**3GPP TSG RAN WG1 #110 R1-220XXXX**

**Toulouse, France, August 22nd – 26th, 2022**

**Agenda Item:** 8.2

**Source:** Moderator (LG Electronics)

**Title:** Summary #1 of PDSCH/PUSCH enhancements (Scheduling/HARQ)

**Document for:** Discussion and decision

# Introduction

This is the summary document for 8.2 on PDSCH/PUSCH enhancements (especially for scheduling and HARQ) for NR above 52.6 GHz, based on the contributions listed in reference section.

# Issue#1: Type-1 HARQ CB when time bundling is configured

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| Company | Views |
| [1] Huawei | Reason for change: 1. When time domain bundling is configured in for type 1 HARQ codebook, UE determines the location of HARQ bit corresponding to PDSCH(s) scheduled by a single DCI based on the last SLIV of the TDRA row indicated in the DCI format no matter whether the PDSCH corresponding to the last SLIV is valid or not. However, the word “scheduled” can be mis interpreted as “transmitted”.
2. The case when there is only one valid PDSCH scheduled by DCI indicating multiple SLIVs is not included.

See TP#A. |
| [2] Fujitsu | Observation 1: The current pseudo-code for Type-1 HARQ-ACK codebook generation with time domain bundling fails to capture the case of single valid PDSCH among multiple PDSCHs scheduled by a single DCI.Observation 2: There are two possible interpretations on the “a PDSCH associated with occasion m”. How to update the pseudo-code to capture the case of single valid PDSCH among multiple scheduled PDSCHs depends on which interpretation we assume.Proposal 1: If Interpretation 1 is the common understanding, adopt CR#1. If Interpretation 2 is the common understanding, adopt CR#2.* + Interpretation 1: “a PDSCH associated with occasion ”is a PDSCH scheduled in the corresponding DL slot of occasion , and the corresponding DL slot of occasion is the DL slot where the last SLIV locates for determining occasion

* + Interpretation 2: “a PDSCH associated with occasion ”is a PDSCH of which the corresponding HARQ-ACK information is mapping to occasion

For interpretation 1, see TP#B.For interpretation 2, see TP#C. |
| [9] LG Electronics | Summary of change:HARQ-ACK bit corresponding to multi-PDSCH scheduling DCI is generated by performing binary AND operation if the number of valid PDSCH receptions for the DCI is more than one. On the other hand, if the number of valid PDSCH receptions for the DCI equals to one, HARQ-ACK bit corresponds to that valid PDSCH without performing binary AND operation across PDSCHs.See TP#D. |

## [Moderator’s note] Three companies proposed TPs discussing how to generate type-1 HARQ-ACK codebook when there is a single valid PDSCH and time domain bundling is configured for multi-PDSCH scheduling DCI. In addition, one company requested a clarification on which interpretation is consistent with current specifications.

Companies are encouraged to express whether this issue needs to be discussed in RAN1#110.

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| Company | Views |
| vivo | We prefer to introduce a TP on how to generate Type-1 codebook when there is only a single valid PDSCH scheduled by a multi-PDSCH scheduling DCI and time domain bundling is configured for multi-PDSCH scheduling. Besides, as discussed by Fujitsu, there may be two interpretations for current pseudo code of Type-1 codebook. We also prefer to clarity which interpretation should be adopted by the spec, as well as whether a corresponding TP is needed or not. |
| Nokia, NSB | There may be room to clarify spec text on the single valid PDSCH handling and, hence, it would be beneficial to discuss the issue in RAN1#110 |
| Fujitsu | As one of the proponents, we think the issue needs to be discussed in RAN1#110.By the way, it seems the change marks in the TPs are lost. I am not sure if it is just my Word problem. |

# Issue#2: Type-2 HARQ CB when both of time bundling and spatial bundling are configured

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| Company | Views |
| [1] Huawei | Reason for change:1. Binary AND operation between 2 TBs belonging to the same PDSCH is not included in the type 2 HARQ codebook generation when multiple PDSCHs are scheduled by single DCI and both time domain and spatial domain bundling are configured.
2. The sentence of “instead of generating one HARQ-ACK information bit per transport block for a serving cell from the serving cells, the UE generates HARQ-ACK information bits” may be misinterpreted as “UE generates HARQ-ACK bits per TB”.

See TP#E. |
| [4] Intel | Summary of change:1. Add binary AND operation for spatial bundling before reusing the specification in 9.1.1 to generate HARQ-ACK for each TBG
2. Revise the text to allow entering the pseudo code for the case with spatial bundling enabled

See TP#F. |
| [6] vivo | Summary of change:Clarify that UE first performs spatial bundling and then time domain bundling.See TP#G. |
| [7] vivo | Proposal 3: For time domain bundling of Type-2 codebook, clarify the corresponding UE behaviour to generate HARQ-ACK information bits for a DL scheduling DCI when spatial bundling is also configured. |
| [10], [11], [12] Nokia | Reason for change:It is unclear how to perform spatial domain HARQ-ACK bundling for Type-2 codebook when UE is configured with HARQ-ACK bundling both in spatial domain and time domain in case of multi-PDSCH scheduling.See TP#H. |

## [Moderator’s note] Four companies proposed TPs to clarify type-2 HARQ-ACK codebook generation especially when both of time bundling and spatial bundling are configured.

Companies are encouraged to express whether this issue needs to be discussed in RAN1#110.

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| Company | Views |
| vivo | In our opinion, this issue should be discussed in RAN1#110, since during RAN1#109-e meeting, this issue was discussed extensively, and almost all companies involved in the discussion thought it should be corrected by introducing a proper TP, but no stable TP was achieved at the end of RAN1#109-e meeting due to limited time.Regarding the TP, TP#E, TP#F or TP#G can be regarded as the starting point. |
| Nokia, NSB | We see that this spec text should be clarified and, hence, should be discussed in RAN1#110 |
| Fujitsu | We think the issue needs to be discussed in RAN1#110. And we slightly prefer the 1st change in TP#E/F. |

# Issue#3: Type-2 HARQ CB when time bundling is configured but spatial bundling is not configured

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| Company | Views |
| [5] vivo | Summary of change:Clarify that for time domain bundling of Type-2 codebook, division of TBGs is applicable only for an enabled TB of a DCI format scheduling more than one PDSCH. For a TB disabled by the DCI format, the UE directly generate HARQ-ACK information bits each of which is set to NACK.See TP#I. |
| [7] vivo | Proposal 1: For time domain bundling of Type-2 codebook, division of TBGs is applicable only for an enabled TB of a DL scheduling DCI.Proposal 2: For time domain bundling of Type-2 codebook, the UE directly generate HARQ-ACK information bits each of which is set to NACK for a disabled TB of a DL scheduling DCI. |

## [Moderator’s note] One company requested a clarification on how to construct TBG and generate corresponding HARQ-ACK information when a TB is disabled for a serving cell configured with 2 TB + multi-PDSCH scheduling DCI + time bundling but not configured with spatial bundling.

Companies are encouraged to express whether this issue needs to be discussed in RAN1#110.

|  |  |
| --- | --- |
| Company | Views |
| vivo | From our perspective, the question that “Is TBGs only applicable for an enabled TB, or also applicable for a disabled TB?” should be clarified, since it has impacts not only on setting HARQ-ACK bits for a serving cell configured with 2 TB + multi-PDSCH scheduling DCI + time bundling but not configured with spatial bundling in a Type-2 codebook, but also on calculating the number of TBGs, which will further impact the calculation of used for power control of PUCCH transmission.Regarding the corresponding TP, TP#I can be regarded as the starting point. |
| Nokia, NSB | This issue may be worth of discussion. |
| Fujitsu | We have one question for clarification on the current spec. According to the text below, we feel the current spec. text already covers how to handle the case of TB disabling (by “if applicable”), and no HARQ-ACK information bits will be generated for the disabled TB. If that is the correct understanding, we may not need to discuss the issue.TS 38.213, h20:“If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for first TBs and, if applicable, generates HARQ-ACK information bits for second TBs in the PDSCH receptions as described in clause 9.1.1 by setting and .” |

# (E) Issue#4: HARQ-ACK timing parameters

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| --- | --- |
| Company | Views |
| [8] Samsung | Reason for change:Rel-17 introduces two HARQ-ACK timing parameters, *dl-DataToUL-ACK-r17* and *dl-DataToUL-ACK-DCI-1-2-r17* for 480kHz and 960kHz SCS, which are not captured in the specification.See TP#J. |

## [Moderator’s note] TP#J seems editorial. So, companies are encouraged to express whether TP#J is agreeable or not.

|  |  |
| --- | --- |
| Company | Views |
| vivo | Support TP#J for alignment between TS38.213 and TS38.331. |
| Nokia, NSB | We are fine with the TP. . |
| Fujitsu | We are fine with the TP. |

# Reference

1. R1-2205769 Corrections on HARQ codebook generation for 52-71GHz spectrum Huawei, HiSilicon
2. R1-2206160 Correction on Type-1 HARQ-ACK codebook determination in TS 38.213 Fujitsu
3. R1-2206535 Discussion on Type-2 HARQ-ACK CB generation when both of spatial bundling and time bundling are configured Intel Corporation
4. R1-2206536 [draft CR] Correction on Type-2 HARQ-ACK CB generation when both of spatial bundling and time bundling are configured Intel Corporation
5. R1-2206736 Correction on division of TBGs for Type-2 codebook vivo
6. R1-2206737 Correction on time domain bundling with spatial bundling for Type-2 codebook vivo
7. R1-2206738 Remaining issues on Type-2 codebook for multi-PDSCH scheduling vivo
8. R1-2206793 Draft CR for HARQ-ACK timing parameters for FR2-2 Samsung
9. R1-2207027 Draft CR for type-1 HARQ-ACK codebook for multi-PDSCH scheduling LG Electronics
10. R1-2207269 Draft CR for spatial HARQ-ACK bundling for type-2 codebook with multi-PDSCH scheduling Nokia, Nokia Shanghai Bell
11. R1-2207608 On spatial HARQ-ACK bundling for type-2 codebook with multi-PDSCH scheduling Nokia, Nokia Shanghai Bell
12. R1-2207717 On spatial HARQ-ACK bundling for type-2 codebook with multi-PDSCH scheduling Nokia, Nokia Shanghai Bell

# TPs

## TP#A (was from [1] Huawei)

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

\*\*\* Unchanged text omitted \*\*\*

A UE determines HARQ-ACK information bits, for a total number of HARQ-ACK information bits, of a HARQ-ACK codebook for transmission in a PUCCH according to the following pseudo-code. In the following pseudo-code, if the UE does not receive a transport block or a CBG, due to the UE not detecting a corresponding DCI format, the UE generates a NACK value for the transport block or the CBG. The cardinality of the set defines a total number of occasions for PDSCH reception or SPS PDSCH release or TCI state update for serving cell corresponding to the HARQ-ACK information bits.

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cells including, when applicable, cells in the set and the set

Set - HARQ-ACK information bit index

Set to the number of serving cells configured by higher layers for the UE

while

Set – index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update

while

if *enableTimeDomainHARQ-Bundling* is provided for serving cell and a PDSCH associated with occasion is indicated by a DCI format indicating a TDRA row that includes more than one SLIV entry

if *harq-ACK-SpatialBundlingPUCCH* is not provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row

 = binary AND operation of the HARQ-ACK information bit(s) corresponding to first transport block(s) in PDSCH reception(s), that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = binary AND operation of the HARQ-ACK information bit(s) corresponding to second transport block(s) in PDSCH reception(s), that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 NACK;

;

 NACK;

end if

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row;

 = binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

else

 = NACK;

end if

;

else

if the PDSCH is associated with the last SLIV in the TDRA row;

 =binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

else

 = NACK;

end if

;

end if

else

## TP#B (was from [2] Fujitsu)

\*\*\* Unchanged text omitted \*\*\*

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cells including, when applicable, cells in the set and the set

Set - HARQ-ACK information bit index

Set to the number of serving cells configured by higher layers for the UE

while

Set – index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update

while

if *enableTimeDomainHARQ-Bundling* is provided for serving cell and a PDSCH associated with occasion is scheduled by a DCI format indicating a TDRA row that includes more than one SLIV entry

if *harq-ACK-SpatialBundlingPUCCH* is not provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row

if two or more PDSCH receptions do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell

 = binary AND operation of the HARQ-ACK information bits corresponding to first transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = binary AND operation of the HARQ-ACK information bits corresponding to second transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 = HARQ-ACK information bit corresponding to a first transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = HARQ-ACK information bit corresponding to a second transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 NACK;

;

 NACK;

end if

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row;

 if two or more PDSCH receptions do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell

 = binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

else

 = binary AND operation of the HARQ-ACK information bits corresponding to a first transport block and a second transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

f the UE receives one transport block, the UE assumes ACK for the second transport block;else

 = NACK;

end if

;

else

if the PDSCH is associated with the last SLIV in the TDRA row;

 if two or more PDSCH receptions do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell

 =binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

else

 = HARQ-ACK information bit corresponding to a transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;else

 = NACK;

end if

;

end if

else

if *harq-ACK-SpatialBundlingPUCCH* is not provided, *PDSCH-CodeBlockGroupTransmission* is not provided, and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell ,

= HARQ-ACK information bit corresponding to a first transport block of this cell;

;

 = HARQ-ACK information bit corresponding to a second transport block of this cell;

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided, and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell ,

 = binary AND operation of the HARQ-ACK information bits corresponding to first and second transport blocks of this cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

;

elseif *PDSCH-CodeBlockGroupTransmission* is provided, and CBGs are indicated by *maxCodeBlockGroupsPerTransportBlock* for serving cell ,

Set - CBG index

while

 = HARQ-ACK information bit corresponding to CBG of the first transport block;

if the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

 = HARQ-ACK information bit corresponding to CBG of the second transport block;

end if

;

end while

, where is the value of *maxNrofCodeWordsScheduledByDCI* for the active DL BWP of serving cell ;

else

 = HARQ-ACK information bit of serving cell ;

;

end if

end if

;

end while

;

end while

\*\*\* Unchanged text omitted \*\*\*

## TP#C (was from [3] Fujitsu)

\*\*\* Unchanged text omitted \*\*\*

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cells including, when applicable, cells in the set and the set

Set - HARQ-ACK information bit index

Set to the number of serving cells configured by higher layers for the UE

while

Set – index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update

while

if *enableTimeDomainHARQ-Bundling* is provided for serving cell and a PDSCH associated with occasion is scheduled by a DCI format indicating a TDRA row that includes more than one SLIV entry

if *harq-ACK-SpatialBundlingPUCCH* is not provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if two or more PDSCH receptions do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

 = binary AND operation of the HARQ-ACK information bits corresponding to first transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = binary AND operation of the HARQ-ACK information bits corresponding to second transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 = HARQ-ACK information bit corresponding to a first transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = HARQ-ACK information bit corresponding to a second transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

end if

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if two or more PDSCH receptions do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

 = binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

else

 = binary AND operation of the HARQ-ACK information bits corresponding to a first transport block and a second transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

if the UE receives one transport block, the UE assumes ACK for the second transport block;

end if

;

else

if two or more PDSCH receptions do not overlap with an uplink symbol indicated by tdd-UL-DL-ConfigurationCommon or tdd-UL-DL-ConfigurationDedicated, scheduled by the DCI format on serving cell c;

 =binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

else

 = HARQ-ACK information bit corresponding to a transport block of a single PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

end if

;

end if

else

if *harq-ACK-SpatialBundlingPUCCH* is not provided, *PDSCH-CodeBlockGroupTransmission* is not provided, and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell ,

= HARQ-ACK information bit corresponding to a first transport block of this cell;

;

 = HARQ-ACK information bit corresponding to a second transport block of this cell;

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided, and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell ,

 = binary AND operation of the HARQ-ACK information bits corresponding to first and second transport blocks of this cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

;

elseif *PDSCH-CodeBlockGroupTransmission* is provided, and CBGs are indicated by *maxCodeBlockGroupsPerTransportBlock* for serving cell ,

Set - CBG index

while

 = HARQ-ACK information bit corresponding to CBG of the first transport block;

if the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

 = HARQ-ACK information bit corresponding to CBG of the second transport block;

end if

;

end while

, where is the value of *maxNrofCodeWordsScheduledByDCI* for the active DL BWP of serving cell ;

else

 = HARQ-ACK information bit of serving cell ;

;

end if

end if

;

end while

;

end while

\*\*\* Unchanged text omitted \*\*\*

## TP#D (was from [9] LG Electronics)

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

\*\*\* Unchanged text is omitted \*\*\*

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cells including, when applicable, cells in the set and the set

Set - HARQ-ACK information bit index

Set to the number of serving cells configured by higher layers for the UE

while

Set – index of occasion for candidate PDSCH reception, or SPS PDSCH release, or TCI state update

while

if *enableTimeDomainHARQ-Bundling* is provided for serving cell and a PDSCH associated with occasion is scheduled by a DCI format indicating a TDRA row that includes more than one SLIV entry

if *harq-ACK-SpatialBundlingPUCCH* is not provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row

if more than one PDSCH receptions scheduled by the DCI format do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*

 = binary AND operation of the HARQ-ACK information bits corresponding to first transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = binary AND operation of the HARQ-ACK information bits corresponding to second transport blocks in PDSCH receptions, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 = HARQ-ACK information bit corresponding to first transport block in a PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

;

 = HARQ-ACK information bit corresponding to second transport block in a PDSCH reception, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format on serving cell ;

else

 NACK;

;

 NACK;

end if

;

elseif *harq-ACK-SpatialBundlingPUCCH* is provided and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for the active DL BWP of serving cell

if the PDSCH is associated with the last SLIV in the TDRA row;

if more than one PDSCH receptions scheduled by the DCI format do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*

 = binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

else

 = binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in a PDSCH, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

if the UE receives one transport block, the UE assumes ACK for the second transport block;

else

 = NACK;

end if

;

else

if the PDSCH is associated with the last SLIV in the TDRA row;

if more than one PDSCH receptions scheduled by the DCI format do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*

 =binary AND operation of the HARQ-ACK information bits corresponding to all transport blocks in PDSCHs, that do not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

else

 = HARQ-ACK information bit corresponding to all transport blocks in a PDSCH, that does not overlap with an uplink symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated*, scheduled by the DCI format of serving cell

else

 = NACK;

end if

;

end if

## TP#E (was from [1] Huawei)

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

\*\*\* Unchanged text omitted \*\*\*

If a UE is provided *numberOfHARQ-BundlingGroups* and is not provided *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over transport block groups (TBGs) for PDSCH receptions where, for a maximum number of PDSCH receptions scheduled by a DCI format on the serving cell, a maximum number of TBGs is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for first TBs and, if applicable, generates HARQ-ACK information bits for second TBs in the PDSCH receptions as described in clause 9.1.1 by setting and . For a TBG associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that TB(s) provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, are correctly received. For a TBG associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the TBG.

If a UE is provided *numberOfHARQ-BundlingGroups* and *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over PDSCH reception groups for PDSCH receptions scheduled by a DCI format on the serving cell where a maximum number of PDSCH reception groups, , is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for the PDSCH receptions as described in clause 9.1.1 by setting and , after binary AND operation of the HARQ-ACK information bits corresponding to the first and second transport blocks of each PDSCH reception, if applicable. For a PDSCH reception group associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that TBs provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, are correctly received. For a PDSCH reception group associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the PDSCH reception group.

If a UE

- is provided *PDSCH-TimeDomainResourceAllocationListForMultiPDSCH* and, if provided, *numberOfHARQ-BundlingGroups* with value for serving cells; and

- is not provided *PDSCH-TimeDomainResourceAllocationListForMultiPDSCH* or is provided *numberOfHARQ-BundlingGroups* with value , for serving cells where

the UE determines the according to the previous pseudo-code with the following modifications

- is used for the determination of a first HARQ-ACK sub-codebook for

- SPS PDSCH reception,

- any DCI format having associated HARQ-ACK information without scheduling PDSCH reception, and

- PDSCH reception scheduled by a DCI format scheduling one PDSCH

- PDSCH reception with for TBG-based HARQ-ACK information on the serving cells,

- is replaced by for the determination of a second HARQ-ACK sub-codebook corresponding to the serving cells for TBG-based HARQ-ACK information, or for TB-based HARQ-ACK information corresponding to multiple PDSCH receptions scheduled by a single DCI format, and

- if, for an active DL BWP of a serving cell, the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode* = *joint,* the serving cell is counted as two times where the first time corresponds to the first CORESETs and the second time corresponds to the second CORESETs, and

- instead of generating one HARQ-ACK information bit per transport block for a serving cell from the serving cells, the UE generates HARQ-ACK information bits per PDSCH receptions scheduled by a DCI format, where is the maximum value between across all serving cells if the UE is provided *numberOfHARQ-BundlingGroups*, and across all serving cells where the UE is not provided *numberOfHARQ-BundlingGroups*, and is the value of *maxNrofCodeWordsScheduledByDCI* for serving cell if *harq-ACK-SpatialBundlingPUCCH* is not provided; else, . If for a serving cell where the UE is provided *numberOfHARQ-BundlingGroups*, it is , the UE generates NACK for the last HARQ-ACK information bits for serving cell . If for a serving cell where the UE is not provided *numberOfHARQ-BundlingGroups*, it is , the UE generates NACK for the last HARQ-ACK information bits for serving cell .

- The pseudo-code operation when *PDSCH-CodeBlockGroupTransmission* is provided is not applicable.

- The counter DAI value and the total DAI value apply separately for each HARQ-ACK sub-codebook.

- The UE generates the HARQ-ACK codebook by appending the second HARQ-ACK sub-codebook to the first HARQ-ACK sub-codebook.

\*\*\* Unchanged text omitted \*\*\*

## TP#F (was from [4] Intel)

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

<Unchanged Text Omitted>

If a UE is provided *numberOfHARQ-BundlingGroups* and *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over PDSCH reception groups for PDSCH receptions scheduled by a DCI format on the serving cell where a maximum number of PDSCH reception groups, , is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for the PDSCH receptions as described in clause 9.1.1 by setting and , after binary AND operation of the HARQ-ACK information bits corresponding to the first and second transport blocks of each PDSCH reception, if applicable. For a PDSCH reception group associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that TBs provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, are correctly received. For a PDSCH reception group associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the PDSCH reception group.

If a UE

- is provided *PDSCH-TimeDomainResourceAllocationListForMultiPDSCH* and, if provided, *numberOfHARQ-BundlingGroups* with value for serving cells; and

- is not provided *PDSCH-TimeDomainResourceAllocationListForMultiPDSCH* or is provided *numberOfHARQ-BundlingGroups* with value , for serving cells where

the UE determines the according to the previous pseudo-code with the following modifications

- is used for the determination of a first HARQ-ACK sub-codebook for

- SPS PDSCH reception,

- any DCI format having associated HARQ-ACK information without scheduling PDSCH reception, and

- PDSCH reception scheduled by a DCI format scheduling one PDSCH

- PDSCH reception with for TBG-based HARQ-ACK information on the serving cells,

- is replaced by for the determination of a second HARQ-ACK sub-codebook corresponding to the serving cells for TBG-based HARQ-ACK information, or for TB-based HARQ-ACK information corresponding to multiple PDSCH receptions scheduled by a single DCI format, and

- if, for an active DL BWP of a serving cell, the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs, and is provided *ackNackFeedbackMode* = *joint,* the serving cell is counted as two times where the first time corresponds to the first CORESETs and the second time corresponds to the second CORESETs, and

- instead of generating one or two HARQ-ACK information bits per PDSCH ~~transport block~~ for a serving cell from the serving cells, the UE generates HARQ-ACK information bits, where is the maximum value between across all serving cells if the UE is provided *numberOfHARQ-BundlingGroups*, and across all serving cells where the UE is not provided *numberOfHARQ-BundlingGroups*, and is the value of *maxNrofCodeWordsScheduledByDCI* for serving cell if *harq-ACK-SpatialBundlingPUCCH* is not provided; else, . If for a serving cell where the UE is provided *numberOfHARQ-BundlingGroups*, it is , the UE generates NACK for the last HARQ-ACK information bits for serving cell . If for a serving cell where the UE is not provided *numberOfHARQ-BundlingGroups*, it is , the UE generates NACK for the last HARQ-ACK information bits for serving cell .

- The pseudo-code operation when *PDSCH-CodeBlockGroupTransmission* is provided is not applicable.

- The counter DAI value and the total DAI value apply separately for each HARQ-ACK sub-codebook.

- The UE generates the HARQ-ACK codebook by appending the second HARQ-ACK sub-codebook to the first HARQ-ACK sub-codebook.

<Unchanged Text Omitted>

## TP#G (was from [6] vivo)

\*\*\* Unchanged text omitted \*\*\*

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

\*\*\* Unchanged text omitted \*\*\*

If a UE is provided *numberOfHARQ-BundlingGroups* and *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over PDSCH reception groups for PDSCH receptions scheduled by a DCI format on the serving cell where a maximum number of PDSCH reception groups, , is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for the PDSCH receptions as described in clause 9.1.1 by setting and , after binary AND operation described in clause 9.1.3.1 if applicable. For a PDSCH reception group associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that TBs provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, are correctly received. For a PDSCH reception group associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the PDSCH reception group.

\*\*\* Unchanged text omitted \*\*\*

## TP#H (was from [10] Nokia)

**<Unchanged parts omitted>**

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

**<Unchanged parts omitted>**

If a UE is provided *numberOfHARQ-BundlingGroups* ~~and is not provided~~ *~~harq-ACK-SpatialBundlingPUCCH~~* for a serving cell , the UE generates HARQ-ACK information over transport block groups (TBGs) for PDSCH receptions where, for a maximum number of PDSCH receptions scheduled by a DCI format on the serving cell, a maximum number of TBGs is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for first TBs and, if applicable, generates HARQ-ACK information bits for second TBs in the PDSCH receptions as described in clause 9.1.1 by setting and . For a TBG associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that TB(s) provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, are correctly received. For a TBG associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the TBG.

~~If a UE is provided~~ *~~numberOfHARQ-BundlingGroups~~* ~~and~~ *~~harq-ACK-SpatialBundlingPUCCH~~* ~~for a serving cell , the UE generates HARQ-ACK information over PDSCH reception groups for PDSCH receptions scheduled by a DCI format on the serving cell where a maximum number of PDSCH reception groups, , is provided by~~ *~~numberOfHARQ-BundlingGroups~~*~~. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for the PDSCH receptions as described in clause 9.1.1 by setting and . For a PDSCH reception group associated with at least one PDSCH that does not overlap with an UL symbol indicated by~~ *~~tdd-UL-DL-ConfigurationCommon~~*~~,~~~~or by~~ *~~tdd-UL-DL-ConfigurationDedicated~~* ~~if provided, the UE assumes that TBs provided by a PDSCH that overlaps with an UL symbol indicated by~~ *~~tdd-UL-DL-ConfigurationCommon~~*~~,~~~~or by~~ *~~tdd-UL-DL-ConfigurationDedicated~~* ~~if provided, are correctly received. For a PDSCH reception group associated only with PDSCHs that overlap with UL symbols indicated by~~ *~~tdd-UL-DL-ConfigurationCommon~~*~~,~~~~or by~~ *~~tdd-UL-DL-ConfigurationDedicated~~* ~~if provided, the UE generates a NACK value for the PDSCH reception group.~~

**<Unchanged parts omitted>**

If and , the UE also determines for obtaining a PUCCH transmission power, as described in clause 7.2.1, with

where

- if , is the value of the counter DAI in the last DCI format scheduling more than one PDSCH receptions for any serving cell from the serving cells with TBG-based HARQ-ACK information or with TB-based HARQ-ACK information that the UE detects within the PDCCH monitoring occasions

- if , is the value of the total DAI in the last DCI format scheduling more than one PDSCH receptions with TBG-based HARQ-ACK information or with TB-based HARQ-ACK information for any serving cell from the serving cells that the UE detects within the PDCCH monitoring occasions

- , if the UE does not detect any DCI format scheduling more than one PDSCH receptions with TBG-based HARQ-ACK information or with TB-based HARQ-ACK information for any serving cell from the serving cells in any of the PDCCH monitoring occasions

- is the total number of DCI formats scheduling more than one PDSCH receptions with TBG-based HARQ-ACK information or with TB-based HARQ-ACK information for any serving cell from the serving cells that the UE detects within the PDCCH monitoring occasions for serving cell . if the UE does not detect any DCI format scheduling more than one PDSCH receptions for serving cell in any of the PDCCH monitoring occasions

- if *harq-ACK-SpatialBundlingPUCCH* is provided,

- if *numberOfHARQ-BundlingGroups* is provided, is the number of ~~PDSCH groups~~ TBGs for first TBs that include at least one PDSCH not overlapping with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* if provided, that the UE receives in serving cell from the serving cells in PDCCH monitoring occasion and the UE reports corresponding HARQ-ACK information in the PUCCH

- if *numberOfHARQ-BundlingGroups* is not provided, is the number of PDSCHs that the UE receives in serving cell from the serving cells in PDCCH monitoring occasion and the UE reports corresponding HARQ-ACK information in the PUCCH

- if harq-ACK-SpatialBundlingPUCCH is not provided,

- if *numberOfHARQ-BundlingGroups* is provided, is the number of TBGs including at least one PDSCH not overlapping with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*, or by *tdd-UL-DL-ConfigurationDedicated* if provided, that the UE receives in serving cell from the serving cells in PDCCH monitoring occasion and the UE reports corresponding HARQ-ACK information in the PUCCH

- if *numberOfHARQ-BundlingGroups* is not provided, is the number of transport blocks in PDSCHs that the UE receives in serving cell from the serving cells in PDCCH monitoring occasion and the UE reports corresponding HARQ-ACK information in the PUCCH.

**<Unchanged parts omitted>**

## TP#I (was from [5] vivo)

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

\*\*\* Unchanged text omitted \*\*\*

If a UE is provided *numberOfHARQ-BundlingGroups* and is not provided *harq-ACK-SpatialBundlingPUCCH* for a serving cell , the UE generates HARQ-ACK information over transport block groups (TBGs) for PDSCH receptions where, for a maximum number of PDSCH receptions scheduled by a DCI format on the serving cell, a maximum number of TBGs for a TB enabled by the DCI format is provided by *numberOfHARQ-BundlingGroups*. If the UE detects a DCI format scheduling PDSCH receptions on the serving cell , the UE generates HARQ-ACK information bits for first TBs if the first TB is enabled by the DCI format and, if applicable, generates HARQ-ACK information bits for second TBs if the second TB is enabled by the DCI format, in the PDSCH receptions as described in clause 9.1.1 by setting and . For a TBG associated with at least one PDSCH that does not overlap with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE assumes that the TB provided by a PDSCH that overlaps with an UL symbol indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, is correctly received. For a TBG associated only with PDSCHs that overlap with UL symbols indicated by *tdd-UL-DL-ConfigurationCommon*,or by *tdd-UL-DL-ConfigurationDedicated* if provided, the UE generates a NACK value for the TBG. For any TB disabled by the DCI format, the UE generates HARQ-ACK information bits, each of which is set to NACK.

\*\*\* Unchanged text omitted \*\*\*

## TP#J (was from [8] Samsung)

9.1.2 Type-1 HARQ-ACK codebook determination

This clause applies if the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*. In clauses 9.1.2, 9.1.2.1, and 9.1.2.2, if the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static* for only one of unicast or multicast HARQ-ACK codebook, the Type-1 HARQ-ACK codebook is generated considering only one of respective unicast or multicast configurations for PDSCH receptions or for PDCCH monitoring for detection of DCI formats.

If a UE is provided *HARQ-feedbackEnabling-disablingperHARQprocess* indicating disabled HARQ-ACK information for a HARQ process associated with a transport block in PDSCH reception occasion on serving cell , the UE reports a NACK value for a HARQ-ACK information bit corresponding to the transport block in a Type-1 HARQ-ACK codebook and does not consider the transport block as received in the determination of in clause 9.1.2.1. If the UE is also provided *PDSCH-CodeBlockGroupTransmission*, the UE reports NACK values for HARQ-ACK information bits corresponding to CBGs of the transport block in the Type-1 HARQ-ACK codebook and does not consider the CBGs as received in the determination of in clause 9.1.2.1. If the UE is also provided *HARQ-feedbackEnablingforSPSactive*, the UE considers a HARQ process associated with a transport block in a first SPS PDSCH reception, after an activation of SPS PDSCH receptions, to have enabled HARQ-ACK information and the UE provides a HARQ-ACK information bit according to a decoding outcome for the transport block in the first SPS PDSCH reception.

If a UE reports HARQ-ACK information associated with a G-RNTI or a G-CS-RNTI with disabled HARQ-ACK information, as described in clause 18, a value of the HARQ-ACK information is a UE implementation choice.

A UE reports HARQ-ACK information for a corresponding PDSCH reception or SPS PDSCH release or TCI state update only in a HARQ-ACK codebook that the UE transmits in a slot indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format as described in clause 9.2.3. The UE reports NACK value(s) for HARQ-ACK information bit(s) in a HARQ-ACK codebook that the UE transmits in a slot not indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format.

If a UE is not provided *pdsch-HARQ-ACK-OneShotFeedback*, the UE does not expect to receive a PDSCH scheduled by a DCI format that the UE detects in any PDCCH monitoring occasion and includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from *dl-DataToUL-ACK-r16* and *dl-DataToUL-ACK-r17*.

If the UE is provided *pdsch-AggregationFactor-r16* in *SPS-Config*, or *pdsch-AggregationFactor* in *SPS-Config-Multicast*, or *pdsch-AggregationFactor* in *PDSCH-Config* and no entry in *pdsch-TimeDomainAllocationList* and *pdsch-TimeDomainAllocationListDCI-1-2* includes *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation-r16*, is a maximum value of *pdsch-AggregationFactor-r16* in *SPS-Config*, or *pdsch-AggregationFactor* in *SPS-Config-Multicast*, or *pdsch-AggregationFactor* in *PDSCH-Config*; otherwise . The UE reports HARQ-ACK information for a PDSCH reception

- from DL slot to DL slot , if is provided by *pdsch-AggregationFactor* or *pdsch-AggregationFactor-r16* [6, TS 38.214], or

- from DL slot to DL slot , if the time domain resource assignment field in the DCI format scheduling the PDSCH reception indicates an entry containing *repetitionNumber,* or

- in DL slot , otherwise

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot , where is

- an UL slot overlapping with the end of the PDSCH reception in DL slot if the UE is provided *subslotLengthForPUCCH* for the HARQ-ACK codebook

- the last UL slot for PUCCH transmission overlapping with DL slot if the UE is not provided *subslotLengthForPUCCH* for the HARQ-ACK codebook

and is a number of slots indicated by the PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format, or provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot , the UE sets a value for each corresponding HARQ-ACK information bit to NACK.

\*\*\* Unchanged text is omitted \*\*\*

9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel

For a serving cell , an active DL BWP, and an active UL BWP, as described in clause 12, the UE determines a set of occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell is deactivated, the UE uses as the active DL BWP for determining the set of occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:

a) on a set of slot timing values associated with the active UL BWP on the primary cell or, if the PUCCH transmission is indicated by a DCI format to be on the PUCCH-sSCell as described in clause 9A, on a set of slot timing values associated with the active UL BWP on the PUCCH-sSCell

- If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for either DCI format 1\_1 or DCI format 1\_2 for serving cell , is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8} for SCS configuration of PUCCH transmission , {7, 8, 12, 16, 20, 24, 28, 32} for , and {13, 16, 24, 32, 40, 48, 56, 64} for

- If the UE is configured to monitor PDCCH for DCI format 1\_1 and is not configured to monitor PDCCH for DCI format 1\_2 for serving cell , is provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17*

- If the UE is configured to monitor PDCCH for DCI format 1\_2 and is not configured to monitor PDCCH for DCI format 1\_1 for serving cell , is provided by *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-DCI-1-2-r17*

- If the UE is configured to monitor PDCCH for DCI format 1\_1 and DCI format 1\_2 for serving cell , is provided by the union of *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17* and *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-DCI-1-2-r17*

- If an inapplicable value in *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17* is provided, the value is excluded from

- If the UE is configured to monitor PDCCH for multicast DCI formats for serving cell

- if the UE is not provided *type1-Codebook-GenerationMode =* 'mode1', is additionally provided by the union of *dl-DataToUL-ACK from pucch-ConfigurationListMulticast1 or pucch-ConfigurationListMulticast2* and *dl-DataToUL-ACK-ForDCI Format4\_1*

- if the UE is not provided *dl-DataToUL-ACK-ForDCI Format4\_1*, is provided by the union of *dl-DataToUL-ACK from pucch-ConfigurationListMulticast1 or pucch-ConfigurationListMulticast2* and the slot timing values {1, 2, 3, 4, 5, 6, 7, 8}

- if the UE is provided *type1-Codebook-GenerationMode =* 'mode1', the UE

- determines a first set as , where is a set of slot timing values for the multicast DCI formats, a second set as , and a third set as

b) on a set of row indexes of a table that is associated with the active DL BWP and defining respective sets of slot offsets , start and length indicators *SLIV*, and PDSCH mapping types for PDSCH reception as described in [6, TS 38.214], where the row indexes of the table are provided by

- the union of row indexes of time domain resource allocation tables for DCI formats the UE is configured to monitor PDCCH for serving cell if the UE is not configured to monitor PDCCH for multicast DCI formats for serving cell , or is not provided *type1-Codebook-GenerationMode =* 'mode1', or, if any, for the first set

- the union of row indexes of time domain resource allocation tables for DCI format 1\_0 and/or DCI format 1\_1 and/or DCI format 1\_2 for serving cell for the second set, if any

- the union of row indexes of time domain resource allocation tables for multicast DCI formats the UE is configured to monitor PDCCH for serving cell for the third set, if any

- if the UE is provided *referenceOfSLIVDCI-1-2*, for each row index with slot offset and PDSCH mapping Type B in a set of row indexes of a table for DCI format 1\_2 [6, TS 38.214], for any PDCCH monitoring occasion in any slot where the UE monitors PDCCH for DCI format 1\_2 and with starting symbol , if for normal cyclic prefix and for extended cyclic prefix, add a new row index in the set of row indexes of the table by replacing the starting symbol of the row index by

c) on the ratio between the downlink SCS configuration and the uplink SCS configuration provided by *subcarrierSpacing* in *BWP-Downlink* and *BWP-Uplink* for the active DL BWP and the active UL BWP, respectively

d) if provided, on *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* as described in clause 11.1

e) if *ca-SlotOffset* is provided, on and provided by *ca-SlotOffset* for serving cell , or on and provided by *ca-SlotOffset* for the primary cell, as described in [4, TS 38.211].

\*\*\* Unchanged text is omitted \*\*\*

If a UE is provided *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17*, the UE does not expect to be indicated by DCI format 1\_0 a slot timing value for transmission of HARQ-ACK information that does not belong to the intersection of the set of slot timing values {1, 2, 3, 4, 5, 6, 7, 8} for SCS configuration of PUCCH transmission , {7, 8, 12, 16, 20, 24, 28, 32} for , and {13, 16, 24, 32, 40, 48, 56, 64} for , and the set of slot timing values provided by for the active DL BWP of a corresponding serving cell.

\*\*\* Unchanged text is omitted \*\*\*

9.1.2.2 Type-1 HARQ-ACK codebook in physical uplink shared channel

If a UE is not provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for unicast or multicast HARQ-ACK information, the UE does not multiplex the unicast or multicast HARQ-ACK information in the PUSCH transmission, respectively.

If a UE is provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for unicast and/or multicast HARQ-ACK information, and would multiplex HARQ-ACK information in a PUSCH transmission that is not scheduled by a DCI format or is scheduled by a DCI format that does not include a DAI field, then

- if the UE has not received any PDSCH or SPS PDSCH release or TCI state update that the UE multiplexes corresponding HARQ-ACK information in the PUSCH, based on a value of a respective PDSCH-to-HARQ\_feedback timing indicator field in a DCI format scheduling the PDSCH reception or the SPS PDSCH release or the TCI state update, or on the value of *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_1 or on the value of *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_2 and the UE is provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for unicast HARQ-ACK information, or on the value of *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 4\_2 and the UE is provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for multicast HARQ-ACK information, in any of the occasions for candidate PDSCH receptions by a DCI format or SPS PDSCH on any serving cell , as described in clause 9.1.2.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission

- else the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1, except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*, unless the UE receives only a SPS PDSCH release, or only a SPS PDSCH reception, or only a TCI state update, or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 if the UE is provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for unicast HARQ-ACK information, or is scheduled by DCI format 4\_1 with a counter DAI field value of 1 if the UE is provided *pdsch-HARQ-ACK-Codebook = 'semi-static'* for multicast HARQ-ACK information, on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception or only for the TCI state update as described in clause 9.1.2.

\*\*\* Unchanged text is omitted \*\*\*

9.1.3 Type-2 HARQ-ACK codebook determination

This clause applies if the UE is configured with *pdsch-HARQ-ACK-Codebook = dynamic* or with *pdsch-HARQ-ACK-Codebook-r16*. Unless stated otherwise, a PDSCH-to-HARQ\_feedback timing indicator field provides an applicable value.

A UE does not expect to multiplex in a Type-2 HARQ-ACK codebook HARQ-ACK information that is in response to a detection of a DCI format that does not include a counter DAI field.

If a UE is provided *HARQ-feedbackEnabling-disablingperHARQprocess* indicating disabled HARQ-ACK information for a HARQ process associated with a transport block for PDCCH monitoring occasion or for SPS PDSCH receptions on serving cell , the UE does not multiplex a HARQ-ACK information bit corresponding to the transport block in a Type-2 HARQ-ACK codebook and does not consider the transport block as received in the determination of or of in clause 9.1.3.1. If the UE is also provided *PDSCH-CodeBlockGroupTransmission*, the UE does not multiplex HARQ-ACK information bits corresponding to CBGs of the transport block in the Type-2 HARQ-ACK codebook and does not consider the CBGs as received in the determination of in clause 9.1.3.1. If the UE is also provided *HARQ-feedbackEnablingforSPSactive*, the UE considers a HARQ process associated with a transport block in a first SPS PDSCH reception, after an activation of SPS PDSCH receptions, to have enabled HARQ-ACK information and the UE provides a HARQ-ACK information bit according to a decoding outcome for the transport block in the first SPS PDSCH reception.

If a UE is indicated to not provide multicast HARQ-ACK information, as described in clause 18, associated with PDCCH monitoring occasion or for SPS PDSCH receptions on serving cell , the UE does not multiplex corresponding HARQ-ACK information bits in a Type-2 HARQ-ACK codebook and does not consider any transport blocks as received in the determination of or of in clause 9.1.3.1.

If a UE receives a first DCI format that the UE detects in a first PDCCH monitoring occasion and includes a PDSCH-to-HARQ\_feedback timing indicator field providing an inapplicable value from *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-r17*,

- if the UE detects a second DCI format, the UE multiplexes the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission in a slot that is indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format, where

- if the UE is not provided *pdsch-HARQ-ACK-Codebook-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception, if any, received after the PDSCHs scheduled by the first DCI format.

- if the UE is provided *pdsch-HARQ-ACK-Codebook-r16*, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format indicates a HARQ-ACK information report for a same PDSCH group index as indicated by the first DCI format as described in clause 9.1.3.3, and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception, if any, received after the PDSCHs scheduled by the first DCI format.

- if the UE is provided *pdsch-HARQ-ACK-Codebook-r16*, the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the PDSCHs scheduled by the first DCI format, and the second DCI format indicates a HARQ-ACK information report for a same PDSCH group index as indicated by the first DCI format as described in clause 9.1.3.3.

- if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the first DCI format does not have associated HARQ-ACK information without scheduling a PDSCH reception or TCI state update, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4, and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception, if any, received after the PDSCHs scheduled by the first DCI format.

- if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the first DCI format does not have associated HARQ-ACK information without scheduling a PDSCH reception or TCI state update, and the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the PDSCHs scheduled by the first DCI format, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4.

- otherwise, the UE does not multiplex the corresponding HARQ-ACK information in a PUCCH or PUSCH transmission.

9.1.3.1 Type-2 HARQ-ACK codebook in physical uplink control channel

If a UE is configured to monitor PDCCH for multicast DCI formats with CRC scrambled by one or more G-RNTIs or G-CS-RNTIs that the UE generates a Type-2 HARQ-ACK codebook, the UE separately applies the procedures in this clause per G-RNTI or per G-CS-RNTI and determines the Type-2 HARQ-ACK codebook by concatenating the Type-2 HARQ-ACK codebook for unicast DCI formats, followed by the HARQ-ACK codebooks for the multicast DCI formats in ascending order of the corresponding G-RNTI values, followed by the HARQ-ACK codebooks for the multicast DCI formats in ascending order of the corresponding G-CS-RNTI values.

A UE determines monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions, or having associated HARQ-ACK information without scheduling PDSCH reception, on an active DL BWP of a serving cell , as described in clause 10.1, and for which the UE transmits HARQ-ACK information in a same PUCCH in slot based on

- PDSCH-to-HARQ\_feedback timing indicator field values, or a *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* value if the PDSCH-to-HARQ\_feedback timing indicator field is not present in a DCI format, for PUCCH transmission with HARQ-ACK information in slot , as described in clause 9.2.3, in response to PDSCH receptions, or in response to a DCI format having associated HARQ-ACK information without scheduling PDSCH reception

- slot offsets [6, TS 38.214] provided by time domain resource assignment field in a DCI format scheduling PDSCH receptions and by *pdsch-AggregationFactor*, or *pdsch-AggregationFactor-r16*, or *repetitionNumber*, when provided.

\*\*\* Unchanged text is omitted \*\*\*

9.2.3 UE procedure for reporting HARQ-ACK

In this clause, for the purpose of determining a PUCCH resource for a PUCCH transmission in a slot using a PUCCH resource indicator field in a DCI format that schedules a PDSCH reception, and for the purpose of determining the slot for the PUCCH transmission

- a UE is assumed to generate HARQ-ACK information regardless of whether or not the PDSCH reception provides a transport block for a HARQ process with disabled HARQ-ACK information as indicated by *HARQ-feedbackEnabling-disablingperHARQprocess*, if provided

- a UE is assumed to not generate HARQ-ACK information associated with a G-RNTI or a G-CS-RNTI with disabled HARQ-ACK information as described in clause 18.

The UE determines a number of HARQ-ACK information bits as described in clauses 9.1 through 9.1.5 and a corresponding set of PUCCH resources as described in clause 9.2.1.

A UE does not expect to transmit more than one PUCCH with HARQ-ACK information in a slot per priority index, if the UE is not provided *ackNackFeedbackMode = separate*.

For DCI format 1\_0, the PDSCH-to-HARQ\_feedback timing indicator field values map to {1, 2, 3, 4, 5, 6, 7, 8} for SCS configuration of PUCCH transmission , to {7, 8, 12, 16, 20, 24, 28, 32} for , and to {13, 16, 24, 32, 40, 48, 56, 64} for . For a unicast DCI format, other than DCI format 1\_0 or requesting Type-3 HARQ-ACK codebook report without scheduling a PDSCH reception as described in clause 9.1.4, the PDSCH-to-HARQ\_feedback timing indicator field values, if present, map to values for a set of number of slots provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17,* or *dl-DataToUL-ACK-DCI-1-2-r17* as defined in Table 9.2.3-1. If the DCI format indicates a cell for the PUCCH transmission, as described in clause 9.A, the PDSCH-to-HARQ\_feedback timing indicator field value maps to slots of the active UL BWP of the cell; otherwise, the PDSCH-to-HARQ\_feedback timing indicator field value maps to slots of the active UL BWP of the PCell. For DCI format 4\_1, the PDSCH-to-HARQ\_feedback timing indicator field values are provided by *dl-DataToUL-ACK-MulticastDciFormat4\_1* or, if *dl-DataToUL-ACK-MulticastDciFormat4\_1* is not provided, by {1, 2, 3, 4, 5, 6, 7, 8}. For DCI format 4\_2, the PDSCH-to-HARQ\_feedback timing indicator field values are provided by *dl-DataToUL-ACK* from *pucch-ConfigurationListMulticast1* or *pucch-ConfigurationListMulticast2.*

If the UE is provided *subslotLengthForPUCCH*, is the last UL slot for PUCCH transmission that overlaps with a PDSCH reception or with a PDCCH reception providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception; otherwise, is the last UL slot for PUCCH transmission that overlaps with the DL slot for the PDSCH reception or with the DL slot for the PDCCH reception in case of a DCI format that triggers a HARQ-ACK information report and does not schedule a PDSCH reception.

For a SPS PDSCH reception ending in DL slot , the UE transmits the PUCCH in UL slot where is provided by the PDSCH-to-HARQ\_feedback timing indicator field, if present, in a DCI format activating the SPS PDSCH reception.

If the UE detects a DCI format that does not include a PDSCH-to-HARQ\_feedback timing indicator field and schedules a PDSCH reception or activates a SPS PDSCH reception ending in DL slot , the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot where is provided by *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1*.

If the UE detects a DCI format scheduling a number of PDSCH receptions ending in DL slot  or if the UE detects a DCI format generating a HARQ-ACK information bit and does not schedule a PDSCH reception through a PDCCH reception ending in DL slot , the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot , where is a number of slots and is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format, if present, or provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1*.

A PUCCH transmission with HARQ-ACK information is subject to the limitations for UE transmissions described in clause 11.1 and clause 11.1.1.

**Table 9.2.3-1: Mapping of PDSCH-to-HARQ\_feedback timing indicator field values to numbers of slots**

|  |  |
| --- | --- |
| **PDSCH-to-HARQ\_feedback timing indicator**  | **Number of slots**  |
| 1 bit | 2 bits | 3 bits |  |
| '0' | '00' | '000' | 1st value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1*  |
| '1' | '01' | '001' | 2nd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  | '10' | '010' | 3rd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  | '11' | '011' | 4th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*,or *dl-DataToUL-ACK-DCI-1-2-r17,* *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  |  | '100' | 5th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  |  | '101' | 6th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  |  | '110' | 7th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |
|  |  | '111' | 8th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17*, or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1* |

For a PUCCH transmission with HARQ-ACK information, a UE determines a PUCCH resource on the cell of the PUCCH transmission, as described in clause 9.A, after determining a set of PUCCH resources for HARQ-ACK information bits, as described in clause 9.2.1. The PUCCH resource determination is based on a PUCCH resource indicator field [5, TS 38.212], if present, in a last DCI format, excluding the SPS activation DCI, among the DCI formats that have a value of a PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17,* or *dl-DataToUL-ACK-DCI-1-2-r17,* or *dl-DataToUL-ACK-MulticastDciFormat4\_1*, indicating a same slot for the PUCCH transmission, that the UE detects and for which the UE transmits corresponding HARQ-ACK information in the PUCCH. For PUCCH resource determination, detected DCI formats are first indexed in an ascending order across serving cells indexes for a same PDCCH monitoring occasion and are then indexed in an ascending order across PDCCH monitoring occasion indexes. For indexing DCI formats within a serving cell for a same PDCCH monitoring occasion, if the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with value 0 for one or more first CORESETs and is provided *coresetPoolIndex* with value 1 for one or more second CORESETs on an active DL BWP of a serving cell, and with *ackNackFeedbackMode* = *joint* for the active UL BWP, detected DCI formats from PDCCH receptions in the first CORESETs are indexed prior to detected DCI formats from PDCCH receptions in the second CORESETs.

The PUCCH resource indicator field values map to values of a set of PUCCH resource indexes, as defined in Table 9.2.3-2 for a PUCCH resource indicator field of 3 bits, provided by *resourceList* for PUCCH resources from a set of PUCCH resources provided by *PUCCH-ResourceSet* with a maximum of eight PUCCH resources. If the PUCCH resource indicator field includes 1 bit or 2 bits, the values map to the first two values or the first four values, respectively, of Table 9.2.3-2. If the last DCI format does not include a PUCCH resource indicator field, the first value of Table 9.2.3-2 is used.

For the first set of PUCCH resources and when the size of *resourceList* is larger than eight, when a UE provides HARQ-ACK information in a PUCCH transmission in response to detecting a last DCI format in a PDCCH reception, among DCI formats with a value of the PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17,* or *dl-DataToUL-ACK-DCI-1-2-r17*, or *dl-DataToUL-ACK-MulticastDciFormat4\_1*, indicating a same slot for the PUCCH transmission, the UE determines a PUCCH resource with index , , as

 

where is a number of CCEs in CORESET of the PDCCH reception for the DCI format as described in clause 10.1, is the index of a first CCE for the PDCCH reception, and is a value of the PUCCH resource indicator field in the DCI format. When the PDCCH reception includes first and second PDCCH candidates from respective first and second search space sets, as described in clause 10.1, the CORESET is associated with the search space set having the smaller index. If

- the first search space set has larger index than the second search space set and includes the first PDCCH candidate and a third PDCCH candidate that have same first CCE index and CCE aggregation levels 8 and 16, or 16 and 8, respectively,

- the second search space set includes the second PDCCH candidate that has same index and same CCE aggregation level as the first PDCCH candidate, and a fourth PDCCH candidate that has same index and same CCE aggregation level as the third PDCCH candidate,

- the CORESET associated with the first search space set has *cce-REG-MappingType* = '*nonInterleaved*' and has duration of one symbol, and

- the second PDCCH candidate has different first CCE index than the fourth PDCCH candidate

the UE determines from the PDCCH candidate with CCE aggregation level 16 among the second PDCCH candidate and the fourth PDCCH candidate.

\*\*\* Unchanged text is omitted \*\*\*

9.2.5.2 UE procedure for multiplexing HARQ-ACK/SR/CSI in a PUCCH

For a transmission occasion of a single CSI report, a PUCCH resource is provided by *pucch-CSI-ResourceList*. For a transmission occasion of multiple CSI reports, corresponding PUCCH resources can be provided by *multi-CSI-PUCCH-ResourceList*. If a UE is provided first and second *PUCCH-Config*, *multi-CSI-PUCCH-ResourceList* is provided by the first *PUCCH-Config*, and *PUCCH-ResourceId* in *pucch-CSI-ResourceList* or *multi-CSI-PUCCH-ResourceList* indicates a corresponding PUCCH resource in *PUCCH-Resource* provided by the first *PUCCH-Config*.

If a UE is provided only one PUCCH resource set for transmission of HARQ-ACK information in response to PDSCH reception scheduled by a DCI format or in response to a DCI format having associated HARQ-ACK information without scheduling PDSCH reception, the UE does not expect to be provided *simultaneousHARQ-ACK-CSI*.

A UE is configured by *maxCodeRate* a code rate for multiplexing HARQ-ACK, SR, and CSI report(s) in a PUCCH transmission using PUCCH format 2, PUCCH format 3, or PUCCH format 4.

If a UE transmits CSI reports using PUCCH format 2, the UE transmits only wideband CSI for each CSI report [6, TS 38.214]. In the following, a Part 1 CSI report refers either to a CSI report with only wideband CSI or to a Part 1 CSI report with wideband CSI and sub-band CSI.

Denote as

-  a total number of HARQ-ACK information bits, if any

-  a total number of SR bits.  if there is no scheduling request bit; otherwise,  as described in clause 9.2.5.1

- , where  is a number of Part 1 CSI report bits for CSI report with priority value ,  is a number of Part 2 CSI report bits, if any, for CSI report with priority value  [6, TS 38.214], and  is a number of CSI reports that include overlapping CSI reports

- , where  is a number of CRC bits, if any, for encoding HARQ-ACK, SR and Part 1 CSI report bits and  is a number of CRC bits, if any, for encoding Part 2 CSI report bits

In the following

- is a code rate given by *maxCodeRate* as in Table 9.2.5.2-1.

-  is a number of PRBs provided by *nrofPRBs*; otherwise, if *nrofPRBs* is not provided, 

-  for PUCCH format 2 or, if the PUCCH resource with PUCCH format 2 includes an orthogonal cover code with length  provided by *occ-Length*, ,  for PUCCH format 3 or, if the PUCCH resource with PUCCH format 3 includes an orthogonal cover code with length  provided by *occ-Length*, , and  for PUCCH format 4, where  is a number of subcarriers per resource block [4, TS 38.211]

-  is equal to a number of PUCCH symbols  for PUCCH format 2 provided by *nrofSymbols* in *PUCCH-format2*. For PUCCH format 3 or for PUCCH format 4,  is equal to a number of PUCCH symbols  for PUCCH format 3 or equal to a number of PUCCH symbols  for PUCCH format 4 provided by *nrofSymbols* in *PUCCH-format3* or *nrofSymbols* in *PUCCH-format4*, respectively, after excluding a number of symbols used for DM-RS transmission for PUCCH format 3 or for PUCCH format 4, respectively [4, TS 38.211]

-  if pi/2-BPSK is the modulation scheme and  if QPSK is the modulation scheme as indicated by *pi2BPSK* for PUCCH format 3 or PUCCH format 4. For PUCCH format 2, 

If a UE has one or more CSI reports and zero or more HARQ-ACK/SR information bits to transmit in a PUCCH where the HARQ-ACK, if any, is in response to a PDSCH reception without a corresponding PDCCH

- if any of the CSI reports are overlapping and the UE is provided by *multi-CSI-PUCCH-ResourceList* with  PUCCH resources in a slot, for PUCCH format 2 and/or PUCCH format 3 and/or PUCCH format 4, as described in clause 9.2.1, where the resources are indexed according to an ascending order for the product of a number of corresponding REs, modulation order , and configured code rate ;

- if , the UE uses PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource 

- else if  and , , the UE transmits a PUCCH conveying HARQ-ACK information, SR and CSI report(s) in a respective PUCCH where the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource 

- else the UE uses the PUCCH format 2 resource , or the PUCCH format 3 resource , or the PUCCH format 4 resource  and the UE selects  CSI report(s) for transmission together with HARQ-ACK information and SR, when any, in ascending priority value as described in [6, TS 38.214]

- else, the UE transmits the  bits in a PUCCH resource provided by *pucch-CSI-ResourceList* and determined as described in clause 9.2.5

If a UE has HARQ-ACK, SR and wideband or sub-band CSI reports to transmit and the UE determines a PUCCH resource with PUCCH format 2, or the UE has HARQ-ACK, SR and wideband CSI reports [6, TS 38.214] to transmit and the UE determines a PUCCH resource with PUCCH format 3 or PUCCH format 4, where

- the UE determines the PUCCH resource using the PUCCH resource indicator field [5, TS 38.212] in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACK-DCI-1-2*, or *dl-DataToUL-ACK-r17,* or *dl-DataToUL-ACK-DCI-1-2-r17*, indicating a same slot for the PUCCH transmission, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

- the UE determines the PUCCH resource set as described in clause 9.2.1 and clause 9.2.3 for  UCI bits

and

- if , the UE transmits the HARQ-ACK, SR, and CSI reports bits by selecting the minimum number  of the  PRBs satisfying  as described in clauses 9.2.3 and 9.2.5.1;

- else, the UE selects  CSI report(s), from the  CSI reports, for transmission together with HARQ-ACK and SR in ascending priority value [6, TS 38.214], where the value of  satisfies  and , where  is a number of CRC bits corresponding to  UCI bits, and  is a number of CRC bits corresponding to  UCI bits.

If a UE is provided a first interlace of PRBs by *interlace0* in *InterlaceAllocation*, the UE has HARQ-ACK, SR and wideband or sub-band CSI reports to transmit, and the UE determines a PUCCH resource with PUCCH format 2, or the UE has HARQ-ACK, SR and wideband CSI reports to transmit and the UE determines a PUCCH resource with PUCCH format 3, where

- the UE determines the PUCCH resource using the PUCCH resource indicator field in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field, or a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in a DCI format, indicating a same slot for the PUCCH transmission, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

- the UE determines the PUCCH resource set as described in clauses 9.2.1 and 9.2.3 for UCI bits

and

- if , the UE transmits the HARQ-ACK, SR, and CSI reports bits in a PUCCH over the first interlace

- else, if the UE is provided a second interlace of PRBs by *interlace1* and if , the UE transmits the HARQ-ACK, SR, and CSI reports bits in a PUCCH over both the first and second interlaces

- else, the procedure is same as the corresponding one when the UE is provided *PUCCH-ResourceSet* by replacing with , or, if the UE is provided *interlace1*, by .

If a UE has HARQ-ACK, SR and sub-band CSI reports to transmit and the UE determines a PUCCH resource with PUCCH format 3 or PUCCH format 4, where

- the UE determines the PUCCH resource using the PUCCH resource indicator field [5, TS 38.212] in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field indicating a same slot for the PUCCH transmission, or by a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the last DCI format, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

- the UE determines the PUCCH resource set as described in clause 9.2.1 and clause 9.2.3 for  UCI bits

and

- if , the UE transmits the HARQ-ACK, SR and the  CSI report bits by selecting the minimum number  of PRBs from the  PRBs satisfying  as described in clauses 9.2.3 and 9.2.5.1

- else,

- if for  Part 2 CSI report priority value(s), it is

 and

,

the UE selects the first  Part 2 CSI reports, according to respective priority value(s) [6, TS 38.214], for transmission together with the HARQ-ACK, SR and  Part 1 CSI reports , where  is the number of Part 1 CSI report bits for the  CSI report and  is the number of Part 2 CSI report bits for the  CSI report priority value,  is a number of CRC bits corresponding to , and  is a number of CRC bits corresponding to 

- else, the UE drops all Part 2 CSI reports and selects  Part 1 CSI report(s), from the  CSI reports in ascending priority value [6, TS 38.214], for transmission together with the HARQ-ACK and SR information bits where the value of  satisfies  and , where is a number of CRC bits corresponding to  UCI bits, and  is a number of CRC bits corresponding to  UCI bits.

If a UE is provided a first interlace of PRBs by *interlace0* in *InterlaceAllocation*, the UE has HARQ-ACK, SR and sub-band CSI reports to transmit, and the UE determines a PUCCH resource with PUCCH format 3, where

- the UE determines the PUCCH resource using the PUCCH resource indicator field in a last of a number of DCI formats that have a value of a PDSCH-to-HARQ\_feedback timing indicator field indicating a same slot for the PUCCH transmission, or a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-DCI-1-2* or *dl-DataToUL-ACK-r17* or *dl-DataToUL-ACK-DCI-1-2-r17* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the last DCI format, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

- the UE determines the PUCCH resource set as described in clauses 9.2.1 and 9.2.3 for UCI bits

and

- if , the UE transmits the HARQ-ACK, SR and the CSI report bits in a PUCCH over the first interlace

- else if the UE is provided a second interlace of PRBs by *interlace1* and if , the UE transmits the HARQ-ACK, SR, and CSI reports bits in a PUCCH over both the first and second interlaces

- else, the procedure is same as the corresponding one when the UE is provided *PUCCH-ResourceSet* by replacing with , or, if the UE is provided *interlace1*, with .

**Table 9.2.5.2-1: Code rate corresponding to value of *maxCodeRate***

|  |  |
| --- | --- |
| *maxCodeRate* | **Code rate**  |
|
| 0 | 0.08 |
| 1 | 0.15 |
| 2 | 0.25 |
| 3 | 0.35 |
| 4 | 0.45 |
| 5 | 0.60 |
| 6 | 0.80 |
| 7 | Reserved |

\*\*\* Unchanged text is omitted \*\*\*