionally coded transport channels and control information.....	21
5.1.4.2.1 Sub-block interleaver.....	22
5.1.4.2.2 Bit collection, selection and transmission.....	23
5.1.5 Code block concatenation.....	24
5.2 Uplink transport channels and control information .....	24
5.2.1 Random access channel .....	24
5.2.2 Uplink shared channel .....	24
5.2.2.1 Transport block CRC attachment.....	25
5.2.2.2 Code block segmentation and code block CRC attachment.....	26
5.2.2.3 Channel coding of UL-SCH.....	26
5.2.2.4 Rate matching .....	26
5.2.2.5 Code block concatenation .....	26
5.2.2.6 Channel coding of control information .....	26
5.2.2.6.1 Channel quality information formats for wideband CQI reports.....	45
5.2.2.6.2 Channel quality information formats for higher layer configured subband CQI reports.....	67
5.2.2.6.3 Channel quality information formats for UE selected subband CQI reports.....	98
5.2.2.6.4 Channel coding for CQI/PMI information in PUSCH.....	120
5.2.2.6.5 Channel coding for more than 11 bits of HARQ-ACK information.....	121
5.2.2.6A Channel coding of AUL-UCI.....	122
5.2.2.7 Data and control multiplexing.....	123
5.2.2.7A Data and control multiplexing for Partial PUSCH Mode 1 .....	124
5.2.2.7B Data and control multiplexing for AUL PUSCH .....	125
5.2.2.8 Channel interleaver .....	126
5.2.3 Uplink control information on PUCCH.....	131
5.2.3.1 Channel coding for UCI HARQ-ACK on PUCCH.....	132

5.2.3.1A	Channel coding for UCI HARQ-ACK on SPUCCH.....	138
5.2.3.2	Channel coding for UCI scheduling request .....	141
5.2.3.3	Channel coding for UCI channel quality information .....	141
5.2.3.3.1	Channel quality information formats for wideband reports.....	142
5.2.3.3.2	Channel quality information formats for UE-selected sub-band reports .....	156
5.2.3.4	Channel coding for UCI channel quality information and HARQ-ACK .....	170
5.2.4	Uplink control information on PUSCH without UL-SCH data .....	171
5.2.4.1	Channel coding of control information .....	171
5.2.4.2	Control information mapping.....	173
5.2.4.3	Channel interleaver .....	173
5.3	Downlink transport channels and control information .....	173
5.3.1	Broadcast channel .....	173
5.3.1.1	Transport block CRC attachment.....	174
5.3.1.2	Channel coding .....	174
5.3.1.3	Rate matching .....	175
5.3.2	Downlink shared channel, Paging channel and Multicast channel .....	175
5.3.2.1	Transport block CRC attachment.....	176
5.3.2.2	Code block segmentation and code block CRC attachment.....	176
5.3.2.3	Channel coding .....	176
5.3.2.4	Rate matching .....	176
5.3.2.5	Code block concatenation .....	176
5.3.3	Downlink control information .....	177
5.3.3.1	DCI formats.....	177
5.3.3.1.1	Format 0 .....	177
5.3.3.1.1A	Format 0A.....	179
5.3.3.1.1B	Format 0B.....	181
5.3.3.1.1C	Format 0C.....	183
5.3.3.1.2	Format 1 .....	184
5.3.3.1.3	Format 1A.....	186
5.3.3.1.3A	Format 1B.....	188
5.3.3.1.4	Format 1C.....	190
5.3.3.1.4A	Format 1D.....	191
5.3.3.1.5	Format 2 .....	192
5.3.3.1.5A	Format 2A.....	196
5.3.3.1.5B	Format 2B.....	198
5.3.3.1.5C	Format 2C.....	200
5.3.3.1.5D	Format 2D.....	203
5.3.3.1.6	Format 3 .....	205
5.3.3.1.7	Format 3A.....	206
5.3.3.1.7A	Format 3B.....	206
5.3.3.1.8	Format 4 .....	207
5.3.3.1.8A	Format 4A.....	209
5.3.3.1.8B	Format 4B.....	211
5.3.3.1.9	Format 5 .....	213
5.3.3.1.9A	Format 5A.....	213
5.3.3.1.10	Format 6-0A .....	214
5.3.3.1.11	Format 6-0B .....	215
5.3.3.1.12	Format 6-1A .....	216
5.3.3.1.13	Format 6-1B .....	219
5.3.3.1.14	Format 6-2 .....	221
5.3.3.1.15	Format 7-0A .....	222
5.3.3.1.16	Format 7-0B .....	223
5.3.3.1.17	Format 7-1A .....	225
5.3.3.1.18	Format 7-1B .....	226
5.3.3.1.19	Format 7-1C .....	226
5.3.3.1.20	Format 7-1D .....	228
5.3.3.1.21	Format 7-1E.....	230
5.3.3.1.22	Format 7-1F.....	230
5.3.3.1.23	Format 7-1G .....	232
5.3.3.2	CRC attachment .....	232
5.3.3.3	Channel coding .....	233
5.3.3.4	Rate matching .....	233

5.3.4	Control format indicator .....	233
5.3.4.1	Channel coding .....	233
5.3.5	HARQ indicator (HI) .....	234
5.3.5.1	Channel coding .....	234
5.4	Sidelink transport channels and control information .....	234
5.4.1	Sidelink broadcast channel .....	234
5.4.1.1	Transport block CRC attachment .....	235
5.4.1.2	Channel coding .....	235
5.4.1.3	Rate matching .....	235
5.4.2	Sidelink shared channel .....	236
5.4.3	Sidelink control information .....	236
5.4.3.1	SCI formats .....	236
5.4.3.1.1	SCI format 0 .....	236
5.4.3.1.2	SCI format 1 .....	237
5.4.4	Sidelink discovery channel .....	237
6	Narrowband IoT .....	237
6.1	Mapping to physical channels .....	237
6.2	Generic procedures .....	238
6.3	Uplink transport channels and control information .....	238
6.3.1	Random access channel .....	238
6.3.2	Uplink shared channel .....	239
6.3.3	Uplink control information on NPUSCH without UL-SCH data .....	239
6.3.4	Scheduling request .....	240
6.4	Downlink transport channels and control information .....	240
6.4.1	Broadcast channel .....	240
6.4.2	Downlink shared channel and Paging channel .....	240
6.4.3	Downlink control information .....	241
6.4.3.1	DCI Format N0 .....	241
6.4.3.2	DCI Format N1 .....	242
6.4.3.3	DCI Format N2 .....	243
<b>Annex A (informative):</b>	<b>Change history .....</b>	<b>244</b>
History .....		250

---

# Foreword

This Technical Specification has been produced by the 3<sup>rd</sup> 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.

**PREVIEW**  
iTech STANDARD  
(standards.itih.ai)  
Full standard:  
<https://standards.itih.ai/catalog/standards/sist/d5a3275c-b5df-4a8a-9c7c-6abb197b5c5/etsi-ts-136-212-v15.7.0-2019-10>

---

# 1 Scope

The present document specifies the coding, multiplexing and mapping to physical channels for E-UTRA.

---

## 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 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".
- [3] 3GPP TS 36.213: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures".
- [4] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".
- [5] 3GPP TS36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification"
- [6] 3GPP TS36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification"
- [7] 3GPP TS23.285, "Technical Specification Group Services and System Aspects; Architecture enhancements for V2X services"
- [8] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".

---

## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

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

**BL/CE:** A Bandwidth-reduced Low-complexity or Coverage Enhanced (BL/CE) UE is capable of coverage enhancement mode A support and intends to access a cell in a coverage enhancement mode or is configured in a coverage enhancement mode.

**Non-BL/CE:** A non-BL/CE UE is a UE that does not fulfil the conditions in the above definition of a BL/CE UE.

### 3.2 Symbols

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



$N_{RB}^{DL}$	Downlink bandwidth configuration, expressed in number of resource blocks [2]
$N_{RB}^{UL}$	Uplink bandwidth configuration, expressed in number of resource blocks [2]
$N_{RB}^{SL}$	Sidelink bandwidth configuration, expressed in number of resource blocks [2]
$N_{subchannel}^{SL}$	Number of sidelink subchannels configured on the resource pool of a subcarrier [2]
$N_{sc}^{RB}$	Resource block size in the frequency domain, expressed as a number of subcarriers
$N_{symb}^{PUSCH}$	Number of SC-FDMA symbols carrying PUSCH in a subframe
$N_{symb}^{PUSCH-initial}$	Number of SC-FDMA symbols carrying PUSCH in the initial PUSCH transmission subframe
$N_{symb}^{UL}$	Number of SC-FDMA symbols in an uplink slot
$N_{symb}^{SL}$	Number of SC-FDMA symbols in a sidelink slot
$N_{SRS}$	Number of SC-FDMA symbols used for SRS transmission in a subframe (0 or 1).

### 3.3 Abbreviations

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

AUL	Autonomous Uplink
AUL-DFI	AUL downlink feedback information
AUL-UCI	AUL uplink control information
BCH	Broadcast channel
CFI	Control Format Indicator
COT	Channel Occupancy Time
CP	Cyclic Prefix
CSI	Channel State Information
DCI	Downlink Control Information
DL-SCH	Downlink Shared channel
EN-DC	E-UTRA NR Dual Connectivity with MCG using E-UTRA and SCG using NR
EPDCCH	Enhanced Physical Downlink Control channel
FDD	Frequency Division Duplexing
HI	HARQ indicator
LAA	Licensed-Assisted Access
MCH	Multicast channel
MPDCCH	MTC Physical Downlink Control Channel
MUST	Multiuser Superposition Transmission
NE-DC	NR E-UTRA Dual Connectivity with MCG using NR and SCG using E-UTRA
NPBCH	Narrowband Physical Broadcast channel
NPDCCH	Narrowband Physical Downlink Control channel
NPDSCH	Narrowband Physical Downlink Shared channel
NPRACH	Narrowband Physical Random Access channel
NPUSCH	Narrowband Physical Uplink Shared channel
PBCH	Physical Broadcast channel
PCFICH	Physical Control Format Indicator channel
PCH	Paging channel
PDCCH	Physical Downlink Control channel
PDSCH	Physical Downlink Shared channel
PHICH	Physical HARQ indicator channel
PMCH	Physical Multicast channel
PMI	Precoding Matrix Indicator
PRACH	Physical Random Access channel
PSBCH	Physical Sidelink Broadcast Channel
PSCCH	Physical Sidelink Control Channel
PSDCH	Physical Sidelink Discovery Channel
PSSCH	Physical Sidelink Shared Channel
PUCCH	Physical Uplink Control channel
PUSCH	Physical Uplink Shared channel
RACH	Random Access channel

RI	Rank Indication
SCI	Sidelink Control Information
SL-BCH	Sidelink Broadcast Channel
SL-DCH	Sidelink Discovery Channel
SL-SCH	Sidelink Shared Channel
SPDCCH	Short Physical Downlink Control channel
SPUCCH	Short Physical Uplink Control channel
SR	Scheduling Request
SRS	Sounding Reference Signal
TDD	Time Division Duplexing
TPMI	Transmitted Precoding Matrix Indicator
UCI	Uplink Control Information
UL-SCH	Uplink Shared channel

## 4 Mapping to physical channels

The mapping to physical channels for Narrowband IoT is provided in subclause 6.1.

### 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, SPUCCH

### 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
MCH	PMCH

**Table 4.2-2**

Control information	Physical Channel
CFI	PCFICH
HI	PHICH
DCI	PDCCH, EPDCCH, MPDCCH, SPDCCH

## 4.3 Sidelink

Table 4.3-1 specifies the mapping of the sidelink transport channels to their corresponding physical channels. Table 4.3-2 specifies the mapping of the sidelink control information to its corresponding physical channel.

**Table 4.3-1**

TrCH	Physical Channel
SL-SCH	PSSCH
SL-BCH	PSBCH
SL-DCH	PSDCH

**Table 4.3-2**

Control information	Physical Channel
SCI	PSCCH

## 5 Channel coding, multiplexing and interleaving

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 Generic procedures

This subclause contains coding procedures which are used for more than one transport channel or control information type.

#### 5.1.1 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  $p_0, p_1, p_2, p_3, \dots, p_{L-1}$ .  $A$  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:

- $g_{\text{CRC24A}}(D) = [D^{24} + D^{23} + D^{18} + D^{17} + D^{14} + D^{11} + D^{10} + D^7 + D^6 + D^5 + D^4 + D^3 + D + 1]$  and;
- $g_{\text{CRC24B}}(D) = [D^{24} + D^{23} + D^6 + D^5 + D + 1]$  for a CRC length  $L = 24$  and;
- $g_{\text{CRC16}}(D) = [D^{16} + D^{12} + D^5 + 1]$  for a CRC length  $L = 16$ .
- $g_{\text{CRC8}}(D) = [D^8 + D^7 + D^4 + D^3 + D + 1]$  for a CRC length of  $L = 8$ .

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

$$a_0 D^{A+23} + a_1 D^{A+22} + \dots + a_{A-1} D^{24} + p_0 D^{23} + p_1 D^{22} + \dots + p_{22} D^1 + p_{23}$$

yields a remainder equal to 0 when divided by the corresponding length-24 CRC generator polynomial,  $g_{\text{CRC24A}}(D)$  or  $g_{\text{CRC24B}}(D)$ , the polynomial:

$$a_0 D^{A+15} + a_1 D^{A+14} + \dots + a_{A-1} D^{16} + p_0 D^{15} + p_1 D^{14} + \dots + p_{14} D^1 + p_{15}$$

yields a remainder equal to 0 when divided by  $g_{\text{CRC16}}(D)$ , and the polynomial:

$$a_0 D^{A+7} + a_1 D^{A+6} + \dots + a_{A-1} D^8 + p_0 D^7 + p_1 D^6 + \dots + p_6 D^1 + p_7$$

yields a remainder equal to 0 when divided by  $g_{\text{CRC8}}(D)$ .

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:

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

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

## 5.1.2 Code block segmentation and code block CRC attachment

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  $Z$ , segmentation of the input bit sequence is performed and an additional CRC sequence of  $L = 24$  bits is attached to each code block. The maximum code block size is:

$$- Z = 6144.$$

If the number of filler bits  $F$  calculated below is not 0, filler bits are added to the beginning of the first block.

Note that if  $B < 40$ , filler bits are added to the beginning of the code block.

The filler bits shall be set to  $\langle NULL \rangle$  at the input to the encoder.

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

if  $B \leq Z$

$$L = 0$$

$$\text{Number of code blocks: } C = 1$$

$$B' = B$$

else

$$L = 24$$

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

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

end if

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

Number of bits in each code block (applicable for  $C \neq 0$  only):

First segmentation size:  $K_+ =$  minimum  $K$  in table 5.1.3-3 such that  $C \cdot K \geq B'$

if  $C = 1$

the number of code blocks with length  $K_+$  is  $C_+ = 1, K_- = 0, C_- = 0$

else if  $C > 1$

Second segmentation size:  $K_- =$  maximum  $K$  in table 5.1.3-3 such that  $K < K_+$

$$\Delta_K = K_+ - K_-$$

$$\text{Number of segments of size } K_- : C_- = \left\lfloor \frac{C \cdot K_+ - B'}{\Delta_K} \right\rfloor.$$

Number of segments of size  $K_+$ :  $C_+ = C - C_-$ .

end if

Number of filler bits:  $F = C_+ \cdot K_+ + C_- \cdot K_- - B'$

for  $k = 0$  to  $F-1$  -- Insertion of filler bits

$c_{0k} = \langle \text{NULL} \rangle$

end for

$k = F$

$s = 0$

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

if  $r < C_-$

$K_r = K_-$

else

$K_r = K_+$

end if

while  $k < K_r - L$

$c_{rk} = b_s$

$k = k + 1$

$s = s + 1$

end while

if  $C > 1$

The sequence  $c_{r0}, c_{r1}, c_{r2}, c_{r3}, \dots, c_{r(K_r-L-1)}$  is used to calculate the CRC parity bits  $p_{r0}, p_{r1}, p_{r2}, \dots, p_{r(L-1)}$  according to subclause 5.1.1 with the generator polynomial  $g_{\text{CRC24B}}(D)$ . For CRC calculation it is assumed that filler bits, if present, have the value 0.

while  $k < K_r$

$c_{rk} = p_{r(k+L-K_r)}$

$k = k + 1$

end while

end if

$k = 0$

end for

### 5.1.3 Channel 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  $d_0^{(i)}, d_1^{(i)}, d_2^{(i)}, d_3^{(i)}, \dots, d_{D-1}^{(i)}$ , where  $D$  is the number of