**3GPP TSG-RAN WG1 Meeting #114 *R1-230XXXX***

**Toulouse, France, August 21-25, 2023**

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| *CR-Form-v12.2* | | | | | | | | |
| **Draft CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.212** | **CR** |  | **rev** | **-** | **Current version:** | **17.5.0** |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | Introduction of Rel-18 XR enhancements for NR | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Huawei | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_XR\_enh-Core | | | | |  | ***Date:*** | | | 2023-09-01 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | B |  | | | | | ***Release:*** | | | Rel-18 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Introduction of Rel-18 XR enhancements for NR | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Support of Rel-18 XR enhancements for NR. Capture agreements on UTO-UCI. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Rel-18 XR enhancements for NR will be incomplete. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 3.3, 6.2.7, 6.3.2.1.3A(new), 6.3.2.1.4, 6.3.2.1.5, 6.3.2.4.2, 6.3.2.7 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.213, TS 38. 214 | | |
| ***affected:*** | |  | **X** | Test specifications | | | |  | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

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

CG Configured grant

CG-DFI CG downlink feedback information

CG-UCI CG uplink control information

CORESET Control resource set

COT Channel occupancy time

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 Demodulation reference signal

HARQ Hybrid automatic repeat request

HARQ-ACK Hybrid automatic repeat request acknowledgement

LDPC Low density parity check

LI Layer indicator

MBS Multicast broadcast services

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

PSBCH Physical sidelink broadcast channel

PSCCH Physical sidelink control channel

PSFCH Physical sidelink feedback channel

PSSCH Physical sidelink shared 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

SCI Sidelink control information

SFCI Sidelink feedback control information

SFN System frame number

SL Sidelink

SL-BCH Sidelink broadcast channel

SL-SCH Sidelink shared channel

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

UTO-UCI Unused transmission occasion uplink control information

VRB Virtual resource block

ZP CSI-RS Zero power CSI-RS

< Unchanged parts are omitted >

6.2.7 Data and control multiplexing

If the higher layer parameter *nrof\_UTO\_UCI* is configured, the procedure in this clause 6.2.7 applies by replacing CG-UCI with UTO-UCI in all the notations and texts, and replacing "when higher layer parameter *cg-UCI-Multiplexing* is configured" with "when UTO-UCI and HARQ-ACK are transmitted on a PUSCH".

Denote the coded bits for UL-SCH as .

Denote the coded bits for HARQ-ACK or jointly coded bits for HARQ-ACK and CG-UCI when the high layer parameter *cg-UCI-Multiplexing* is configured, 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 coded bits for CG-UCI without HARQ-ACK, 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 or if both HARQ-ACK and CG-UCI are present on the same PUSCH with UL-SCH, let

-  and ;

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

- ;

- ;

- ; and

- ;

- if CG-UCI is present for transmission on the PUSCH with UL-SCH and without HARQ-ACK, 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 only 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 or if both HARQ-ACK and CG-UCI are present on the same PUSCH with UL-SCH, let ;

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

- if CG-UCI is present for transmission on the PUSCH without HARQ-ACK, let ;

- 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 and without CG-UCI

the number of reserved resource elements for potential HARQ-ACK transmission is calculated according to Clause 6.3.2.4.2.1, 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 or if both HARQ-ACK and CG-UCI are present on the same PUSCH with UL-SCH,

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 2A:**

If CG-UCI is present for transmission on the PUSCH without HARQ-ACK,

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 without CG-UCI 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

< Unchanged parts are omitted >

6.3.2 Uplink control information on PUSCH

< Unchanged parts are omitted >

6.3.2.1 UCI bit sequence generation

< Unchanged parts are omitted >

6.3.2.1.3 CG-UCI

For CG-UCI bits transmitted on a CG PUSCH when the higher layer parameter *cg-RetransmissionTimer* is configured, the CG-UCI bit sequence is determined as follows:

- set for and , where the CG-UCI bit sequence is given by Table 6.3.2.1.3-1, mapped in the order from upper part to lower part.

Table 6.3.2.1.3-1: Mapping order of CG-UCI fields

|  |  |
| --- | --- |
| **Field** | **Bitwidth** |
| HARQ process number | 5 if *nrofHARQ-Processes-v1700* in *ConfiguredGrantConfig* is configured;  4 otherwise. |
| Redundancy version | 2 |
| New data indicator | 1 |
| Channel Occupancy Time (COT) sharing information | if both higher layer parameter *ul-toDL-COT-SharingED-Threshold* and higher layer parameter *cg-COT-SharingList* are configured, or if both higher layer parameter *semiStaticChannelAccessConfigUE* and higher layer parameter *cg-COT-SharingList* are configured, or if higher layer parameter *cg-COT-SharingList* is configured in frequency range 2-2, where *C* is the number of combinations configured in *cg-COT-SharingList;*  1 if higher layer parameter *ul-toDL-COT-SharingED-Threshold* is not configured, and if higher layer parameter *semiStaticChannelAccessConfigUE* is not configured, and if higher layer parameter *cg-COT-SharingOffset* is configured;  0 otherwise.  If a UE indicates COT sharing other than "no sharing" in a CG PUSCH within the UE's initiated COT, the UE should provide consistent COT sharing information in all the subsequent CG PUSCHs, if any, occurring within the same UE's initiated COT such that the same DL starting point and duration are maintained. |

6.3.2.1.3A UTO-UCI

For UTO-UCI bits transmitted on a CG PUSCH when the higher layer parameter *nrof\_UTO\_UCI* is configured, the UTO-UCI bit sequence is determined as follows:

- set for and , where is provided by *nrof\_UTO\_UCI*, and the UTO-UCI bit sequence is given by clause x.x of [5, TS 38.213].

6.3.2.1.4 HARQ-ACK and CG-UCI/UTO-UCI

If the higher layer parameter *nrof\_UTO\_UCI* is configured, the procedure in this clause 6.3.2.1.4 applies by replacing CG-UCI with UTO-UCI in all the notations and texts, and replacing "When higher layer parameter *cg-UCI-Multiplexing* is configured" with "When UTO-UCI and HARQ-ACK are transmitted on a PUSCH".

When higher layer parameter *cg-UCI-Multiplexing* is configured, the UCI bit sequence is determined as follows, where .

- The CG-UCI bits are mapped to the UCI bit sequence, where for . The CG-UCI bit sequence is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part, and is number of CG-UCI bits;

- The HARQ-ACK bits are mapped to the UCI bit sequence , where for . The HARQ-ACK bit sequence is given by Clause 9.1 of [5, TS38.213], and is number of HARQ-ACK bits.

##### 6.3.2.1.5 UCI with different priority indexes

If the higher layer parameter *nrof\_UTO\_UCI* is configured, the procedure in this clause 6.3.2.1.5 applies by replacing CG-UCI with UTO-UCI in all the notations and texts, and replacing "is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part" with "is given by clause x.x of [5, TS 38.213]".

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 1, the following UCI bit sequences are generated, , and if any, according to the following:

- If CSI part 1 is also transmitted on the PUSCH,

- Set for as the bit sequence of CSI part 1, where 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 .

- Set for and , where the HARQ-ACK bit sequence associated with priority index 0 is given by Clause 9.1 of [5, TS 38.213].

- Otherwise, set for and , where the HARQ-ACK bit sequence associated with priority index 0 is given by Clause 9.1 of [5, TS 38.213].

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 1, and CSI if any are transmitted on a PUSCH associated with priority index 0, the following UCI bit sequences are generated,, if any, and if any, according to the following:

- If HARQ-ACK bits associated with priority index 1 and CSI are transmitted on the PUSCH without UL-SCH and the CSI includes CSI part 1 without CSI part 2, and there is only one HARQ-ACK bit associated with priority index 1 given by Clause 9.1 of [5, TS 38.213], set , , and ; otherwise, set for and , where the HARQ-ACK bit sequence associated with priority index 1 is given by Clause 9.1 of [5, TS 38.213];

- Set for as the bit sequence of CSI part 1, if CSI part 1 is also transmitted on the PUSCH, where 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 ;

- Set for as the bit sequence of CSI part 2, if CSI part 2 is also transmitted on the PUSCH, where 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 .

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH, the following UCI bit sequences are generated,, , and if any, according to the following:

- Set for and if HARQ-ACK bits associated with priority index 1 are transmitted without CG-UCI associated with priority index 1, where the HARQ-ACK bit sequence associated with priority index 1 is given by Clause 9.1 of [5, TS 38.213];

- Set for and if CG-UCI associated with priority index 1 is transmitted without HARQ-ACK bits associated with priority index 1, where the CG-UCI bit sequence associated with priority index 1 is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part;

- Set as follows, if both CG-UCI associated with priority index 1 and HARQ-ACK bits associated with priority index 1 are transmitted, where

- The CG-UCI bits are mapped to the UCI bit sequence , where for . The CG-UCI bit sequence is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part, and is number of CG-UCI bits

- The HARQ-ACK bits are mapped to the UCI bit sequence , where for . The HARQ-ACK bit sequence associated with priority index 1 is given by Clause 9.1 of [5, TS 38.213].

- If CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 1,

- Set for as the bit sequence of CSI part 1, where 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 .

- Set for and , where the HARQ-ACK bit sequence associated with priority index 0 is given by Clause 9.1 of [5, TS 38.213].

- Otherwise,

- Set for and , where the HARQ-ACK bit sequence associated with priority index 0 is given by Clause 9.1 of [5, TS 38.213].

- Set for and , if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0, where the CSI part 1 sequence is given by Table 6.3.2.1.2-6 by replacing , 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 CSI part 1 sequence starting with .

If *uci-MuxWithDiffPrio* is configured, and CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any, HARQ-ACK bits associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 0, the following UCI bit sequences are generated,, , and if any, according to the following:

- Set for and , where the HARQ-ACK bit sequence associated with priority index 1 is given by Clause 9.1 of [5, TS 38.213];

- Set for and if CG-UCI associated with priority index 0 is transmitted without HARQ-ACK bits associated with priority index 0, where the CG-UCI bit sequence associated with priority index 0 is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part;

- Set as follows if both CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 are transmitted, where

- The CG-UCI bits are mapped to the UCI bit sequence , where for . The CG-UCI bit sequence is given by Table 6.3.2.1.3-1 mapped in the order from upper part to lower part, and is number of CG-UCI bits

- The HARQ-ACK bits are mapped to the UCI bit sequence , where for . The HARQ-ACK bit sequence associated with priority index 0 is given by Clause 9.1 of [5, TS 38.213].

- Set for and , if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0, where the CSI part 1 sequence is given by Table 6.3.2.1.2-6 by replacing , 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 CSI part 1 sequence starting with .

< Unchanged parts are omitted >

6.3.2.4 Rate matching

6.3.2.4.1 UCI encoded by Polar code

< Unchanged parts are omitted >

###### 6.3.2.4.1.2 CSI part 1

For CSI part 1 transmission on PUSCH not using repetition type B with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table, or if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is equal to 1, 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 Clause 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;

- if HARQ-ACK is present for transmission on the same PUSCH with UL-SCH and without CG-UCI, where is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH as defined in clause 6.3.2.4.1.1 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 Clause 6.2.7; or

- if both HARQ-ACK and CG-UCI are present on the same PUSCH with UL-SCH, where is the number of coded modulation symbols per layer for HARQ-ACK and CG-UCI transmitted on the PUSCH as defined in clause 6.3.2.4.1.5; or

- if CG-UCI is present on the same PUSCH with UL-SCH and without HARQ-ACK, where is the number of coded modulation symbols per layer for CG-UCI transmitted on the PUSCH as defined in clause 6.3.2.4.1.4;

-  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 not using repetition type B with UL-SCH, and if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is larger than 1, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as , is determined as follows:

where

- is the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI;

- is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission of TB processing over multiple slots in the slot with the CSI part 1 transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission of TB processing over multiple slots in the slot with the CSI part 1 transmission and is the total number of OFDM symbols of the PUSCH in the slot, including all OFDM symbols used for DMRS;

- and all the other notations in the formula are defined the same as for PUSCH not using repetition type B and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

For CSI part 1 transmission on an actual repetition of a PUSCH with repetition Type B 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 resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission assuming a nominal repetition without segmentation, and is the total number of OFDM symbols in a nominal repetition of the PUSCH, including all OFDM symbols used for DMRS;

- for any OFDM symbol that carries DMRS of the PUSCH assuming a nominal repetition without segmentation, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH assuming a nominal repetition without segmentation, where is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission assuming a nominal repetition without segmentation;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the actual repetition of the PUSCH transmission, and is the total number of OFDM symbols in the actual repetition of the PUSCH transmission, including all OFDM symbols used for DMRS;

- for any OFDM symbol that carries DMRS of the actual repetition of the PUSCH transmission, ;

- for any OFDM symbol that does not carry DMRS of the actual repetition of the PUSCH transmission, where is the number of subcarriers in OFDM symbol that carries PTRS, in the actual repetition of the PUSCH transmission;

- and all the other notations in the formula are defined the same as for PUSCH not using repetition type B and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

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 Clause 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 Clause 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 Clause 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 Clause 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 Clause 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 not using repetition type B with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table, or if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is equal to 1, 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 Clause 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;

- if HARQ-ACK is present for transmission on the same PUSCH with UL-SCH and without CG-UCI, where is the number of coded modulation symbols per layer for HARQ-ACK transmitted on the PUSCH as defined in clause 6.3.2.4.1.1 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; or

- if both HARQ-ACK and CG-UCI are present on the same PUSCH with UL-SCH, where is the number of coded modulation symbols per layer for HARQ-ACK and CG-UCI transmitted on the PUSCH as defined in clause 6.3.2.4.1.5; or

- if CG-UCI is present on the same PUSCH with UL-SCH and without HARQ-ACK, where is the number of coded modulation symbols per layer for CG-UCI transmitted on the PUSCH as defined in clause 6.3.2.4.1.4;

-  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 not using repetition type B with UL-SCH, and if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is larger than 1, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as , is determined as follows:

where

- is the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI;

- is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission of TB processing over multiple slots in the slot with the CSI part 2 transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission of TB processing over multiple slots in the slot with the CSI part 2 transmission and is the total number of OFDM symbols of the PUSCH in the slot, including all OFDM symbols used for DMRS;

- and all the other notations in the formula are defined the same as for PUSCH not using repetition type B and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

For CSI part 2 transmission on an actual repetition of a PUSCH with repetition Type B 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 resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission assuming a nominal repetition without segmentation, and is the total number of OFDM symbols in a nominal repetition of the PUSCH, including all OFDM symbols used for DMRS;

- for any OFDM symbol that carries DMRS of the PUSCH assuming a nominal repetition without segmentation, ;

- for any OFDM symbol that does not carry DMRS of the PUSCH assuming a nominal repetition without segmentation, where is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission assuming a nominal repetition without segmentation;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the actual repetition of the PUSCH transmission, and is the total number of OFDM symbols in the actual repetition of the PUSCH transmission, including all OFDM symbols used for DMRS;

- for any OFDM symbol that carries DMRS of the actual repetition of the PUSCH transmission, ;

- for any OFDM symbol that does not carry DMRS of the actual repetition of the PUSCH transmission, where is the number of subcarriers in OFDM symbol that carries PTRS, in the actual repetition of the PUSCH transmission;

- and all the other notations in the formula are defined the same as for PUSCH not using repetition type B and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

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 Clause 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 Clause 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 .

6.3.2.4.1.4 CG-UCI

For CG-UCI transmission on PUSCH with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table, or if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is equal to 1, the number of coded modulation symbols per layer for CG-UCI transmission, denoted as , is determined as follows:

where

- is the number of CG-UCI bits;

- is the number of CRC bits for CG-UCI determined according to Clause 6.3.1.2.1;

- ;

- is the number of code blocks for UL-SCH of the PUSCH transmission;

- is the *r*-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 *l* that carries PTRS, in the PUSCH transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol *l*, for =0,1,2,…, , 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 CG-UCI transmission on PUSCH with UL-SCH, and if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is larger than 1, the number of coded modulation symbols per layer for CG-UCI transmission, denoted as , is determined as follows:

where

- is the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI;

- is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission of TB processing over multiple slots in the slot with the CG-UCI transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission of TB processing over multiple slots in the slot with the CG-UCI transmission and is the total number of OFDM symbols of the PUSCH in the slot, including all OFDM symbols used for DMRS;

- 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 of TB processing over multiple slots in the slot with the CG-UCI transmission;

- and all the other notations in the formula are defined the same as for PUSCH with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

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

Rate matching is performed according to Clause 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 Clause 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 *r*.

6.3.2.4.1.5 HARQ-ACK and CG-UCI

For HARQ-ACK and CG-UCI transmission on PUSCH with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table, or if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is equal to 1, the number of coded modulation symbols per layer for HARQ-ACK and CG-UCI transmission, denoted as , is determined as follows:

where

- is the number of HARQ-ACK bits;

- is the number of CG-UCI bits;

- if , ; otherwise is the number of CRC bits for HARQ-ACK and CG-UCI determined according to Clause 6.3.1.2.1;

- ;

- is the number of code blocks for UL-SCH of the PUSCH transmission;

- is the *r*-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 *l* that carries PTRS, in the PUSCH transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol *l*, for =0,1,2,…, , 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 and CG-UCI transmission on PUSCH with UL-SCH, and if *numberOfSlotsTBoMS* is present in the resource allocation table and the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI is larger than 1, the number of coded modulation symbols per layer for HARQ-ACK and CG-UCI transmission, denoted as , is determined as follows:

where

- is the value of *numberOfSlotsTBoMS* in the row indicated by the Time domain resource assignment field in DCI;

- is the number of subcarriers in OFDM symbol that carries PTRS, in the PUSCH transmission of TB processing over multiple slots in the slot with the HARQ-ACK and CG-UCI transmission;

- is the number of resource elements that can be used for transmission of UCI in OFDM symbol , for , in the PUSCH transmission of TB processing over multiple slots in the slot with the HARQ-ACK and CG-UCI transmission and is the total number of OFDM symbols of the PUSCH in the slot, including all OFDM symbols used for DMRS;

- 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 of TB processing over multiple slots in the slot with the HARQ-ACK and CG-UCI transmission;

- and all the other notations in the formula are defined the same as for PUSCH with UL-SCH and if *numberOfSlotsTBoMS* is not present in the resource allocation table.

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

Rate matching is performed according to Clause 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 Clause 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 *r*.

6.3.2.4.1.6 UCI with different priority indexes

In this clause, is equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 1, and equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 0. is equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 0, and equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 1.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 1:

- If CSI part 1 is also transmitted on the PUSCH,

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.1.2, by assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.1.2 is 0 bit.

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.1.3, by taking HARQ-ACK with priority index 0 as CSI part 2 and replacing by , and assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.1.3 is 0 bit.

- Otherwise, perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.1.2, by taking HARQ-ACK with priority index 0 as CSI-part 1 and replacing by , and assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.1.2 is 0 bit.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 1, and CSI if any are transmitted on a PUSCH associated with priority index 0:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.1.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.1.2, by taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH.

- Perform rate matching for CSI part 2 according to clause 6.3.2.4.1.3, by taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 2 is also transmitted on the PUSCH.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.1.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by , if HARQ-ACK bits associated with priority index 1 are transmitted without CG-UCI associated with priority index 1.

- Perform rate matching for CG-UCI with priority index 1 according to clause 6.3.2.4.1.4, if CG-UCI associated with priority index 1 is transmitted without HARQ-ACK bits associated with priority index 1.

- Perform rate matching for CG-UCI with priority index 1 and HARQ-ACK with priority index 1 according to clause 6.3.2.4.1.5, if both CG-UCI associated with priority index 1 and HARQ-ACK bits associated with priority index 1 are transmitted, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- If CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 1,

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.1.2, by taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.1.3, by taking HARQ-ACK with priority index 0 as CSI part 2 and replacing by , and taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Otherwise,

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.1.2, by taking HARQ-ACK with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.1.3, by taking CSI part 1 as CSI part 2 and replacing by , taking HARQ-ACK with priority index 0 as CSI-part 1 and taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.

If *uci-MuxWithDiffPrio* is configured, and CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any, HARQ-ACK bits associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 0:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.1.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- Perform rate matching for CG-UCI associated with priority index 0 according to clause 6.3.2.4.1.2, if CG-UCI associated with priority index 0 is transmitted without HARQ-ACK bits associated with priority index 0, by taking CG-UCI associated with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 as HARQ-ACK.

- Perform rate matching for CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 according to clause 6.3.2.4.1.2, if both CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 are transmitted, by taking CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 as HARQ-ACK.

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.1.3, by taking CSI part 1 as CSI part 2 and replacing by , taking CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any as CSI-part 1 and taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.

6.3.2.4.2 UCI encoded by channel coding of small block lengths

If the higher layer parameter *nrof\_UTO\_UCI* is configured, the procedures in this clause and the clauses it refers to apply by replacing CG-UCI with UTO-UCI in all the notations and texts.

6.3.2.4.2.1 HARQ-ACK

For HARQ-ACK transmission on PUSCH, the number of coded modulation symbols per layer for HARQ-ACK transmission, denoted as , is determined according to Clause 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 Clause 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, the number of coded modulation symbols per layer for CSI part 1 transmission, denoted as , is determined according to Clause 6.3.2.4.1.2, by setting the number of CRC bits .

Rate matching is performed according to Clause 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, the number of coded modulation symbols per layer for CSI part 2 transmission, denoted as , is determined according to Clause 6.3.2.4.1.3, by setting the number of CRC bits .

Rate matching is performed according to Clause 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 .

6.3.2.4.2.4 CG-UCI

For CG-UCI transmission on PUSCH, the number of coded modulation symbols per layer for CG-UCI transmission, denoted as , is determined according to Clause 6.3.2.4.1.4, by setting the number of CRC bits .

The input bit sequence to rate matching is .

Rate matching is performed according to Clause 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 .

6.3.2.4.2.5 HARQ-ACK and CG-UCI

For HARQ-ACK and CG-UCI transmission on PUSCH, the number of coded modulation symbols per layer for HARQ-ACK and CG-UCI transmission, denoted as , is determined according to Clause 6.3.2.4.1.5, by setting the number of CRC bits .

The input bit sequence to rate matching is .

Rate matching is performed according to Clause 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 .

6.3.2.4.2.6 UCI with different priority indexes

In this clause, is equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 1, and equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 0. is equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 0, and equal to defined in [5, TS38.213] in case of PUSCH associated with priority index 1.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 1:

- If CSI part 1 is also transmitted on the PUSCH,

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.2.2, by assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.2.2 is 0 bit.

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.2.3, by taking HARQ-ACK with priority index 0 as CSI part 2 and replacing by , and assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.2.3 is 0 bit.

- Otherwise, perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.2.2, by taking HARQ-ACK with priority index 0 as CSI-part 1 and replacing by , and assuming the number of HARQ-ACK information bits to be transmitted on PUSCH in clause 6.3.2.4.2.2 is 0 bit.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 1, and CSI if any are transmitted on a PUSCH associated with priority index 0:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.2.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.2.2, by taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH.

- Perform rate matching for CSI part 2 according to clause 6.3.2.4.2.3, by taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 2 is also transmitted on the PUSCH.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.2.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by , if HARQ-ACK bits associated with priority index 1 are transmitted without CG-UCI associated with priority index 1.

- Perform rate matching for CG-UCI with priority index 1 according to clause 6.3.2.4.2.4, if CG-UCI associated with priority index 1 is transmitted without HARQ-ACK bits associated with priority index 1.

- Perform rate matching for CG-UCI with priority index 1 and HARQ-ACK with priority index 1 according to clause 6.3.2.4.2.5, if both CG-UCI associated with priority index 1 and HARQ-ACK bits associated with priority index 1 are transmitted, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- If CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 1,

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.2.2, by taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.2.3, by taking HARQ-ACK with priority index 0 as CSI part 2 and replacing by , and taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Otherwise,

- Perform rate matching for HARQ-ACK with priority index 0 according to clause 6.3.2.4.2.2, by taking HARQ-ACK with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 if any as HARQ-ACK, and taking CG-UCI associated with priority index 1 if any as CG-UCI.

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.2.3, by taking CSI part 1 as CSI part 2 and replacing by , taking HARQ-ACK with priority index 0 as CSI-part 1 and taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.

If *uci-MuxWithDiffPrio* is configured, and CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any, HARQ-ACK bits associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 0:

- Perform rate matching for HARQ-ACK with priority index 1 according to clause 6.3.2.4.2.1, by taking HARQ-ACK with priority index 1 as HARQ-ACK and replacing by .

- Perform rate matching for CG-UCI associated with priority index 0 according to clause 6.3.2.4.2.2, if CG-UCI associated with priority index 0 is transmitted without HARQ-ACK bits associated with priority index 0, by taking CG-UCI associated with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 as HARQ-ACK.

- Perform rate matching for CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 according to clause 6.3.2.4.2.2, if both CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 are transmitted, by taking CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 as CSI-part 1 and replacing by and taking HARQ-ACK with priority index 1 as HARQ-ACK.

- Perform rate matching for CSI part 1 according to clause 6.3.2.4.2.3, by taking CSI part 1 as CSI part 2 and replacing by , taking CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any as CSI-part 1 and taking HARQ-ACK with priority index 1 as HARQ-ACK, if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.

< Unchanged parts are omitted >

6.3.2.7 Multiplexing of coded UCI bits with different priority indexes to PUSCH

If the higher layer parameter *nrof\_UTO\_UCI* is configured, the procedure in this clause 6.3.2.7 applies by replacing CG-UCI with UTO-UCI in all the notations and texts.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 1,

- If CSI part 1 is also transmitted on the PUSCH, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 0 as CSI part 2, and assuming the number of HARQ-ACK information in Clause 6.2.7 is 0 bit;

- Otherwise, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 0 as CSI-part 1, and assuming the number of HARQ-ACK information in Clause 6.2.7 is 0 bit.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 1, and CSI if any are transmitted on a PUSCH associated with priority index 0, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 1 as HARQ-ACK.

If *uci-MuxWithDiffPrio* is configured, and HARQ-ACK bits associated with priority index 0, HARQ-ACK bits associated with priority index 1 and/or CG-UCI associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH,

- if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 1, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 1 as HARQ-ACK, and taking HARQ-ACK with priority index 0 as CSI part 2;

- otherwise, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 1 if any as HARQ-ACK, taking CG-UCI associated with priority index 1 if any as CG-UCI, taking HARQ-ACK with priority index 0 as CSI part 1, and taking CSI part 1 as CSI part 2 if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.

If *uci-MuxWithDiffPrio* is configured, and CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any, HARQ-ACK bits associated with priority index 1, and CSI part 1 if any are transmitted on a PUSCH associated with priority index 0, the coded UCI bits are multiplexed onto PUSCH according to the procedures in Clause 6.2.7 by taking HARQ-ACK with priority index 1 as HARQ-ACK, taking CG-UCI associated with priority index 0 and HARQ-ACK bits associated with priority index 0 if any as CSI part 1, and taking CSI part 1 as CSI part 2 if CSI part 1 is also transmitted on the PUSCH and the PUSCH is associated with priority index 0.