**3GPP TSG RAN WG1 #107-e** **R1-210xxxx**

**e-Meeting, November 11th – 19th, 2021**

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| *CR-Form-v12.0* |
| **DRAFT CHANGE REQUEST** |
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|  | **38.213** | **CR** |  | **rev** |  | **Current version:** | **16.7.0** |  |
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| *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 multicast-broadcast services in NR |
|  |  |
| ***Source to WG:*** | Samsung |
| ***Source to TSG:*** |  |
|  |  |
| ***Work item code:*** | NR\_MBS-Core |  | ***Date:*** | 2021-11-29 |
|  |  |  |  |  |
| ***Category:*** | B |  | ***Release:*** | Rel-17 |
|  | *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 canbe 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-12 (Release 12)**Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
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| ***Reason for change:*** | Introduction of multicast-broadcast services (MBS) in NR. |
|  |  |
| ***Summary of change:*** | Add description related to MBS support including the configuration of MBS frequency resource, HARQ-ACK reporting, and PDCCH monitoring. |
|  |  |
| ***Consequences if not approved:*** | Incomplete support for MBS in NR. |
|  |  |
| ***Clauses affected:*** | 3.3, 9, 9.1, 9.1.2, 9.1.2.1, 9.1.3.1, 10.1, 18 (new)  |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS 38.211, TS 38.212, TS 38.214 |
| ***affected:*** |  | **X** |  Test specifications | TS/TR ... CR ...  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications | TS/TR ... CR ...  |
|  |  |
| ***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 [1, TR 21.905].

BPRE Bits per resource element

BWP Bandwidth part

CB Code block

CBG Code block group

CBR Channel busy ratio

CCE Control channel element

CORESET Control resource set

CP Cyclic prefix

CRC Cyclic redundancy check

C-RNTI Cell RNTI

CS-RNTI Configured scheduling RNTI

CSI Channel state information

CSS Common search space

DAI Downlink assignment index

DAPS Dual active protocol stack

DC Dual connectivity

DCI Downlink control information

DL Downlink

DL-SCH Downlink shared channel

EPRE Energy per resource element

EN-DC E-UTRA NR dual connectivity with MCG using E-UTRA and SCG using NR

FR1 Frequency range 1

FR2 Frequency range 2

G-RNTI Group RNTI

G-CS-RNTI Group configured scheduling RNTI

GSCN Global synchronization channel number

HARQ-ACK Hybrid automatic repeat request acknowledgement

MBS Multicast broadcast services

MCG Master cell group

MCS Modulation and coding scheme

NDI New Data Indicator

NE-DC E-UTRA NR dual connectivity with MCG using NR and SCG using E-UTRA

NR-DC NR NR dual connectivity

PBCH Physical broadcast channel

PCell Primary cell

PDCCH Physical downlink control channel

PDSCH Physical downlink shared channel

PRACH Physical random access channel

PRB Physical resource block

PRG Physical resource block group

PSCell Primary secondary cell

PSBCH Physical sidelink broadcast channel

PSCCH Physical sidelink control channel

PSFCH Physical sidelink feedback channel

PSS Primary synchronization signal

PSSCH Physical sidelink shared channel

PUCCH Physical uplink control channel

PUCCH-SCell PUCCH SCell

PUSCH Physical uplink shared channel

QCL Quasi co-location

RB Resource block

RE Resource element

RLM Radio link monitoring

RRM Radio resource management

RS Reference signal

RSRP Reference signal received power

SCG Secondary cell group

SCI Sidelink control information

SCS Subcarrier spacing

SFCI Sidelink feedback control information

SFN System frame number

SL Sidelink

SLIV Start and length indicator value

SPS Semi-persistent scheduling

SR Scheduling request

SRI SRS resource indicator

SRS Sounding reference signal

SSS Secondary synchronization signal

TA Timing advance

TAG Timing advance group

TCI Transmission Configuration Indicator

UCI Uplink control information

UE User equipment

UL Uplink

UL-SCH Uplink shared channel

USS UE-specific search space

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

# 9 UE procedure for reporting control information

If a UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG.

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.

- When the procedures are applied for SCG, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including PSCell), serving cell, serving cells belonging to the SCG respectively. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If a UE is configured with a PUCCH-SCell, the UE shall apply the procedures described in this clause for both primary PUCCH group and secondary PUCCH group

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the primary PUCCH group respectively.

- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group. If *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16* is provided, *pdsch-HARQ-ACK-Codebook* is replaced by *pdsch-HARQ-ACK-Codebook-secondaryPUCCHgroup-r16*. If *harq-ACK-SpatialBundlingPUCCH-secondaryPUCCHgroup* is provided, *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUCCH-secondaryPUCCHgroup*. If *harq-ACK-SpatialBundlingPUSCH-secondaryPUCCHgroup* is provided, *harq-ACK-SpatialBundlingPUSCH* is replaced by *harq-ACK-SpatialBundlingPUSCH-secondaryPUCCHgroup*.

If a UE is provided *pdsch-HARQ-ACK-CodebookList-r16*, *pdsch-HARQ-ACK-Codebook* is replaced by the relevant entry in *pdsch-HARQ-ACK-CodebookList-r16*.

If a UE

- is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a value of 0 for first CORESETs on active DL BWPs of serving cells, and

- is provided *coresetPoolIndex* with a value of 1 for second CORESETs on active DL BWPs of the serving cells, and

- is provided *ackNackFeedbackMode* = *separate*

the UE shall separately apply the procedures described in clauses 9.1 and 9.2.3 for reporting HARQ-ACK information associated with the first CORESETs on active DL BWP of the serving cells and for reporting HARQ-ACK information associated with the second CORESETs on active DL BWP of the serving cells, and the UE does not expect to be provided with *subslotLengthForPUCCH* or to be indicated by *pdsch-HARQ-ACK-CodebookList* to generate two HARQ-ACK codebooks on active DL BWP of the serving cells. HARQ-ACK information reporting is associated with a CORESET through a reception of a PDCCH with a DCI format triggering the reporting of the HARQ-ACK information by the UE.

For NR-DC when both the MCG and the SCG operate either in FR1 or in FR2 and for a power headroom report transmitted on the MCG or the SCG, the UE computes *PH* assuming that the UE does not transmit PUSCH/PUCCH on any serving cell of the SCG or the MCG, respectively.

If a UE is configured for NR-DC operation, the UE does not expect to be configured with a PUCCH-SCell.

A PUSCH or a PUCCH transmission other than PUCCH transmissions with SL HARQ-ACK reports, including repetitions if any, can be of priority index 0 or of priority index 1. For a configured grant PUSCH transmission, a UE determines a priority index from *phy-PriorityIndex*, if provided. For a PUCCH transmission with HARQ-ACK information corresponding to a SPS PDSCH reception or a SPS PDSCH release, a UE determines a priority index from *harq-CodebookID*, if provided. For a PUCCH transmission with SR, a UE determines the corresponding priority as described in clause 9.2.4. For a PUSCH transmission with semi-persistent CSI report, a UE determines a priority index from a priority indicator field, if provided, in a DCI format that activates the semi-persistent CSI report. If a priority index is not provided to a UE for a PUSCH or a PUCCH transmission other than PUCCH transmissions with SL HARQ-ACK reports, the priority index is 0.

If a UE is provided one *PUCCH-Config*

- if the UE is provided *subslotLengthForPUCCH* in the *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in the *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the *PUCCH-Config*

If a UE is provided two *PUCCH-Config*

- if the UE is provided *subslotLengthForPUCCH* in the first *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 0 or any CSI report configuration in any *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the first *PUCCH-Config*

- if the UE is provided *subslotLengthForPUCCH* in the second *PUCCH-Config*, the PUCCH resource for any SR configuration with priority index 1 in any *PUCCH-Config* is within the *subslotLengthForPUCCH* symbols in the second *PUCCH-Config*

If in an active DL BWP a UE monitors PDCCH either for detection of DCI format 0\_1 and DCI format 1\_1 or for detection of DCI format 0\_2 and DCI format 1\_2, a priority index can be provided by a priority indicator field. If a UE indicates a capability to monitor, in an active DL BWP, PDCCH for detection of DCI format 0\_1 and DCI format 1\_1 and for detection of DCI format 0\_2 and DCI format 1\_2, a DCI format 0\_1 or a DCI format 0\_2 can schedule a PUSCH transmission of any priority, a DCI format 1\_1 or a DCI format 1\_2 can schedule a PDSCH reception and trigger a PUCCH transmission with corresponding HARQ-ACK information of any priority and a DCI format 1\_1 can indicate SCell dormancy and trigger a PUCCH transmission with corresponding HARQ-ACK information of any priority.

When a UE determines overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUCCH of larger and/or smaller priority index, the UE resolves the overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUCCH of each priority index as described in clause 9.2.5 and 9.2.6 before resolving the overlapping for PUCCH transmissions without SL HARQ-ACK or the overlapping for PUCCH transmissions and PUSCH transmissions.

When a UE determines overlapping for PUCCH and/or PUSCH transmissions of different priority indexes other than PUCCH transmissions with SL HARQ-ACK reports before considering limitations for UE transmission as described in clause 11.1, including repetitions if any, the UE first resolves the overlapping for PUCCH and/or PUSCH transmissions of smaller priority index as described in clauses 9.2.5 and 9.2.6. Then,

- if a transmission of a first PUCCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of a transmission of a second PUSCH or a second PUCCH of smaller priority index, the UE cancels the repetition of a transmission of the second PUSCH or the second PUCCH before the first symbol that would overlap with the first PUCCH transmission

- if a transmission of a first PUSCH of larger priority index scheduled by a DCI format in a PDCCH reception would overlap in time with a repetition of the transmission of a second PUCCH of smaller priority index, the UE cancels the repetition of the transmission of the second PUCCH before the first symbol that would overlap with the first PUSCH transmission

where

- the overlapping is applicable before or after resolving overlapping among channels of larger priority index, if any, as described in clauses 9.2.5 and 9.2.6

- any remaining PUCCH and/or PUSCH transmission after overlapping resolution is subjected to the limitations for UE transmission as described in clause 11.1

- the UE expects that the transmission of the first PUCCH or the first PUSCH, respectively, would not start before after a last symbol of the corresponding PDCCH reception

- is the PUSCH preparation time for a corresponding UE processing capability assuming [6, TS 38.214], based on and as subsequently defined in this clause, and is determined by a reported UE capability

If a UE is scheduled by a DCI format in a first PDCCH reception to transmit a first PUCCH or a first PUSCH of larger priority index that overlaps with a second PUCCH or a second PUSCH transmission of smaller priority index that, if any, is scheduled by a DCI format in a second PDCCH

- is based on a value of corresponding to the smallest SCS configuration of the first PDCCH, the second PDCCHs, the first PUCCH or the first PUSCH, and the second PUCCHs or the second PUSCHs

- if the overlapping group includes the first PUCCH

- if *processingType2Enabled* of *PDSCH-ServingCellConfig* is set to *enable* for the serving cell where the UE receives the first PDCCH and for all serving cells where the UE receives the PDSCHs corresponding to the second PUCCHs, and if *processingType2Enabled* of *PUSCH-ServingCellConfig* is set to *enable* for the serving cells with the second PUSCHs, is 5 for , 5.5 for  and 11 for

- else, is 10 for =0*,* 12 for , 23 for , and 36 for ;

- if the overlapping group includes the first PUSCH

- if *processingType2Enabled* of *PUSCH-ServingCellConfig* is set to *enable* for the serving cells with the first PUSCH and the second PUSCHs and if *processingType2Enabled* of *PDSCH-ServingCellConfig* is set to *enable* for all serving cells where the UE receives the PDSCHs corresponding to the second PUCCHs, is 5 for , 5.5 for  and 11 for

- else, is 10 for =0*,* 12 for , 23 for , and 36 for ;

If a UE would transmit the following channels, including repetitions if any, that would overlap in time

- a first PUCCH of larger priority index with SR and a second PUCCH or PUSCH of smaller priority index, or

- a configured grant PUSCH of larger priority index and a PUCCH of smaller priority index, or

- a first PUCCH of larger priority index with HARQ-ACK information only in response to PDSCH(s) reception without corresponding PDCCH(s) and a second PUCCH of smaller priority index with HARQ-ACK information only in response to PDSCH(s) reception without corresponding PDCCH(s), or a second PUCCH of smaller priority index with SR and/or CSI, or a configured grant PUSCH with smaller priority index, or a PUSCH of smaller priority index with SP-CSI report(s) without a corresponding PDCCH, or

 - a PUSCH of larger priority index with SP-CSI reports(s) without a corresponding PDCCH and a PUCCH of smaller priority index with SR, or CSI, or HARQ-ACK information only in response to PDSCH(s) reception without corresponding PDCCH(s), or

- a configured grant PUSCH of larger priority index and a configured PUSCH of smaller priority index on a same serving cell

the UE is expected to cancel a repetition of the PUCCH/PUSCH transmissions of smaller priority index before the first symbol overlapping with the PUCCH/PUSCH transmission of larger priority index if the repetition of the PUCCH/PUSCH transmissions of smaller priority index overlaps in time with the PUCCH/PUSCH transmissions of larger priority index.

When a UE determines overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUSCH of smaller priority index, including repetitions if any, after resolving the overlapping PUCCH other than PUCCH transmissions with SL HARQ-ACK reports and/or PUSCH transmissions, if the PUSCH includes no UCI, the UE resolves the overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUSCH of smaller priority index as described in clauses 9.2.5 and 9.2.6.

When a UE determines overlapping for PUCCH transmissions with SL HARQ-ACK reports and PUSCH of larger priority index only, including repetitions if any, after resolving the overlapping PUCCH other than PUCCH transmissions with SL HARQ-ACK reports and/or PUSCH transmissions, the UE does not transmit the PUCCH with SL HARQ-ACK reports

where

- the UE expects that the transmission of the PUSCH would not start before after a last symbol of the corresponding PDCCH reception;

- is the PUSCH preparation time for a corresponding UE processing capability assuming [6, TS 38.214], based on and as subsequently defined in this clause, and is determined by a reported UE capability.

The UE expects the PUCCH and PUSCH transmissions fulfill the conditions in clause 9 and clause 9.2.5 for UCI multiplexing replacing the reference time of "end of PDSCH" with "end of the last symbol of a last PSFCH reception occasion" as described in 16.5 and *Tproc,*1 with *Tprep*.

A UE does not expect that a PUCCH carrying SL HARQ-ACK reports overlaps with PUSCH with aperiodic or semi-persistent CSI reports.

A UE does not expect to be scheduled to transmit a PUCCH or a PUSCH with smaller priority index that would overlap in time with a PUCCH of larger priority index with HARQ-ACK information only in response to a PDSCH reception without a corresponding PDCCH. A UE does not expect to be scheduled to transmit a PUCCH of smaller priority index that would overlap in time with a PUSCH of larger priority index with SP-CSI report(s) without a corresponding PDCCH.

In the remaining of this clause, a UE multiplexes UCIs with same priority index in a PUCCH or a PUSCH before considering limitations for UE transmission as described in clause 11.1. A PUCCH or a PUSCH is assumed to have a same priority index as a priority index of UCIs a UE multiplexes in the PUCCH or the PUSCH.

In the remaining of this clause, the multiplexing or prioritization for overlapping channels are for overlapping channels with same priority index or for overlapping channels with a PUCCH carrying SL HARQ-ACK information.

In the remaining of this clause, if a UE is provided *subslotLengthForPUCCH*, a slot for an associated PUCCH resource of a PUCCH transmission with HARQ-ACK information includes a number of symbols indicated by *subslotLengthForPUCCH*, unless stated otherwise.

If a UE would transmit on a serving cell a PUSCH without UL-SCH that overlaps with a PUCCH transmission on a serving cell that includes positive SR information, the UE does not transmit the PUSCH.

If a UE would transmit CSI reports on overlapping physical channels, the UE applies the priority rules described in [6, TS 38.214] for the multiplexing of CSI reports.

If a UE has overlapping resources for PUCCH transmissions in a slot and at least one of the PUCCH transmissions is with repetitions over multiple slots, the UE first follows the procedures described in clause 9.2.6 for resolving the overlapping among the resources for the PUCCH transmissions.

If a UE

- would multiplex UCI in a PUCCH transmission that overlaps with a PUSCH transmission, and

- the PUSCH and PUCCH transmissions fulfill the conditions in clause 9.2.5 for UCI multiplexing,

the UE

- multiplexes only HARQ-ACK information, if any, from the UCI in the PUSCH transmission and does not transmit the PUCCH if the UE multiplexes aperiodic or semi-persistent CSI reports in the PUSCH;

- multiplexes only HARQ-ACK information and CSI reports, if any, from the UCI in the PUSCH transmission and does not transmit the PUCCH if the UE does not multiplex aperiodic or semi-persistent CSI reports in the PUSCH.

A UE does not expect to multiplex in a PUSCH transmission in one slot with SCS configuration UCI of same type that the UE would transmit in PUCCHs in different slots with SCS configuration if .

A UE does not expect to multiplex in a PUSCH transmission or in a PUCCH transmission HARQ-ACK information that the UE would transmit in different PUCCHs.

A UE does not expect a PUCCH resource that results from multiplexing overlapped PUCCH resources, if applicable, to overlap with more than one PUSCHs if each of the more than one PUSCHs includes aperiodic CSI reports.

A UE does not expect to detect a DCI format scheduling a PDSCH reception or a SPS PDSCH release, a DCI format 1\_1 indicating SCell dormancy, or a DCI format including a One-shot HARQ-ACK request field with value 1, and indicating a resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot if the UE previously detects a DCI format scheduling a PUSCH transmission in the slot and if the UE multiplexes HARQ-ACK information in the PUSCH transmission.

If a UE multiplexes aperiodic CSI in a PUSCH and the UE would multiplex UCI that includes HARQ-ACK information in a PUCCH that overlaps with the PUSCH and the timing conditions for overlapping PUCCHs and PUSCHs in clause 9.2.5 are fulfilled, the UE multiplexes only the HARQ-ACK information in the PUSCH and does not transmit the PUCCH.

If a UE transmits multiple PUSCHs in a slot on respective serving cells that include first PUSCHs that are scheduled by DCI formats and second PUSCHs configured by respective *ConfiguredGrantConfig* or *semiPersistentOnPUSCH*, and the UE would multiplex UCI in one of the multiple PUSCHs, and the multiple PUSCHs fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in a PUSCH from the first PUSCHs.

If a UE transmits multiple PUSCHs in a slot on respective serving cells and the UE would multiplex UCI in one of the multiple PUSCHs and the UE does not multiplex aperiodic CSI in any of the multiple PUSCHs, the UE multiplexes the UCI in a PUSCH of the serving cell with the smallest *ServCellIndex* subject to the conditions in clause 9.2.5 for UCI multiplexing being fulfilled. If the UE transmits more than one PUSCHs in the slot on the serving cell with the smallest *ServCellIndex* that fulfil the conditions in clause 9.2.5 for UCI multiplexing, the UE multiplexes the UCI in the earliest PUSCH that the UE transmits in the slot.

If a UE transmits a PUSCH over multiple slots and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot that overlaps with the PUSCH transmission in one or more slots of the multiple slots, and the PUSCH transmission in the one or more slots fulfills the conditions in clause 9.2.5 for multiplexing the HARQ-ACK and/or CSI information, the UE multiplexes the HARQ-ACK and/or CSI information in the PUSCH transmission in the one or more slots. The UE does not multiplex HARQ-ACK and/or CSI information in the PUSCH transmission in a slot from the multiple slots if the UE would not transmit a single-slot PUCCH with HARQ-ACK and/or CSI information in the slot in case the PUSCH transmission was absent.

If a UE transmits a PUSCH with repetition Type B and the UE would transmit a PUCCH with HARQ-ACK and/or CSI information over a single slot that overlaps with the PUSCH transmission in one or more slots, the UE expects all actual repetitions of the PUSCH transmission [6, TS 38.214] that would overlap with the PUCCH transmission to fulfill the conditions in clause 9.2.5 for multiplexing the HARQ-ACK and/or CSI information, and the UE multiplexes the HARQ-ACK and/or CSI information in the earliest actual PUSCH repetition of the PUSCH transmission that would overlap with the PUCCH transmission and includes more than one symbol. The UE does not expect that all actual repetitions that would overlap with the PUCCH transmission do not include more than one symbol.

If the PUSCH transmission over the multiple slots is scheduled by a DCI format that includes a DAI field, the value of the DAI field is applicable for multiplexing HARQ-ACK information in the PUSCH transmission in any slot from the multiple slots where the UE multiplexes HARQ-ACK information.

When a UE would multiplex HARQ-ACK information in a PUSCH transmission that is configured by a *ConfiguredGrantConfig*, and includes CG-UCI [5, TS 38.212], the UE multiplexes the HARQ-ACK information in the PUSCH transmission if the UE is provided *cg-UCI-Multiplexing*; otherwise, the UE does not transmit the PUSCH and multiplexes the HARQ-ACK information in a PUCCH transmission or in another PUSCH transmission.

In the following, DCI formats with CRC scrambled by C-RNTI or CS-RNTI or MCS-C-RNTI are also referred to as unicast DCI formats and DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI are also referred to as multicast DCI formats.

## 9.1 HARQ-ACK codebook determination

If a UE is provided *pdsch-HARQ-ACK-CodebookList*, the UE can be indicated by *pdsch-HARQ-ACK-CodebookList* to generate one or two HARQ-ACK codebooks. If the UE is indicated to generate one HARQ-ACK codebook, the HARQ-ACK codebook is associated with a PUCCH of priority index 0. If a UE is provided *pdsch-HARQ-ACK-CodebookList*, the UE multiplexes in a same HARQ-ACK codebook only HARQ-ACK information associated with a same priority index. If the UE is indicated to generate two HARQ-ACK codebooks

- a first HARQ-ACK codebook is associated with a PUCCH of priority index 0 and a second HARQ-ACK codebook is associated with a PUCCH of priority index 1

- the UE is provided first and second for each of {*PUCCH-Config*, *UCI-OnPUSCH*, *PDSCH*-*codeBlockGroupTransmission*} by {*PUCCH-ConfigurationList*, *UCI-OnPUSCH-ListDCI-0-1*, *PDSCH-CodeBlockGroupTransmissionList*} or {*PUCCH-ConfigurationList*, *UCI-OnPUSCH-ListDCI-0-2*, *PDSCH-CodeBlockGroupTransmissionList*}, respectively, for use with the first and second HARQ-ACK codebooks, respectively

If a UE receives a PDSCH without receiving a corresponding PDCCH, or if the UE receives a PDCCH indicating a SPS PDSCH release, the UE generates one corresponding HARQ-ACK information bit. If the UE generates two HARQ-ACK codebooks, the UE is indicated by *harq-CodebookID*, per SPS PDSCH configuration, a HARQ-ACK codebook index for multiplexing the corresponding HARQ-ACK information bit.

If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback* and the UE detects a DCI format in any PDCCH monitoring occasion that 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

- the UE does not expect that the PDSCH-to-HARQ\_feedback timing indicator field of the DCI format provides an inapplicable value from *dl-DataToUL-ACK-r16*

In the remaining of this clause, reference is to one HARQ-ACK codebook and to DCI formats that schedule PDSCH reception, or indicate SPS PDSCH release, or indicate SCell dormancy without scheduling a PDSCH reception and are associated with the HARQ-ACK codebook.

If a UE is required to receive SPS PDSCHs in a slot according to Clause 5.1 of [6] and Clause 11.1 for SPS configurations that are indicated to be released by a DCI format, the UE is not expected to receive the DCI format in the slot if the end of the last symbol of the PDCCH reception is after the end of a last symbol of any of the SPS PDSCH receptions. For a SPS configuration subject to *pdsch-AggregationFactor* or *pdsch-AggregationFactor-r16*, the UE is not expected to receive the DCI format in a slot containing a SPS PDSCH transmission occasion other than the first transmission occasion required to be received by the UE for a TB.

If a UE is configured to receive SPS PDSCHs in a slot for SPS configurations that are indicated to be released by a DCI format, and if the UE receives the PDCCH providing the DCI format in the slot, and if HARQ-ACK information for the SPS PDSCH release and the SPS PDSCH receptions would be multiplexed in a same PUCCH, the UE does not expect to receive the SPS PDSCHs, does not generate HARQ-ACK information for the SPS PDSCH receptions, and generates a HARQ-ACK information bit for the SPS PDSCH release.

If a UE is configured to receive SPS PDSCH(s) in a slot for SPS configuration(s), the UE does not expect to receive a PDCCH providing a DCI format in the slot to indicate SPS PDSCH release of these SPS configuration(s), if HARQ-ACK information for the SPS PDSCH release and the SPS PDSCH reception(s) would map to different PUCCHs.

If a UE detects a DCI format 1\_1 indicating

- SCell dormancy without scheduling a PDSCH reception, as described in clause 10.3, and

- is provided *pdsch-HARQ-ACK-Codebook = dynamic* or *pdsch-HARQ-ACK-Codebook-r16*

the UE generates a HARQ-ACK information bit as described in clause 9.1.3 for a DCI format 1\_1 indicating SCell dormancy and the HARQ-ACK information bit value is ACK.

If a UE is not provided *PDSCH-CodeBlockGroupTransmission*, the UE generates one HARQ-ACK information bit per transport block.

For a HARQ-ACK information bit, a UE generates a positive acknowledgement (ACK) if the UE detects a DCI format that provides a SPS PDSCH release or correctly decodes a transport block, and generates a negative acknowledgement (NACK) if the UE does not correctly decode the transport block. A HARQ-ACK information bit value of 0 represents a NACK while a HARQ-ACK information bit value of 1 represents an ACK.

In the following, the CRC for a DCI format is scrambled with a C-RNTI, an MCS-C-RNTI, or a CS-RNTI, or a G-RNTI, or a G-CS-RNTI.

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

### 9.1.2 Type-1 HARQ-ACK codebook determination

This clause applies if the UE is configured with *pdsch-HARQ-ACK-Codebook = semi-static*.

A UE does not expect to be configured with *pdsch-HARQ-ACK-Codebook = semi-static* for a codebook if a UE is provided *subslotLength-ForPUCCH* for the codebook.

A UE reports HARQ-ACK information for a corresponding PDSCH reception or SPS PDSCH release 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. 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*.

If the UE is provided *pdsch-AggregationFactor-r16* in *SPS-Config* 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 *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 the last UL slot overlapping with DL slot 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* 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.

If a UE reports HARQ-ACK information in a PUCCH only for

- a SPS PDSCH release indicated by DCI format 1\_0 with counter DAI field value of 1, or

- a PDSCH reception scheduled by DCI format 1\_0 with counter DAI field value of 1 on the PCell, or

- SPS PDSCH reception(s) associated with a CS-RNTI

within the occasions for candidate PDSCH receptions as determined in clause 9.1.2.1, the UE determines a HARQ-ACK codebook only for the SPS PDSCH release or only for the PDSCH reception or only for one SPS PDSCH reception according to corresponding occasion(s) on respective serving cell(s), where the value of counter DAI in DCI format 1\_0 is according to Table 9.1.3-1 and HARQ-ACK information bits in response to more than one SPS PDSCH receptions that the UE is configured to receive are ordered according to the following pseudo-code; otherwise, the procedures in clause 9.1.2.1 and clause 9.1.2.2 for a HARQ-ACK codebook determination apply.

Set to the number of serving cells configured to the UE

Set to the number of SPS PDSCH configuration configured to the UE for serving cell

Set to the number of DL slots for SPS PDSCH reception on serving cell with HARQ-ACK information multiplexed on the PUCCH

Set – HARQ-ACK information bit index

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cell

while

Set – SPS PDSCH configuration index: lower indexes correspond to lower RRC indexes of corresponding SPS configurations

while

Set – slot index

while

if {

a UE is configured to receive SPS PDSCHs from slot to slot for SPS PDSCH configuration on serving cell , excluding SPS PDSCHs that are not required to be received in any slot among overlapping SPS PDSCHs, if any according to [6, TS 38.214], or based on a UE capability for a number of PDSCH receptions in a slot according to [6, TS 38.214], or due to overlapping with a set of symbols indicated as uplink by *tdd-UL-DL-ConfigurationCommon* or by *tdd-UL-DL-ConfigurationDedicated* where is provided by *pdsch-AggregationFactor-r16* in *sps-Config* or, if *pdsch-AggregationFactor-r16* is not included in *sps-Config*, by *pdsch-AggregationFactor* in *pdsch-config*, and

HARQ-ACK information for the SPS PDSCH is associated with the PUCCH

}

 = HARQ-ACK information bit for this SPS PDSCH reception

;

end if

;

end while

;

end while

;

end while

#### 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

a) 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}

b) 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*

c) 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-ForDCIFormat1\_2*

d) 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* and *dl-DataToUL-ACK-ForDCIFormat1\_2*

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

- if the UE does not indicate a *capability* or is not provided *Type1-Intersection*, is additionally provided by the union of the set of slot timing values for the multicast DCI formats [12, TS 38.331]

- if the UE indicates *capability* and is provided *Type1-Intersection*, the UE

- determines a first set as , where is a set of slot timing values for the multicast DCI formats [12, TS 38.331], 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 does not indicate a *capability*, or is not provided *Type1-Intersection*, 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

a) 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-SlotOffsetfor serving cell , or on and provided by ca-SlotOffsetfor the primary cell, as described in [4, TS 38.211].

If a UE

- is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a value of 0 for first CORESETs on active DL BWPs of serving cells, and

- is provided *coresetPoolIndex* with a value of 1 for second CORESETs on active DL BWPs of the serving cells, and

- is provided *ackNackFeedbackMode* = *joint*

where

- a serving cell is placed in a first set of serving cells if the serving cell includes a first CORESET, and

- a serving cell is placed in a second set of serving cells if the serving cell includes a second CORESET, and

- serving cells are placed in a set according to an ascending order of a serving cell index

the UE generates a Type-1 HARQ-ACK codebook for the set and the set of serving cells separately by setting and in the following pseudo-code. The UE concatenates the HARQ-ACK codebook generated for the set followed by the HARQ-ACK codebook generated for the set to obtain a total number of  HARQ-ACK information bits.

If a UE is provided *fdmed-Reception-Multicast* and the UE is configured to monitor PDCCH for detection of unicast DCI formats and to monitor PDCCH for detection of multicast DCI format associated with G-RNTI or G-CS-RNTI

- a serving cell is placed in a first set of serving cells if the UE is configured to monitor PDCCH for DCI formats 1\_0/1\_1/1\_2 for scheduling on serving cell , and

- a serving cell is placed in a second set of serving cells if the UE is configured to monitor PDCCH for multicast DCI formats for scheduling on serving cell , and

- serving cells are placed in a set according to an ascending order of a serving cell index

the UE generates a Type-1 HARQ-ACK codebook for the set and the set of serving cells separately by setting and in the following pseudo-code. The UE concatenates the HARQ-ACK codebook generated for the set followed by the HARQ-ACK codebook generated for the set to obtain a total number of HARQ-ACK information bits.

If the UE is configured to monitor PDCCH for DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI and indicates *capability* and is provided *Type1-Intersection*, the UE separately applies the following pseudo-code for each of the first set, the second set, and third set as the set of slot timing values , and for the corresponding sets of row indexes as to obtain first, second, and third Type-1 HARQ-ACK sub-codebooks, and concatenates the first, second, and third, Type-1 HARQ-ACK sub-codebooks to obtain the Type-1 HARQ-ACK codebook.

For the set of slot timing values, the UE determines a set of occasions for candidate PDSCH receptions or SPS PDSCH releases according to the following pseudo-code. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to a single SPS PDSCH release is same as for a corresponding SPS PDSCH reception. A location in the Type-1 HARQ-ACK codebook for HARQ-ACK information corresponding to multiple SPS PDSCH releases by a single DCI format is same as for a corresponding SPS PDSCH reception with the lowest SPS configuration index among the multiple SPS PDSCH releases.

Set - index of occasion for candidate PDSCH reception or SPS PDSCH release

Set

Set

Set to the cardinality of set

Set *k* =0 – index of slot timing values , in descending order of the slot timing values, in set for serving cell

If a UE is not provided *ca-SlotOffset* for any serving cell of PDSCH receptions and for the serving cell of corresponding PUCCH transmission with HARQ-ACK information

while

if

Set – index of a DL slot within an UL slot

while

Set to the set of rows

Set to the cardinality of

Set – index of row in set

if slot starts at a same time as or after a slot for an active DL BWP change on serving cell or an active UL BWP change on the PCell and slot is before the slot for the active DL BWP change on serving cell or the active UL BWP change on the PCell

;

else

while

if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row is configured as ULwhere is the *k*-th slot timing value in set ,

;

else

;

end if

end while

if the UE does not indicate a capability to receive more than one unicast PDSCH or multicast PDSCH per slot and ,

;

;

else

Set to the cardinality of

Set to the smallest last OFDM symbol index, as determined by the *SLIV*, among all rows of

while

Set

while

if for start OFDM symbol index for row

; - index of occasion for candidate PDSCH reception or SPS PDSCH release associated with row

;

;

else

;

end if

end while

;

Set to the smallest last OFDM symbol index among all rows of ;

end while

end if

;

end if

end while

end if

;

end while

else

while 

if

Set  – index of a DL slot within an UL slot

while 

Set  to the set of rows

Set  to the cardinality of 

Set  – index of row in set 

if slot  starts at a same time as or after a slot for an active DL BWP change on serving cell  or an active UL BWP change on the PCell and slot

 is before the slot for the active DL BWP change on serving cell  or the active UL BWP change on the PCell

;

else

while 

if the UE is provided *tdd-UL-DL-ConfigurationCommon*, or *tdd-UL-DL-ConfigurationDedicated* and, for each slot from slot to slot , at least one symbol of the PDSCH time resource derived by row  is configured as ULwhere  is the *k*-th slot timing value in set ,

;

else

;

end if

end while

if the UE does not indicate a capability to receive more than one unicast PDSCH or multicast PDSCH per slot and ,

;

;

else

Set  to the cardinality of 

Set  to the smallest last OFDM symbol index, as determined by the *SLIV*, among all rows of 

while 

Set 

while 

if  for start OFDM symbol index  for row 

; - index of occasion for candidate PDSCH reception or SPS PDSCH release associated with row 

;

;

else

;

end if

end while



;

Set  to the smallest last OFDM symbol index among all rows of ;

end while

end if

;

end if

end while

end if

;

end while

end if

If the UE indicates a capability to receive more than one PDSCH per slot, for occasions of candidate PDSCH receptions corresponding to rows of associated with a same value of , where , the UE does not expect to receive more than one PDSCH in a same DL slot associated with a same *coresetPoolIndex* value if provided, or if *coresetPoolIndex* is not provided.

If a UE receives a SPS PDSCH, or a SPS PDSCH release, or a PDSCH that is scheduled by a DCI format that does not support CBG-based PDSCH receptions and if

- the UE is configured with one serving cell, and

- , and

- *PDSCH-CodeBlockGroupTransmission* is provided to the UE

the UE generates HARQ-ACK information only for the transport block in the PDSCH or only for the SPS PDSCH release.

If a UE receives a SPS PDSCH, or a SPS PDSCH release, or a PDSCH that is scheduled by a DCI format that does not support CBG-based PDSCH receptions and if

- the UE is configured with more than one serving cells, or

- , and

- *PDSCH-CodeBlockGroupTransmission* is provided to the UE

the UE repeats times the HARQ-ACK information for the transport block in the PDSCH or for the SPS PDSCH release.

A UE does not expect to detect a DCI format switching a DL BWP within symbols prior to a first symbol of a PUCCH transmission where the UE multiplexes HARQ-ACK information, where is defined in clause 9.2.3.

If a UE is provided *dl-DataToUL-ACK* or *dl-DataToUL-ACK-ForDCIFormat1\_2*, 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} and the set of slot timing values provided by for the active DL BWP of a corresponding serving cell.

If *maxNrofCodeWordsScheduledByDCI* indicates reception of two transport blocks, when the UE receives a PDSCH with one transport block or a SPS PDSCH release, the HARQ-ACK information is associated with the first transport block and the UE generates a NACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is not provided and generates HARQ-ACK information with value of ACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is provided.

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 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

while

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 while

;

end while

If , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as described in clause 7.2.1, as where

- are all DL cells where the UE is configured to receive unicast or multicast PDSCHs

- is the cardinality for the union of all sets of occasions for unicast or multicast PDSCH receptions or SPS PDSCH releases for serving cell

- is the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* and *PDSCH-CodeBlockGroupTransmission* are not provided, or the number of transport blocks the UE receives in PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that does not support CBG-based PDSCH receptions, or the number of PDSCH receptions if *harq-ACK-SpatialBundlingPUCCH* is provided or SPS PDSCH release in PDSCH reception occasion for serving cell and the UE reports corresponding HARQ-ACK information in the PUCCH.

- is the number of CBGs the UE receives in a PDSCH reception occasion for serving cell if *PDSCH-CodeBlockGroupTransmission* is provided and the PDSCH reception is scheduled by a DCI format that supports CBG-based PDSCH receptions and the UE reports corresponding HARQ-ACK information in the PUCCH.

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

#### 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 that the UE generates a Type-2 HARQ-ACK codebook, the UE separately applies the procedures in this clause per G-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.

A UE determines monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or SPS PDSCH release or indicating SCell dormancy 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 for PUCCH transmission with HARQ-ACK information in slot in response to PDSCH receptions, SPS PDSCH release or SCell dormancy indication

- 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.

The set of PDCCH monitoring occasions for a DCI format scheduling PDSCH receptions or SPS PDSCH release or indicating SCell dormancy is defined as the union of PDCCH monitoring occasions across active DL BWPs of configured serving cells. PDCCH monitoring occasions are indexed in an ascending order of their start times. The cardinality of the set of PDCCH monitoring occasions defines a total number of PDCCH monitoring occasions.

A value of the counter downlink assignment indicator (DAI) field in DCI formats denotes the accumulative number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s), SPS PDSCH release or SCell dormancy indication associated with the DCI formats is present up to the current serving cell and current PDCCH monitoring occasion,

- first, if the UE indicates by *type2-HARQ-ACK-Codebook* support for more than one PDSCH reception on a serving cell that are scheduled from a same PDCCH monitoring occasion, in increasing order of the PDSCH reception starting time for the same {serving cell, PDCCH monitoring occasion} pair,

- second in ascending order of serving cell index, and

- third in ascending order of PDCCH monitoring occasion index , where .

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 value of the counter DAI is in the order of the first CORESETs and then the second CORESETs for a same serving cell index and a same PDCCH monitoring occasion index.

The value of the total DAI, when present [5, TS 38.212], in a DCI format denotes the total number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH reception(s), SPS PDSCH release or SCell dormancy indication associated with DCI formats is present, up to the current PDCCH monitoring occasion and is updated from PDCCH monitoring occasion to PDCCH monitoring occasion. 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 total DAI value counts the {serving cell, PDCCH monitoring occasion}-pair(s) for both the first CORESETs and the second CORESETs.

Denote by the number of bits for the counter DAI and set . Denote by the value of the counter DAI in a DCI format scheduling PDSCH reception, SPS PDSCH release or SCell dormancy indication on serving cell in PDCCH monitoring occasion according to Table 9.1.3-1 or Table 9.1.3-1A. Denote by the value of the total DAI in a DCI format in PDCCH monitoring occasion according to Table 9.1.3-1. The UE assumes a same value of total DAI in all DCI formats that include a total DAI field in PDCCH monitoring occasion . A UE does not expect to multiplex, in a same Type-2 HARQ-ACK codebook, HARQ-ACK information that is in response to detection of DCI formats with different number of bits for the counter DAI field.

If the UE transmits HARQ-ACK information in a PUCCH in slot and for any PUCCH format, the UE determines the , for a total number of HARQ-ACK information bits, according to the following pseudo-code:

Set – PDCCH with DCI format scheduling PDSCH reception, SPS PDSCH release or SCell dormancy indication monitoring occasion index: lower index corresponds to earlier PDCCH monitoring occasion

Set

Set

Set

Set

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

- 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 two times where the first time corresponds to the first CORESETs and the second time corresponds to the second CORESETs

- if the UE indicates *type2-HARQ-ACK-Codebook*, a serving cell is counted times where is the number of PDSCH receptions that can be scheduled for the serving cell by DCI formats in PDCCH receptions at a same PDCCH monitoring occasion based on the reported value of *type2-HARQ-ACK-Codebook*

Set to the number of PDCCH monitoring occasion(s)

while

Set – serving cell index: lower indexes correspond to lower RRC indexes of corresponding cell

while

if PDCCH monitoring occasion is before an active DL BWP change on serving cell or an active UL BWP change on the PCell and an active DL BWP change is not triggered in PDCCH monitoring occasion

;

else

if there is a PDSCH on serving cell associated with PDCCH in PDCCH monitoring occasion , or there is a PDCCH indicating SPS PDSCH release or SCell dormancy on serving cell

if

end if

if

else

end if

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

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

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

elseif *harq-ACK-SpatialBundlingPUCCH* is provided to the UE and is a monitoring occasion for PDCCH with a DCI format that supports PDSCH reception with two transport blocks and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks in at least one configured DL BWP of a serving cell,

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

else

 = HARQ-ACK information bit of this cell

end if

end if

end if

end while

end while

if UE does not set and

end if

if

end if

if *harq-ACK-SpatialBundlingPUCCH* is not provided to the UE and the UE is configured by *maxNrofCodeWordsScheduledByDCI* with reception of two transport blocks for at least one configured DL BWP of a serving cell,

else

end if

 for any

If a UE is configured to receive SPS PDSCH and the UE multiplexes HARQ-ACK information for one activated SPS PDSCH reception in the PUCCH in slot , the UE generates one HARQ-ACK information bit associated with the SPS PDSCH reception and appends it to the HARQ-ACK information bits.

If a UE is configured to receive SPS PDSCH and the UE multiplexes HARQ-ACK information for multiple activated SPS PDSCH receptions in the PUCCH in slot , the UE generates the HARQ-ACK information as described in clause 9.1.2 and appends it to the HARQ-ACK information bits.

For a PDCCH monitoring occasion with DCI format scheduling PDSCH reception or SPS PDSCH release or indicating SCell dormancy in the active DL BWP of a serving cell, when a UE receives a PDSCH with one transport block or a SPS PDSCH release or indicating SCell dormancy and the value of *maxNrofCodeWordsScheduledByDCI* is 2, the HARQ-ACK information is associated with the first transport block and the UE generates a NACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is not provided and generates HARQ-ACK information with value of ACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is provided.

If a UE is not provided *PDSCH-CodeBlockGroupTransmission* for any serving cells, or for PDSCH receptions scheduled by a DCI format that does not support CBG-based PDSCH receptions, or for SPS PDSCH reception, or for a DCI format generating a HARQ-ACK information bit without scheduling a PDSCH reception, and if , the UE determines a number of HARQ-ACK information bits for obtaining a transmission power for a PUCCH, as described in clause 7.2.1, as

where

- is a number of serving cells where the UE is configured to receive unicast PDSCHs

- is a number of serving cells where the UE is configured to receive multicast PDSCHs for a G-RNTI or a G-CS-RNTI

- is a total number of G-RNTIs or G-CS-RNTIs configured to the UE

- is the number of PDCCH monitoring occasions for unicast DCI formats

- is the number of PDCCH monitoring occasions for multicast DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI

- where the number of bits for the counter DAI field in unicast DCI formats

- where the number of bits for the counter DAI field in multicast DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI

- if , is the value of the counter DAI in the last DCI format scheduling PDSCH reception or generating a HARQ-ACK information bit without scheduling a PDSCH reception, for any serving cell that the UE detects within the PDCCH monitoring occasions

- if , is the value of the counter DAI in the last multicast DCI format with G-RNTI , or G-CS-RNTI , scheduling PDSCH reception or generating a HARQ-ACK information bit without scheduling a PDSCH reception, that the UE detects within the PDCCH monitoring occasions

- if or if

- if the UE does not detect any DCI format that includes a total DAI field in a last PDCCH monitoring occasion within the or PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception, or generating a HARQ-ACK information bit without scheduling a PDSCH reception, for any serving cell , or , respectively, is the value of the counter DAI in a last DCI format the UE detects in the last PDCCH monitoring occasion

- if the UE detects at least one DCI format that includes a total DAI field in a last PDCCH monitoring occasion within the or , for G-RNTI or G-CS-RNTI , PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception, or generating a HARQ-ACK information bit without scheduling a PDSCH reception, for any serving cell , or , respectively, is the value of the total DAI in the at least one DCI format that includes a total DAI field

- or if the UE does not detect any DCI format scheduling PDSCH reception, or generating a HARQ-ACK information bit without scheduling a PDSCH reception, for any serving cell in any of the or PDCCH monitoring occasions, respectively.

- or , for G-RNTI or G-CS-RNTI , is the total number of DCI formats scheduling PDSCH receptions, or generating a HARQ-ACK information bit without scheduling a PDSCH reception, that the UE detects within the or PDCCH monitoring occasions, respectively, for serving cell . or if the UE does not detect any DCI format scheduling PDSCH reception, or generating a HARQ-ACK information bit without scheduling a PDSCH reception, for serving cell in any of the or , respectively, PDCCH monitoring occasions.

- if the value of *maxNrofCodeWordsScheduledByDCI* is 2 for any serving cell and *harq-ACK-SpatialBundlingPUCCH* is not provided; otherwise, .

- .

- or , for G-RNTI or G-CS-RNTI , is the number of transport blocks the UE receives in a PDSCH scheduled by a DCI format that the UE detects in PDCCH monitoring occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* is not provided, or the number of PDSCH scheduled by a DCI format that the UE detects in PDCCH monitoring occasion for serving cell if *harq-ACK-SpatialBundlingPUCCH* is provided, or the number of DCI format that the UE detects and generates a HARQ-ACK information bit without scheduling a PDSCH reception in PDCCH monitoring occasion for serving cell .

- or , for G-RNTI or G-CS-RNTI , is the number of SPS PDSCH receptions by the UE on serving cell for which the UE transmits corresponding HARQ-ACK information in the same PUCCH as for HARQ-ACK information corresponding to PDSCH receptions within the or PDCCH monitoring occasions, respectively.

If a UE

- is provided *PDSCH-CodeBlockGroupTransmission* for serving cells; and

- is not provided *PDSCH-CodeBlockGroupTransmission*, 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 release,

- SPS PDSCH reception,

- DCI format 1\_1 indicating SCell dormancy, and

- for TB-based PDSCH receptions on the serving cells and on the serving cells,

- is replaced by for the determination of a second HARQ-ACK sub-codebook corresponding to the serving cells for CBG-based PDSCH receptions, 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, where  is the maximum value of across all serving cells and  is the value of *maxNrofCodeWordsScheduledByDCI* for serving cell . If for a serving cell it is , the UE generates NACK for the last HARQ-ACK information bits for serving cell

- the pseudo-code operation when *harq-ACK-SpatialBundlingPUCCH* 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

If , 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 CBG-based PDSCH reception for any serving cell that the UE detects within the PDCCH monitoring occasions

- if , is the value of the total DAI in the last DCI format scheduling CBG-based PDSCH reception for any serving cell that the UE detects within the PDCCH monitoring occasions

- , if the UE does not detect any DCI format scheduling CBG-based PDSCH reception for any serving cell in any of the PDCCH monitoring occasions

- is the total number of DCI formats scheduling CBG-based PDSCH receptions that the UE detects within the PDCCH monitoring occasions for serving cell . if the UE does not detect any DCI format scheduling CBG-based PDSCH reception for serving cell in any of the PDCCH monitoring occasions

- is the number of CBGs the UE receives in a PDSCH scheduled by a DCI format that supports CBG-based PDSCH reception that the UE detects in PDCCH monitoring occasion for serving cell and the UE reports corresponding HARQ-ACK information in the PUCCH

Table 9.1.3-1: Value of counter DAI for and of total DAI

|  |  |  |
| --- | --- | --- |
| DAIMSB, LSB |  or  | Number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH transmission(s) associated with PDCCH or PDCCH indicating SPS PDSCH release or DCI format 1\_1 indicating SCell dormancy is present, denoted as and  |
| 0,0 | 1 |  |
| 0,1 | 2 |  |
| 1,0 | 3 |  |
| 1,1 | 4 |  |

Table 9.1.3-1A: Value of counter DAI for

|  |  |  |
| --- | --- | --- |
| **DAI** |  | **Number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH transmission(s) associated with PDCCH or PDCCH indicating SPS PDSCH release is present, denoted as and**  |
| 0 | 1 |  |
| 1 | 2 |  |

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

### 9.2.3 UE procedure for reporting HARQ-ACK

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 a 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-ACKForDCIFormat1\_2*, as defined in Table 9.2.3-1. For multicast DCI formats, the PDSCH-to-HARQ\_feedback timing indicator field values are determined as described in [12, TS 38.331].

If the UE is provided *subslotLengthForPUCCH*, is the last UL slot that overlaps with the PDSCH reception or with the PDCCH reception in case of SPS PDSCH release or in case of SCell dormancy indication or in case of the DCI format that requests Type-3 HARQ-ACK codebook report and does not schedule a PDSCH reception; otherwise, is the last UL slot that overlaps with the DL slot for the PDSCH reception or with the DL slot for the PDCCH reception in case of SPS PDSCH release or in case of SCell dormancy indication or in case of the DCI format that requests Type-3 HARQ-ACK codebook 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-ACKForDCIFormat1\_2*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1*.

If the UE detects a DCI format scheduling a PDSCH reception 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 , or if the UE detects a DCI format that requests Type-3 HARQ-ACK codebook report and does not schedule a PDSCH reception through a PDCCH reception ending in DL slot , as described in clause 9.1.4, 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-ACKForDCIFormat1\_2*, or *dl-DataToUL-ACK-MulticastDciFormat1\_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-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1*  |
| '1' | '01' | '001' | 2nd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  | '10' | '010' | 3rd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  | '11' | '011' | 4th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  |  | '100' | 5th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  |  | '101' | 6th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  |  | '110' | 7th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |
|  |  | '111' | 8th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, *dl-DataToUL-ACK-MulticastDciFormat1\_0*, or *dl-DataToUL-ACK-MulticastDciFormat1\_1* |

For a PUCCH transmission with HARQ-ACK information, a UE determines a PUCCH resource 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, 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*, *dl-DataToUL-ACK-r16*, *dl-DataToUL-ACKForDCIFormat1\_2*, or *dl-DataToUL-ACK-MulticastDciFormat1\_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 where, 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-ACKForDCIFormat1\_2*, or *dl-DataToUL-ACK-MulticastDciFormat1\_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. If the DCI format does not include a PUCCH resource indicator field, .

Table 9.2.3-2: Mapping of PUCCH resource indication field values to a PUCCH resource in a PUCCH resource set with maximum 8 PUCCH resources

|  |  |
| --- | --- |
| PUCCH resource indicator  | PUCCH resource |
| 1 bit | 2 bits | 3 bits |  |
| '0' | '00' | '000' | 1st PUCCH resource provided by *pucch-ResourceId* obtained from the 1st value of *resourceList* |
| '1' | '01' | '001' | 2nd PUCCH resource provided by *pucch-ResourceId* obtained from the 2nd value of *resourceList* |
|  | '10' | '010' | 3rd PUCCH resource provided by *pucch-ResourceId* obtained from the 3rd value of *resourceList* |
|  | '11' | '011' | 4th PUCCH resource provided by *pucch-ResourceId* obtained from the 4th value of *resourceList* |
|  |  | '100' | 5th PUCCH resource provided by *pucch-ResourceId* obtained from the 5th value of *resourceList* |
|  |  | '101' | 6th PUCCH resource provided by *pucch-ResourceId* obtained from the 6th value of *resourceList* |
|  |  | '110' | 7th PUCCH resource provided by *pucch-ResourceId* obtained from the 7th value of *resourceList* |
|  |  | '111' | 8th PUCCH resource provided by *pucch-ResourceId* obtained from the 8th value of *resourceList* |

If a UE determines a first resource for a PUCCH transmission with HARQ-ACK information corresponding only to a PDSCH reception without a corresponding PDCCH or detects a first DCI format indicating a first resource for a PUCCH transmission with corresponding HARQ-ACK information in a slot and also detects at a later time a second DCI format indicating a second resource for a PUCCH transmission with corresponding HARQ-ACK information in the slot, the UE does not expect to multiplex HARQ-ACK information corresponding to the second DCI format in a PUCCH resource in the slot if the PDCCH reception that includes the second DCI format is not earlier than  from the beginning of a first symbol of the first resource for PUCCH transmission in the slot where, and are defined in clause 4.1 of [4, TS 38.211] and corresponds to the smallest SCS configuration among the SCS configurations of the PDCCHs providing the DCI formats and the SCS configuration of the PUCCH. If *processingType2Enabled* of *PDSCH-ServingCellConfig* is set to *enable* for the serving cell with the second DCI format and for all serving cells with corresponding HARQ-ACK information multiplexed in the PUCCH transmission in the slot, for ,  for ,  for ; otherwise,  for ,  for ,  for ,  for .

If a UE is not provided *SPS-PUCCH-AN-List* and transmits HARQ-ACK information corresponding only to a PDSCH reception without a corresponding PDCCH, a PUCCH resource for corresponding PUCCH transmission with HARQ-ACK information is provided by *n1PUCCH-AN*.

If a UE transmits a PUCCH with HARQ-ACK information using PUCCH format 0, the UE determines values  and  for computing a value of cyclic shift  [4, TS 38.211] where  is provided by *initialCyclicShift* of *PUCCH-format0* or, if *initialCyclicShift* is not provided, by the initial cyclic shift index as described in clause 9.2.1 and  is determined from the value of one HARQ-ACK information bit or from the values of two HARQ-ACK information bits as in Table 9.2.3-3 and Table 9.2.3-4, respectively.

Table 9.2.3-3: Mapping of values for one HARQ-ACK information bit to sequences for PUCCH format 0

|  |  |  |
| --- | --- | --- |
| HARQ-ACK Value | 0 | 1 |
| **Sequence cyclic shift** |  |  |

Table 9.2.3-4: Mapping of values for two HARQ-ACK information bits to sequences for PUCCH format 0

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| HARQ-ACK Value | {0, 0} | {0, 1} | {1, 1} | {1, 0} |
| **Sequence cyclic shift** |  |  |  |  |

If a UE transmits a PUCCH with HARQ-ACK information using PUCCH format 1, the UE is provided a value for  by *initialCyclicShift* of *PUCCH-format1* or, if *initialCyclicShift* is not provided, by the initial cyclic shift index as described in clause 9.2.1.

If a UE transmits a PUCCH with  HARQ-ACK information bits and  bits using PUCCH format 2 or PUCCH format 3 in a PUCCH resource that includes  PRBs, the UE determines a number of PRBs  for the PUCCH transmission to be the minimum number of PRBs, that is smaller than or equal to a number of PRBs  provided respectively by *nrofPRBs* of *PUCCH-format2* or *nrofPRBs* of *PUCCH-format3* and start from the first PRB from the number of PRBs, that results to  and, if , , where , , , and  are defined in clause 9.2.5.2. For PUCCH format 3, if  is not equal  according to [4, TS 38.211],  is increased to the nearest allowed value of *nrofPRBs* for *PUCCH-format3*[12, TS 38.331]. If , the UE transmits the PUCCH over  PRBs.

If a UE is provided a first interlace of PRBs by *interlace0* in *InterlaceAllocation* and transmits a PUCCH with HARQ-ACK information bits and bits using PUCCH format 2 or PUCCH format 3, the UE transmits the PUCCH over the first interlace if ; otherwise, if the UE is provided a second interlace by *interlace1* in *PUCCH-format2* or *PUCCH-format3*, the UE transmits the PUCCH over the first and second interlaces.

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

## 10.1 UE procedure for determining physical downlink control channel assignment

A set of PDCCH candidates for a UE to monitor is defined in terms of PDCCH search space sets. A search space set can be a CSS set or a USS set. A UE monitors PDCCH candidates in one or more of the following search spaces sets

- a Type0-PDCCH CSS set configured by *pdcch-ConfigSIB1* in *MIB* or by *searchSpaceSIB1* in *PDCCH-ConfigCommon* or by *searchSpaceZero* in *PDCCH-ConfigCommon* for a DCI format with CRC scrambled by a SI-RNTI, or by *searchSpaceZero* in *PDCCH-ConfigCommon* when *pdcch-Config-Broadcast* is not provided, for a DCI format with CRC scrambled by a MCCH-RNTI or a G-RNTI, on the primary cell of the MCG

- a Type0A-PDCCH CSS set configured by *searchSpaceOtherSystemInformation* in *PDCCH-ConfigCommon* for a DCI format with CRC scrambled by a SI-RNTI on the primary cell of the MCG

- a Type0B-PDCCH CSS set configured by *searchSpaceBroadcast* in *pdcch-Config-MCCH* and *pdcch-Config-MTCH* for a DCI format with CRC scrambled by a MCCH-RNTI or a G-RNTI, on the primary cell of the MCG

- a Type1-PDCCH CSS set configured by *ra-SearchSpace* in *PDCCH-ConfigCommon* for a DCI format with CRC scrambled by a RA-RNTI, a MsgB-RNTI, or a TC-RNTI on the primary cell

- a Type2-PDCCH CSS set configured by *pagingSearchSpace* in *PDCCH-ConfigCommon* for a DCI format with CRC scrambled by a P-RNTI on the primary cell of the MCG

- a Type3-PDCCH CSS set configured by *SearchSpace* in *PDCCH-Config* with *searchSpaceType* = *common* for DCI formats with CRC scrambled by INT-RNTI, SFI-RNTI, TPC-PUSCH-RNTI, TPC-PUCCH-RNTI, TPC-SRS-RNTI, or CI-RNTI and, only for the primary cell, C-RNTI, MCS-C-RNTI, CS-RNTI(s), or PS-RNTI, or G-RNTI, or G-CS-RNTI and

- a USS set configured by *SearchSpace* in *PDCCH-Config* with *searchSpaceType* = *ue-Specific* for DCI formats with CRC scrambled by C-RNTI, MCS-C-RNTI, SP-CSI-RNTI, CS-RNTI(s), SL-RNTI, SL-CS-RNTI, or SL Semi-Persistent Scheduling V-RNTI.

In the following, DCI formats with CRC scrambled by C-RNTI or CS-RNTI or MCS-C-RNTI are also referred to as unicast DCI formats, DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI are also referred to as multicast DCI formats, and DCI formats with CRC scrambled by MCCH-RNTI or G-RNTI for MTCH scheduling PDSCH receptions are also referred to as broadcast DCI formats.

For a DL BWP, if a UE is not provided *searchSpaceSIB1* for Type0-PDCCH CSS set by *PDCCH-ConfigCommon*, the UE does not monitor PDCCH candidates for a Type0-PDCCH CSS set on the DL BWP. The Type0-PDCCH CSS set is defined by the CCE aggregation levels and the number of PDCCH candidates per CCE aggregation level given in Table 10.1-1. If the active DL BWP and the initial DL BWP have same SCS and same CP length and the active DL BWP includes all RBs of the CORESET with index 0, or the active DL BWP is the initial DL BWP, the CORESET configured for Type0-PDCCH CSS set has CORESET index 0 and the Type0-PDCCH CSS set has search space set index 0.

For a DL BWP, if a UE is not provided *searchSpaceOtherSystemInformation* for Type0A-PDCCH CSS set, the UE does not monitor PDCCH for Type0A-PDCCH CSS set on the DL BWP. The CCE aggregation levels and the number of PDCCH candidates per CCE aggregation level for Type0A-PDCCH CSS set are given in Table 10.1-1.

For a DL BWP, if a UE is not provided *ra-SearchSpace* for Type1-PDCCH CSS set, the UE does not monitor PDCCH for Type1-PDCCH CSS set on the DL BWP. If the UE has not been provided a Type3-PDCCH CSS set or a USS set and the UE has received a C-RNTI and has been provided a Type1-PDCCH CSS set, the UE monitors PDCCH candidates for DCI format 0\_0 and DCI format 1\_0 with CRC scrambled by the C-RNTI in the Type1-PDCCH CSS set.

If a UE is not provided *pagingSearchSpace* for Type2-PDCCH CSS set, the UE does not monitor PDCCH for Type2-PDCCH CSS set on the DL BWP. The CCE aggregation levels and the number of PDCCH candidates per CCE aggregation level for Type2-PDCCH CSS set are given in Table 10.1-1.

If a UE is provided a zero value for *searchSpaceID* in *PDCCH-ConfigCommon* for a Type0/0A/2-PDCCH CSS set, or is not provided *searchSpaceBroadcast*, the UE determines monitoring occasions for PDCCH candidates of the Type0/0A/2-PDCCH CSS set as described in clause 13, and the UE is provided a C-RNTI, the UE monitors PDCCH candidates only at monitoring occasions associated with a SS/PBCH block, where the SS/PBCH block is determined by the most recent of

- a MAC CE activation command indicating a TCI state of the active BWP that includes a CORESET with index 0, as described in [6, TS 38.214], where the TCI-state includes a CSI-RS which is quasi-co-located with the SS/PBCH block, or

- a random access procedure that is not initiated by a PDCCH order that triggers a contention-free random access procedure

If a UE monitors PDCCH candidates for DCI formats with CRC scrambled by a C-RNTI and the UE is provided a non-zero value for *searchSpaceID* in *PDCCH-ConfigCommon* for a Type0/0A/2-PDCCH CSS set, or monitors PDCCH candidates for DCI formats with CRC scrambled by a MCCH-RNTI or a G-RNTI and the UE is provided a non-zero value for *searchSpaceBroadcast* in *pdcch-Config-MCCH* and *pdcch-Config-MTCH* for a Type0/0B-PDCCH CSS set, the UE determines monitoring occasions for PDCCH candidates of the Type0/0A/2-PDCCH CSS set, or of the Type0/0B-PDCCH set, respectively, based on the search space set associated with the value of *searchSpaceID*.

The UE may assume that the DM-RS antenna port associated with PDCCH receptions in the CORESET configured by *pdcch-ConfigSIB1* in *MIB*, the DM-RS antenna port associated with corresponding PDSCH receptions, and the corresponding SS/PBCH block are quasi co-located with respect to average gain, quasi co-location 'typeA' and 'typeD' properties, when applicable [6, TS 38.214], if the UE is not provided a TCI state indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in the CORESET. The value for the DM-RS scrambling sequence initialization is the cell ID. A SCS is provided by *subCarrierSpacingCommon* in *MIB*.

For single cell operation or for operation with carrier aggregation in a same frequency band, a UE does not expect to monitor a PDCCH in a Type0/0A/2/3-PDCCH CSS set or in a USS set if a DM-RS for monitoring a PDCCH in a Type1-PDCCH CSS set is not configured with same *qcl-Type* set to 'typeD' properties [6, TS 38.214] with a DM-RS for monitoring the PDCCH in the Type0/0A/2/3-PDCCH CSS set or in the USS set, and if the PDCCH or an associated PDSCH overlaps in at least one symbol with a PDCCH the UE monitors in a Type1-PDCCH CSS set or with an associated PDSCH.

If a UE is provided

- one or more search space sets by corresponding one or more of *searchSpaceZero, searchSpaceSIB1*, *searchSpaceOtherSystemInformation*, *pagingSearchSpace*, *ra-SearchSpace*, and

- a C-RNTI, an MCS-C-RNTI, or a CS-RNTI

the UE monitors PDCCH candidates for DCI format 0\_0 and DCI format 1\_0 with CRC scrambled by the C-RNTI, the MCS-C-RNTI, or the CS-RNTI in the one or more search space sets in a slot where the UE monitors PDCCH candidates for at least a DCI format 0\_0 or a DCI format 1\_0 with CRC scrambled by SI-RNTI, RA-RNTI, MsgB-RNTI, or P-RNTI.

If a UE is provided

- one or more search space sets by corresponding one or more of *searchSpaceZero, searchSpaceSIB1*, *searchSpaceOtherSystemInformation*, *pagingSearchSpace*, *ra-SearchSpace*, or a CSS set by *PDCCH-Config*, and

- a SI-RNTI, a P-RNTI, a RA-RNTI, a MsgB-RNTI, a SFI-RNTI, an INT-RNTI, a TPC-PUSCH-RNTI, a TPC-PUCCH-RNTI, or a TPC-SRS-RNTI

then, for a RNTI from any of these RNTIs, the UE does not expect to process information from more than one DCI format with CRC scrambled with the RNTI per slot.

Table 10.1-1: CCE aggregation levels and maximum number of PDCCH candidates per CCE aggregation level for CSS sets configured by *searchSpaceSIB1*

|  |  |
| --- | --- |
| CCE Aggregation Level | Number of Candidates |
| 4 | 4 |
| 8 | 2 |
| 16 | 1 |

For each DL BWP configured to a UE in a serving cell, the UE can be provided by higher layer signalling with

- CORESETs if *coresetPoolIndex* is not provided, or if a value of *coresetPoolIndex* is same for all CORESETs if *coresetPoolIndex* is provided

- CORESETs if *coresetPoolIndex* is not provided for a first CORESET, or is provided and has a value 0 for a first CORESET, and is provided and has a value 1 for a second CORESET

For each CORESET, the UE is provided the following by *ControlResourceSet*:

- a CORESET index , by *controlResourceSetId*  or by *controlResourceSetId-v1610*, where

- if *coresetPoolIndex* is not provided, or if a value of *coresetPoolIndex* is same for all CORESETs if *coresetPoolIndex* is provided;

- if *coresetPoolIndex* is not provided for a first CORESET, or is provided and has a value 0 for a first CORESET, and is provided and has a value 1 for a second CORESET;

- a DM-RS scrambling sequence initialization value by *pdcch-DMRS-ScramblingID*;

- a precoder granularity for a number of REGs in the frequency domain where the UE can assume use of a same DM-RS precoder by *precoderGranularity*;

- a number of consecutive symbols provided by *duration*;

- a set of resource blocks provided by *frequencyDomainResources*;

- CCE-to-REG mapping parameters provided by *cce-REG-MappingType*;

- an antenna port quasi co-location, from a set of antenna port quasi co-locations provided by *TCI-State*, indicating quasi co-location information of the DM-RS antenna port for PDCCH reception in a respective CORESET;

- an indication for a presence or absence of a transmission configuration indication (TCI) field for a DCI format, other than DCI format 1\_0, that schedules PDSCH receptions or indicates SPS PDSCH release or indicates SCell dormancy or indicates a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH and is transmitted by a PDCCH in CORESET , by *tci-PresentInDCI* or tci-PresentDCI-1-2.

When *precoderGranularity* = *allContiguousRBs*, a UE does not expect

- to be configured a set of resource blocks of a CORESET that includes more than four sub-sets of resource blocks that are not contiguous in frequency

- any RE of a CORESET to overlap with any RE determined from *lte-CRS-ToMatchAround*, or from *LTE-CRS-PatternList*, or with any RE of a SS/PBCH block.

For each CORESET in a DL BWP of a serving cell, a respective *frequencyDomainResources* provides a bitmap

- if a CORESET is not associated with any search space set configured with *freqMonitorLocations*, the bits of the bitmap have a one-to-one mapping with non-overlapping groups of 6 consecutive PRBs, in ascending order of the PRB index in the DL BWP bandwidth of PRBs with starting common RB position , where the first common RB of the first group of 6 PRBs has common RB index if *rb-Offset* is not provided, or the first common RB of the first group of 6 PRBs has common RB index where is provided by *rb-Offset.*

- if a CORESET is associated with at least one search space set configured with *freqMonitorLocations*, the first bits of the bitmap have a one-to-one mapping with non-overlapping groups of 6 consecutive PRBs, in ascending order of the PRB index in each RB set in the DL BWP bandwidth of PRBs with starting common RB position [6, TS 38.214], where the first common RB of the first group of 6 PRBs has common RB index and *k* is indicated by *freqMonitorLocations* if provided for a search space set; otherwise, . , is a number of available PRBs in the RB set 0 for the DL BWP, and is provided by *rb-Offset* or if *rb-Offset* is not provided.If a UE is provided RB sets in the DL BWP, the UE expects that the RBs of the CORESET are within the union of the PRBs in the RB sets of the DL BWP.

For a CORESET other than a CORESET with index 0,

- if a UE has not been provided a configuration of TCI state(s) by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* for the CORESET, or has been provided initial configuration of more than one TCI states for the CORESET by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* but has not received a MAC CE activation command for one of the TCI states as described in [11, TS 38.321], the UE assumes that the DM-RS antenna port associated with PDCCH receptions is quasi co-located with the SS/PBCH block the UE identified during the initial access procedure;

- if a UE has been provided a configuration of more than one TCI states by *tci-StatesPDCCH-ToAddList* and *tci-StatesPDCCH-ToReleaseList* for the CORESET as part of Reconfiguration with sync procedure as described in [12, TS 38.331] but has not received a MAC CE activation command for one of the TCI states as described in [11, TS 38.321], the UE assumes that the DM-RS antenna port associated with PDCCH receptions is quasi co-located with the SS/PBCH block or the CSI-RS resource the UE identified during the random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].

For a CORESET with index 0, the UE assumes that a DM-RS antenna port for PDCCH receptions in the CORESET is quasi co-located with

- the one or more DL RS configured by a TCI state, where the TCI state is indicated by a MAC CE activation command for the CORESET, if any, or

- a SS/PBCH block the UE identified during a most recent random access procedure not initiated by a PDCCH order that triggers a contention-free random access procedure, if no MAC CE activation command indicating a TCI state for the CORESET is received after the most recent random access procedure.

For a CORESET other than a CORESET with index 0, if a UE is provided a single TCI state for a CORESET, or if the UE receives a MAC CE activation command for one of the provided TCI states for a CORESET, the UE assumes that the DM-RS antenna port associated with PDCCH receptions in the CORESET is quasi co-located with the one or more DL RS configured by the TCI state. For a CORESET with index 0, the UE expects that a CSI-RS configured with *qcl-Type* set to 'typeD' in a TCI state indicated by a MAC CE activation command for the CORESET is provided by a SS/PBCH block

- if the UE receives a MAC CE activation command for one of the TCI states, the UE applies the activation command in the first slot that is after slot where is the slot where the UE would transmit a PUCCH with HARQ-ACK information for the PDSCH providing the activation command and is the SCS configuration for the PUCCH. The active BWP is defined as the active BWP in the slot when the activation command is applied.

If the UE is provided by *simultaneousTCI-UpdateList1* or *simultaneousTCI-UpdateList2* up to two lists of cells for simultaneous TCI state activation, the UE applies the antenna port quasi co-location provided by *TCI-States* with same activated *tci-StateID* value to CORESETs with a same index in all configured DL BWPs of all configured cells in a list determined from a serving cell index, where *tci-StateID*, the CORESET index and the serving cell index are provided by a MAC CE command.

For each DL BWP configured to a UE in a serving cell, the UE is provided by higher layers with search space sets where, for each search space set from the search space sets, the UE is provided the following by *SearchSpace*:

- a search space set index , , by *searchSpaceId*

- an association between the search space set and a CORESET by *controlResourceSetId* or by *controlResourceSetId-v1610*

- a PDCCH monitoring periodicity of slots and a PDCCH monitoring offset of slots, by *monitoringSlotPeriodicityAndOffset*

- a PDCCH monitoring pattern within a slot, indicating first symbol(s) of the CORESET within a slot for PDCCH monitoring, by *monitoringSymbolsWithinSlot*

- a duration of slots indicating a number of slots that the search space set exists by *duration*

- a number of PDCCH candidates per CCE aggregation level by *aggregationLevel1*, *aggregationLevel2*, *aggregationLevel4*, *aggregationLevel8*, and *aggregationLevel16*, for CCE aggregation level 1, CCE aggregation level 2, CCE aggregation level 4, CCE aggregation level 8, and CCE aggregation level 16, respectively

- an indication that search space set is either a CSS set or a USS set by *searchSpaceType*

- if search space set is a CSS set

- an indication by *dci-Format0-0-AndFormat1-0* to monitor PDCCH candidates for DCI format 0\_0 and DCI format 1\_0

- an indication by *dci-Format2-0* to monitor one or two PDCCH candidates, or to monitor one PDCCH candidate per RB set if the UE is provided *freqMonitorLocations* for the search space set, for DCI format 2\_0 and a corresponding CCE aggregation level

- an indication by *dci-Format2-1* to monitor PDCCH candidates for DCI format 2\_1

- an indication by *dci-Format2-2* to monitor PDCCH candidates for DCI format 2\_2

- an indication by *dci-Format2-3* to monitor PDCCH candidates for DCI format 2\_3

- an indication by *dci-Format2-4* to monitor PDCCH candidates for DCI format 2\_4

- an indication by *dci-Format2-6* to monitor PDCCH candidates for DCI format 2\_6

- an indication by *dci-FormatX* to monitor PDCCH candidates for either or both the first DCI format and the second DCI format

- if search space set is a USS set, an indication by *dci-Formats* to monitor PDCCH candidates either for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or an indication by *dci-FormatsExt* to monitor PDCCH candidates for DCI format 0\_2 and DCI format 1\_2, or for DCI format 0\_1, DCI format 1\_1, DCI format 0\_2, and DCI format 1\_2, or an indication by *dci-FormatsSL* to monitor PDCCH candidates for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or for DCI format 3\_0, or for DCI format 3\_1, or for DCI format 3\_0 and DCI format 3\_1

- a bitmap by *freqMonitorLocations*, if provided, to indicate an index of one or more RB sets for the search space set , where the MSB in the bitmap corresponds to RB set in the DL BWP. For RB set indicated in the bitmap, the first PRB of the frequency domain monitoring location confined within the RB set is given by , where is the index of first common RB of the RB set [6, TS 38.214], and is provided by *rb-Offset* or if *rb-Offset* is not provided. For each RB set with a corresponding value of 1 in the bitmap, the frequency domain resource allocation pattern for the monitoring location is determined based on the first bits in *frequencyDomainResources* provided by the associated CORESET configuration.

If the *monitoringSymbolsWithinSlot* indicates to a UE to monitor PDCCH in a subset of up to three consecutive symbols that are same in every slot where the UE monitors PDCCH for all search space sets, the UE does not expect to be configured with a PDCCH SCS other than 15 kHz if the subset includes at least one symbol after the third symbol.

A UE does not expect to be provided a first symbol and a number of consecutive symbols for a CORESET that results to a PDCCH candidate mapping to symbols of different slots.

A UE does not expect any two PDCCH monitoring occasions on an active DL BWP, for a same search space set or for different search space sets, in a same CORESET to be separated by a non-zero number of symbols that is smaller than the CORESET duration.

A UE determines a PDCCH monitoring occasion on an active DL BWP from the PDCCH monitoring periodicity, the PDCCH monitoring offset, and the PDCCH monitoring pattern within a slot. For search space set , the UE determines that a PDCCH monitoring occasion(s) exists in a slot with number [4, TS 38.211] in a frame with number  if (. +-). The UE monitors PDCCH candidates for search space set for consecutive slots, starting from slot , and does not monitor PDCCH candidates for search space set for the next  consecutive slots.

A USS at CCE aggregation level is defined by a set of PDCCH candidates for CCE aggregation level .

If a UE is configured with *CrossCarrierSchedulingConfig* for a serving cell the carrier indicator field value corresponds to the value indicated by *CrossCarrierSchedulingConfig.*

For an active DL BWP of a serving cell on which a UE monitors PDCCH candidates in a USS, if the UE is not configured with a carrier indicator field, the UE monitors the PDCCH candidates without carrier indicator field. For an active DL BWP of a serving cell on which a UE monitors PDCCH candidates in a USS, if a UE is configured with a carrier indicator field, the UE monitors the PDCCH candidates with carrier indicator field.

A UE does not expect to monitor PDCCH candidates on an active DL BWP of a secondary cell if the UE is configured to monitor PDCCH candidates with carrier indicator field corresponding to that secondary cell in another serving cell. For the active DL BWP of a serving cell on which the UE monitors PDCCH candidates, the UE monitors PDCCH candidates at least for the same serving cell.

For a search space set associated with CORESET , the CCE indexes for aggregation level corresponding to PDCCH candidate of the search space set in slot for an active DL BWP of a serving cell corresponding to carrier indicator field value are given by

where

for any CSS, ;

for a USS, , , for , for , for , and ;

;

 is the number of CCEs, numbered from 0 to , in CORESET and, if any, per RB set;

 is the carrier indicator field value if the UE is configured with a carrier indicator field by *CrossCarrierSchedulingConfig* for the serving cell on which PDCCH is monitored; otherwise, including for any CSS, ;

, where is the number of PDCCH candidates the UE is configured to monitor for aggregation level of a search space set for a serving cell corresponding to ;

for any CSS, ;

for a USS, is the maximum of over all configured values for a CCE aggregation level of search space set ;

the RNTI value used for is the C-RNTI.

A UE does not expect to be provided *freqMonitorLocations* for a search space set in a serving cell if *intraCellGuardBandsDL-List* indicates that no intra-cell guard-bands are configured for the serving cell.

A UE that

- is configured for operation with carrier aggregation, and

- indicates support of search space sharing through *searchSpaceSharingCA-UL* or through *searchSpaceSharingCA-DL*, and

- has a PDCCH candidate with CCE aggregation level in CORESET for a first DCI format scheduling PUSCH transmission or UL grant Type 2 PUSCH release, other than DCI format 0\_0, or for a second DCI format scheduling PDSCH reception or SPS PDSCH release or indicating SCell dormancy or indicating a request for a Type-3 HARQ-ACK codebook report without scheduling PDSCH, other than DCI format 1\_0, having a first size and associated with serving cell ,

can receive a corresponding PDCCH through a PDCCH candidate with CCE aggregation level in CORESET for a first DCI format or for a second DCI format, respectively, having a second size and associated with serving cell if the first size and the second size are same.

A UE expects to monitor PDCCH candidates for up to 4 sizes of DCI formats that include up to 3 sizes of DCI formats with CRC scrambled by C-RNTI per serving cell. The UE counts a number of sizes for DCI formats per serving cell based on a number of configured PDCCH candidates in respective search space sets for the corresponding active DL BWP.

A UE does not expect to detect, in a same PDCCH monitoring occasion, a DCI format with CRC scrambled by a SI-RNTI, RA-RNTI, MsgB-RNTI, TC-RNTI, P-RNTI, C-RNTI, CS-RNTI, or MCS-RNTI and a DCI format with CRC scrambled by a SL-RNTI or a SL-CS-RNTI for scheduling respective PDSCH reception and PSSCH transmission on a same serving cell.

A PDCCH candidate with index for a search space set using a set of CCEs in a CORESET on the active DL BWP for serving cell is not counted for monitoring if there is a PDCCH candidate with index for a search space set , or if there is a PDCCH candidate with index and , in the CORESET on the active DL BWP for serving cell using a same set of CCEs, the PDCCH candidates have identical scrambling, and the corresponding DCI formats for the PDCCH candidates have a same size; otherwise, the PDCCH candidate with index is counted for monitoring.

Table 10.1-2 provides the maximum number of monitored PDCCH candidates, , per slot for a UE in a DL BWP with SCS configuration for operation with a single serving cell.

Table 10.1-2: Maximum number of monitored PDCCH candidates per slot for a DL BWP with SCS configuration for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number of monitored PDCCH candidates per slot and per serving cell  |
| 0 | 44 |
| 1 | 36 |
| 2 | 22 |
| 3 | 20 |

Table 10.1-2A provides the maximum number of monitored PDCCH candidates, , per span for a UE in a DL BWP with SCS configuration for operation with a single serving cell.

Table 10.1-2A: Maximum number of monitored PDCCH candidates in a span for combination (X, Y) for a DL BWP with SCS configuration for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number of monitored PDCCH candidates per span for combination and per serving cell  |
|  | (2, 2) | (4, 3) | (7, 3) |
| 0 | 14 | 28 | 44 |
| 1 | 12 | 24 | 36 |

Table 10.1-3 provides the maximum number of non-overlapped CCEs, , for a DL BWP with SCS configuration that a UE is expected to monitor corresponding PDCCH candidates per slot for operation with a single serving cell.

CCEs for PDCCH candidates are non-overlapped if they correspond to

- different CORESET indexes, or

- different first symbols for the reception of the respective PDCCH candidates.

Table 10.1-3: Maximum number of non-overlapped CCEs per slot for a DL BWP with SCS configuration for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number of non-overlapped CCEs per slot and per serving cell  |
| 0 | 56 |
| 1 | 56 |
| 2 | 48 |
| 3 | 32 |

Table 10.1-3A provides the maximum number of non-overlapped CCEs, , for a DL BWP with SCS configuration that a UE is expected to monitor corresponding PDCCH candidates per span for operation with a single serving cell.

Table 10.1-3A: Maximum number of non-overlapped CCEs in a span for combination (X, Y) for a DL BWP with SCS configuration for a single serving cell

|  |  |
| --- | --- |
|  | Maximum number of non-overlapped CCEs per span for combination and per serving cell  |
|  | (2, 2) | (4, 3) | (7, 3) |
| 0 | 18 | 36 | 56 |
| 1 | 18 | 36 | 56 |

If a UE

- does not report *pdcch-BlindDetectionCA* or is not provided *BDFactorR*,

- reports *pdcch-BlindDetectionCA*, the UE can be indicated by *BDFactorR* either or

If a UE is configured with downlink cells for which the UE is not provided *monitoringCapabilityConfig-r16,* or is provided *monitoringCapabilityConfig-r16* = *r15monitoringcapability* but not provided *CORESETPoolIndex*, with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration where , the UE is not required to monitor, on the active DL BWPs of the scheduling cells,

- more than PDCCH candidates or more than non-overlapped CCEs per slot for each scheduled cell when the scheduling cell is from the downlink cells, or

- more than PDCCH candidates or more than non-overlapped CCEs per slot for each scheduled cell when the scheduling cell is from the downlink cells

- more than PDCCH candidates or more than non-overlapped CCEs per slot for CORESETs with same *coresetPoolIndex* value for each scheduled cell when the scheduling cell is from the downlink cells

 is replaced by , if a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability.*

If a UE

- is configured with downlink cells for which the UE is not provided *monitoringCapabilityConfig,* or is provided *monitoringCapabilityConfig-r16* = *r15monitoringcapability* but not provided *coresetPoolIndex*,

- with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cell(s) using SCS configuration , where , and

- a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell,

the UE is not required to monitor more than  PDCCH candidates or more than non-overlapped CCEs per slot on the active DL BWP(s) of scheduling cell(s) from the downlink cells. is replaced by if a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig-r16* = *r15monitoringcapability* and *monitoringCapabilityConfig-r16* = *r16monitoringcapability*.

For each scheduled cell from the downlink cells, the UE is not required to monitor on the active DL BWP with SCS configuration of the scheduling cell more than PDCCH candidates or more than non-overlapped CCEs per slot.

For each scheduled cell from the downlink cells, the UE is not required to monitor on the active DL BWP with SCS configuration of the scheduling cell

- more than PDCCH candidates or more than non-overlapped CCEs per slot

- more than PDCCH candidates or more than non-overlapped CCEs per slot for CORESETs with same *coresetPoolIndex* value

If a UE is configured with downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , the UE is not required to monitor, on the active DL BWP of the scheduling cell, more than PDCCH candidates or more than non-overlapped CCEs per span for each scheduled cell when the scheduling cell is from the downlink cells. If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig* = *r15monitoringcapability* and *monitoringCapabilityConfig* = *r16monitoringcapability*, is replaced by .

If a UE is configured only with downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* and with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration , and with of the downlink cells using combination for PDCCH monitoring, where , a DL BWP of an activated cell is the active DL BWP of the activated cell, and a DL BWP of a deactivated cell is the DL BWP with index provided by *firstActiveDownlinkBWP-Id* for the deactivated cell, the UE is not required to monitor more than PDCCH candidates or more than non-overlapped CCEs

- per set of spans on the active DL BWP(s) of all scheduling cell(s) from the downlink cells within every symbols, if the union of PDCCH monitoring occasions on all scheduling cells from the downlink cells results to PDCCH monitoring according to the combination and any pair of spans in the set is within symbols, where first symbols start at a first symbol with a PDCCH monitoring occasion and next symbols start at a first symbol with a PDCCH monitoring occasion that is not included in the first symbols

- per set of spans across the active DL BWP(s) of all scheduling cells from the downlink cells, with at most one span per scheduling cell for each set of spans, otherwise

where is a number of configured cells with associated PDCCH candidates monitored in the active DL BWPs of the scheduling cells using SCS configuration . If a UE is configured with downlink cells for which the UE is provided both *monitoringCapabilityConfig* = *r15monitoringcapability* and *monitoringCapabilityConfig* = *r16monitoringcapability*, is replaced by .

For each scheduled cell from the downlink cells using combination , the UE is not required to monitor on the active DL BWP with SCS configuration of the scheduling cell, more than PDCCH candidates or more than non-overlapped CCEs per span.

A UE does not expect to be configured CSS sets, except for CSS sets for multicast DCI formats, that result to corresponding total, or per scheduled cell, numbers of monitored PDCCH candidates and non-overlapped CCEs per slot or per span that exceed the corresponding maximum numbers per slot or per span, respectively.

For same cell scheduling or for cross-carrier scheduling, a UE does not expect a number of PDCCH candidates, and a number of corresponding non-overlapped CCEs per slot or per span on a secondary cell to be larger than the corresponding numbers that the UE is capable of monitoring on the secondary cell per slot or per span, respectively. If a UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for the primary cell, except the first span of each slot, the UE does not expect a number of PDCCH candidates and a number of corresponding non-overlapped CCEs per span on the primary cell to be larger than the corresponding numbers that the UE is capable of monitoring on the primary cell per span.

For cross-carrier scheduling, the number of PDCCH candidates for monitoring and the number of non-overlapped CCEs per span or per slot are separately counted for each scheduled cell.

For all search space sets within a slot or within a span in slot , denote by a set of CSS sets, except for CSS sets for multicast DCI formats, with cardinality of and by a set of USS sets and CSS sets for multicast DCI formats with cardinality of . The location of search space sets , , in is according to an ascending order of the search space set index.

Denote by , , the number of counted PDCCH candidates for monitoring for CSS set and by , , the number of counted PDCCH candidates for monitoring for search space set .

For the CSS sets in , a UE monitors PDCCH candidates requiring a total of non-overlapping CCEs in a slot or in a span.

The UE allocates PDCCH candidates for monitoring to USS sets for the primary cell having an active DL BWP with SCS configuration in a slot if the UE is not provided *monitoringCapabilityConfig* for the primary cell or if the UE is provided *monitoringCapabilityConfig* = *r15monitoringcapability* for the primary cell, or in the first span of each slot if the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for the primary cell, according to the following pseudocode. If for the USS sets for scheduling on the primary cell the UE is not provided *coresetPoolIndex* for first CORESETs, or is provided *coresetPoolIndex* with value 0 for first CORESETs, and is provided *coresetPoolIndex* with value 1 for second CORESETs, and if or , the following pseudocode applies only to USS sets associated with the first CORESETs. A UE does not expect to monitor PDCCH in a USS set without allocated PDCCH candidates for monitoring. In the following pseudocode, if the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for the primary cell,and are replaced by and respectively, and and are replaced by and respectively.

Denote by the set of non-overlapping CCEs for search space set and by the cardinality of where the non-overlapping CCEs for search space set are determined considering the allocated PDCCH candidates for monitoring for the CSS sets in and the allocated PDCCH candidates for monitoring for all search space sets , .

Set

Set

Set

while AND

allocate PDCCH candidates for monitoring to search space set

;

;

 ;

end while

If a UE

- is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and

- monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs that have been configured with same or different *qcl-Type* set to 'typeD' properties on active DL BWP(s) of one or more cells

the UE monitors PDCCHs only in a CORESET, and in any other CORESET from the multiple CORESETs that have been configured with *qcl-Type* set to same 'typeD' properties as the CORESET, on the active DL BWP of a cell from the one or more cells

- the CORESET corresponds to the CSS set with the lowest index in the cell with the lowest index containing CSS, if any; otherwise, to the USS set with the lowest index in the cell with lowest index

- the lowest USS set index is determined over all USS sets with at least one PDCCH candidate in overlapping PDCCH monitoring occasions

- for the purpose of determining the CORESET, a SS/PBCH block is considered to have different QCL 'typeD' properties than a CSI-RS

- for the purpose of determining the CORESET, a first CSI-RS associated with a SS/PBCH block in a first cell and a second CSI-RS in a second cell that is also associated with the SS/PBCH block are assumed to have same QCL 'typeD' properties

- the allocation of non-overlapping CCEs and of PDCCH candidates for PDCCH monitoring is according to all search space sets associated with the multiple CORESETs on the active DL BWP(s) of the one or more cells

 - the number of active TCI states is determined from the multiple CORESETs

If a UE

- is configured for single cell operation or for operation with carrier aggregation in a same frequency band, and

- monitors PDCCH candidates in overlapping PDCCH monitoring occasions in multiple CORESETs where none of the CORESETs has TCI-states configured with *qcl-Type* set to 'typeD',

the UE is required to monitor PDCCH candidates in overlapping PDCCH monitoring occasions for search space sets associated with different CORESETs.

For a scheduled cell and at any time, a UE expects to have received at most 16 PDCCHs for DCI formats with CRC scrambled by C-RNTI, CS-RNTI, or MCS-C-RNTI scheduling 16 PDSCH receptions for which the UE has not received any corresponding PDSCH symbol and at most 16 PDCCHs for DCI formats with CRC scrambled by C-RNTI, CS-RNTI, or MCS-C-RNTI scheduling 16 PUSCH transmissions for which the UE has not transmitted any corresponding PUSCH symbol.

If a UE is not provided *monitoringCapabilityConfig* = *r16monitoringcapability* for any serving cell, and

- is not configured for NR-DC operation and indicates through *pdcch-BlindDetectionCA* a capability to monitor PDCCH candidates for downlink cells and the UE is configured with downlink cells or uplink cells, or

- is configured with NR-DC operation and for a cell group with downlink cells or uplink cells

the UE expects to have respectively received at most PDCCHs for

- DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PDSCH receptions for which the UE has not received any corresponding PDSCH symbol over all downlink cells

- DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PUSCH transmissions for which the UE has not transmitted any corresponding PUSCH symbol over all uplink cells

If a UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for all serving cells*,* and

- is not configured for NR-DC operation and indicates through *pdcch-MonitoringCA* a capability to monitor PDCCH candidates for downlink cells and the UE is configured with downlink cells or uplink cells, or

- is configured with NR-DC operation and for a cell group with downlink cells or uplink cells

the UE expects to have respectively received at most PDCCHs for

- DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PDSCH receptions for which the UE has not received any corresponding PDSCH symbol over all downlink cells

- DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PUSCH transmissions for which the UE has not transmitted any corresponding PUSCH symbol over all uplink cells.

If a UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for at least one serving cell and is not provided *monitoringCapabilityConfig* = *r16monitoringcapability* for at least one serving cell,and

- is not configured for NR-DC operation, and indicates a capability to monitor PDCCH candidates for downlink cells and downlink cells, and the UE is configured with downlink cell or uplink cell, or

- is configured with NR-DC operation and for a cell group with downlink cells or uplink cells

the UE expects to have respectively received

- at most PDCCHs for DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PDSCH receptions for which the UE has not received any corresponding PDSCH symbol over all serving cells that are not provided *monitoringCapabilityConfig* = *r16monitoringcapability*

- at most PDCCHs for DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PUSCH transmissions for which the UE has not transmitted any corresponding PUSCH symbol over all serving cells that are not provided *monitoringCapabilityConfig* = *r16monitoringcapability*

- at most PDCCHs for DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PDSCH receptions for which the UE has not received any corresponding PDSCH symbol over all serving cells that are provided *monitoringCapabilityConfig* = *r16monitoringcapability*

- at most PDCCHs for DCI formats with CRC scrambled by a C-RNTI, or a CS-RNTI, or a MCS-C-RNTI scheduling PUSCH transmissions for which the UE has not transmitted any corresponding PUSCH symbol over all serving cells that are provided *monitoringCapabilityConfig* = *r16monitoringcapability*

If a UE

- is configured to monitor a first PDCCH candidate for a DCI format 0\_0 and a DCI format 1\_0 from a CSS set and a second PDCCH candidate for a DCI format 0\_0 and a DCI format 1\_0 from a USS set in a CORESET with index zero on an active DL BWP, and

- the DCI formats 0\_0/1\_0 associated with the first PDCCH candidate and the DCI formats 0\_0/1\_0 associated with the second PDCCH candidate have same size, and

- the UE receives the first PDCCH candidate and the second PDCCH candidate over a same set of CCEs, and

- the first PDCCH candidate and the second PDCCH candidate have identical scrambling, and

- the DCI formats 0\_0/1\_0 for the first PDCCH candidate and the DCI formats 0\_0/1\_0 for the second PDCCH candidate have CRC scrambled by either C-RNTI, or MCS-C-RNTI, or CS-RNTI

the UE decodes only the DCI formats 0\_0/1\_0 associated with the first PDCCH candidate.

If a UE detects a DCI format with inconsistent information, the UE discards all the information in the DCI format.

A UE configured with a bandwidth part indicator in a DCI format determines, in case of an active DL BWP or of an active UL BWP change, that the information in the DCI format is applicable to the new active DL BWP or UL BWP, respectively, as described in clause 12.

For unpaired spectrum operation, if a UE is not configured for PUSCH/PUCCH transmission on serving cell , the UE does not expect to monitor PDCCH on serving cell if the PDCCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10, TS 38.133]) on serving cell and if the UE is not capable of simultaneous reception and transmission on serving cell and serving cell .

If a UE is provided *resourceBlocks* and s*ymbolsInResourceBlock* in *RateMatchPattern*, or if the UE is additionally provided *periodicityAndPattern* in *RateMatchPattern*, the UE can determine a set of RBs in symbols of a slot that are not available for PDSCH reception as described in [6, TS 38.214]. If a PDCCH candidate in a slot is mapped to one or more REs that overlap with REs of any RB in the set of RBs in symbols of the slot, the UE does not expect to monitor the PDCCH candidate.

A UE does not expect to be configured with *dci-FormatsSL* and *dci-FormatsExt* in a same USS.

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

# 18 Multicast Broadcast Services

This clause is applicable only for PDCCH receptions, PDSCH receptions, and PUCCH transmissions for MBS on a serving cell. DCI formats with CRC scrambled by G-RNTI or G-CS-RNTI scheduling PDSCH receptions are referred to as multicast DCI formats and the PDSCH receptions are referred to as multicast PDSCH receptions. DCI formats with CRC scrambled by MCCH-RNTI or G-RNTI for MTCH scheduling PDSCH receptions are referred to as broadcast DCI formats and the PDSCH receptions are referred to as broadcast PDSCH receptions. HARQ-ACK information associated with multicast DCI formats or multicast PDSCH receptions is referred to as multicast HARQ-ACK information.

A UE can be provided one or more G-RNTIs per serving cell for scrambling the CRC of multicast DCI formats for scheduling PDSCH receptions. The UE can be provided one or more G-CS-RNTI per serving cell for scrambling the CRC of multicast DCI formats providing activation/release for SPS PDSCH receptions.

A UE can be configured by *cfr-Config-MCCH-MTCH* an MBS frequency resource for PDCCH and PDSCH receptions providing MCCH and MTCH [12, TS 38.331]; otherwise, the MBS frequency resource is same as for the CORESET with index 0 that is associated with the Type0-PDCCH CSS set for PDCCH and PDSCH receptions providing MCCH and MTCH.

In clauses referring to a higher layer parameter value provided by *PDCCH-ConfigCommon* or *PDSCH-ConfigCommon*, when applicable a corresponding higher layer parameter value for MCCH/MTCH PDCCH receptions or PDSCH receptions, respectively, is provided as described in [12, TS 38.331].

A UE monitors PDCCH for scheduling PDSCH receptions for MCCH or MTCH as described in clause 10.1.

A UE can be configured, per DL BWP by *cfr-Config-Multicast*, an MBS frequency resource within the DL BWP for PDCCH and PDSCH receptions [4, TS 38.211]. If *cfr-Config-Multicast* does not include *locationAndBandwidth*, the MBS frequency resource is the active DL BWP.

In clauses referring to a higher layer parameter value provided by *PDCCH-Config* or *PDSCH-Config* or *SPS-Config* for a DL BWP, when applicable a corresponding higher layer parameter value for multicast PDCCH, PDSCH, or SPS PDSCH receptions is provided as described in [12, TS 38.331].

In clauses referring to a higher layer parameter value provided by a first or second *PUCCH-Config*, when applicable a corresponding higher layer parameter value for PUCCH transmissions associated with multicast PDCCH or PDSCH receptions is provided as described in [12, TS 38.331].. In clauses referring to a higher layer parameter value provided by *SPS-PUCCH-AN* or *SPS-PUCCH-AN-List*, when applicable a corresponding higher layer parameter value for PUCCH transmissions associated with multicast SPS PDSCH receptions is provided as described in [12, TS 38.331]. In clauses referring to a higher layer parameter value provided by *pdsch-HARQ-ACK-Codebook* or *pdsch-HARQ-ACK-CodebookList*, when applicable a corresponding higher layer parameter value for HARQ-ACK codebooks associated with multicast HARQ-ACK information is provided as described in [12, TS 38.331].

A UE monitors PDCCH for scheduling PDSCH receptions or for activation/release of SPS PDSCH receptions for a corresponding SPS PDSCH configuration as described in clause 10.1.

A UE indicating a *capability* to support first and second HARQ-ACK reporting modes, can be configured by *harq-Feedback-Option-Multicast* for a G-RNTI or for a G-CS-RNTI to provide HARQ-ACK information for a transport block reception associated with the G-RNTI or with the G-CS-RNTI, respectively, according to the first HARQ-ACK reporting mode or according to the second HARQ-ACK reporting mode. The second HARQ-ACK reporting mode is not applicable for DCI formats having associated HARQ-ACK information without scheduling a PDSCH reception. For the first HARQ-ACK reporting mode, the UE generates HARQ-ACK information with ACK value when a UE correctly decodes a transport block or detects a DCI format indicating an SPS PDSCH release; otherwise, the UE generates HARQ-ACK information with NACK value, as described in clauses 9 and 9.1 through 9.3. For the second HARQ-ACK reporting mode, the UE does not transmit a PUCCH that would include only HARQ-ACK information with ACK values.

If a UE is provided *pucch-Config-Multicast1* for PUCCH transmissions with a priority value, the UE transmits a PUCCH with the priority value according to *pucch-Config-Multicast1* for each G-RNTI or G-CS-RNTI that the UE provides associated HARQ-ACK information according to the first HARQ-ACK reporting mode.

A PDSCH reception providing an initial transmission of a transport block is scheduled only by a multicast DCI format. For the first HARQ-ACK reporting mode, a PDSCH reception providing a retransmission of the transport block can be scheduled either by a multicast DCI format using a same G-RNTI as the G-RNTI of the initial transmission of the transport block, or by a unicast DCI format using a C-RNTI [6, TS 38.214].

An activation for SPS PDSCH receptions using a G-CS-RNTI for a corresponding SPS PDSCH configuration is provided only by a multicast DCI format as described in clause 10.2 by replacing CS-RNTI with the G-CS-RNTI. A release for SPS PDSCH receptions using a G-CS-RNTI for a corresponding SPS PDSCH configuration is provided by a multicast DCI format as described in clause 10.2 by replacing CS-RNTI with the G-CS-RNTI, or by a DCI format with CRC scrambled by CS-RNTI. For the first HARQ-ACK reporting mode and for a transport block that a UE received in a SPS PDSCH, a PDSCH reception providing a retransmission of the transport block can be scheduled either by a unicast DCI format using a CS-RNTI or by a multicast DCI format using a same G-CS-RNTI as the G-CS-RNTI of the initial transmission of the transport block [6, TS 38.214].

A UE can be configured per G-RNTI or per G-CS-RNTI, by *harq-FeedbackEnabler-Multicast* with value set to ‘enabled’, to provide HARQ-ACK information for PDSCH receptions. When the UE is not provided *harq-FeedbackEnabler-Multicast* for a G-RNTI or G-CS-RNTI, or when the UE is provided *harq-FeedbackEnabler-Multicast* with value set to ‘disabled’, the UE does not provide HARQ-ACK information for respective PDSCH receptions. When the UE indicates a *capability* for whether or not the UE can generate HARQ-ACK information for PDSCH receptions based on an indication by a multicast DCI format and is provided *harq-FeedbackEnabler-Multicast* with value set to ‘dci-enabler’ for a G-RNTI or a G-CS-RNTI, the UE determines whether or not to provide the HARQ-ACK information for PDSCH receptions based on an indication by the multicast DCI format associated with the G-RNTI or the G-CS-RNTI [4, TS 38.212].

For the second HARQ-ACK reporting mode, if a UE would multiplex HARQ-ACK information associated with multicast DCI formats and HARQ-ACK information associated with unicast DCI formats in a PUCCH, or with P/SP-CSI in a PUCCH, or in a PUSCH, the UE provides HARQ-ACK information according to the first HARQ-ACK reporting mode.

If a UE is provided multiple G-RNTIs or G-CS-RNTIs, a configuration for a HARQ-ACK codebook type applies to all G-RNTIs or G-CS-RNTIs.

If a UE is provided *pdsch-HARQ-ACK-Codebook-Multicast = semi-static*, the UE generates a Type-1 HARQ-ACK codebook as described in clauses 9.1.2 and 9.1.2.1.

If a UE is provided *pdsch-HARQ-ACK-Codebook-Multicast = dynamic*, the UE generates a Type-2 HARQ-ACK codebook as described in clause 9.1.3.1.

If, for unicast and multicast HARQ-ACK information of same priority value, a UE

- is provided either *pdsch-HARQ-ACK-Codebook = dynamic* and *pdsch-HARQ-ACK-Codebook-Multicast = semi-static*, or *pdsch-HARQ-ACK-Codebook = semi-static* and *pdsch-HARQ-ACK-Codebook-Multicast = dynamic*, and

- would multiplex the unicast and multicast HARQ-ACK information in a same PUCCH or PUSCH

the UE

- appends the HARQ-ACK codebooks for the multicast HARQ-ACK information to the HARQ-ACK codebooks for the unicast HARQ-ACK information

- if , the UE determines for obtaining a power of a PUCCH transmission with the HARQ-ACK information, as described in clause 7.2.1, as a sum of the value from clause 9.1.2.1 and the value from clause 9.1.3.1.

A UE determines a PUCCH resource for a PUCCH transmission with HARQ-ACK information as described in clauses 9.2 and 9.2.1 through 9.2.5. If the UE multiplexes HARQ-ACK information associated with unicast DCI formats and HARQ-ACK information associated with multicast DCI formats in a same PUCCH, the last DCI format that the UE uses to determine the PUCCH resource, as described in clause 9.2.3, is a last unicast DCI format.