**3GPP TSG RAN WG1 #106bis-e** **R1-210xxxx**

**e-Meeting, October 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 for extending NR operation to 71 GHz | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Samsung | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | | 2021-11-01 |
|  |  | | | |  | |  | | |  |
| ***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 can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-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 for extending of NR operation to 71 GHz. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Add description for enhancements on synchronization, HARQ-ACK codebook construction for multi-PDSCH operation, PUCCH transmission, PDCCH monitoring including for Type0-PDCCH CSS sets. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Incomplete support for NR extension to 71 GHz. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 4, 9, 9.1.2.1, 9.1.2.2, 9.1.3.1, 9.2.1, 9.2.2, 9.2.3, 9.2.5.1, 9.2.5.2, 13 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **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:*** | |  | | | | | | | | |

# 4 Synchronization procedures

## 4.1 Cell search

Cell search is the procedure for a UE to acquire time and frequency synchronization with a cell and to detect the physical layer Cell ID of the cell.

A UE receives the following synchronization signals (SS) in order to perform cell search: the primary synchronization signal (PSS) and secondary synchronization signal (SSS) as defined in [4, TS 38.211].

A UE assumes that reception occasions of a physical broadcast channel (PBCH), PSS, and SSS are in consecutive symbols, as defined in [4, TS 38.211], and form a SS/PBCH block. The UE assumes that SSS, PBCH DM-RS, and PBCH data have same EPRE. The UE may assume that the ratio of PSS EPRE to SSS EPRE in a SS/PBCH block is either 0 dB or 3 dB. If the UE has not been provided dedicated higher layer parameters, the UE may assume that the ratio of PDCCH DMRS EPRE to SSS EPRE is within -8 dB and 8 dB when the UE monitors PDCCHs for a DCI format 1\_0 with CRC scrambled by SI-RNTI, P-RNTI, or RA-RNTI.

For a half frame with SS/PBCH blocks, the first symbol indexes for candidate SS/PBCH blocks are determined according to the SCS of SS/PBCH blocks as follows, where index 0 corresponds to the first symbol of the first slot in a half-frame.

- Case A - 15 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes of .

- For operation without shared spectrum channel access:

- For carrier frequencies smaller than or equal to 3 GHz, .

- For carrier frequencies within FR1 larger than 3 GHz, .

- For operation with shared spectrum channel access, as described in [15, TS 37.213], .

- Case B - 30 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies smaller than or equal to 3 GHz, . For carrier frequencies within FR1 larger than 3 GHz, .

- Case C - 30 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes .

- For operation without shared spectrum channel access

- For paired spectrum operation

- For carrier frequencies smaller than or equal to 3 GHz, . For carrier frequencies within FR1 larger than 3 GHz, .

- For unpaired spectrum operation

- For carrier frequencies smaller than 1.88 GHz, . For carrier frequencies within FR1 equal to or larger than 1.88 GHz, .

- For operation with shared spectrum channel access, .

- Case D - 120 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies within FR2, .

- Case E - 240 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes . For carrier frequencies within FR2, .

- Case F – 480 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes .

- Case G – 960 kHz SCS: the first symbols of the candidate SS/PBCH blocks have indexes .

From the above cases, if the SCS of SS/PBCH blocks is not provided by *ssbSubcarrierSpacing*, the applicable cases for a cell depend on a respective frequency band, as provided in [8-1, TS 38.101-1] and [8-2, TS 38.101-2]. A same case applies for all SS/PBCH blocks on the cell. If a 30 kHz SS/PBCH block SCS is indicated by *ssbSubcarrierSpacing*, Case B applies for frequency bands with only 15 kHz SS/PBCH block SCS as specified in [8-1, TS 38.101-1], and the case specified for 30 kHz SS/PBCH block SCS in [8-1, TS 38.101-1] applies for frequency bands with 30 kHz SS/PBCH block SCS or both 15 kHz and 30 kHz SS/PBCH block SCS as specified in [8-1, TS 38.101-1]. For a UE configured to operate with carrier aggregation over a set of cells in a frequency band of FR2 or with frequency-contiguous carrier aggregation over a set of cells in a frequency band of FR1, if the UE is provided SCS values by *ssbSubcarrierSpacing* for receptions of SS/PBCH blocks on any cells from the set of cells, the UE expects the SCS values to be same.

The candidate SS/PBCH blocks in a half frame are indexed in an ascending order in time from 0 to , where is determined according to SS/PBCH block patterns for Cases A through G. is a maximum number of SS/PBCH block indexes in a cell, and the maximum number of transmitted SS/PBCH blocks within a half frame is .

- For operation without shared spectrum channel access,

- For operation with shared spectrum channel access, for and 15 kHz SCS of SS/PBCH blocks and for and 30 kHz SCS of SS/PBCH blocks

For , a UE determines the 2 LSB bits of a candidate SS/PBCH block index per half frame from a one-to-one mapping with an index of the DM-RS sequence transmitted in the PBCH as described in [4, TS 38.211].

For , a UE determines the 3 LSB bits of a candidate SS/PBCH block index per half frame from a one-to-one mapping with an index of the DM-RS sequence transmitted in the PBCH as described in [4, TS 38.211]

- for , the UE determines the 1 MSB bit of the candidate SS/PBCH block index from PBCH payload bit as described in [5, TS 38.212]

- for , the UE determines the 2 MSB bits of the candidate SS/PBCH block index from PBCH payload bits as described in [5, TS 38.212]

- for , the UE determines the 3 MSB bits of the candidate SS/PBCH block index from PBCH payload bits as described in [5, TS 38.212]

A UE can be provided per serving cell by *ssb-periodicityServingCell* a periodicity of the half frames for reception of the SS/PBCH blocks for the serving cell. If the UE is not configured a periodicity of the half frames for receptions of the SS/PBCH blocks, the UE assumes a periodicity of a half frame. A UE assumes that the periodicity is same for all SS/PBCH blocks in the serving cell.

For initial cell selection, a UE may assume that half frames with SS/PBCH blocks occur with a periodicity of 2 frames.

For operation without shared spectrum channel access, an SS/PBCH block index is same as a candidate SS/PBCH block index.

For operation with shared spectrum channel access, a UE assumes that transmission of SS/PBCH blocks in a half frame is within a discovery burst transmission window that starts from the first symbol of the first slot in a half-frame. The UE can be provided per serving cell by *discoveryBurstWindowLength* a duration of the discovery burst transmission window. If *discoveryBurstWindowLength* is not provided, the UE assumes that the duration of the discovery burst transmission window is a half frame. For a serving cell, the UE assumes that a periodicity of the discovery burst transmission window is same as a periodicity of half frames for receptions of SS/PBCH blocks in the serving cell. The UE assumes that one or more SS/PBCH blocks indicated by *ssb-PositionsInBurst* may be transmitted within the discovery burst transmission window and have candidate SS/PBCH blocks indexes corresponding to SS/PBCH block indexes provided by *ssb-PositionsInBurst*. If MSB , , of *ssb-PositionsInBurst* is set to 1, the UE assumes that SS/PBCH block(s) within the discovery burst transmission window with candidate SS/PBCH block index(es) corresponding to SS/PBCH block index equal to may be transmitted; if MSB is set to 0, the UE assumes that the SS/PBCH block(s) are not transmitted.

For operation with shared spectrum channel access, a UE assumes that SS/PBCH blocks in a serving cell that are within a same discovery burst transmission window or across discovery burst transmission windows are quasi co-located with respect to average gain, quasi co-location 'typeA' and 'typeD' properties, when applicable [6, TS 38.214], if a value of is same among the SS/PBCH blocks. is an index of a DM-RS sequence transmitted in a PBCH of a corresponding SS/PBCH block, and is either provided by *ssb-PositionQCL* or, if *ssb-PositionQCL* is not provided,obtained from a *MIB* provided by a SS/PBCH block according to Table 4.1-1 with [4, TS 38.211]. *subCarrierSpacingCommon* indicates SCS of RMSI only for the case of operation without shared spectrum channel access. The UE can determine an SS/PBCH block index according to , or according to where is the candidate SS/PBCH block index. The UE assumes that within a discovery burst transmission window, a number of transmitted SS/PBCH blocks on a serving cell is not larger than and a number of transmitted SS/PBCH blocks with a same SS/PBCH block index is not larger than one.

Table 4.1-1: Mapping between the combination of *subCarrierSpacingCommon* and LSB of *ssb-SubcarrierOffset* to

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| *subCarrierSpacingCommon* | LSB of *ssb-SubcarrierOffset* |  |
| scs15or60 | 0 | 1 |
| scs15or60 | 1 | 2 |
| scs30or120 | 0 | 4 |
| scs30or120 | 1 | 8 |

Upon detection of a SS/PBCH block, the UE determines from *MIB* that a CORESET for Type0-PDCCH CSS set, as described in clause 13, is present if [4, TS 38.211] for FR1 or if for FR2. The UE determines from *MIB* that a CORESET for Type0-PDCCH CSS set is not present if for FR1 or if for FR2; the CORESET for Type0-PDCCH CSS set may be provided by *PDCCH-ConfigCommon*.

For a serving cell without transmission of SS/PBCH blocks, a UE acquires time and frequency synchronization with the serving cell based on receptions of SS/PBCH blocks on the PCell, or on the PSCell, or on an SCell if applicable as described in [10, TS 38.133], of the cell group for the serving cell.

\*\*\* 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 *,* 12 for , 23 for , 36 for , 144 for , and 288 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 *,* 12 for , 23 for , 36 for , 144 for , and 288 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.

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

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

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

a) on a set of slot timing values associated with the active UL BWP

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 on 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*

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

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 the set of rows includes a row with more than one entry as described in [6, TS 38.214], the set of row indexes and the set of slot timing values are updated in this clause according to the following pseudo-code.

set to the set of rows

set to the cardinality of

set – index of row in set

set

set

while

set to the set of entries for row

set to the set of values of entries for row

set

set to the cardinality of

set to the cardinality of

set – index of element in set – index of element in

while

;

;

end while

while

;

;

end while

;

end while

;

;

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 – 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 , or if HARQ-ACK information for PDSCH time resource derived by row in slot cannot be provided in slot

;

else

;

end if

end while

if the UE does not indicate a capability to receive more than one unicast 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 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

- 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.

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

If a UE would multiplex HARQ-ACK information in a PUSCH transmission that is not scheduled by a DCI format or is scheduled by a DCI format that does not include a DAI field, then

- if the UE has not received any PDSCH or SPS PDSCH release that the UE transmits corresponding HARQ-ACK information in the PUSCH, based on a value of a respective PDSCH-to-HARQ\_feedback timing indicator field in a DCI format scheduling the PDSCH reception or the SPS PDSCH release or on the value of *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_1 or on the value of *dl-DataToUL-ACK-ForDCI-Format1-2* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in DCI format 1\_2, in any of the occasions for candidate PDSCH receptions by a DCI format or SPS PDSCH on any serving cell , as described in clause 9.1.2.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission;

- else the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1, except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*, unless the UE receives only a SPS PDSCH release, or only SPS PDSCH reception, or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception as described in clause 9.1.2.

A UE sets to NACK value in the HARQ-ACK codebook any HARQ-ACK information corresponding to PDSCH reception or SPS PDSCH release that the UE detects in a PDCCH monitoring occasion that starts after a PDCCH monitoring occasion where the UE detects a DCI format scheduling the PUSCH transmission.

A UE does not expect to detect a DCI format switching a DL BWP within symbols prior to a first symbol of a PUSCH transmission where the UE multiplexes HARQ-ACK information, where is defined in [6, TS 38.214].

If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by DCI format that includes a DAI field, the UE generates the HARQ-ACK codebook as described in clause 9.1.2.1 when a value of the DAI field is except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*. The UE does not generate a HARQ-ACK codebook for multiplexing in the PUSCH transmission when unless the UE receives only a SPS PDSCH release, or only SPS PDSCH(s), or only a PDSCH that is scheduled by DCI format 1\_0 with a counter DAI field value of 1 on the PCell in the occasions for candidate PDSCH receptions in which case the UE generates HARQ-ACK information only for the SPS PDSCH release or only for the PDSCH reception as described in clause 9.1.2. if the PUSCH is scheduled by a DCI format that includes a DAI field and the DAI field is set to '0'; otherwise, .

### 9.1.3 Type-2 HARQ-ACK codebook determination

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

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

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

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

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

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

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

- if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback*, the first DCI format does not indicate SPS PDSCH release or SCell dormancy, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4, and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception, if any, received after the PDSCH scheduled by the first DCI format.

- if the UE is provided *pdsch-HARQ-ACK-OneShotFeedback-r16*, the first DCI format does not indicate SPS PDSCH release or SCell dormancy, and the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the PDSCH scheduled by the first DCI format, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4.

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

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

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, or a *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-ForDCI-Format1-2* value if the PDSCH-to-HARQ\_feedback timing indicator field is not present in a DCI format, for PUCCH transmission with HARQ-ACK information in slot , as described in clause 9.2.3, in response to PDSCH receptions, 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 detects a first DCI format scheduling one PDSCH reception or having associated HARQ-ACK information without scheduling a PDSCH reception, if any, and a second DCI format scheduling more than one PDSCH reception on a serving cell from the serving cells, if any, and the UE would provide corresponding HARQ-ACK information in a same PUCCH, the UE determines the according to the previous pseudo-code with the following modifications

- the UE determines a first HARQ-ACK sub-codebook based on each detected DCI format scheduling one PDSCH reception or having associated HARQ-ACK information without scheduling a PDSCH reception, or SPS PDSCH receptions, if any, and

- the UE determines a second HARQ-ACK sub-codebook based on each detected DCI format scheduling more than one PDSCH reception, and

- instead of generating one HARQ-ACK information bit per transport block for serving cell , the UE generates HARQ-ACK information bits where is the maximum value of across all serving cells, is a maximum number of PDSCH receptions that can be scheduled by a DCI format on serving cell as described in [6, TS 38.214], and is the value of *maxNrofCodeWordsScheduledByDCI* for serving cell . If, for serving cell , the UE detects a DCI format that schedules PDSCH receptions and , the UE generates NACK for the last HARQ-ACK information bits

- the pseudo-code operation when *harq-ACK-SpatialBundlingPUCCH* is provided is not applicable

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

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

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

If a UE is not provided *PDSCH-CodeBlockGroupTransmission* for each of the 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 SPS PDSCH release, or for SCell dormancy indication, 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

- if , is the value of the counter DAI in the last DCI format scheduling PDSCH reception or indicating SPS PDSCH release or indicating SCell dormancy, for any serving cell that the UE detects within the PDCCH monitoring occasions.

- if

- if the UE does not detect any DCI format that includes a total DAI field in a last PDCCH monitoring occasion within the PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception, indicating SPS PDSCH release or indicating SCell dormancy for any serving cell , 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 PDCCH monitoring occasions where the UE detects at least one DCI format scheduling PDSCH reception, indicating SPS PDSCH release or indicating SCell dormancy for any serving cell , is the value of the total DAI in the at least one DCI format that includes a total DAI field

- if the UE does not detect any DCI format scheduling PDSCH reception, indicating SPS PDSCH release or indicating SCell dormancy for any serving cell in any of the PDCCH monitoring occasions.

- is the total number of a DCI format scheduling PDSCH reception, indicating SPS PDSCH release or indicating SCell dormancy that the UE detects within the PDCCH monitoring occasions for serving cell . if the UE does not detect any DCI format scheduling PDSCH reception, indicating SPS PDSCH release or indicating SCell dormancy for serving cell in any of the PDCCH monitoring occasions.

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

- 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 indicate SPS PDSCH release in PDCCH monitoring occasion for serving cell , or the number of DCI format that the UE detects and indicate SCell dormancy in PDCCH monitoring occasion for serving cell .

- 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 PDCCH monitoring occasions.

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

- 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

|  |  |  |
| --- | --- | --- |
| DAI MSB, 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 UCI reporting in physical uplink control channel

UCI types reported in a PUCCH include HARQ-ACK information, SR, LRR, and CSI. UCI bits include HARQ-ACK information bits, if any, SR information bits, if any, LRR information bit, if any, and CSI bits, if any. The HARQ-ACK information bits correspond to a HARQ-ACK codebook as described in clause 9.1. For the remaining of this clause, any reference to SR is applicable for SR and/or for LRR.

A UE may transmit one or two PUCCHs on a serving cell in different symbols within a slot. When the UE transmits two PUCCHs in a slot and the UE is not provided *ackNackFeedbackMode* = *separate*, at least one of the two PUCCHs uses PUCCH format 0 or PUCCH format 2.

If a UE is provided *ackNackFeedbackMode* = *separate*, the UE may transmit up to two PUCCHs with HARQ-ACK information in different symbols within a slot.

In clauses 9.2.3, 9.2.5.1 and 9.2.5.2, a UE assumes 11 CRC bits if a number of respective UCI bits is larger than or equal to 360; otherwise, the UE determines a number of CRC bits based on the number of respective UCI bits as described in [5, TS 38.212].

### 9.2.1 PUCCH Resource Sets

If a UE does not have dedicated PUCCH resource configuration, provided by *PUCCH-ResourceSet* in *PUCCH-Config*, a PUCCH resource set is provided by *pucch-ResourceCommon* through an index to a row of Table 9.2.1-1 for transmission of HARQ-ACK information on PUCCH in an initial UL BWP of PRBs. For operation in FR2-2, *pucch-ResourceCommon* also provides a number of RBs for the PUCCH resource set; otherwise .

The PUCCH resource set includes sixteen resources, each corresponding to a PUCCH format, a first symbol, a duration, a PRB offset , and a cyclic shift index set for a PUCCH transmission.

The UE transmits a PUCCH using frequency hopping if not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon*; otherwise, the UE transmits a PUCCH without frequency hopping.

An orthogonal cover code with index 0 is used for a PUCCH resource with PUCCH format 1 in Table 9.2.1-1 except when index 3, 7, or 11 is indicated by *pucch-ResourceCommon* and *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon* is provided.

The UE transmits the PUCCH using the same spatial domain transmission filter as for a PUSCH transmission scheduled by a RAR UL grant as described in clause 8.3.

If a UE is not provided any of *pdsch-HARQ-ACK-Codebook*, *pdsch-HARQ-ACK-Codebook-r16*, or *pdsch-HARQ-ACK-OneShotFeedback*, the UE generates at most one HARQ-ACK information bit.

If the UE provides HARQ-ACK information in a PUCCH transmission in response to detecting a DCI format scheduling a PDSCH reception or a SPS PDSCH release, the UE determines a PUCCH resource with index , , as , where is a number of CCEs in a CORESET of a PDCCH reception with 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 and a UE is provided a PUCCH resource by *pucch-ResourceCommon* and is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon*

- the UE determines the first PRB index of the PUCCH transmission in the first hop as and the first PRB index of the PUCCH transmission in the second hop as , where is the total number of initial cyclic shift indexes in the set of initial cyclic shift indexes

- the UE determines the initial cyclic shift index in the set of initial cyclic shift indexes as

If and a UE is provided a PUCCH resource by *pucch-ResourceCommon* and is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon*

- the UE determines the first PRB index of the PUCCH transmission in the first hop as and the first PRB index of the PUCCH transmission in the second hop as

- the UE determines the initial cyclic shift index in the set of initial cyclic shift indexes as



If a UE is provided a PUCCH resource by *pucch-ResourceCommon* and is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon*

- the UE determines for the PUCCH resource an interlace index as where is a number of interlaces [4, TS 38.211] and is an interlace index offset and is as given in Table 9.2.1-1

- the UE determines an initial cyclic shift index in a set of initial cyclic shift indexes as , where is the total number of initial cyclic shifts indexes in the set of initial cyclic shift indexes in Table 9.2.1-1

- if *pucch-ResourceCommon* indicates

- index 0: the first symbol is 9 for a PUCCH resource with PUCCH format 0 if

- index 1 or 2: the first symbol is 9 for a PUCCH resource with PUCCH format 0 if

- index 3, 7, or 11: an orthogonal cover code with index 1 is used for a PUCCH resource with PUCCH format 1 if ; otherwise, an orthogonal cover code with index 0 is used for a PUCCH resource with PUCCH format 1

- the UE does not expect *pucch-ResourceCommon* to indicate index 15

Table 9.2.1-1: PUCCH resource sets before dedicated PUCCH resource configuration

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Index | **PUCCH format** | **First symbol** | **Number of symbols** | **PRB offset** | **Set of initial CS indexes** |
| 0 | 0 | 12 | 2 | 0 | {0, 3} |
| 1 | 0 | 12 | 2 | 0 | {0, 4, 8} |
| 2 | 0 | 12 | 2 | 3 | {0, 4, 8} |
| 3 | 1 | 10 | 4 | 0 | {0, 6} |
| 4 | 1 | 10 | 4 | 0 | {0, 3, 6, 9} |
| 5 | 1 | 10 | 4 | 2 | {0, 3, 6, 9} |
| 6 | 1 | 10 | 4 | 4 | {0, 3, 6, 9} |
| 7 | 1 | 4 | 10 | 0 | {0, 6} |
| 8 | 1 | 4 | 10 | 0 | {0, 3, 6, 9} |
| 9 | 1 | 4 | 10 | 2 | {0, 3, 6, 9} |
| 10 | 1 | 4 | 10 | 4 | {0, 3, 6, 9} |
| 11 | 1 | 0 | 14 | 0 | {0, 6} |
| 12 | 1 | 0 | 14 | 0 | {0, 3, 6, 9} |
| 13 | 1 | 0 | 14 | 2 | {0, 3, 6, 9} |
| 14 | 1 | 0 | 14 | 4 | {0, 3, 6, 9} |
| 15 | 1 | 0 | 14 |  | {0, 3, 6, 9} |

If a UE has dedicated PUCCH resource configuration, the UE is provided by higher layers with one or more PUCCH resources.

A PUCCH resource includes the following parameters:

- a PUCCH resource index provided by *pucch-ResourceId*

- an index of the first PRB prior to frequency hopping or for no frequency hopping by *startingPRB*, if a UE is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- an index of the first PRB after frequency hopping by *secondHopPRB*, if a UE is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- an indication for intra-slot frequency hopping by *intraSlotFrequencyHopping*, if a UE is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- an index of a first interlace by *interlace0*, if a UE is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- if provided, an index of a second interlace by *interlace1*, if a UE is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- an index of an RB set by *rb-SetIndex*, if a UE is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- a configuration for a PUCCH format provided by *format*

The UE expects that *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon* and *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated* are provided either in all UL BWPs or in none of the UL BWPs for a serving cell.

If a UE is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*, the UE determines available RBs for PUCCH transmissions within the active UL BWP as the intersection of RBs corresponding to an interlace index provided by *interlace0* and, if provided, *interlace1*, and RBs of an RB set provided by *rb-SetIndex*. The intersection results in RBs in the first interlace and the UE expects that is either 10 or 11. If *interlace1* is provided, the intersection results in RBs in the second interlace and the UE expects that is either 10 or 11.

If the *format* indicates *PUCCH-format0*,the PUCCH format configured for a PUCCH resource is PUCCH format 0, where the PUCCH resource also includes an index for an initial cyclic shift provided by *initialCyclicShift*, a number of symbols for a PUCCH transmission provided by *nrofSymbols*, a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. For PUCCH transmission in FR2-2, the PUCCH resource also includes a number of PRBs provided by *nrofPRBs.*

If the *format* indicates *PUCCH-format1*,the PUCCH format configured for a PUCCH resource is PUCCH format 1, where the PUCCH resource also includes an index for an initial cyclic shift provided by *initialCyclicShift*, a number of symbols for a PUCCH transmission provided by *nrofSymbols*, a first symbol for the PUCCH transmission provided by *startingSymbolIndex*, and an index for an orthogonal cover code by *timeDomainOCC*. For PUCCH transmission in FR2-2, the PUCCH resource also includes a number of PRBs provided by *nrofPRBs.*

If the *format* indicates *PUCCH-format2* or *PUCCH-format3*,the PUCCH format configured for a PUCCH resource is PUCCH format 2 or PUCCH format 3, respectively, where the PUCCH resource also includes a number of PRBs provided by *nrofPRBs*, a number of symbols for a PUCCH transmission provided by *nrofSymbols*, and a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. If a UE is provided by *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated,* and the *format* indicates *PUCCH-format2* or *PUCCH-format3* and *PUCCH-ResourceExt* is provided,the PUCCH resource also includes an index of a second interlace by *interlace1*, if provided; otherwise, if *interlace1* is not provided, the PUCCH resource also includes, if provided, an orthogonal cover code length by *occ-Length* and an orthogonal cover code index by *occ-Index*. If the *format* indicates *PUCCH-format3* and *PUCCH-ResourceExt* is provided, the UE assumes that the [4, TS38.211] PRBs with the lowest indexes within the first, and if configured, second interlace are used for PUCCH transmission.

If the *format* indicates *PUCCH-format4*, the PUCCH format configured for a PUCCH resource is PUCCH format 4, where the PUCCH resource also includes a number of symbols for a PUCCH transmission provided by *nrofSymbols*, an orthogonal cover code length by *occ-Length*, an orthogonal cover code index by *occ-Index*, and a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. For PUCCH transmission in FR2-2, the PUCCH resource also includes a number of PRBs provided by *nrofPRBs.*

If a UE is provided *subslotLengthForPUCCH* in a *PUCCH-Config*, the first symbol of a PUCCH resource provided by *PUCCH-ResourceSet* or *SPS-PUCCH-AN-List* in *PUCCH-Config* or by *n1PUCCH-AN* in SPS-Config for multiplexing HARQ-ACK in a PUCCH transmission is relative to the first symbol of the *subslotLengthForPUCCH* symbols [12, TS 38.331]. For the remaining cases, the first symbol of a PUCCH resource is relative to the first symbol of a slot with  symbols [4, TS 38.211].

A UE can be configured up to four sets of PUCCH resources in a *PUCCH-Config*. A PUCCH resource set is provided by *PUCCH-ResourceSet* and is associated with a PUCCH resource set index provided by *pucch-ResourceSetId*, with a set of PUCCH resource indexes provided by *resourceList* that provides a set of *pucch-ResourceId* used in the PUCCH resource set, and with a maximum number of UCI information bits the UE can transmit using a PUCCH resource in the PUCCH resource set provided by *maxPayloadSize*. For the first PUCCH resource set, the maximum number of UCI information bits is 2. A maximum number of PUCCH resource indexes for a set of PUCCH resources is provided by *maxNrofPUCCH-ResourcesPerSet*. The maximum number of PUCCH resources in the first PUCCH resource set is 32 and the maximum number of PUCCH resources in the other PUCCH resource sets is 8.

If the UE transmits UCI information bits, that include HARQ-ACK information bits, the UE determines a PUCCH resource set to be

- a first set of PUCCH resources with *pucch-ResourceSetId* = 0 if including 1 or 2 HARQ-ACK information bits and a positive or negative SR on one SR transmission occasion if transmission of HARQ-ACK information and SR occurs simultaneously, or

- a second set of PUCCH resources with *pucch-ResourceSetId* = 1, if provided by higher layers, if where is equal to *maxPayloadSize* if *maxPayloadSize* is provided for the PUCCH resource set with *pucch-ResourceSetId* = 1; otherwise is equal to 1706, or

- a third set of PUCCH resources with *pucch-ResourceSetId* = 2, if provided by higher layers, if where is equal to *maxPayloadSize* if *maxPayloadSize* is provided for the PUCCH resource set with *pucch-ResourceSetId* = 2; otherwise is equal to 1706, or

- a fourth set of PUCCH resources with *pucch-ResourceSetId* = 3, if provided by higher layers, if .

If the UE is provided *SPS-PUCCH-AN-List* and transmits UCI information bits that include only HARQ-ACK information bits in response to one or more SPS PDSCH receptions and SR, if any, the UE determines a PUCCH resource to be

- a PUCCH resource provided by *sps-PUCCH-AN-ResourceID* obtained from the first entry in *sps-PUCCH-AN-List* if including 1 or 2 HARQ-ACK information bits and a positive or negative SR on one SR transmission occasion if transmission of HARQ-ACK information and SR occurs simultaneously, or

- a PUCCH resource provided by *sps-PUCCH-AN-ResourceID* obtained from the second entry in *sps-PUCCH-AN-List*, if provided, if where is either provided by *maxPayloadSize* obtained from the second entry in *sps-PUCCH-AN-List* or is otherwise equal to 1706, or

- a PUCCH resource provided by *sps-PUCCH-AN-ResourceID* obtained from the third entry in *sps-PUCCH-AN-List*, if provided, if where is either provided by *maxPayloadSize* obtained from the third entry in *sps-PUCCH-AN-List* or is otherwise equal to 1706, or

- a PUCCH resource provided by *sps-PUCCH-AN-ResourceID* obtained from the fourth entry in *sps-PUCCH-AN-List*, if provided, if where is equal to 1706.

### 9.2.2 PUCCH Formats for UCI transmission

If a UE is not transmitting PUSCH, and the UE is transmitting UCI, the UE transmits UCI in a PUCCH using

- PUCCH format 0 if

- the transmission is over 1 symbol or 2 symbols,

- the number of HARQ-ACK information bits with positive or negative SR (HARQ-ACK/SR bits) is 1 or 2

- PUCCH format 1 if

- the transmission is over 4 or more symbols,

- the number of HARQ-ACK/SR bits is 1 or 2

- PUCCH format 2 if

- the transmission is over 1 symbol or 2 symbols,

- the number of UCI bits is more than 2

- PUCCH format 3 if

- the transmission is over 4 or more symbols,

- the number of UCI bits is more than 2,

- the PUCCH resource does not include an orthogonal cover code, or the UE is provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

- PUCCH format 4 if

- the transmission is over 4 or more symbols,

- the number of UCI bits is more than 2,

- the PUCCH resource includes an orthogonal cover code and the UE is not provided *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*

A spatial setting for a PUCCH transmission is provided by *PUCCH-SpatialRelationInfo* if the UE is configured with a single value for *pucch-SpatialRelationInfoId*; otherwise, if the UE is provided multiple values for *PUCCH-SpatialRelationInfo*, the UE determines a spatial setting for the PUCCH transmission as described in [11, TS 38.321]. The UE applies corresponding actions in [11, TS 38.321] and a corresponding setting for a spatial domain filter to transmit PUCCH in the first slot that is after slot where is the slot where the UE would transmit a PUCCH with HARQ-ACK information with ACK value corresponding to a PDSCH reception providing the *PUCCH-SpatialRelationInfo*, each slot consists of symbols as defined in [4, TS 38.211],and is the SCS configuration for the PUCCH

- If *PUCCH-SpatialRelationInfo* provides *ssb-Index*, the UE transmits the PUCCH using a same spatial domain filter as for a reception of a SS/PBCH block with index provided by *ssb-Index* for a same serving cell or, if *servingCellId* is provided, for a serving cell indicated by *servingCellId*

- else if *PUCCH-SpatialRelationInfo* provides *csi-RS-Index*, the UE transmits the PUCCH using a same spatial domain filter as for a reception of a CSI-RS with resource index provided by *csi-RS-Index* for a same serving cell or, if *servingCellId* is provided, for a serving cell indicated by *servingCellId*

- else *PUCCH-SpatialRelationInfo* provides *srs*, the UE transmits the PUCCH using a same spatial domain filter as for a transmission of a SRS with resource index provided by *resource* for a same serving cell and/or active UL BWP or, if *servingCellId* and/or *uplinkBWP* are provided, for a serving cell indicated by *servingCellId* and/or for an UL BWP indicated by *uplinkBWP*

If a UE

- is not provided *pathlossReferenceRSs* in *PUCCH-PowerControl*,

- is provided *enableDefaultBeamPL-ForPUCCH*, and

- is not provided *PUCCH-SpatialRelationInfo*, and

- is not provided coresetPoolIndex value of 1 for any CORESET, or is provided coresetPoolIndex value of 1 for all CORESETs, in ControlResourceSet and no codepoint of a TCI field, if any, in a DCI format of any search space set maps to two TCI states [5, TS 38.212]

a spatial setting for a PUCCH transmission from the UE is same as a spatial setting for PDCCH receptions by the UE in the CORESET with the lowest ID on the active DL BWP of the PCell. For a PUCCH transmission over multiple slots, a same spatial setting applies to the PUCCH transmission in each of the multiple slots.

A number of DMRS symbols for a PUCCH transmission using PUCCH format 3 or 4 is provided by *additionalDMRS*.

Use of /2-BPSK, instead of QPSK, for a PUCCH transmission using PUCCH format 3 or 4 is indicated by *pi2BPSK*.

### 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.

If the UE is provided *subslotLengthForPUCCH*, is the last UL slot for PUCCH transmission 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 for PUCCH transmission that overlaps with the DL slot for the PDSCH reception or with the DL slot for the PDCCH reception in case of 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 the last UL slot for PUCCH transmission that overlaps with slot and 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 the last UL slot for PUCCH transmission that overlaps with slot and is provided by *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2*.

If the UE detects a DCI format scheduling a number of PDSCH receptions ending in DL slot  or if the UE detects a DCI format indicating a SPS PDSCH release or indicating SCell dormancy 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 the last UL slot for PUCCH transmission that overlaps with slot and 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*.

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*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
| '1' | '01' | '001' | 2nd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  | '10' | '010' | 3rd value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  | '11' | '011' | 4th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  |  | '100' | 5th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  |  | '101' | 6th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  |  | '110' | 7th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |
|  |  | '111' | 8th value provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2* | |

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*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2*, 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*, 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 , for , and 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 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* 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, or for PUCCH transmission in FR2-2 using PUCCH format 4, if is not equal according to [4, TS 38.211], is increased to the nearest allowed value of *nrofPRBs* [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 \*\*\*

#### 9.2.5.1 UE procedure for multiplexing HARQ-ACK or CSI and SR in a PUCCH

In the following, a UE is configured to transmit PUCCHs for respective SRs in a slot, as determined by a set of *schedulingRequestResourceId*, a *schedulingRequestResourceId* associated with *schedulingRequestID-BFR-SCell*, and a *schedulingRequestResourceId* associated with *schedulingRequestID-LBT-SCell*, with SR transmission occasions that would overlap with a transmission of a PUCCH with HARQ-ACK information from the UE in the slot or with a transmission of a PUCCH with CSI report(s) from the UE in the slot.

If a UE would transmit a PUCCH with positive SR and at most two HARQ-ACK information bits in a resource using PUCCH format 0, the UE transmits the PUCCH in the resource using PUCCH format 0 in PRB(s) for HARQ-ACK information as described in clause 9.2.3. The UE determines a value of and for computing a value of cyclic shift [4, TS 38.211] where is provided by *initialCyclicShift* of *PUCCH-format0*, 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 9.2.5-1 and Table 9.2.5-2, respectively.

If the UE would transmit negative SR and a PUCCH with at most two HARQ-ACK information bits in a resource using PUCCH format 0, the UE transmits the PUCCH in the resource using PUCCH format 0 for HARQ-ACK information as described in clause 9.2.3.

Table 9.2.5-1: Mapping of values for one HARQ-ACK information bit and positive SR to sequences for PUCCH format 0

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

Table 9.2.5-2: Mapping of values for two HARQ-ACK information bits and positive SR to sequences for PUCCH format 0

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

If a UE would transmit SR in a resource using PUCCH format 0 and HARQ-ACK information bits in a resource using PUCCH format 1 in a slot, the UE transmits only a PUCCH with the HARQ-ACK information bits in the resource using PUCCH format 1.

If the UE would transmit positive SR in a first resource using PUCCH format 1 and at most two HARQ-ACK information bits in a second resource using PUCCH format 1 in a slot, the UE transmits a PUCCH with HARQ-ACK information bits in the first resource using PUCCH format 1 as described in clause 9.2.3. If a UE would not transmit a positive SR in a resource using PUCCH format 1 and would transmit at most two HARQ-ACK information bits in a resource using PUCCH format 1 in a slot, the UE transmits a PUCCH in the resource using PUCCH format 1 for HARQ-ACK information as described in clause 9.2.3.

If a UE would transmit a PUCCH with HARQ-ACK information bits in a resource using PUCCH format 2 or PUCCH format 3 or PUCCH format 4 in a slot, as described in clauses 9.2.1 and 9.2.3, bits representing a negative or positive SR, in ascending order of the values of *schedulingRequestResourceId*,a *schedulingRequestResourceId* associated with *schedulingRequestID-BFR-SCell*, and a *schedulingRequestResourceId* associated with *schedulingRequestID-LBT-SCell*, are appended to the HARQ-ACK information bits and the UE transmits the combined UCI bits in a PUCCH using a resource with PUCCH format 2 or PUCCH format 3 or PUCCH format 4 that the UE determines as described in clauses 9.2.1 and 9.2.3. If one of the SRs is a positive LRR, the value of the bits indicates the positive LRR. An all-zero value for the bits represents a negative SR value across all SRs.

If a UE would transmit a PUCCH with CSI report bits in a resource using PUCCH format 2 or PUCCH format 3 or PUCCH format 4 in a slot, bits representing corresponding negative or positive SR, in ascending order of the values of *schedulingRequestResourceId*, a *schedulingRequestResourceId* associated with *schedulingRequestID-BFR-SCell*, and a *schedulingRequestResourceId* associated with *schedulingRequestID-LBT-SCell*, are prepended to the CSI information bits as described in clause 9.2.5.2 and the UE transmits a PUCCH with the combined UCI bits in a resource using the PUCCH format 2 or PUCCH format 3 or PUCCH format 4 for CSI reporting. If one of the SRs is a positive LRR, the value of the bits indicates the positive LRR. An all-zero value for the bits represents a negative SR value across all SRs.



If a UE transmits a PUCCH with HARQ-ACK information bits, SR bits, and CRC bits 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 by *nrofPRBs* and starts 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 or for PUCCH format 4 for operation in FR2-2, if is not equal according to [4, TS 38.211], is increased to the nearest allowed value of *nrofPRBs* [12, TS 38.331]. If , the UE transmits the PUCCH over the PRBs.

If a UE is provided a first interlace of PRBs by *interlace0* in *InterlaceAllocation* and transmits a PUCCH with HARQ-ACK information bits, SR bits, and CRC 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.

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

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

If a UE is provided only one PUCCH resource set for transmission of HARQ-ACK information in response to PDSCH reception scheduled by a DCI format or in response to a SPS PDSCH release or in response to a SCell dormancy indication, the UE does not expect to be provided *simultaneousHARQ-ACK-CSI*.

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

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

Denote as

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



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



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



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



In the following

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



- is a number of PRBs provided by *nrofPRBs* and, for PUCCH transmission using PUCCH format 4 that is not in FR2-2, for PUCCH format 4



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



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



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



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

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



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



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



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



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



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

- the UE determines the PUCCH resource using the PUCCH resource indicator field [5, TS 38.212] in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field, if present, or a value of *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2*, indicating a same slot for the PUCCH transmission, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

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



and

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



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



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

- the UE determines the PUCCH resource using the PUCCH resource indicator field in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field, or a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-ForDCI-Format1-2* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in a DCI format, indicating a same slot for the PUCCH transmission, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

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

and

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

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

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

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

- the UE determines the PUCCH resource using the PUCCH resource indicator field [5, TS 38.212] in a last of a number of DCI formats with a value of a PDSCH-to-HARQ\_feedback timing indicator field indicating a same slot for the PUCCH transmission, or by a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-ForDCI-Format1-2* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the last DCI format,from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

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



and

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



- else,

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



and



,



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



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



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

- the UE determines the PUCCH resource using the PUCCH resource indicator field in a last of a number of DCI formats that have a value of a PDSCH-to-HARQ\_feedback timing indicator field indicating a same slot for the PUCCH transmission, or a value provided by *dl-DataToUL-ACK* or *dl-DataToUL-ACK-r16* or *dl-DataToUL-ACK-ForDCI-Format1-2* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the last DCI format, from a PUCCH resource set provided to the UE for HARQ-ACK transmission, and

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

and

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

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

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

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

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

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

# 13 UE procedure for monitoring Type0-PDCCH CSS sets

If during cell search a UE determines from *MIB* that a CORESET for Type0-PDCCH CSS set is present, as described in clause 4.1, the UE determines a number of consecutive resource blocks and a number of consecutive symbols for the CORESET of the Type0-PDCCH CSS set from *controlResourceSetZero* in *pdcch-ConfigSIB1*, as described in Tables 13-1 through 13-10, for operation without shared spectrum channel access in FR1 and FR2-1, or as described in Tables 13-1A and 13-4A for operation with shared spectrum channel access in FR1, or as described in Tables 13-10A, 13-10B and 13-10C for FR2-2, and determines PDCCH monitoring occasions from *searchSpaceZero* in *pdcch-ConfigSIB1*, included in *MIB*, as described in Tables 13-11 through 13-15. and are the SFN and slot index within a frame of the CORESET based on SCS of the CORESET and and are the SFN and slot index based on SCS of the CORESET, respectively, where the SS/PBCH block with index overlaps in time with system frame and slot . The symbols of the CORESET associated with *pdcch-ConfigSIB1* in *MIB* or with *searchSpaceSIB1* in *PDCCH-ConfigCommon* have normal cyclic prefix.

For operation without shared spectrum channel access, a UE assumes that the offset in Tables 13-1 through 13-10 and Tables 13-10A, 13-10B and 13-10C is defined with respect to the SCS of the CORESET for Type0-PDCCH CSS set from the smallest RB index of the CORESET for Type0-PDCCH CSS set to the smallest RB index of the common RB overlapping with the first RB of the corresponding SS/PBCH block. The SCS of the CORESET for Type0-PDCCH CSS set is provided by *subCarrierSpacingCommon* for FR1 and FR2-1 and same as the SCS of the corresponding SS/PBCH block for FR2-2. In Tables 13-7, 13-8, and 13-10 is defined in [4, TS 38.211].

For operation with shared spectrum channel access, a UE determines an offset from a smallest RB index of the CORESET for Type0-PDCCH CSS set to a smallest RB index of the common RB overlapping with a first RB of the corresponding SS/PBCH block

- according to the offset in Table 13-1A or Table 13-4A, if the frequency position of the SS/PBCH block corresponds to the GSCN of a synchronization raster entry as defined in [8-1, TS 38.101-1], and

- according to a sum of a first offset and a second offset if the frequency position of the SS/PBCH block is provided by *ssbFrequency* in a measurement configuration associated with a reporting configuration providing *reportCGI* and does not correspond to the GSCN of a synchronization raster entry as defined in [8-1, TS 38.101-1], where

- the first offset is provided in Table 13-1A or Table 13-4A, and

- the second offset is determined as the offset from a smallest RB index of the common RB overlapping with the first RB of the SS/PBCH block indicated in the measurement configuration to a smallest RB index of the common RB overlapping with the first RB of a SS/PBCH block hypothetically located at the GSCN of a synchronization raster entry, where the single synchronization raster entry is located in the same channel as the SS/PBCH block used for the shared spectrum channel access procedure, as described in [15, TS 37.213]

where the offsets are defined with respect to the SCS of the CORESET for Type0-PDCCH CSS set that is same as the SCS of the corresponding SS/PBCH block.

For operation without shared spectrum channel access and for the SS/PBCH block and CORESET multiplexing pattern 1, a UE monitors PDCCH in the Type0-PDCCH CSS set over two consecutive slots starting from slot . For SS/PBCH block with index , the UE determines an index of slot as that is in a frame with system frame number (SFN) satisfying if , or in a frame with SFN satisfying if . and are provided by Tables 13-11 and 13-12, and based on the SCS for PDCCH receptions in the CORESET [4, TS 38.211]. The index for the first symbol of the CORESET in slots and is the first symbol index provided by Tables 13-11 and 13-12.

For operation with shared spectrum channel access and for the SS/PBCH block and CORESET multiplexing pattern 1, a UE monitors PDCCH in the Type0-PDCCH CSS set over slots that include Type0-PDCCH monitoring occasions associated with SS/PBCH blocks that are quasi co-located with the SS/PBCH block that provides a CORESET for Type0-PDCCH CSS set with respect to average gain, quasi co-location 'typeA' and 'typeD' properties, when applicable [6, TS 38.214]. For a candidate SS/PBCH block index , where , two consecutive slots starting from slot include the associated Type0-PDCCH monitoring occasions. The UE determines an index of slot as that is in a frame with system frame number (SFN) satisfying if , or in a frame with SFN satisfying if . and are provided by Table 13-11, and based on the SCS for PDCCH receptions in the CORESET [4, TS 38.211]. The index for the first symbol of the CORESET in slots and is the first symbol index provided by Table 13-11. The UE does not expect to be configured with , or with , when .

For the SS/PBCH block and CORESET multiplexing patterns 2 and 3, a UE monitors PDCCH in the Type0-PDCCH CSS set over one slot with Type0-PDCCH CSS set periodicity equal to the periodicity of SS/PBCH block. For the SS/PBCH block and CORESET multiplexing patterns 2 and 3, if the active DL BWP is the initial DL BWP, the UE is expected to be able to perform radio link monitoring, as described in clause 5, and measurements for radio resource management [10, TS 38.133] using a SS/PBCH block that provides a CORESET for Type0-PDCCH CSS set. For a SS/PBCH block with index , the UE determines the slot index and based on parameters provided by Tables 13-13 through 13-15.

Table 13-1: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {15, 15} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 | 0 |
| 1 | 1 | 24 | 2 | 2 |
| 2 | 1 | 24 | 2 | 4 |
| 3 | 1 | 24 | 3 | 0 |
| 4 | 1 | 24 | 3 | 2 |
| 5 | 1 | 24 | 3 | 4 |
| 6 | 1 | 48 | 1 | 12 |
| 7 | 1 | 48 | 1 | 16 |
| 8 | 1 | 48 | 2 | 12 |
| 9 | 1 | 48 | 2 | 16 |
| 10 | 1 | 48 | 3 | 12 |
| 11 | 1 | 48 | 3 | 16 |
| 12 | 1 | 96 | 1 | 38 |
| 13 | 1 | 96 | 2 | 38 |
| 14 | 1 | 96 | 3 | 38 |
| 15 | Reserved | | | |

Table 13-1A: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {15, 15} kHz for frequency bands operated with shared spectrum channel access

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 96 | 1 | 10 |
| 1 | 1 | 96 | 1 | 12 |
| 2 | 1 | 96 | 1 | 14 |
| 3 | 1 | 96 | 1 | 16 |
| 4 | 1 | 96 | 2 | 10 |
| 5 | 1 | 96 | 2 | 12 |
| 6 | 1 | 96 | 2 | 14 |
| 7 | 1 | 96 | 2 | 16 |
| 8 | Reserved | | | |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-2: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {15, 30} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 | 5 |
| 1 | 1 | 24 | 2 | 6 |
| 2 | 1 | 24 | 2 | 7 |
| 3 | 1 | 24 | 2 | 8 |
| 4 | 1 | 24 | 3 | 5 |
| 5 | 1 | 24 | 3 | 6 |
| 6 | 1 | 24 | 3 | 7 |
| 7 | 1 | 24 | 3 | 8 |
| 8 | 1 | 48 | 1 | 18 |
| 9 | 1 | 48 | 1 | 20 |
| 10 | 1 | 48 | 2 | 18 |
| 11 | 1 | 48 | 2 | 20 |
| 12 | 1 | 48 | 3 | 18 |
| 13 | 1 | 48 | 3 | 20 |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-3: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 15} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 48 | 1 | 2 |
| 1 | 1 | 48 | 1 | 6 |
| 2 | 1 | 48 | 2 | 2 |
| 3 | 1 | 48 | 2 | 6 |
| 4 | 1 | 48 | 3 | 2 |
| 5 | 1 | 48 | 3 | 6 |
| 6 | 1 | 96 | 1 | 28 |
| 7 | 1 | 96 | 2 | 28 |
| 8 | 1 | 96 | 3 | 28 |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-4: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands with minimum channel bandwidth 5 MHz or 10 MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 | 0 |
| 1 | 1 | 24 | 2 | 1 |
| 2 | 1 | 24 | 2 | 2 |
| 3 | 1 | 24 | 2 | 3 |
| 4 | 1 | 24 | 2 | 4 |
| 5 | 1 | 24 | 3 | 0 |
| 6 | 1 | 24 | 3 | 1 |
| 7 | 1 | 24 | 3 | 2 |
| 8 | 1 | 24 | 3 | 3 |
| 9 | 1 | 24 | 3 | 4 |
| 10 | 1 | 48 | 1 | 12 |
| 11 | 1 | 48 | 1 | 14 |
| 12 | 1 | 48 | 1 | 16 |
| 13 | 1 | 48 | 2 | 12 |
| 14 | 1 | 48 | 2 | 14 |
| 15 | 1 | 48 | 2 | 16 |

Table 13-4A: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands operated with shared spectrum channel access

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 48 | 1 | 0 |
| 1 | 1 | 48 | 1 | 1 |
| 2 | 1 | 48 | 1 | 2 |
| 3 | 1 | 48 | 1 | 3 |
| 4 | 1 | 48 | 2 | 0 |
| 5 | 1 | 48 | 2 | 1 |
| 6 | 1 | 48 | 2 | 2 |
| 7 | 1 | 48 | 2 | 3 |
| 8 | Reserved | | | |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-5: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 15} kHz for frequency bands with minimum channel bandwidth 40MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 48 | 1 | 4 |
| 1 | 1 | 48 | 2 | 4 |
| 2 | 1 | 48 | 3 | 4 |
| 3 | 1 | 96 | 1 | 0 |
| 4 | 1 | 96 | 1 | 56 |
| 5 | 1 | 96 | 2 | 0 |
| 6 | 1 | 96 | 2 | 56 |
| 7 | 1 | 96 | 3 | 0 |
| 8 | 1 | 96 | 3 | 56 |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-6: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {30, 30} kHz for frequency bands with minimum channel bandwidth 40MHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 | 0 |
| 1 | 1 | 24 | 2 | 4 |
| 2 | 1 | 24 | 3 | 0 |
| 3 | 1 | 24 | 3 | 4 |
| 4 | 1 | 48 | 1 | 0 |
| 5 | 1 | 48 | 1 | 28 |
| 6 | 1 | 48 | 2 | 0 |
| 7 | 1 | 48 | 2 | 28 |
| 8 | 1 | 48 | 3 | 0 |
| 9 | 1 | 48 | 3 | 28 |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-7: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {120, 60} kHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 48 | 1 | 0 |
| 1 | 1 | 48 | 1 | 8 |
| 2 | 1 | 48 | 2 | 0 |
| 3 | 1 | 48 | 2 | 8 |
| 4 | 1 | 48 | 3 | 0 |
| 5 | 1 | 48 | 3 | 8 |
| 6 | 1 | 96 | 1 | 28 |
| 7 | 1 | 96 | 2 | 28 |
| 8 | 2 | 48 | 1 | -41 if  -42 if |
| 9 | 2 | 48 | 1 | 49 |
| 10 | 2 | 96 | 1 | -41 if  -42 if |
| 11 | 2 | 96 | 1 | 97 |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-8: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {120, 120} kHz for FR2-1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 | 0 |
| 1 | 1 | 24 | 2 | 4 |
| 2 | 1 | 48 | 1 | 14 |
| 3 | 1 | 48 | 2 | 14 |
| 4 | 3 | 24 | 2 | -20 if  -21 if |
| 5 | 3 | 24 | 2 | 24 |
| 6 | 3 | 48 | 2 | -20 if  -21 if |
| 7 | 3 | 48 | 2 | 48 |
| 8 | Reserved | | | |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-9: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {240, 60} kHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 96 | 1 | 0 |
| 1 | 1 | 96 | 1 | 16 |
| 2 | 1 | 96 | 2 | 0 |
| 3 | 1 | 96 | 2 | 16 |
| 4 | Reserved | | | |
| 5 | Reserved | | | |
| 6 | Reserved | | | |
| 7 | Reserved | | | |
| 8 | Reserved | | | |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-10: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {240, 120} kHz

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 48 | 1 | 0 |
| 1 | 1 | 48 | 1 | 8 |
| 2 | 1 | 48 | 2 | 0 |
| 3 | 1 | 48 | 2 | 8 |
| 4 | 2 | 24 | 1 | -41 if  -42 if |
| 5 | 2 | 24 | 1 | 25 |
| 6 | 2 | 48 | 1 | -41 if  -42 if |
| 7 | 2 | 48 | 1 | 49 |
| 8 | Reserved | | | |
| 9 | Reserved | | | |
| 10 | Reserved | | | |
| 11 | Reserved | | | |
| 12 | Reserved | | | |
| 13 | Reserved | | | |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-10A: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {120, 120} kHz for FR2-2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 |  |
| 1 | 1 | 48 | 1 |  |
| 2 | 1 | 48 | 2 |  |
| 3 | 1 | 96 | 1 |  |
| 4 | 1 | 96 | 2 |  |
| 5 | 3 | 24 | 2 |  |
| 6 | 3 | 48 | 2 |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |

Table 13-10B: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {480, 480} kHz for FR2-2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 |  |
| 1 | 1 | 48 | 1 |  |
| 2 | 1 | 48 | 2 |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |

Table 13-10C: Set of resource blocks and slot symbols of CORESET for Type0-PDCCH search space set when {SS/PBCH block, PDCCH} SCS is {960, 960} kHz for FR2-2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index | SS/PBCH block and CORESET multiplexing pattern | Number of RBs | Number of Symbols | Offset (RBs) |
| 0 | 1 | 24 | 2 |  |
| 1 | 1 | 48 | 1 |  |
| 2 | 1 | 48 | 2 |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |

Table 13-11: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and FR1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index |  | Number of search space sets per slot |  | **First symbol index** |
| 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 2 | 2 | 1 | 1 | 0 |
| 3 | 2 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 4 | 5 | 1 | 1 | 0 |
| 5 | 5 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 6 | 7 | 1 | 1 | 0 |
| 7 | 7 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 8 | 0 | 1 | 2 | 0 |
| 9 | 5 | 1 | 2 | 0 |
| 10 | 0 | 1 | 1 | 1 |
| 11 | 0 | 1 | 1 | 2 |
| 12 | 2 | 1 | 1 | 1 |
| 13 | 2 | 1 | 1 | 2 |
| 14 | 5 | 1 | 1 | 1 |
| 15 | 5 | 1 | 1 | 2 |

Table 13-12: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and FR2-1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index |  | Number of search space sets per slot |  | **First symbol index** |
| 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 2 | 2.5 | 1 | 1 | 0 |
| 3 | 2.5 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 4 | 5 | 1 | 1 | 0 |
| 5 | 5 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 6 | 0 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 7 | 2.5 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 8 | 5 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 9 | 7.5 | 1 | 1 | 0 |
| 10 | 7.5 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 11 | 7.5 | 2 | 1/2 | {0, if is even}, {, if is odd} |
| 12 | 0 | 1 | 2 | 0 |
| 13 | 5 | 1 | 2 | 0 |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-12A: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and {SS/PBCH block, PDCCH} SCS {480, 480} kHz or {960, 960} kHz in FR2-2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index |  | Number of search space sets per slot |  | **First symbol index** |
| 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 2 | X | 1 | 1 | 0 |
| 3 | X | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 4 | 5 | 1 | 1 | 0 |
| 5 | 5 | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 6 | 0 | 2 | 1/2 | {0, if is even}, {Y, if is odd} |
| 7 | X | 2 | 1/2 | {0, if is even}, {Y, if is odd} |
| 8 | 5 | 2 | 1/2 | {0, if is even}, {Y, if is odd} |
| 9 | 5+X | 1 | 1 | 0 |
| 10 | 5+X | 2 | 1/2 | {0, if is even}, {7, if is odd} |
| 11 | 5+X | 2 | 1/2 | {0, if is even}, {Y, if is odd} |
| 12 | 0 | 1 | 2 | 0 |
| 13 | 5 | 1 | 2 | 0 |
| 14 | Reserved | | | |
| 15 | Reserved | | | |

Table 13-12B: Parameters for PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 1 and {SS/PBCH block, PDCCH} SCS {120, 120} kHz in FR2-2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Index |  | Number of search space sets per slot |  | **First symbol index** |
| 0 |  |  |  |  |
| 1 |  |  |  |  |
| 2 |  |  |  |  |
| 3 |  |  |  |  |
| 4 |  |  |  |  |
| 5 |  |  |  |  |
| 6 |  |  |  |  |
| 7 |  |  |  |  |
| 8 |  |  |  |  |
| 9 |  |  |  |  |
| 10 |  |  |  |  |
| 11 |  |  |  |  |
| 12 |  |  |  |  |
| 13 |  |  |  |  |
| 14 |  |  |  |  |
| 15 |  |  |  |  |

Table 13-13: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 2 and {SS/PBCH block, PDCCH} SCS {120, 60} kHz

|  |  |  |
| --- | --- | --- |
| Index | PDCCH monitoring occasions (SFN and slot number) | **First symbol index**  **(*k* = 0, 1, … 15)** |
| 0 |  | 0, 1, 6, 7 for  , , , |
| 1 | Reserved | |
| 2 | Reserved | |
| 3 | Reserved | |
| 4 | Reserved | |
| 5 | Reserved | |
| 6 | Reserved | |
| 7 | Reserved | |
| 8 | Reserved | |
| 9 | Reserved | |
| 10 | Reserved | |
| 11 | Reserved | |
| 12 | Reserved | |
| 13 | Reserved | |
| 14 | Reserved | |
| 15 | Reserved | |

Table 13-14: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 2 and {SS/PBCH block, PDCCH} SCS {240, 120} kHz

|  |  |  |
| --- | --- | --- |
| Index | PDCCH monitoring occasions (SFN and slot number) | **First symbol index**  **(*k* = 0, 1, …, 7)** |
| 0 | or | 0, 1, 2, 3, 0, 1 in , , , , , ()  12, 13 in , () |
| 1 | Reserved | |
| 2 | Reserved | |
| 3 | Reserved | |
| 4 | Reserved | |
| 5 | Reserved | |
| 6 | Reserved | |
| 7 | Reserved | |
| 8 | Reserved | |
| 9 | Reserved | |
| 10 | Reserved | |
| 11 | Reserved | |
| 12 | Reserved | |
| 13 | Reserved | |
| 14 | Reserved | |
| 15 | Reserved | |

Table 13-15: PDCCH monitoring occasions for Type0-PDCCH CSS set - SS/PBCH block and CORESET multiplexing pattern 3 and {SS/PBCH block, PDCCH} SCS {120, 120} kHz

|  |  |  |
| --- | --- | --- |
| Index | PDCCH monitoring occasions (SFN and slot number) | **First symbol index**  **(*k* = 0, 1, … 15)** |
| 0 |  | 4, 8, 2, 6 in  , , , |
| 1 | Reserved | |
| 2 | Reserved | |
| 3 | Reserved | |
| 4 | Reserved | |
| 5 | Reserved | |
| 6 | Reserved | |
| 7 | Reserved | |
| 8 | Reserved | |
| 9 | Reserved | |
| 10 | Reserved | |
| 11 | Reserved | |
| 12 | Reserved | |
| 13 | Reserved | |
| 14 | Reserved | |
| 15 | Reserved | |

If a UE detects a first SS/PBCH block and determines that a CORESET for Type0-PDCCH CSS set is not present, and for for FR1 or for for FR2, the UE may determine the nearest (in the corresponding frequency direction) global synchronization channel number (GSCN) of a second SS/PBCH block having a CORESET for an associated Type0-PDCCH CSS set as . is the GSCN of the first SS/PBCH block and is a GSCN offset provided by Table 13-16 for FR1 and Table 13-17 for FR2. If the UE detects the second SS/PBCH block and the second SS/PBCH block does not provide a CORESET for Type0-PDCCH CSS set, as described in clause 4.1, the UE may ignore the information related to GSCN of SS/PBCH block locations for performing cell search.

If a UE detects a SS/PBCH block and determines that a CORESET for Type0-PDCCH CSS set is not present, and for for FR1 or for for FR2, the UE determines that there is no SS/PBCH block having an associated Type0-PDCCH CSS set within a GSCN range . and are respectively determined by *controlResourceSetZero* and *searchSpaceZero* in *pdcch-ConfigSIB1*. If the GSCN range is , the UE determines that there is no information for a second SS/PBCH block with a CORESET for an associated Type0-PDCCH CSS set on the detected SS/PBCH block.

If a UE does not detect any SS/PBCH block providing a CORESET for Type0-PDCCH CSS set, as described in clause 4.1, within a time period determined by the UE, the UE may ignore the information related to GSCN of SS/PBCH locations in performing cell search.

Table 13-16: Mapping between the combination of and *controlResourceSetZero* and *searchSpaceZero* in *pdcch-ConfigSIB1* to for FR1

|  |  |  |
| --- | --- | --- |
|  | *16×controlResourceSetZero +searchSpaceZero* |  |
| 24 | 0, 1, …, 255 | 1, 2, …, 256 |
| 25 | 0, 1, …, 255 | 257, 258, …, 512 |
| 26 | 0, 1, …, 255 | 513, 514, …., 768 |
| 27 | 0, 1, …, 255 | -1, -2, …, -256 |
| 28 | 0, 1, …, 255 | -257, -258, …, -512 |
| 29 | 0, 1, …, 255 | -513, -514, …., -768 |
| 30 | 0, 1, …, 255 | Reserved, Reserved, …, Reserved |

Table 13-17: Mapping between the combination of and *controlResourceSetZero* and *searchSpaceZero* in *pdcch-ConfigSIB1* to for FR2

|  |  |  |
| --- | --- | --- |
|  | *16×controlResourceSetZero +searchSpaceZero* |  |
| 12 | 0, 1, …, 255 | 1, 2, …, 256 |
| 13 | 0, 1, …, 255 | -1, -2, …, -256 |
| 14 | 0, 1, …, 255 | Reserved, Reserved, …, Reserved |