**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 of further enhancements on MIMO for NR | | | | | | | | | |
|  |  | | | | | | | | | |
| ***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)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Introduction of MIMO enhancements. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Add description for enhancements on link recovery, power control, reporting of UL control information, and reception of DL control information. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Incomplete support for MIMO enhancements. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 6, 7, 7.1.1, 7.2.1, 7.3.1, 7.7.1, 9, 9.1.2, 9.1.2.1, 9.1.2.2, 9.1.3, 9.1.3.1, 9.1.3.2, 9.2.1, 9.2.2, 9.2.3, 9.2.4, 9.2.5, 9.2.6, 10, 10.1, 11, 11.2A, 12 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS 38.212, TS 38.214, TS 38.321, TS 38.331 | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

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

# 6 Link recovery procedures

A UE can be provided, for each BWP of a serving cell, a set of periodic CSI-RS resource configuration indexes by *failureDetectionResourcesToAddModList* and a set of periodic CSI-RS resource configuration indexes and/or SS/PBCH block indexes by *candidateBeamRSList* or *candidateBeamRSListExt* or *candidateBeamRSSCellList* for radio link quality measurements on the BWP of the serving cell. Instead of the sets and , for each BWP of a serving cell where the UE is provided two coresetPoolIndex values 0 and 1 for respective first and second CORESETs, or is not provided coresetPoolIndex value for first CORESETs and is provided coresetPoolIndex value of 1 for second CORESETs, each having one activated TCI state, the UE can be provided respective two sets and of periodic CSI-RS resource configuration indexes by *failureDetectionResourcesToAddModList1* and *failureDetectionResourcesToAddModList2*, respectively, and corresponding two sets and of periodic CSI-RS resource configuration indexes and/or SS/PBCH block indexes by *candidateBeamRSList1* and *candidateBeamRSList2*, respectively, for radio link quality measurements on the BWP of the serving cell. The sets and are associated with the first CORESETs and the sets and are associated with the second CORESETs.

If the UE is not provided by *failureDetectionResourcesToAddModList* for a BWP of the serving cell, the UE determines the set to include periodic CSI-RS resource configuration indexes with same values as the RS indexes in the RS sets indicated by *TCI-State* for respective CORESETs that the UE uses for monitoring PDCCH and, if there are two RS indexes in a TCI state, the set includes RS indexes configured with *qcl-Type* set to 'typeD' for the corresponding TCI states. The UE expects the set to include up to two RS indexes. The UE expects the set or the set to include up to a number of RS indexes indicated by *capabilityparametername*. The UE expects single port RS in the set , or , or . The UE expects single-port or two-port CSI-RS with frequency density equal to 1 or 3 REs per RB in the set , or , or .

The thresholds Qout,LR and Qin,LR correspond to the default value of *rlmInSyncOutOfSyncThreshold*, as described in [10, TS 38.133] for Qout, and to the value provided by *rsrp-ThresholdSSB* or *rsrp-ThresholdBFR*, respectively.

The physical layer in the UE assesses the radio link quality according to the set , , or , of resource configurations against the threshold Qout,LR. For the set , the UE assesses the radio link quality only according to SS/PBCH blocks on the PCell or the PSCell or periodic CSI-RS resource configurations that are quasi co-located, as described in [6, TS 38.214], with the DM-RS of PDCCH receptions monitored by the UE. The UE applies the Qin,LR threshold to the L1-RSRP measurement obtained from a SS/PBCH block. The UE applies the Qin,LR threshold to the L1-RSRP measurement obtained for a CSI-RS resource after scaling a respective CSI-RS reception power with a value provided by *powerControlOffsetSS*.

In non-DRX mode operation, the physical layer in the UE provides an indication to higher layers when the radio link quality for all corresponding resource configurations in the set , or in the set and/or , that the UE uses to assess the radio link quality is worse than the threshold Qout,LR, and for the set and/or if the UE is provided the sets and . The physical layer informs the higher layers when the radio link quality is worse than the threshold Qout,LR with a periodicity determined by the maximum between the shortest periodicity among the SS/PBCH blocks on the PCell or the PSCell and/or the periodic CSI-RS configurations in the set , , or that the UE uses to assess the radio link quality and 2 msec. In DRX mode operation, the physical layer provides an indication to higher layers when the radio link quality is worse than the threshold Qout,LR with a periodicity determined as described in [10, TS 38.133].

For the PCell or the PSCell, upon request from higher layers, the UE provides to higher layers the periodic CSI-RS configuration indexes and/or SS/PBCH block indexes from the set , or , or and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold.

For the SCell, upon request from higher layers, the UE indicates to higher layers whether there is at least one periodic CSI-RS configuration index or SS/PBCH block index from the set , or , or with corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, and provides the periodic CSI-RS configuration indexes or SS/PBCH block indexes from the set , or , or and the corresponding L1-RSRP measurements that are larger than or equal to the Qin,LR threshold, if any.

For the PCell or the PSCell, a UE can be provided a CORESET through a link to a search space set provided by *recoverySearchSpaceId,* as described in clause 10.1, for monitoring PDCCH in the CORESET. If the UE is provided *recoverySearchSpaceId*, the UE does not expect to be provided another search space set for monitoring PDCCH in the CORESET associated with the search space set provided by *recoverySearchSpaceId*.

For the PCell or the PSCell, the UE can be provided, by *PRACH-ResourceDedicatedBFR*, a configuration for PRACH transmission as described in clause 8.1. For PRACH transmission in slot and according to antenna port quasi co-location parameters associated with periodic CSI-RS resource configuration or with SS/PBCH block associated with index provided by higher layers [11, TS 38.321], the UE monitors PDCCH in a search space set provided by *recoverySearchSpaceId* for detection of a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI starting from slot within a window configured by *BeamFailureRecoveryConfig*. For PDCCH monitoring in a search space set provided by *recoverySearchSpaceId* and for corresponding PDSCH reception, the UE assumes the same antenna port quasi-collocation parameters as the ones associated with index until the UE receives by higher layers an activation for a TCI state or any of the parameters *tci-StatesPDCCH-ToAddList* and/or *tci-StatesPDCCH-ToReleaseList*. After the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI in the search space set provided by *recoverySearchSpaceId*, the UE continues to monitor PDCCH candidates in the search space set provided by *recoverySearchSpaceId* until the UE receives a MAC CE activation command for a TCI state or *tci-StatesPDCCH-ToAddList* and/or *tci-StatesPDCCH-ToReleaseList.*

For the PCell or the PSCell, after 28 symbols from a last symbol of a first PDCCH reception in a search space set provided by *recoverySearchSpaceId* for which the UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI and until the UE receives an activation command for *PUCCH-SpatialRelationInfo* [11, TS 38.321] or is provided *PUCCH-SpatialRelationInfo* for PUCCH resource(s), the UE transmits a PUCCH on a same cell as the PRACH transmission using

- a same spatial filter as for the last PRACH transmission

- a power determined as described in clause 7.2.1 with , , and

For the PCell or the PSCell, after 28 symbols from a last symbol of a first PDCCH reception in a search space set provided by *recoverySearchSpaceId* where a UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI, the UE assumes same antenna port quasi-collocation parameters as the ones associated with index for PDCCH monitoring in a CORESET with index 0.

For the PCell or the PSCell, if BFR MAC CE [11, TS 38.321] is transmitted in Msg3 or MsgA of contention based random access procedure, and if a PUCCH resource is provided with *PUCCH-SpatialRelationInfo*, after 28 symbols from the last symbol of the PDCCH reception that determines the completion of the contention based random access procedure as described in clause 5.1.5 of [11, TS 38.321], the UE transmits the PUCCH on a same cell as the PRACH transmission using

- a same spatial filter as for the last PRACH transmission

- a power determined as described in clause 7.2.1 with , , and , where is the SS/PBCH block index selected for the last PRACH transmission.

A UE can be provided, by *schedulingRequestID-BFR-SCell*, a configuration for PUCCH transmission with a link recovery request (LRR) as described in clause 9.2.4. If the PCell or the PSCell is associated with sets and , and with sets and , the UE can be provided by *schedulingRequestIDForMTRPBFR* a first configuration for PUCCH transmission with a LRR and, if the UE provides *twoLRRcapability*, a second configuration for PUCCH transmission with a LRR.

The UE can provide in a first PUSCH MAC CE index(es) for at least corresponding SCell(s) with radio link quality worse than Qout,LR, indication(s) of presence of for corresponding SCell(s), and index(es) for a periodic CSI-RS configuration or for a SS/PBCH block provided by higher layers, as described in [11, TS 38.321], if any, for corresponding SCell(s).

For serving cells associated with sets and , and with sets and , the UE can provide in a MAC CE index(es) for cell(s) with and/or having radio link quality worse than Qout,LR, the index(es) of those and/or , and indication(s) of presence of and of index(es) , if any, from corresponding sets and/or for the serving cells.

After 28 symbols from a last symbol of a PDCCH reception with a DCI format scheduling a PUSCH transmission with a same HARQ process number as for the transmission of the first PUSCH and having a toggled NDI field value, the UE

- monitors PDCCH in all CORESETs on the SCell(s) indicated by the MAC CE using the same antenna port quasi co-location parameters as the ones associated with the corresponding index(es) , if any

- transmits PUCCH on a PUCCH-SCell using a same spatial domain filter as the one corresponding to , if any, for periodic CSI-RS or SS/PBCH block reception, as described in clause 9.2.2, and using a power determined as described in clause 7.2.1 with , , and , if

- the UE is provided *PUCCH-SpatialRelationInfo* for the PUCCH,

- a PUCCH with the LRR was either not transmitted or was transmitted on the PCell or the PSCell, and

- the PUCCH-SCell is included in the SCell(s) indicated by the MAC-CE

where the SCS configuration for the 28 symbols is the smallest of the SCS configurations of the active DL BWP for the PDCCH reception and of the active DL BWP(s) of the at least one SCell.

For serving cells associated with sets and , and with sets and , after 28 symbols from a last symbol of a first PDCCH reception in a search space set provided by *recoverySearchSpaceId* where a UE detects a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI, the UE assumes antenna port quasi-collocation parameters

- corresponding to from , if any, for the first CORESETs,

- corresponding to from , if any, for the second CORESETs

where the SCS configuration for the 28 symbols is the smallest of the SCS configurations of the active DL BWP for the PDCCH reception and of the active DL BWP(s) of the serving cells.

# 7 Uplink Power control

Uplink power control determines a power for PUSCH, PUCCH, SRS, and PRACH transmissions.

A UE does not expect to simultaneously maintain more than four pathloss estimates per serving cell for all PUSCH/PUCCH/SRS transmissions as described in clauses 7.1.1, 7.2.1, and 7.3.1, except for SRS transmissions configured by *SRS-PosResourceSet* as described in clause 7.3.1. If the UE is provided a number of RS resources for pathloss estimation for PUSCH/PUCCH/SRS transmissions that is larger than 4, the UE maintains for pathloss estimation RS resources corresponding to RS resource indexes as described in clauses 7.1.1, 7.2.1, and 7.3.1. If an RS resource updated by MAC CE, as described in clauses 7.1.1, 7.2.1 and 7.3.1, is one from the RS resources the UE maintains for pathloss estimation for PUSCH/PUCCH/SRS transmissions, the UE applies the pathloss estimation based on the RS resources starting from the first slot that is after slot where is the slot where the UE would transmit a PUCCH or PUSCH with HARQ-ACK information for the PDSCH providing the MAC CE and is the SCS configuration for the PUCCH or PUSCH, respectively*.*

A PUSCH/PUCCH/SRS/PRACH transmission occasion is defined by a slot index within a frame with system frame number , a first symbol within the slot, and a number of consecutive symbols . For a PUSCH transmission with repetition Type B, a PUSCH transmission occasion is a nominal repetition [6, TS 38.214].

In the remaining of this clause, if a UE is provided *TCI-State\_r17* and for an indicated *tci-StateID* as described in [6, TS 38.214]

- in clauses 7.1.1, 7.2.1, and 7.3.1, the RS index for obtaining the downlink pathloss estimate and quasi-collocation information is provided by *SourceRS-Info*

- in clause 7.1.1, if *p0-Alpha-CLID-PUSCH-Set* is provided, the values of , , and the PUSCH power control adjustment state are provided by *p0-Alpha-CLID-PUSCH-Set* associated with the indicated *tci-StateID*

- in clause 7.2.1, if *p0-Alpha-CLID-PUCCHSet* is provided, the values of and the PUCCH power control adjustment state are provided by *p0-Alpha-CLID-PUCCH-Set* associated with the indicated *tci-StateID*

- in clause 7.3.1, if *p0-Alpha-CLID-SRS-Set* is provided, the values of , , and PUSCH power control adjustment state are provided by *p0-Alpha-CLID-SRS-Set* associated with the indicated *tci-StateID*

In the remaining of this clause, if a PDCCH reception by a UE includes two PDCCH candidates from corresponding search space sets, as described in clause 10.1

- a PDCCH monitoring occasion is the union of the PDCCH monitoring occasions for the two PDCCH candidates

- the end of the PDCCH reception in the end of the later PDCCH candidate

The PDCCH reception includes the two PDCCH candidates also when the UE is not required to monitor one of the two PDCCH candidates as described in clause 10, clause 11.1, and clause 11.1.1.

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

### 7.1.1 UE behaviour

If a UE transmits a PUSCH on active UL BWP of carrier of serving cell using parameter set configuration with index and PUSCH power control adjustment state with index , the UE determines the PUSCH transmission power in PUSCH transmission occasion as

[dBm]



where,

- is the UE configured maximum output power defined in [8-1, TS 38.101-1], [8-2, TS38.101-2] and [8-3, TS38.101-3] for carrier of serving cell in PUSCH transmission occasion .

- is a parameter composed of the sum of a component and a component where .

- If a UE established dedicated RRC connection using a Type-1 random access procedure, as described in clause 8, and is not provided *P0-PUSCH-AlphaSet* or for a PUSCH (re)transmission corresponding to a RAR UL grant as described in clause 8.3,

, , and ,

where is provided by *preambleReceivedTargetPower* [11, TS 38.321] and is provided by *msg3-DeltaPreamble*, or dB if *msg3-DeltaPreamble* is not provided, for carrier of serving cell

- If a UE established dedicated RRC connection using a Type-2 random access procedure, as described in clause 8, and is not provided *P0-PUSCH-AlphaSet*,or for a PUSCH transmission for Type-2 random access procedure as described in clause 8.1A,

, , and ,

where is provided by *msgA-preambleReceivedTargetPower*, or by *preambleReceivedTargetPower* if *msgA-preambleReceivedTargetPower* isnot provided and is provided by *msgA-DeltaPreamble*, or dB if *msgA-DeltaPreamble* is not provided, for carrier of serving cell

- For a PUSCH (re)transmission configured by *ConfiguredGrantConfig*, , is provided by *p0-NominalWithoutGrant*, or if *p0-NominalWithoutGrant* is not provided

- If the UE is provided *mTRP-PUSCH*, for a retransmission of a configured grant Type 1 PUSCH, or for activation or retransmission of a configured grant Type 2 PUSCH, scheduled by a DCI format that includes a TRP index field, and for active UL BWP of carrier of serving cell

- If the TRP index value is 00, first value is provided by the value of *p0-PUSCH-Alpha* in *ConfiguredGrantConfig*.

- If the TRP index value is 01, second value is provided by the value of *p0-PUSCH-Alpha2* in *ConfiguredGrantConfig*.

- If the TRP index value is 10 or 11, first and second values are respectively provided by the values of *p0-PUSCH-Alpha* and by *p0-PUSCH-Alpha2* in *ConfiguredGrantConfig*.

- else

- is provided by *p0-PUSCH-Alpha* in *ConfiguredGrantConfig*.

- For , a value, applicable for all , is provided by *p0-NominalWithGrant,* or if *p0-NominalWithGrant* is not provided, for each carrier of serving cell and a set of values are provided by a set of *p0* in *P0-PUSCH-AlphaSet* indicated by a respective set of *p0-PUSCH-AlphaSetId* for active UL BWP of carrier of serving cell

- If the UE is provided by *SRI-PUSCH-PowerControl* more than one values of *p0-PUSCH-AlphaSetId* and if a DCI format scheduling the PUSCH transmission includes an SRI field, the UE obtains a mapping from *sri-PUSCH-PowerControlId* in *SRI-PUSCH-PowerControl* between a set of values for the SRI field in the DCI format [5, TS 38.212] and a set of indexes provided by *p0-PUSCH-AlphaSetId* that map to a set of *P0-PUSCH-AlphaSet* values and determines the value of from the *p0-PUSCH-AlphaSetId* value that is mapped to the SRI field value. If the DCI format scheduling the PUSCH transmission includes two SRI fields, the UE obtains a mapping from *sri-PUSCH-PowerControlId* in *SRI-PUSCH-PowerControl* between a set of values for the two SRI fields and a set of indexes provided by *p0-PUSCH-AlphaSetId* that map to a set of *P0-PUSCH-AlphaSet* values, and determines first and second values of from the *p0-PUSCH-AlphaSetId* values that are mapped to the values of the first and second SRI fields, respectively.

- If the DCI format also includes an open-loop power control parameter set indication field and a value of the open-loop power control parameter set indication field is '1', the UE determines a value of from a first value in *P0-PUSCH-Set* with a *p0-PUSCH-SetId* value mapped to the SRI field value.

- If the UE is provided by *SRI-PUSCH-PowerControl* more than one values of *p0-PUSCH-AlphaSetId* and if a DCI format scheduling the PUSCH transmission includes two SRI fields

- If a value of the open-loop power control parameter set indication field is '0', the UE determines two values of from the *p0-PUSCH-AlphaSetId* values in *SRI-PUSCH-PowerControl* that are mapped to the two SRI values.

- If a value of the open-loop power control parameter set indication field is '1', the UE determines two values of from first values in *P0-PUSCH-Set* and *P0-PUSCH-Set2* with *p0-PUSCH-SetId* values mapped to the two SRI values, respectively.- If the PUSCH transmission, except for the PUSCH retransmission corresponding to a RAR UL grant, is scheduled by a DCI format that does not include an SRI field, or if *SRI-PUSCH-PowerControl* is not provided to the UE, ,

- If *P0-PUSCH-Set* is provided to the UE and the DCI format includes an open-loop power control parameter set indication field and the UE is not provided *mTRP-PUSCH*, the UE determines a value of from

- a first *P0-PUSCH-AlphaSet* in *p0-AlphaSets* if a value of the open-loop power control parameter set indication field is '0' or '00'

- a first value in *P0-PUSCH-Set* with the lowest *p0-PUSCH-SetID* value if a value of the open-loop power control parameter set indication field is '1' or '01'

- a second value in *P0-PUSCH-Set* with the lowest *p0-PUSCH-SetID* value if a value of the open-loop power control parameter set indication field is '10'

- else, the UE determines from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets*

- If the UE is provided *mTRP-PUSCH* and the PUSCH transmission is scheduled by a DCI format that does not include an SRI field

- If *P0-PUSCH-Set* is provided to the UE and the DCI format includes an open-loop power control parameter set indication field, the UE determines first and second values of as

- first and second *P0-PUSCH-AlphaSet* in *p0-AlphaSets* if the open-loop power control parameter set indication value is '0' or '00'

- first value in *P0-PUSCH-Set* with *p0-PUSCH-SetID* value mapped to the first SRI value in the first *p0-PUSCH-SetList* and first value in *P0-PUSCH-Set* with *p0-PUSCH-SetID* value mapped to the second SRI value in the second *p0-PUSCH-SetList*, respectively, if the open-loop power control parameter set indication value is '1' or '01'

- second value in *P0-PUSCH-Set* with *p0-PUSCH-SetID* value mapped to the first SRI value in the first *p0-PUSCH-SetList* and second value in *P0-PUSCH-Set* with *p0-PUSCH-SetID* value mapped to the second SRI value in the second *p0-PUSCH-SetList*, respectively, if the open-loop power control parameter set indication value is '01' or '11'

- else

- the UE determines from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets*- For

- For ,

- if and *msgA-Alpha* is provided, is the value of *msgA-Alpha*

- elseif or *msgA-Alpha* is not provided, and *msg3-Alpha* is provided, is the value of *msg3-Alpha*

- else,

- For ,

- If the UE is provided *mTRP-PUSCH*, for a retransmission of a configured grant Type 1 PUSCH, or for activation or retransmission of a configured grant Type 2 PUSCH, scheduled by a DCI format that includes a TRP index field, and for active UL BWP of carrier of serving cell

- If the TRP index value is 00, first value is provided by *p0-PUSCH-Alpha* in *ConfiguredGrantConfig*.

- If the TRP index value is 01, first value is provided by *p0-PUSCH-Alpha2* in *ConfiguredGrantConfig*.

- If the TRP index value is 10 or 11, first and second values are respectively provided by *p0-PUSCH-Alpha* and *p0-PUSCH-Alpha2* in *ConfiguredGrantConfig*.

- else is provided by *alpha* obtained from *p0-PUSCH-Alpha* in *ConfiguredGrantConfig* providing an index *P0-PUSCH-AlphaSetId* to a set of *P0-PUSCH-AlphaSet* for active UL BWP of carrier of serving cell

- For , a set of values are provided by a set of *alpha* in *P0-PUSCH-AlphaSet* indicated by a respective set of *p0-PUSCH-AlphaSetId* for active UL BWP of carrier of serving cell

- If the UE is provided *SRI-PUSCH-PowerControl* and more than one values of *p0-PUSCH-AlphaSetId* in *p0-AlphaSets* and in *p0-AlphaSets2*

- if a DCI format scheduling the PUSCH transmission includes two SRI fields the UE is provided *mTRP-PUSCH*, for a PUSCH transmission scheduled by a DCI format that includes a TRP index field, and for active UL BWP of carrier of serving cell

- if the TRP index value is 00, the UE determines a value of from the *p0-PUSCH-AlphaId* value that is mapped to the first SRI field associated with a first SRS resource set with usage set to ‘*codebook*’ or ‘*nonCodebook*’

- if the TRP index value is 01, the UE determines a value of from the *p0-PUSCH-AlphaId* value that is mapped to the second SRI field associated with a second SRS resource set with usage set to ‘*codebook*’ or ‘*nonCodebook*’

- if the TRP index value is 10 or 11, the UE determines first and second values of from the *p0-PUSCH-AlphaId* values that are mapped to the first and second SRI fields, respectively

- else, if a DCI format scheduling the PUSCH transmission includes one SRI field,

- the UE obtains a mapping from *sri-PUSCH-PowerControlId* in *SRI-PUSCH-PowerControl* between a set of values for the SRI field in the DCI format [5, TS 38.212] and a set of indexes provided by *p0-PUSCH-AlphaSetId* that map to a set of *P0-PUSCH-AlphaSet* values and determines the values of from the *p0-PUSCH-AlphaSetId* value that is mapped to the SRI field value

- If the PUSCH transmission except for the PUSCH retransmission corresponding to a RAR UL grant is scheduled by a DCI format that does not include an SRI field, or if *SRI-PUSCH-PowerControl* is not provided to the UE, , and the UE determines from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets*

- is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks for PUSCH transmission occasion on active UL BWP of carrier of serving cell and is a SCS configuration defined in [4, TS 38.211]

- is a downlink pathloss estimate in dB calculated by the UE using reference signal (RS) index for the active DL BWP, as described in clause 12, of carrier of serving cell

- If the UE is not provided *PUSCH-PathlossReferenceRS* and *enableDefaultBeamPL-ForSRS*,or before the UE is provided dedicated higher layer parameters, the UE calculates using a RS resource from an SS/PBCH block with same SS/PBCH block index as the one the UE uses to obtain *MIB*

- If the UE is configured with a number of RS resource indexes, up to the value of *maxNrofPUSCH-PathlossReferenceRSs*, and a respective set of RS configurations for the number of RS resource indexes by *PUSCH-PathlossReferenceRS*, the set of RS resource indexes can include one or both of a set of SS/PBCH block indexes, each provided by *ssb-Index* when a value of a corresponding *pusch-PathlossReferenceRS-Id* maps to a SS/PBCH block index, and a set of CSI-RS resource indexes, each provided by *csi-RS-Index* when a value of a corresponding *pusch-PathlossReferenceRS-Id* maps to a CSI-RS resource index. The UE identifies a RS resource index in the set of RS resource indexes to correspond either to a SS/PBCH block index or to a CSI-RS resource index as provided by *pusch-PathlossReferenceRS-Id* in *PUSCH-PathlossReferenceRS*

- If the PUSCH transmission is scheduled by a RAR UL grant as described in clause 8.3, or for a PUSCH transmission for Type-2 random access procedure as described in clause 8.1A, the UE uses the same RS resource index as for a corresponding PRACH transmission

- If the UE is provided *SRI-PUSCH-PowerControl* and more than one values of *PUSCH-PathlossReferenceRS-Id*, the UE obtains a mapping from *sri-PUSCH-PowerControlId* in *SRI-PUSCH-PowerControl* between a set of values for the SRI field, or for first and second SRI fields, in a DCI format scheduling the PUSCH transmission and a set of *PUSCH-PathlossReferenceRS-Id* values and determines the RS resource index , or respective first and second RS resource indexes , from the value of *PUSCH-PathlossReferenceRS-Id* that is mapped to the SRI field value, or from the values of *PUSCH-PathlossReferenceRS-Id* that are mapped to respective first and second SRI field values, where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

- If the PUSCH transmission is scheduled by DCI format 0\_0, and if the UE is provided a spatial setting by PUCCH-SpatialRelationInfo for a PUCCH resource with a lowest index for active UL BWP of each carrier and serving cell , as described in clause 9.2.2, the UE uses the same RS resource index as for a PUCCH transmission in the PUCCH resource with the lowest index

- If the PUSCH transmission is not scheduled by DCI format 0\_0, and if the UE is provided *enableDefaultBeamPL-ForSRS* and is not provided *PUSCH-PathlossReferenceRS* and *PUSCH-PathlossReferenceRS-r16,* the UE uses the same RS resource index as for an SRS resource set with an SRS resource associated with the PUSCH transmission

- If

- the PUSCH transmission is scheduled by DCI format 0\_0 and the UE is not provided a spatial setting for a PUCCH transmission, or

- the PUSCH transmission is scheduled by DCI format 0\_1 or DCI format 0\_2 that does not include an SRI field, or

- *SRI-PUSCH-PowerControl* is not provided to the UE,

the UE determines a RS resource index with a respective *PUSCH-PathlossReferenceRS-Id* value being equal to zero where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

- If

- the PUSCH transmission is scheduled by DCI format 0\_0 on serving cell ,

- the UE is not provided PUCCH resources for the active UL BWP of serving cell , and

- the UE is provided *enableDefaultBeamPL-ForPUSCH0-0*

the UE determines a RS resource index providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the serving cell . If the CORESET has two activated TCI states, as described in clause 10.1, the UE determines the RS resource index based on the first TCI state.

- If

- the PUSCH transmission is scheduled by DCI format 0\_0 on serving cell ,

- the UE is not provided a spatial setting for PUCCH resources on the active UL BWP of the primary cell [11, TS 38.321], and

- the UE is provided *enableDefaultBeamPL-ForPUSCH0-0*

the UE determines a RS resource index providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the serving cell . If the CORESET has two activated TCI states, as described in clause 10.1, the UE determines the RS resource index based on the first TCI state.

- For a PUSCH transmission configured by *ConfiguredGrantConfig,* if *rrc-ConfiguredUplinkGrant* is included in *ConfiguredGrantConfig*, a RS resource index is provided by a value of *pathlossReferenceIndex* included in *rrc-ConfiguredUplinkGrant* where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*. If the UE is provided *mTRP-PUSCH* and for configured grant Type 2 PUSCH, first and second RS resource indexes are provided by respective values of *pathlossReferenceIndex* and *pathlossReferenceIndex2* in *rrc-ConfiguredUplinkGrant*.

- For a PUSCH transmission configured by *ConfiguredGrantConfig* that does not include *rrc-ConfiguredUplinkGrant*, the UE determines a RS resource index from a value of *PUSCH-PathlossReferenceRS-Id* that is mapped to a SRI field value in a DCI format activating the PUSCH transmission. If the DCI format activating the PUSCH transmission includes two SRI fields, the UE determines first and second RS resource indexes from respective first and second values of *PUSCH-PathlossReferenceRS-Id* that are mapped to the first and second SRI values. If the DCI format activating the PUSCH transmission does not include an SRI field, the UE determines a RS resource index with a respective *PUSCH-PathlossReferenceRS-Id* value being equal to zero. If the UE is provided *mTRP-PUSCH*, the UE determines first and second RS resource indexes with respective first and second *PUSCH-PathlossReferenceRS-Id* value being equal to zero and one, where the RS resource is either on serving cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

- If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, a mapping between *sri-PUSCH-PowerControlId* and *PUSCH-PathlossReferenceRS-Id* values can be updated by a MAC CE as described in [11, TS 38.321]

- For a PUSCH transmission scheduled by a DCI format that does not include an SRI field, or for a PUSCH transmission configured by *ConfiguredGrantConfig* and activated, as described in clause 10.2, by a DCI format that does not include an SRI field, the UE determines a RS resource index from the *PUSCH-PathlossReferenceRS-Id* mapped to *sri-PUSCH-PowerControlId* = 0. If the UE is provided *mTRP-PUSCH*, the UE determines first and second RS resource indexes from respective *PUSCH-PathlossReferenceRS-Id* mapped to *sri-PUSCH-PowerControlId* = 0 and *sri-PUSCH-PowerControlId* = 1.

= *referenceSignalPower* – higher layer filtered RSRP, where *referenceSignalPower* is provided by higher layers and RSRP is defined in [7, TS 38.215] for the reference serving cell and the higher layer filter configuration provided by *QuantityConfig* is defined in [12, TS 38.331] for the reference serving cell

If the UE is not configured periodic CSI-RS reception, *referenceSignalPower* is provided by *ss-PBCH-BlockPower*. If the UE is configured periodic CSI-RS reception, *referenceSignalPower* is provided either by *ss-PBCH-BlockPower* or by *powerControlOffsetSS* providing an offset of the CSI-RS transmission power relative to the SS/PBCH block transmission power [6, TS 38.214]. If *powerControlOffsetSS* is not provided to the UE, the UE assumes an offset of 0 dB.

- for and for where is provided by *deltaMCS* for each UL BWP of each carrier and serving cell . If the PUSCH transmission is over more than one layer [6, TS 38.214], . and , for active UL BWP of each carrier and each serving cell , are computed as below

- for PUSCH with UL-SCH data and for CSI transmission in a PUSCH without UL-SCH data, where

- is a number of transmitted code blocks, is a size for code block , and is a number of resource elements determined as , where is a number of symbols for PUSCH transmission occasion on active UL BWP of carrier of serving cell, is a number of subcarriers excluding DM-RS subcarriers and phase-tracking RS samples [4, TS 38.211] in PUSCH symbol and assuming no segmentation for a nominal repetition in case the PUSCH transmission is with repetition Type B, , and , are defined in [5, TS 38.212]

- when the PUSCH includes UL-SCH data and , as described in clause 9.3, when the PUSCH includes CSI and does not include UL-SCH data

- is the modulation order and is the target code rate, as described in [6, TS 38.214], provided by the DCI format scheduling the PUSCH transmission that includes CSI and does not include UL-SCH data

- For the PUSCH power control adjustment state for active UL BWP of carrier of serving cell in PUSCH transmission occasion

- is a TPC command value included in a DCI format that schedules the PUSCH transmission occasion on active UL BWP of carrier of serving cell or jointly coded with other TPC commands in a DCI format 2\_2 with CRC scrambled by TPC-PUSCH-RNTI, as described in clause 11.3

- if the UE is configured with *twoPUSCH-PC-AdjustmentStates* and if the UE is not configured with *twoPUSCH-PC-AdjustmentStates* or if the PUSCH transmission is scheduled by a RAR UL grant as described in clause 8.3

- If the UE is provided *mTRP-PUSCH*, for a retransmission of a configured grant Type 1 PUSCH, or for activation or retransmission of a configured grant Type 2 PUSCH, scheduled by a DCI format that includes a TRP index field, and for active UL BWP of carrier of serving cell

- If the TRP index value is 00, is equal to the value of *powerControlLoopToUse* in *ConfiguredGrantConfig*.

- If the TRP index value is 01, is equal to the value of *powerControlLoopToUse2* in *ConfiguredGrantConfig*.

- If the TRP index value is 10 or 11, a first and a second are respectively equal to *powerControlLoopToUse* and *powerControlLoopToUse2* in *ConfiguredGrantConfig*.

- else, for a PUSCH (re)transmission configured by *ConfiguredGrantConfig*, the value of is provided to the UE by *powerControlLoopToUse* in *ConfiguredGrantConfig*.

- If the UE is provided *SRI-PUSCH-PowerControl*, the UE obtains a mapping between a set of values for the SRI field in a DCI format scheduling the PUSCH transmission and the value(s) provided by *sri-PUSCH-ClosedLoopIndex* and determines the value that is mapped to the SRI field value

- If the PUSCH transmission is scheduled by a DCI format that does not include an SRI field, or if an *SRI-PUSCH-PowerControl* is not provided to the UE,

- If the UE obtains one TPC command from a DCI format 2\_2 with CRC scrambled by a TPC-PUSCH-RNTI, the value is provided by the closed loop indicator field in DCI format 2\_2

- If the UE is provided *twoPUSCH-PC-AdjustmentStates*

- If the DCI format includes two TPC command values [5, TS 38.212], the UE applies the first TPC command value for and applies the second TPC command value for

- If the DCI format includes one TPC command value, the UE applies the TPC command value for both and

- If the DCI format includes two TPC command values and a TRP index value

- If the TRP index value is 00, the UE applies the first TPC command value for and ignores the second TPC command value

- If the TRP index value is 01, the UE applies the second TPC command value for and ignores the first TPC command value

- If the UE is not provided *twoPUCCH-PC-AdjustmentStates* and the DCI format includes two TPC command values, the UE applies the first TPC command value for the *closedLoopIndex* value associated with the RS resource index of the PUSCH transmission and ignores the second TPC command value- is the PUSCH power control adjustment state for active UL BWP of carrier of serving cell and PUSCH transmission occasion if the UE is not provided *tpc-Accumulation*, where

- The values are given in Table 7.1.1-1

- is a sum of TPC command values in a set of TPC command values with cardinality that the UE receives between symbols before PUSCH transmission occasion and symbols before PUSCH transmission occasion on active UL BWP of carrier of serving cell for PUSCH power control adjustment state , where is the smallest integer for which symbols before PUSCH transmission occasion is earlier than symbols before PUSCH transmission occasion

- If a PUSCH transmission is scheduled by a DCI format, is a number of symbols for active UL BWP of carrier of serving cell after a last symbol of a corresponding PDCCH reception and before a first symbol of the PUSCH transmission

- If a PUSCH transmission is configured by *ConfiguredGrantConfig*, is a number of symbols equal to the product of a number of symbols per slot, , and the minimum of the values provided by *k2* in *PUSCH-ConfigCommon* for active UL BWP of carrier of serving cell

- If the UE has reached maximum power for active UL BWP of carrier of serving cell at PUSCH transmission occasion and , then

- If UE has reached minimum power for active UL BWP of carrier of serving cell at PUSCH transmission occasion and , then

- A UE resets accumulation of a PUSCH power control adjustment state for active UL BWP of carrier of serving cell to

- If a configuration for a corresponding value is provided by higher layers

- If a configuration for a corresponding value is provided by higher layers

where is determined from the value of as

- If and the UE is provided higher *SRI-PUSCH-PowerControl*, is the *sri-PUSCH-ClosedLoopIndex* value(s) configured in any *SRI-PUSCH-PowerControl* with the *sri-P0-PUSCH-AlphaSetId* value corresponding to

- If and the UE is not provided *SRI-PUSCH-PowerControl* or ,

- If , is provided by the value of *powerControlLoopToUse*

- is the PUSCH power control adjustment state for active UL BWP of carrier of serving cell and PUSCH transmission occasion if the UE is provided *tpc-Accumulation*, where



- absolute values are given in Table 7.1.1-1

If the UE transmits a PUSCH associated with the first RS resource index , the UE applies the first value and for determining . If the UE transmits a PUSCH associated with the second RS resource index , the UE applies the second value and or if *twoPUSCH-PC-AdjustmentStates* is provided or not provided, respectively, for determining .- If the UE receives a random access response message in response to a PRACH transmission or a MsgA transmission on active UL BWP of carrier of serving cell as described in clause 8

- , where and

- is a TPC command value indicated in a random access response grant of the random access response message corresponding to a PRACH transmission according to Type-1 random access procedure, or in a random access response grant of the random access response message corresponding to a MsgA transmission according to Type-2 random access procedure with RAR message(s) for fallbackRAR, on active UL BWP of carrier in the serving cell , and

- and is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last random access preamble for carrier in the serving cell , is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks for the first PUSCH transmission on active UL BWP of carrier of serving cell, and is the power adjustment of first PUSCH transmission on active UL BWP of carrier of serving cell .



- If the UE transmits the PUSCH in PUSCH transmission occasion on active UL BWP of carrier of serving cell as described in clause 8.1A, , where

- , and

- and is provided by higher layers and corresponds to the total power ramp-up requested by higher layers, is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks, and is the power adjustment of the PUSCH transmission in PUSCH transmission occasion .



Table 7.1.1-1: Mapping of TPC Command Field in a DCI format scheduling a PUSCH transmission, or in DCI format 2\_2 with CRC scrambled by TPC-PUSCH-RNTI, or in DCI format 2\_3, to absolute and accumulated values or values

|  |  |  |
| --- | --- | --- |
| TPC Command Field | Accumulated or [dB] | Absolute or [dB] |
| 0 | -1 | -4 |
| 1 | 0 | -1 |
| 2 | 1 | 1 |
| 3 | 3 | 4 |

## 7.2 Physical uplink control channel

If the 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 term 'serving cell' in this clause refers to serving cell belonging to the MCG.

- When the procedures are applied for SCG, the term 'serving cell' in this clause refers to serving cell belonging to the SCG. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If the 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 term 'serving cell' in this clause refers to serving cell belonging to the primary PUCCH group.

- When the procedures are applied for the secondary PUCCH group, the term 'serving cell' in this clause refers to serving cell belonging to the secondary PUCCH group. 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*.

### 7.2.1 UE behaviour

If a UE transmits a PUCCH on active UL BWP of carrier in the primary cell using PUCCH power control adjustment state with index , the UE determines the PUCCH transmission power in PUCCH transmission occasion as

[dBm]



where

- is the UE configured maximum output power defined in [8-1, TS 38.101-1], [8-2, TS38.101-2] and [8-3, TS38.101-3] for carrier of primary cell in PUCCH transmission occasion

- is a parameter composed of the sum of a component , provided by *p0-nominal*, or dBm if *p0-nominal* is not provided, for carrier of primary cell and, if provided, a component provided by *p0-PUCCH-Value* in *P0-PUCCH* for active UL BWP of carrier of primary cell , where . is a size for a set of values provided by *maxNrofPUCCH-P0-PerSet*. The set of values is provided by *p0-Set*. If *p0-Set* is not provided to the UE, ,

- If the UE is provided *PUCCH-SpatialRelationInfo*, the UE obtains a mapping, by an index provided by *p0-PUCCH-Id*, between a set of *pucch-SpatialRelationInfoId* values and a set of *p0-PUCCH-Value* values. If the UE is provided more than one values for *pucch-SpatialRelationInfoId* and the UE receives an activation command [11, TS 38.321] indicating a value of *pucch-SpatialRelationInfoId*, the UE determines the *p0-PUCCH-Value* value through the link to a corresponding *p0-PUCCH-Id* index. The UE applies the activation command in the first slot that is after slot where is the slot where the UE would transmit a PUCCH with HARQ-ACK information for the PDSCH providing the activation command and is the SCS configuration for the PUCCH

- If the UE is not provided *PUCCH-SpatialRelationInfo*, the UE obtains the *p0-PUCCH-Value* value from the *P0-PUCCH* with *p0-PUCCH-Id* value equal to the minimum *p0-PUCCH-Id* value in *p0-Set*

- is a bandwidth of the PUCCH resource assignment expressed in number of resource blocks for PUCCH transmission occasion on active UL BWP of carrier of primary cell and is a SCS configuration defined in [4, TS 38.211]- is a downlink pathloss estimate in dB calculated by the UE using RS resource index as described in clause 7.1.1 for the active DL BWP of carrier of the primary cell as described in clause 12

- If the UE is not provided *pathlossReferenceRSs* or before the UE is provided dedicated higher layer parameters, the UE calculates using a RS resource obtained from an SS/PBCH block with same SS/PBCH block index as the one the UE uses to obtain *MIB*

- If the UE is provided a number of RS resource indexes, the UE calculates using RS resource with index , where . is a size for a set of RS resources provided by *maxNrofPUCCH-PathlossReferenceRSs*. The set of RS resources is provided by *pathlossReferenceRSs*. The set of RS resources can include one or both of a set of SS/PBCH block indexes, each provided by *ssb-Index* in *PUCCH-PathlossReferenceRS* when a value of a corresponding *pucch-PathlossReferenceRS-Id* maps to a SS/PBCH block index, and a set of CSI-RS resource indexes, each provided by *csi-RS-Index* when a value of a corresponding *pucch-PathlossReferenceRS-Id* maps to a CSI-RS resource index. The UE identifies a RS resource in the set of RS resources to correspond either to a SS/PBCH block index or to a CSI-RS resource index as provided by *pucch-PathlossReferenceRS-Id* in *PUCCH-PathlossReferenceRS*

- If the UE is provided *pathlossReferenceRSs* and *PUCCH-SpatialRelationInfo*, the UE obtains a mapping, by indexes provided by corresponding values of *pucch-PathlossReferenceRS-Id*, between a set of *pucch-SpatialRelationInfoId* values and a set of *referenceSignal* values provided by *PUCCH-PathlossReferenceRS*. If the UE is provided more than one values for *pucch-SpatialRelationInfoId* and the UE receives an activation command [11, TS 38.321] indicating a value of *pucch-SpatialRelationInfoId*, the UE determines the *referenceSignal* value in *PUCCH-PathlossReferenceRS* through the link to a corresponding *pucch-PathlossReferenceRS-Id* index. The UE applies the activation command in the first slot that is after slot where is the slot where the UE would transmit a PUCCH with HARQ-ACK information for the PDSCH providing the activation command and is the SCS configuration for the PUCCH

- If *PUCCH-SpatialRelationInfo* includes *servingCellId* indicating a serving cell, the UE receives the RS for resource index on the active DL BWP of the serving cell

- If the UE is provided *pathlossReferenceRSs* and is not provided *PUCCH-SpatialRelationInfo*, the UE obtains the *referenceSignal* value in *PUCCH-PathlossReferenceRS* from the *pucch-PathlossReferenceRS-Id* with index 0 in *PUCCH-PathlossReferenceRS* where the RS resource is either on the primary cell or, if provided, on a serving cell indicated by a value of *pathlossReferenceLinking*

- If the UE

- is not provided *pathlossReferenceRSs*, and

- is not provided *PUCCH-SpatialRelationInfo,* and

- is provided *enableDefaultBeamPL-ForPUCCH*, 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]

the UE determines a RS resource index providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP of the primary cell. If the CORESET has two activated TCI states, as described in clause 10.1, the UE determines the RS resource index based on the first activated TCI state. For a PUCCH transmission over multiple slots, a same applies to the PUCCH transmission in each of the multiple slots.

- The parameter is a value of *deltaF-PUCCH-f0* for PUCCH format 0, *deltaF-PUCCH-f1* for PUCCH format 1, *deltaF-PUCCH-f2* for PUCCH format 2, *deltaF-PUCCH-f3* for PUCCH format 3, and *deltaF-PUCCH-f4* for PUCCH format 4, if provided; otherwise .

- is a PUCCH transmission power adjustment component on active UL BWP of carrier of primary cell

- For a PUCCH transmission using PUCCH format 0 or PUCCH format 1, where

- is a number of PUCCH format 0 symbols or PUCCH format 1 symbols for the PUCCH transmission as described in clause 9.2.

- for PUCCH format 0

- for PUCCH format 1

- for PUCCH format 0

- for PUCCH format 1, where is a number of UCI bits in PUCCH transmission occasion

- For a PUCCH transmission using PUCCH format 2 or PUCCH format 3 or PUCCH format 4 and for a number of UCI bits smaller than or equal to 11, , where

-

- is a number of HARQ-ACK information bits that the UE determines as described in clause 9.1.2.1 or 16.5.1.1 for Type-1 HARQ-ACK codebook and as described in clause 9.1.3.1 or 9.1.3.3 or 16.5.2.1 for Type-2 HARQ-ACK codebook.is the same as  as described in clause 9.1.4 for Type-3 HARQ-ACK codebook. If the UE is not provided any of *pdsch-HARQ-ACK-Codebook*, *pdsch-HARQ-ACK-Codebook-r16*, or *pdsch-HARQ-ACK-OneShotFeedback*, if the UE includes a HARQ-ACK information bit in the PUCCH transmission; otherwise,

- is a number of SR information bits that the UE determines as described in clause 9.2.5.1

- is a number of CSI information bits that the UE determines as described in clause 9.2.5.2

- is a number of resource elements determined as , where is a number of subcarriers per resource block excluding subcarriers used for DM-RS transmission, and is a number of symbols excluding symbols used for DM-RS transmission, as defined in clause 9.2.5.2, for PUCCH transmission occasion on active UL BWP of carrier of primary cell

- For a PUCCH transmission using PUCCH format 2 or PUCCH format 3 or PUCCH format 4 and for a number of UCI bits larger than 11, , where

-

-

- is a number of HARQ-ACK information bits that the UE determines as described in clause 9.1.2.1 or 16.5.1.1 for Type-1 HARQ-ACK codebook and as described in clause 9.1.3.1 or 9.1.3.3 or 16.5.2.1 for Type-2 HARQ-ACK codebook, or as described in clause 9.1.4 for Type-3 HARQ-ACK codebook. If the UE is not provided any of *pdsch-HARQ-ACK-Codebook*, *pdsch-HARQ-ACK-Codebook-r16*, or *pdsch-HARQ-ACK-OneShotFeedback*, if the UE includes a HARQ-ACK information bit in the PUCCH transmission; otherwise,

- is a number of SR information bits that the UE determines as described in clause 9.2.5.1

- is a number of CSI information bits that the UE determines as described in clause 9.2.5.2

- is a number of CRC bits that the UE determines as described in clause 9.2

- is a number of resource elements that the UE determines as , where is a number of subcarriers per resource block excluding subcarriers used for DM-RS transmission, and is a number of symbols excluding symbols used for DM-RS transmission, as defined in clause 9.2.5.2, for PUCCH transmission occasion on active UL BWP of carrier of primary cell.

- For the PUCCH power control adjustment state for active UL BWP of carrier of primary cell and PUCCH transmission occasion

- is a TPC command value included in a DCI format associated with the PUCCH transmission for active UL BWP of carrier of the primary cell that the UE detects for PUCCH transmission occasion , or is jointly coded with other TPC commands in a DCI format 2\_2 with CRC scrambled by TPC-PUCCH-RNTI [5, TS 38.212], as described in clause 11.3

- if the UE is provided *twoPUCCH-PC-AdjustmentStates* and *PUCCH-SpatialRelationInfo* and if the UE is not provided *twoPUCCH-PC-AdjustmentStates* or *PUCCH-SpatialRelationInfo*- If the UE obtains a TPC command value from a DCI format associated with the PUCCH transmission and if the UE is provided *PUCCH-SpatialRelationInfo*, the UE obtains a mapping, by an index provided by *p0-PUCCH-Id*, between a set of *pucch-SpatialRelationInfoId* values and a set of values for *closedLoopIndex* that provide the value(s). If the UE receives an activation command indicating a value of *pucch-SpatialRelationInfoId*, the UE determines the value *closedLoopIndex* that provides the value of through the link to a corresponding *p0-PUCCH-Id* index

- If the UE obtains a TPC command from a DCI format 2\_2 with CRC scrambled by a TPC-PUCCH-RNTI, the value is provided by the closed loop indicator field in DCI format 2\_2

- If the UE transmits the PUCCH with repetitions, as described in clause 9.2.6,

- If the UE is provided *twoPUCCH-PC-AdjustmentStates* for a respective PUCCH resource

- If the DCI format includes two TPC command values [5, TS 38.212], the UE applies the first TPC command value for and applies the second TPC command value for

- If the DCI format includes one TPC command value, the UE applies the TPC command value for both and

- If the UE is not provided *twoPUCCH-PC-AdjustmentStates* for a respective PUCCH resource and the DCI format includes two TPC command values, the UE applies the first TPC command value for the *closedLoopIndex* value associated with the PUCCH resource [11, TS 38.321] and ignores the second TPC command value- is the current PUCCH power control adjustment state for active UL BWP of carrier of primary cell and PUCCH transmission occasion , where

- The values are given in Table 7.1.2-1

- is a sum of TPC command values in a set of TPC command values with cardinality that the UE receives between symbols before PUCCH transmission occasion and symbols before PUCCH transmission occasion on active UL BWP of carrier of primary cell for PUCCH power control adjustment state, where is the smallest integer for which symbols before PUCCH transmission occasion is earlier than symbols before PUCCH transmission occasion



- If the PUCCH transmission is in response to a detection by the UE of a DCI format, is a number of symbols for active UL BWP of carrier of primary cell after a last symbol of a corresponding PDCCH reception and before a first symbol of the PUCCH transmission

- If the PUCCH transmission is not in response to a detection by the UE of a DCI format, is a number of symbols equal to the product of a number of symbols per slot, , and the minimum of the values provided by *k2* in *PUSCH-ConfigCommon* for active UL BWP of carrier of primary cell

- If the UE has reached maximum power for active UL BWP of carrier of primary cell at PUCCH transmission occasion and , then

- If UE has reached minimum power for active UL BWP of carrier of primary cell at PUCCH transmission occasion and , then

- If a configuration of a value for a corresponding PUCCH power control adjustment state for active UL BWP of carrier of primary cell is provided by higher layers,

-

If the UE is provided *PUCCH-SpatialRelationInfo*, the UE determines the value of from the value of based on a *pucch-SpatialRelationInfoId* value associated with the *p0-PUCCH-Id* value corresponding to and with the *closedLoopIndex* value corresponding to ; otherwise,

- Else,

- , where , and is

- the TPC command value indicated in a random access response grant corresponding to a PRACH transmission according to Type-1 random access procedure, or in a random access response grant corresponding to MsgA transmissions according to Type-2 random access procedure with RAR message(s) for fallbackRAR, or

- the TPC command value indicated in a successRAR corresponding to MsgA transmissions for Type-2 random access procedure, or

- the TPC command value in a DCI format with CRC scrambled by C-RNTI or MCS-C-RNTI that the UE detects in a first PDCCH reception in a search space set provided by *recoverySearchSpaceId* if the PUCCH transmission is a first PUCCH transmission after 28 symbols from a last symbol of the first PDCCH reception,

and, if the UE transmits PUCCH on active UL BWP of carrier of primary cell ,

;

otherwise,

where is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble for active UL BWP of carrier of primary cell , and corresponds to PUCCH format 0 or PUCCH format 1

Table 7.2.1-1: Mapping of TPC Command Field in a DCI format to accumulated values

|  |  |
| --- | --- |
| TPC Command Field | Accumulated [dB] |
| 0 | -1 |
| 1 | 0 |
| 2 | 1 |
| 3 | 3 |

## 7.3 Sounding reference signals

For SRS, a UE splits a linear value of the transmit power on active UL BWP of carrier of serving cell equally across the configured antenna ports for SRS.

### 7.3.1 UE behaviour

If a UE transmits SRS based on a configuration by *SRS-ResourceSet* on active UL BWP of carrier of serving cell using SRS power control adjustment state with index , the UE determines the SRS transmission power in SRS transmission occasion as

 [dBm]

where,

- is the UE configured maximum output power defined in [8, TS 38.101-1], [8-2, TS38.101-2] and [TS 38.101-3] for carrier of serving cell in SRS transmission occasion

- is provided by *p0* for active UL BWP of carrier of serving cell and SRS resource set provided by *SRS-ResourceSet* and *SRS-ResourceSetId*

- is a SRS bandwidth expressed in number of resource blocks for SRS transmission occasion on active UL BWP of carrier of serving cell and is a SCS configuration defined in [4, TS 38.211]

- is provided by *alpha* for active UL BWP of carrier of serving cell and SRS resource set

- is a downlink pathloss estimate in dB calculated by the UE using RS resource index as described in clause 7.1.1 for the active DL BWP of serving cell and SRS resource set [6, TS 38.214]. The RS resource index is provided by *pathlossReferenceRS* associated with the SRS resource set and is either an *ssb-Index* providing a SS/PBCH block index or a *csi-RS-Index* providing a CSI-RS resource index. If the UE is provided *enablePL-RS-UpdateForPUSCH-SRS*, a MAC CE [11, TS 38.321] can provide by *SRS-PathlossReferenceRS-Id* a corresponding RS resource index for aperiodic or semi-persistent SRS resource set

- If the UE is not provided *pathlossReferenceRS* or *SRS-PathlossReferenceRS-Id*, or before the UE is provided dedicated higher layer parameters, the UE calculates using a RS resource obtained from an SS/PBCH block with same SS/PBCH block index as the one the UE uses to obtain *MIB*

- If the UE is provided *pathlossReferenceLinking*, the RS resource is on a serving cell indicated by a value of *pathlossReferenceLinking*

- If the UE

- is not provided *pathlossReferenceRS* or *SRS-PathlossReferenceRS-Id*,

- is not provided *spatialRelationInfo*, and

- is provided *enableDefaultBeamPL-ForSRS*, 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]

the UE determines a RS resource index providing a periodic RS resource configured with *qcl-Type* set to 'typeD' in

- the TCI state or the QCL assumption of a CORESET with the lowest index in the active DL BWP, if CORESETs are provided in the active DL BWP of serving cell . If the CORESET has two activated TCI states, as described in clause 10.1, the UE determines the RS resource index based on the first TCI state.

- the active PDSCH TCI state with lowest ID [6, TS 38.214] in the active DL BWP, if CORESETs are not provided in the active DL BWP of serving cell

- For the SRS power control adjustment state for active UL BWP of carrier of serving cell and SRS transmission occasion

- , where is the current PUSCH power control adjustment state as described in clause 7.1.1, if *srs-PowerControlAdjustmentStates* indicates a same power control adjustment state for SRS transmissions and PUSCH transmissions; or

-  if the UE is not configured for PUSCH transmissions on active UL BWP of carrier of serving cell , or if *srs-PowerControlAdjustmentStates* indicates separate power control adjustment states between SRS transmissions and PUSCH transmissions, and if *tpc-Accumulation* is not provided, where

- The values are given in Table 7.1.1-1

- is jointly coded with other TPC commands in a PDCCH with DCI format 2\_3, as described in clause 11.4

- is a sum of TPC command values in a set of TPC command values with cardinality that the UE receives between symbols before SRS transmission occasion and symbols before SRS transmission occasion on active UL BWP of carrier of serving cell for SRS power control adjustment state, where is the smallest integer for which symbols before SRS transmission occasion is earlier than symbols before SRS transmission occasion

- if the SRS transmission is aperiodic, is a number of symbols for active UL BWP of carrier of serving cell after a last symbol of a corresponding PDCCH triggering the SRS transmission and before a first symbol of the SRS transmission

- if the SRS transmission is semi-persistent or periodic, is a number of symbols equal to the product of a number of symbols per slot, , and the minimum of the values provided by *k2* in *PUSCH-ConfigCommon* for active UL BWP of carrier of serving cell

- If the UE has reached maximum power for active UL BWP of carrier of serving cell at SRS transmission occasion and , then

- If UE has reached minimum power for active UL BWP of carrier of serving cell at SRS transmission occasion and , then

- If a configuration for a value or for a value for a corresponding SRS power control adjustment state for active UL BWP of carrier of serving cell is provided by higher layers

-

- Else

-

where

is the TPC command value indicated in the random access response grant corresponding to the random access preamble that the UE transmitted on active UL BWP of carrier of the serving cell , and

;

where is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble for active UL BWP of carrier of serving cell .

- if the UE is not configured for PUSCH transmissions on active UL BWP of carrier of serving cell , or if *srs-PowerControlAdjustmentStates* indicates separate power control adjustment states between SRS transmissions and PUSCH transmissions, and *tpc-Accumulation* is provided, and the UE detects a DCI format 2\_3 symbols before a first symbol of SRS transmission occasion , where absolute values of are provided in Table 7.1.1-1

- if *srs-PowerControlAdjustmentStates* indicates a same power control adjustment state for SRS transmissions and PUSCH transmissions, the update of the power control adjustment state for SRS transmission occasion occurs at the beginning of each SRS resource in the SRS resource set ; otherwise, the update of the power control adjustment state SRS transmission occasion occurs at the beginning of the first transmitted SRS resource in the SRS resource set .

If a UE transmits SRS based on a configuration by *SRS-PosResourceSet* on active UL BWP of carrier of serving cell , the UE determines the SRS transmission power in SRS transmission occasion as

 [dBm]

where,

- and are provided by *p0-r16* and *alpha-r16* respectively, for active UL BWP of carrier of serving cell , and SRS resource set is indicated by *SRS-PosResourceSetId* from *SRS-PosResourceSet*, and

- is a downlink pathloss estimate in dB calculated by the UE, as described in clause 7.1.1 in case of an active DL BWP of a serving cell , using RS resource indexed in a serving or non-serving cell for SRS resource set [6, TS 38.214]. A configuration for RS resource index associated with SRS resource set is provided by *pathlossReferenceRS-Pos*

- if a *ssb-IndexNcell* is provided, *referenceSignalPower* is provided by *ss-PBCH-BlockPower-r16*

- if a *dl-PRS-ResourceId* is provided, *referenceSignalPower* is provided by *dl-PRS-ResourcePower*

If the UE determines that the UE is not able to accurately measure , or the UE is not provided with *pathlossReferenceRS-Pos*, the UE calculates using a RS resource obtained from the SS/PBCH block of the serving cell that the UE uses to obtain *MIB*

The UE may indicate a capability for a number of pathloss estimates that the UE can simultaneously maintain for all SRS resource sets provided by *SRS-PosResourceSet* in addition to the up to four pathloss estimates that the UE maintains per serving cell for PUSCH/PUCCH transmissions and for SRS transmissions configured by *SRS-Resource*.

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

### 7.7.1 Type 1 PH report

If a UE determines that a Type 1 power headroom report for an activated serving cell is based on an actual PUSCH transmission then, for PUSCH transmission occasion on active UL BWP of carrier of serving cell , the UE computes the Type 1 power headroom report as

[dB]



where , , , , , and are defined in clause 7.1.1.

If a UE is configured with multiple cells for PUSCH transmissions, where a SCS configuration on active UL BWP of carrier of serving cell is smaller than a SCS configuration on active UL BWP of carrier of serving cell , and if the UE provides a Type 1 power headroom report in a PUSCH transmission in a slot on active UL BWP that overlaps with multiple slots on active UL BWP , the UE provides a Type 1 power headroom report for the first PUSCH, if any, on the first slot of the multiple slots on active UL BWP that fully overlaps with the slot on active UL BWP . If a UE is configured with multiple cells for PUSCH transmissions, where a same SCS configuration on active UL BWP of carrier of serving cell and active UL BWP of carrier of serving cell , and if the UE provides a Type 1 power headroom report in a PUSCH transmission in a slot on active UL BWP , the UE provides a Type 1 power headroom report for the first PUSCH, if any, on the slot on active UL BWP that overlaps with the slot on active UL BWP .

If a UE is configured with multiple cells for PUSCH transmissions and provides a Type 1 power headroom report in a PUSCH transmission with PUSCH repetition Type B having a nominal repetition that spans multiple slots on active UL BWP and overlaps with one or more slots on active UL BWP , the UE provides a Type 1 power headroom report for the first PUSCH, if any, on the first slot of the one or more slots on active UL BWP that overlaps with the multiple slots of the nominal repetition on active UL BWP .

For a UE configured with EN-DC/NE-DC and capable of dynamic power sharing, if E-UTRA Dual Connectivity PHR [14, TS 36.321] is triggered, the UE provides power headroom of the first PUSCH, if any, on the determined NR slot as described in clause 7.7.

If a UE is configured with multiple cells for PUSCH transmissions, the UE does not consider for computation of a Type 1 power headroom report in a first PUSCH transmission that includes an initial transmission of transport block on active UL BWP of carrier of serving cell , a second PUSCH transmission on active UL BWP of carrier of serving cell that overlaps with the first PUSCH transmission if

- the second PUSCH transmission is scheduled by a DCI format in a PDCCH received in a second PDCCH monitoring occasion, and

- the second PDCCH monitoring occasion is after a first PDCCH monitoring occasion where the UE detects the earliest DCI format scheduling an initial transmission of a transport block after a power headroom report was triggered

or

- the second PUSCH transmission is after the first uplink symbol of the first PUSCH transmission minus *T'proc,2*=*Tproc,2* where *Tproc,2* is determined according to [6, TS 38.214] assuming *d2,1* =1, *d2,2*=0, and with *µDL* corresponding to the subcarrier spacing of the active downlink BWP of the scheduling cell for a configured grant if the first PUSCH transmission is on a configured grant after a power headroom report was triggered.

If the UE determines that a Type 1 power headroom report for an activated serving cell is based on a reference PUSCH transmission then, for PUSCH transmission occasion on active UL BWP of carrier of serving cell , the UE computes the Type 1 power headroom report as

[dB]



where is computed assuming MPR=0 dB, A-MPR=0 dB, P-MPR=0 dB. TC = 0 dB. MPR, A-MPR, P-MPR and TC are defined in [8-1, TS 38.101-1], [8-2, TS38.101-2] and [8-3, TS 38.101-3]. The remaining parameters are defined in clause 7.1.1 where and are obtained using and *p0-PUSCH-AlphaSetId* *=* 0, is obtained using *pusch-PathlossReferenceRS-Id =* 0, and .

If a UE is configured with two UL carriers for a serving cell and the UE determines a Type 1 power headroom report for the serving cell based on a reference PUSCH transmission, the UE computes a Type 1 power headroom report for the serving cell assuming a reference PUSCH transmission on the UL carrier provided by *pusch-Config*. If the UE is provided *pusch-Config* for both UL carriers, the UE computes a Type 1 power headroom report for the serving cell assuming a reference PUSCH transmission on the UL carrier provided by *pucch-Config*. If *pucch-Config* is not provided to the UE for any of the two UL carriers, the UE computes a Type 1 power headroom report for the serving cell assuming a reference PUSCH transmission on the non-supplementary UL carrier.

If a UE transmits a PUSCH associated with a RS resource index , as described in clause 7.1.1, on active UL BWP of carrier of serving cell in slot and provides a Type 1 power headroom report for an actual PUSCH repetition associated with the RS resource index , the Type 1 power headroom report is for the first PUSCH repetition associated with the RS resource index that overlaps with slot.

If a UE transmits a PUSCH associated with a first RS resource index , as described in clause 7.1.1, on active UL BWP of carrier of serving cell in slot and indicates a capability to provide a Type 1 power headroom report for PUSCH repetition associated with a second RS resource index , as described in clause 7.1.1,

- if the UE provides a Type 1 power headroom report for an actual PUSCH repetition associated with the first RS resource index ,

- if the UE transmits PUSCH repetitions associated with the second RS resource index in slot , the UE provides a Type 1 power headroom report for a first actual PUSCH repetition associated with the second RS resource index that overlaps with slot

- otherwise, the UE provides a Type 1 power headroom report for a reference PUSCH transmission associated with the second RS resource index

- otherwise, if the UE provides a Type 1 power headroom report for a reference PUSCH transmission associated with the first RS resource index , the UE provides a Type 1 power headroom report for a reference PUSCH transmission associated with the second RS resource index

\*\*\* 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*.

In the remaining of this clause, when a PDCCH reception by a UE includes two PDCCH candidates from corresponding search space sets, as described in clause 10.1

- a PDCCH monitoring occasion is the union of the PDCCH monitoring occasions for the two PDCCH candidates

- the start of the PDCCH reception is the start of the earlier PDCCH candidate

- the end of the PDCCH reception in the end of the later PDCCH candidate

The PDCCH reception includes the two PDCCH candidates also when the UE is not required to monitor one of the two PDCCH candidates as described in clause 10, clause 11.1, and clause 11.1.1.

In the remaining of this clause, a last DCI format is the DCI format that a UE detects in a last PDCCH monitoring occasion from the PDCCH monitoring occasions for which the UE would provide HARQ-ACK information in a PUCCH in a same slot.

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, a DCI format 1\_1 can indicate SCell dormancy and trigger a PUCCH transmission with corresponding HARQ-ACK information of any priority, and DCI format 1\_1 or DCI format 1\_2 can indicate a TCI state update and trigger a PUCCH transmission with corresponding HARQ-ACK information of any priority.

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

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

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

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

where

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

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

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

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

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

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

- if the overlapping group includes the first PUCCH

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

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

- if the overlapping group includes the first PUSCH

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

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

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

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

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

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

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

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

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

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

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

where

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

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

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

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

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

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

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

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

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

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

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

If a UE

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

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

the UE

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

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

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

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

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

A UE does not expect to detect a DCI format scheduling a PDSCH reception or having associated HARQ-ACK information without scheduling a PDSCH reception, 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.

## 9.1 HARQ-ACK codebook determination

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

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

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

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

If a UE is provided *pdsch-HARQ-ACK-OneShotFeedback* and the UE detects a DCI format in any PDCCH monitoring occasion that includes a One-shot HARQ-ACK request field with value 1

- the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4

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

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

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

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

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

If a UE detects a DCI format 1\_1 indicating

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

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

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

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

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

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

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

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

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

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

A UE reports HARQ-ACK information for a corresponding PDSCH reception or SPS PDSCH release or TCI state update only in a HARQ-ACK codebook that the UE transmits in a slot indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format. The UE reports NACK value(s) for HARQ-ACK information bit(s) in a HARQ-ACK codebook that the UE transmits in a slot not indicated by a value of a PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format.

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

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

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

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

- in DL slot , otherwise

only in a HARQ-ACK codebook that the UE includes in a PUCCH or PUSCH transmission in slot , where is the last UL slot overlapping with DL slot and is a number of slots indicated by the PDSCH-to-HARQ\_feedback timing indicator field in a corresponding DCI format or provided by *dl-DataToUL-ACK* if the PDSCH-to-HARQ\_feedback timing indicator field is not present in the DCI format. If the UE reports HARQ-ACK information for the PDSCH reception in a slot other than slot , the UE sets a value for each corresponding HARQ-ACK information bit to NACK.

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

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

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

- SPS PDSCH reception(s)

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

Set to the number of serving cells configured to the UE

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

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

Set – HARQ-ACK information bit index

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

while

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

while

Set – slot index

while

if {

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

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

}

= HARQ-ACK information bit for this SPS PDSCH reception

;

end if

;

end while

;

end while

;

end while

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

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

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

a) If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for either DCI format 1\_1 or DCI format 1\_2 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.

For the set of slot timing values, the UE determines a set of  occasions for candidate PDSCH receptions or SPS PDSCH releases or TCI state update 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. If a UE provides HARQ-ACK information corresponding to detection of a DCI format that provides TCI state update without scheduling PDSCH reception, as described in [6, TS 38.214], a location in the Type-1 HARQ-ACK codebook for the HARQ-ACK information is same as when the DCI format schedules a PDSCH reception with CBGs or with transport blocks that are correctly decoded.

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

Set 

Set 

Set  to the cardinality of set 

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

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

while 

if 

Set  – index of a DL slot within an UL slot

while 

Set  to the set of rows

Set  to the cardinality of 

Set  – index of row in set 

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

;

else

while 

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

;

else

;

end if

end while

if the UE does not indicate a capability to receive more than one unicast PDSCH 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, or TCI state update 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 or TCI state update 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 TCI state update, 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, or only for the TCI state update.

If a UE receives a SPS PDSCH, or a SPS PDSCH release, or TCI state update, 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 or for the TCI state update.

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 or a TCI state update, 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 or TCI state update for serving cell  corresponding to the HARQ-ACK information bits.

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

Set - HARQ-ACK information bit index

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

while 

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

while 

if *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 or TCI state update 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 or TCI state update that the UE multiplexes corresponding HARQ-ACK information in the PUSCH, based on a value of a respective PDSCH-to-HARQ\_feedback timing indicator field in a DCI format scheduling the PDSCH reception or the SPS PDSCH release or the TCI state update or on the value of *dl-DataToUL-ACK* 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 TCI state update, 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 or only for the TCI state update 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 or TCI state update 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 TCI state update, 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 TCI state update 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 or TCI state update, the UE detects the second DCI format in any PDCCH monitoring occasion after the first one, and the second DCI format includes a One-shot HARQ-ACK request field with value 1, the UE includes the HARQ-ACK information in a Type-3 HARQ-ACK codebook, as described in clause 9.1.4, and where the slot indicated by the value of the PDSCH-to-HARQ\_feedback timing indicator field in the second DCI format is no later than a slot for HARQ-ACK information in response to a SPS PDSCH reception, if any, received after the 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 or TCI state update, and the UE receives the second DCI format later than the slot for HARQ-ACK information in response to a SPS PDSCH reception received after the 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 having associated HARQ-ACK information without scheduling PDSCH receptions on an active DL BWP of a serving cell , as described in clause 10.1, and for which the UE transmits HARQ-ACK information in a same PUCCH in slot based on

- PDSCH-to-HARQ\_feedback timing indicator field values for PUCCH transmission with HARQ-ACK information in slot in response to PDSCH receptions or in response to DCI formats having associated HARQ-ACK information without scheduling PDSCH receptions

- 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 DCI formats scheduling PDSCH receptions or having associated HARQ-ACK information without scheduling PDSCH receptions 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) or HARQ-ACK information 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) or HARQ-ACK information 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 or having associated HARQ-ACK information without scheduling PDSCH reception 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 or having associated HARQ-ACK information without scheduling PDSCH reception, 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 providing a DCI format with associated HARQ-ACK information without scheduling a PDSCH reception 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.

The UE generates HARQ-ACK information with ACK value in response to a detection of a DCI format that does not trigger a Type-3 HARQ-ACK codebook report and has associated HARQ-ACK information without scheduling a PDSCH reception.

For a PDCCH monitoring occasion with DCI format scheduling PDSCH reception or having associated HARQ-ACK information without scheduling a PDSCH reception in the active DL BWP of a serving cell, when a UE receives a PDSCH with one transport block or detects a DCI format having the associated HARQ-ACK information report and the value of *maxNrofCodeWordsScheduledByDCI* is 2, the HARQ-ACK information is associated with the first transport block and the UE generates a NACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is not provided and generates HARQ-ACK information with value of ACK for the second transport block if *harq-ACK-SpatialBundlingPUCCH* is provided.

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

where

- if , is the value of the counter DAI in the last DCI format scheduling PDSCH reception having associated HARQ-ACK information without scheduling PDSCH reception, 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, or having associated HARQ-ACK information without scheduling PDSCH reception 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, or having associated HARQ-ACK information without scheduling PDSCH reception 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, or having associated HARQ-ACK information without scheduling PDSCH reception for any serving cell in any of the PDCCH monitoring occasions.

- is the total number of a DCI format scheduling PDSCH reception, or having associated HARQ-ACK information without scheduling PDSCH reception that the UE detects within the PDCCH monitoring occasions for serving cell . if the UE does not detect any DCI format scheduling PDSCH reception, or having associated HARQ-ACK information without scheduling PDSCH reception 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 formats that the UE detects and have associated HARQ-ACK information without scheduling PDSCH receptions 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,

- TCI state update, 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 providing TCI state update 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 or providing TCI state update** **is present, denoted as and** |
| 0 | 1 |  |
| 1 | 2 |  |

#### 9.1.3.2 Type-2 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 PDCCH within the monitoring occasions for DCI formats scheduling PDSCH receptions, or providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception, on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission;

- else, the UE generates the HARQ-ACK codebook as described in clause 9.1.3.1, except that *harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.

If a UE multiplexes HARQ-ACK information in a PUSCH transmission that is scheduled by a DCI format that includes a DAI field, the UE generates the HARQ-ACK codebook as described in clause 9.1.3.1, with the following modifications:

- For the pseudo-code for the HARQ-ACK codebook generation in clause 9.1.3.1, after the completion of the and loops, the UE sets where is the value of the DAI field according to Table 9.1.3-2

- For the case of first and second HARQ-ACK sub-codebooks, the DCI format includes a first DAI field corresponding to the first HARQ-ACK sub-codebook and a second DAI field corresponding to the second HARQ-ACK sub-codebook

*- harq-ACK-SpatialBundlingPUCCH* is replaced by *harq-ACK-SpatialBundlingPUSCH*.

If a UE is not provided *PDSCH-CodeBlockGroupTransmission* and the UE is scheduled for a PUSCH transmission by DCI format that includes a DAI field with value and the UE has not received any PDCCH within the monitoring occasions for PDCCH with DCI format scheduling PDSCH receptions or having associated HARQ-ACK information without scheduling PDSCH receptions on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information in the PUSCH transmission.

If a UE is provided *PDSCH-CodeBlockGroupTransmission* and the UE is scheduled for a PUSCH transmission by DCI format that includes a DAI field with first value or with second value and the UE has not received any PDCCH within the monitoring occasions for PDCCH with DCI format scheduling PDSCH reception or having associated HARQ-ACK information without scheduling PDSCH reception, on any serving cell and the UE does not have HARQ-ACK information in response to a SPS PDSCH reception to multiplex in the PUSCH, as described in clause 9.1.3.1, the UE does not multiplex HARQ-ACK information for the first sub-codebook or for the second sub-codebook, respectively, in the PUSCH transmission.

Table 9.1.3-2: Value of DAI

|  |  |  |
| --- | --- | --- |
| DAI MSB, LSB |  | Number of {serving cell, PDCCH monitoring occasion}-pair(s) in which PDSCH transmission(s) associated with PDCCH or PDCCH indicating SPS PDSCH release or providing TCI state update 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 |  |

\*\*\* 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.

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 having associated HARQ-ACK information without scheduling a PDSCH reception, 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. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1, the CORESET is associated with the search space set having the smaller index.

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 PRB index of the PUCCH transmission in the first hop as and the 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 PRB index of the PUCCH transmission in the first hop as and the 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*.

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*.

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*.

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 by a UE is provided by

- *tci-StateID-r17*, if provided;

- *PUCCH-SpatialRelationInfo* if the UE is configured with a single value for *pucch-SpatialRelationInfoId*;

- as described in [11, TS 38.321], if the UE is provided multiple values for *PUCCH-SpatialRelationInfo*. 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 that overlaps with a PDSCH reception or with a PDCCH reception providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception; otherwise, is the last UL slot that overlaps with the DL slot for the PDSCH reception or with the DL slot for the PDCCH reception.

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

If the UE detects a DCI format that does not include a PDSCH-to-HARQ\_feedback timing indicator field and schedules a PDSCH reception or activates a SPS PDSCH reception ending in DL slot , the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot where is provided by *dl-DataToUL-ACK*, or *dl-DataToUL-ACK-r16*, or *dl-DataToUL-ACKForDCIFormat1\_2*.

If the UE detects a DCI format scheduling a PDSCH reception ending in DL slot  or if the UE detects a DCI format for which the UE generates HARQ-ACK information through a PDCCH reception ending in DL slot , the UE provides corresponding HARQ-ACK information in a PUCCH transmission within UL slot , where is a number of slots and is indicated by the PDSCH-to-HARQ\_feedback timing indicator field in the DCI format, if present, or provided by *dl-DataToUL-ACK*, *dl-DataToUL-ACK-r16*, or *dl-DataToUL-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. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1, the CORESET is associated with the search space set having the smaller index. If the DCI format does not include a PUCCH resource indicator field, .



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

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

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



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

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



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

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

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

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

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



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



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

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

### 9.2.5 UE procedure for reporting multiple UCI types

This clause is applicable to the case that a UE has resources for PUCCH transmissions or for PUCCH and PUSCH transmissions that overlap in time and each PUCCH transmission is over a single slot without repetitions. Any case that a PUCCH transmission is with repetitions over multiple slots is described in clause 9.2.6. If a UE is configured with multiple PUCCH resources in a slot to transmit CSI reports

- if the UE is not provided *multi-CSI-PUCCH-ResourceList* or if PUCCH resources for transmissions of CSI reports do not overlap in the slot, the UE determines a first resource corresponding to a CSI report with the highest priority [6, TS 38.214]

- if the first resource includes PUCCH format 2, and if there are remaining resources in the slot that do not overlap with the first resource, the UE determines a CSI report with the highest priority, among the CSI reports with corresponding resources from the remaining resources, and a corresponding second resource as an additional resource for CSI reporting

- if the first resource includes PUCCH format 3 or PUCCH format 4, and if there are remaining resources in the slot that include PUCCH format 2 and do not overlap with the first resource, the UE determines a CSI report with the highest priority, among the CSI reports with corresponding resources from the remaining resources, and a corresponding second resource as an additional resource for CSI reporting

- if the UE is provided *multi-CSI-PUCCH-ResourceList* and if any of the multiple PUCCH resources overlap, the UE multiplexes all CSI reports in a resource from the resources provided by *multi-CSI-PUCCH-ResourceList*, as described in clause 9.2.5.2.

A UE multiplexes DL HARQ-ACK information, with or without SR, and CSI report(s) in a same PUCCH if the UE is provided *simultaneousHARQ-ACK-CSI*; otherwise, the UE drops the CSI report(s) and includes only DL HARQ-ACK information, with or without SR, in the PUCCH. If the UE would transmit multiple PUCCHs in a slot that include DL HARQ-ACK information and CSI report(s), the UE expects to be provided a same configuration for *simultaneousHARQ-ACK-CSI* each of PUCCH formats 2, 3, and 4.

If a UE would multiplex CSI reports that include Part 2 CSI reports in a PUCCH resource, the UE determines the PUCCH resource and a number of PRBs for the PUCCH resource or a number of Part 2 CSI reports assuming that each of the CSI reports indicates rank 1.

If a UE would transmit multiple overlapping PUCCHs in a slot or overlapping PUCCH(s) and PUSCH(s) in a slot and, when applicable as described in clauses 9.2.5.1 and 9.2.5.2, the UE is configured to multiplex different UCI types in one PUCCH, and at least one of the multiple overlapping PUCCHs or PUSCHs is in response to a DCI format detection by the UE, the UE multiplexes all corresponding UCI types if the following conditions are met. If one of the PUCCH transmissions or PUSCH transmissions is in response to a DCI format detection by the UE, the UE expects that the first symbol of the earliest PUCCH or PUSCH, among a group overlapping PUCCHs and PUSCHs in the slot, satisfies the following timeline conditions

- is not before a symbol with CP starting after after a last symbol of any corresponding PDSCH, is given by maximum of where for the i-th PDSCH with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, , is selected for the i-th PDSCH following [6, TS 38.214], is selected based on the UE PDSCH processing capability of the i-th PDSCH and SCS configuration , where corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i-th PDSCH, the i-th PDSCH, the PUCCH with corresponding HARQ-ACK transmission for the i-th PDSCH, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.

- is not before a symbol with CP starting after after a last symbol of a PDCCH reception providing a DCI format having associated HARQ-ACK information without scheduling a PDSCH reception. is given by maximum of where for the i-th PDCCH providing the DCI format with corresponding HARQ-ACK transmission on a PUCCH which is in the group of overlapping PUCCHs and PUSCHs, , as described in clause 10.2, where corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH, the PUCCH with corresponding HARQ-ACK information, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.

- if there is no aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, is not before a symbol with CP starting after after a last symbol of

- any PDCCH with the DCI format scheduling an overlapping PUSCH, and

- any PDCCH providing a DCI format with corresponding HARQ-ACK information in an overlapping PUCCH in the slot

If there is at least one PUSCH in the group of overlapping PUCCHs and PUSCHs, is given by maximum of where for the i-th PUSCH which is in the group of overlapping PUCCHs and PUSCHs, , , and are selected for the i-th PUSCH following [6, TS 38.214], is selected based on the UE PUSCH processing capability of the i-th PUSCH and SCS configuration , where  corresponds to the smallest SCS configuration among the SCS configurations used for the PDCCH scheduling the i-th PUSCH, the PDCCHs scheduling the PDSCHs, or providing the DCI formats without scheduling PDSCHs, with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs/PUSCHs, and all PUSCHs in the group of overlapping PUCCHs and PUSCHs.

If there is no PUSCH in the group of overlapping PUCCHs and PUSCHs, is given by maximum of where for the i-th PDSCH, or the i-th PDCCH providing a DCI format without scheduling PDSCH, with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs, , is selected based on the UE PUSCH processing capability of the PUCCH serving cell if configured.   is selected based on the UE PUSCH processing capability 1, if PUSCH processing capability is not configured for the PUCCH serving cell. is selected based on the smallest SCS configuration between the SCS configuration used for the PDCCH scheduling the i-th PDSCH, or providing the i-th DCI format without scheduling PDSCH with corresponding HARQ-ACK information on a PUCCH which is in the group of overlapping PUCCHs, and the SCS configuration for the PUCCH serving cell.

- if there is an aperiodic CSI report multiplexed in a PUSCH in the group of overlapping PUCCHs and PUSCHs, is not before a symbol with CP starting after after a last symbol of

- any PDCCH with the DCI format scheduling an overlapping PUSCH, and

- any PDCCH scheduling a PDSCH, or providing a DCI format, with corresponding HARQ-ACK information in an overlapping PUCCH in the slot

where corresponds to the smallest SCS configuration among the SCS configuration of the PDCCHs, the smallest SCS configuration for the group of the overlapping PUSCHs, and the smallest SCS configuration of CSI-RS associated with the DCI format scheduling the PUSCH with the multiplexed aperiodic CSI report, and for , for , and for . is defined in [6, TS 38.214] and it is applied only if of Table 5.4-1 in [6, TS 38.214] is applied to the determination of .

- , , , , , and are defined in [6, TS 38.214] and and are defined in [4, TS 38.211].

If a UE would transmit multiple overlapping PUCCHs in a slot or overlapping PUCCH(s) and PUSCH(s) in a slot, one of the PUCCHs includes HARQ-ACK information in response to an SPS PDSCH reception, and any PUSCH is not in response to a DCI format detection, the UE expects that the first symbol of the earliest PUCCH or PUSCH satisfies the first of the previous timeline conditions with the exception that components associated to a SCS configuration for a PDCCH scheduling a PDSCH or a PUSCH are absent from the timeline conditions.



A UE does not expect a PUCCH or a PUSCH that is in response to a DCI format detection to overlap with any other PUCCH or PUSCH that does not satisfy the above timing conditions.

A UE that

- 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*

does not expect a PUCCH or a PUSCH transmission triggered by a detection of a DCI format in a PDCCH received in a CORESET from the first CORESETs to overlap in time with a PUCCH or a PUSCH transmission triggered by a detection of a DCI format in a PDCCH received in a CORESET from the second CORESETs.

If there is one or more aperiodic CSI reports multiplexed on a PUSCH in the group of overlapping PUCCHs and PUSCHs and if symbol is before symbol that is a next uplink symbol with CP starting after after the end of the last symbol of



- the last symbol of aperiodic CSI-RS resource for channel measurements, and

- the last symbol of aperiodic CSI-IM used for interference measurements, and

- the last symbol of aperiodic NZP CSI-RS for interference measurements, when aperiodic CSI-RS is used for channel measurement for triggered CSI report



the UE is not required to update the CSI report for the triggered CSI report *.* is defined in [6, TS 38.214] and corresponds to the smallest SCS configuration among the SCS configurations of the PDCCHs scheduling the PUSCHs, the smallest SCS configuration of aperiodic CSI-RSs associated with DCI formats provided by the PDCCHs triggering the aperiodic CSI reports, and the smallest SCS configuration of the overlapping PUCCHs and PUSCHs and for , for and for .



If a UE would transmit multiple PUCCHs in a slot that include HARQ-ACK information, and/or SR, and/or CSI reports and any PUCCH with HARQ-ACK information in the slot satisfies the above timing conditions and does not overlap with any other PUCCH or PUSCH in the slot that does not satisfy the above timing conditions, the UE multiplexes the HARQ-ACK information, and/or SR, and/or CSI reports and determines corresponding PUCCH(s) for transmission in the slot according to the following pseudo-code. If the multiple PUCCHs do not include HARQ-ACK information and do not overlap with any PUSCH transmission by the UE in response to a DCI format detection by the UE, the timing conditions do not apply.

If

- a UE is not provided *multi-CSI-PUCCH-ResourceList*, and

- a resource for a PUCCH transmission with HARQ-ACK information in response to SPS PDSCH reception and/or a resource for a PUCCH associated with a SR occasion overlap in time with two resources for respective PUCCH transmissions with two CSI reports, and

- there is no resource for a PUCCH transmission with HARQ-ACK information in response to a DCI format detection that overlaps in time with any of the previous resources, and

- the following pseudo code results to the UE attempting to determine a single PUCCH resource from the HARQ-ACK and/or the SR resource and the two PUCCH resources with CSI reports

the UE

- multiplexes the HARQ-ACK information and/or the SR in the resource for the PUCCH transmission with the CSI report having the higher priority, and

- does not transmit the PUCCH with the CSI report having the lower priority

Set to the set of resources for transmission of corresponding PUCCHs in a single slot without repetitions where



- a resource with earlier first symbol is placed before a resource with later first symbol

- for two resources with same first symbol, the resource with longer duration is placed before the resource with shorter duration

- for two resources with same first symbol and same duration, the placement is arbitrary

- the above three steps for the set are according to a subsequent pseudo-code for a function



- a resource for negative SR transmission that does not overlap with a resource for HARQ-ACK or CSI transmission is excluded from set



- if the UE is not provided *simultaneousHARQ-ACK-CSI* and resources for transmission of HARQ-ACK information include PUCCH format 0 or PUCCH format 2, resources that include PUCCH format 2, or PUCCH format 3, or PUCCH format 4 for transmission of CSI reports are excluded from the set if they overlap with any resource from the resources for transmission of HARQ-ACK information



- if the UE is not provided *simultaneousHARQ-ACK-CSI* and at least one of the resources for transmission of HARQ-ACK information includes PUCCH format 1, PUCCH format 3, or PUCCH format 4

- resources that include PUCCH format 3 or PUCCH format 4 for transmission of CSI reports are excluded from the set



- resources that include PUCCH format 2 for transmission of CSI reports are excluded from the set if they overlap with any resource from the resources for transmission of HARQ-ACK information



Set to the cardinality of



Set to be the first symbol of resource in the slot



Set to be the number of symbols of resource in the slot



Set - index of first resource in set



Set - counter of overlapped resources



while



if and resource overlaps with resource



else

if



determine a single resource for multiplexing UCI associated with resources as described in clauses 9.2.5.0, 9.2.5.1 and 9.2.5.2



set the index of the single resource to 



% start from the beginning after reordering unmerged resources at next step



% function that re-orders resources in current set



Set to the cardinality of



else



end if

end if

end while

The function performs the following pseudo-code



{



while % the next two while loops are to re-order the unmerged resources



while



if OR



end if



end while



end while

}

For each PUCCH resource in the set that satisfies the aforementioned timing conditions, when applicable,



- the UE transmits a PUCCH using the PUCCH resource if the PUCCH resource does not overlap in time with a PUSCH transmission after multiplexing UCI following the procedures described in clauses 9.2.5.1 and 9.2.5.2

- the UE multiplexes HARQ-ACK information and/or CSI reports in a PUSCH if the PUCCH resource overlaps in time with a PUSCH transmission, as described in clause 9.3, and does not transmit SR. In case the PUCCH resource overlaps in time with multiple PUSCH transmissions, the PUSCH for multiplexing HARQ-ACK information and/or CSI is selected as described in clause 9. If the PUSCH transmission by the UE is not in response to a DCI format detection and the UE multiplexes only CSI reports, the timing conditions are not applicable

- the UE does not expect the resource to overlap with a second resource of a PUCCH transmission over multiple slots if the resource is obtained from a group of resources that do not overlap with the second resource.

clauses 9.2.5.0, 9.2.5.1 and 9.2.5.2 assume the following

- resources for transmissions of UCI types, prior to multiplexing or dropping, overlap in a slot

- multiplexing conditions of corresponding UCI types in a single PUCCH are satisfied, and

- the UE does not transmit any PUSCH time-overlapping with PUCCH in the slot.

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

### 9.2.6 PUCCH repetition procedure

For PUCCH formats 1, 3, or 4, a UE can be configured a number of slots, , for repetitions of a PUCCH transmission by respective *nrofSlots*. If a UE is provided a *PUCCH-config* that includes *subslotLengthForPUCCH,* the UE does not expect the *PUCCH-config* to include *nrofSlots*.

For ,

- the UE repeats the PUCCH transmission with the UCI over slots

- a PUCCH transmission in each of the slots has a same number of consecutive symbols, as provided by *nrofSymbols* in *PUCCH-format1*, *nrofSymbols* in *PUCCH-format3*, or *nrofSymbols* in *PUCCH-format4*

- a PUCCH transmission in each of the slots has a same first symbol, as provided by *startingSymbolIndex* in *PUCCH-format1*, *startingSymbolIndex* in *PUCCH-format3*, or *startingSymbolIndex* in *PUCCH-format4*

- the UE is configured by *interslotFrequencyHopping* whether or not to perform frequency hopping for PUCCH transmissions in different slots

- if the UE is configured to perform frequency hopping for PUCCH transmissions across different slots

- the UE performs frequency hopping per slot

- the UE transmits the PUCCH starting from a first PRB, provided by *startingPRB*, in slots with even number and starting from the second PRB, provided by *secondHopPRB*, in slots with odd number. The slot indicated to the UE for the first PUCCH transmission has number 0 and each subsequent slot until the UE transmits the PUCCH in slots is counted regardless of whether or not the UE transmits the PUCCH in the slot

- the UE does not expect to be configured to perform frequency hopping for a PUCCH transmission within a slot

- If the UE is not configured to perform frequency hopping for PUCCH transmissions across different slots and if the UE is configured to perform frequency hopping for a PUCCH transmission within a slot, the frequency hopping pattern between the first PRB and the second PRB is same within each slot

If the UE determines that, for a PUCCH transmission in a slot, the number of symbols available for the PUCCH transmission is smaller than the value provided by *nrofSymbols* for the corresponding PUCCH format, the UE does not transmit the PUCCH in the slot.

A SS/PBCH block symbol is a symbol of an SS/PBCH block with candidate SS/PBCH block index corresponding to the SS/PBCH block index indicated to a UE by *ssb-PositionsInBurst* in *SIB1* or *ssb-PositionsInBurst* in *ServingCellConfigCommon*, as described in clause 4.1.

For unpaired spectrum, the UE determines the slots for a PUCCH transmission starting from a slot indicated to the UE as described in clause 9.2.3 for HARQ-ACK reporting, or a slot determined as described in clause 9.2.4 for SR reporting or in clause 5.2.1.4 of [6, TS 38.214] for CSI reporting and having

- an UL symbol, as described in clause 11.1, or flexible symbol that is not SS/PBCH block symbol provided by *startingSymbolIndex* in *PUCCH-format1*, or in *PUCCH-format3*, or in *PUCCH-format4* as a first symbol, and

- consecutive UL symbols, as described in clause 11.1, or flexible symbols that are not SS/PBCH block symbols, starting from the first symbol, equal to or larger than a number of symbols provided by *nrofsymbols* in *PUCCH-format1*, or in *PUCCH-format3*, or in *PUCCH-format4*

For paired spectrum or supplementary uplink band, the UE determines the slots for a PUCCH transmission as the consecutive slots starting from a slot indicated to the UE as described in clause 9.2.3 for HARQ-ACK reporting, or a slot determined as described in clause 9.2.4 for SR reporting or in clause 5.2.1.4 of [6, TS 38.214] for CSI reporting.

If a UE would transmit a PUCCH over a first number of slots and the UE would transmit a PUSCH with repetition Type A over a second number of slots, and the PUCCH transmission would overlap with the PUSCH transmission in one or more slots, and the conditions in clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied in the overlapping slots, the UE transmits the PUCCH and does not transmit the PUSCH in the overlapping slots.

If a UE would transmit a PUCCH over a first number of slots and the UE would transmit a PUSCH with repetition Type B over a second number of slots, and the PUCCH transmission would overlap with actual PUSCH repetitions in one or more slots, and the conditions in clause 9.2.5 for multiplexing the UCI in the PUSCH are satisfied for the overlapping actual PUSCH repetitions, the UE transmits the PUCCH and does not transmit the overlapping actual PUSCH repetitions.

A UE does not multiplex different UCI types in a PUCCH transmission with repetitions over slots. If a UE would transmit a first PUCCH over more than one slot and at least a second PUCCH over one or more slots, and the transmissions of the first PUCCH and the second PUCCH would overlap in a number of slots then, for each slot of the number of slots and with UCI type priority of HARQ-ACK > SR > CSI with higher priority > CSI with lower priority

- the UE does not expect the first PUCCH and any of the second PUCCHs to start at a same slot and include a UCI type with same priority

- if the first PUCCH and any of the second PUCCHs include a UCI type with same priority, the UE transmits the PUCCH starting at an earlier slot and does not transmit the PUCCH starting at a later slot

- if the first PUCCH and any of the second PUCCHs do not include a UCI type with same priority, the UE transmits the PUCCH that includes the UCI type with higher priority and does not transmit the PUCCH that include the UCI type with lower priority

When a PUCCH resource used for repetitions of a PUCCH transmission by a UE includes first and second spatial settings, or first and second sets of power control parameters, as described in [11, TS 38.321] and in clause 7.2.1, the UE

- uses the first and second spatial settings, or the first and second sets of power control parameters, for first and second repetitions of the PUCCH transmission, respectively, when ,

- alternates between the first and second spatial settings, or between the first and second sets of power control parameters, respectively, per repetitions of the PUCCH transmission, where if *mappingPattern* = ‘cyclicMapping’; else, .

A UE does not expect a PUCCH that is in response to a DCI format detection to overlap with any other PUCCH that does not satisfy the corresponding timing conditions in clause 9.2.5.

If a UE would transmit a PUCCH over slots and the UE does not transmit the PUCCH in a slot from the slots due to overlapping with another PUCCH transmission in the slot, the UE counts the slot in the number of slots.

For DAPS operation, if a UE would transmit a PUCCH over slots on the source MCG and the UE does not transmit the PUCCH in a slot from the slots due to overlapping in time with UE transmission on the target MCG in the slot, the UE counts the slot in the number of slots.

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

# 10 UE procedure for receiving control information

If the UE is configured with a SCG, the UE shall apply the procedures described in this clause for both MCG and SCG except for PDCCH monitoring in Type0/0A/2-PDCCH CSS sets where the UE is not required to apply the procedures in this clause for the 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.

A UE monitors a set of PDCCH candidates in one or more CORESETs on the active DL BWP on each activated serving cell configured with PDCCH monitoring according to corresponding search space sets where monitoring implies receiving each PDCCH candidate and decoding according to the monitored DCI formats.

In the remaining of this clause, when a PDCCH reception by a UE includes two PDCCH candidates from corresponding search space sets, as described in clause 10.1

- a PDCCH monitoring occasion is the union of the PDCCH monitoring occasions for the two PDCCH candidates

- the start of the PDCCH reception is the start of the earlier PDCCH candidate

- the end of the PDCCH reception in the end of the later PDCCH candidate

The PDCCH reception includes the two PDCCH candidates also when the UE is not required to monitor one of the two PDCCH candidates as described in clause 10, clause 11.1, and clause 11.1.1.

If a UE is provided *monitoringCapabilityConfig* for a serving cell, the UE obtains an indication to monitor PDCCH on the serving cell for a maximum number of PDCCH candidates and non-overlapping CCEs

- per slot, as in Tables 10.1-2 and 10.1-3, if *monitoringCapabilityConfig* = *r15monitoringcapability*, or

- per span, as in Tables 10.1-2A and 10.1-3A, if *monitoringCapabilityConfig* = *r16monitoringcapability*

If the UE is not provided *monitoringCapabilityConfig*, the UE monitors PDCCH on the serving cell for a maximum number of PDCCH candidates and non-overlapping CCEs per slot.

A UE can indicate a capability to monitor PDCCH according to one or more of the combinations = (2, 2), (4, 3), and (7, 3) per SCS configuration of and . A span is a number of consecutive symbols in a slot where the UE is configured to monitor PDCCH. Each PDCCH monitoring occasion is within one span. If a UE monitors PDCCH on a cell according to combination , the UE supports PDCCH monitoring occasions in any symbol of a slot with minimum time separation of symbols between the first symbol of two consecutive spans, including across slots. A span starts at a first symbol where a PDCCH monitoring occasion starts and ends at a last symbol where a PDCCH monitoring occasion ends, where the number of symbols of the span is up to .

If a UE indicates a capability to monitor PDCCH according to multiple combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of for one or more of the multiple combinations , the UE monitors PDCCH on the cell according to the combination , from the one or more combinations , that is associated with the largest maximum number of and defined in Table 10.1-2A and Table 10.1-3A. The UE expects to monitor PDCCH according to the same combination in every slot on the active DL BWP of a cell.

A UE capability for PDCCH monitoring per slot or per span on an active DL BWP of a serving cell is defined by a maximum number of PDCCH candidates and non-overlapped CCEs the UE can monitor per slot or per span, respectively, on the active DL BWP of the serving cell.

For monitoring of a PDCCH candidate by a UE, if the UE

- has received *ssb-PositionsInBurst* in *SIB1* and has not received *ssb-PositionsInBurst* in *ServingCellConfigCommon* for a serving cell, and

- does not monitor PDCCH candidates in a Type0-PDCCH CSS set, and

- at least one RE for a PDCCH candidate overlaps with at least one RE of a candidate SS/PBCH block corresponding to a SS/PBCH block index provided by *ssb-PositionsInBurst* in *SIB1*,

the UE is not required to monitor the PDCCH candidate.

For monitoring of a PDCCH candidate by a UE, if the UE

- has received *ssb-PositionsInBurst* in *ServingCellConfigCommon* or in *AdditionalPCIInfo* for a serving cell, and

- does not monitor PDCCH candidates in a Type0-PDCCH CSS set, and

- at least one RE for a PDCCH candidate overlaps with at least one RE of a candidate SS/PBCH block corresponding to a SS/PBCH block index provided by *ssb-PositionsInBurst* in *ServingCellConfigCommon*,

the UE is not required to monitor the PDCCH candidate.

If a UE monitors the PDCCH candidate for a Type0-PDCCH CSS set on the serving cell according to the procedure described in clause 13, the UE may assume that no SS/PBCH block is transmitted in REs used for monitoring the PDCCH candidate on the serving cell.

If at least one RE of a PDCCH candidate for a UE on the serving cell overlaps with at least one RE of *lte-CRS-ToMatchAround*, or of *LTE-CRS-PatternList*, the UE is not required to monitor the PDCCH candidate.

If a UE is provided *availableRB-SetsPerCell,* the UE is not required to monitor PDCCH candidates that overlap with any RB from RB sets that are indicated as unavailable for receptions by an available RB set indicator field in DCI format 2\_0 as described in clause 11.1.1. If the UE does not obtain the available RB set indicator for a symbol, the UE monitors PDCCH candidates on all RB sets in the symbol.

If a UE can support

- a first set of serving cells where the UE is either not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a single value for all CORESETs on all DL BWPs of each scheduling cell from the first set of serving cells, and

- a second set of serving cells where the UE is not provided *coresetPoolIndex* or is provided *coresetPoolIndex* with a value 0 for a first CORESET, and with a value 1 for a second CORESET on any DL BWP of each scheduling cell from the second set of serving cells

the UE determines, for the purpose of reporting *pdcch-BlindDetectionCA*, a number of serving cells as where is a value reported by the UE.

If a UE indicates in *UE-NR-Capability* a carrier aggregation capability larger than 4 serving cells and the UE is not provided *monitoringCapabilityConfig* for any downlink cell or if the UE is provided *monitoringCapabilityConfig* = *r15monitoringcapability* for all downlink cells where the UE monitors PDCCH, the UE includes in *UE-NR-Capability* an indication for a maximum number of PDCCH candidates and for a maximum number of non-overlapped CCEs the UE can monitor per slot when the UE is configured for carrier aggregation operation over more than 4 cells. When a UE is not configured for NR-DC operation, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per slot that corresponds to downlink cells, where

- is if the UE does not provide *pdcch-BlindDetectionCA* where is the number of configured downlink serving cells

- otherwise, is the value of *pdcch-BlindDetectionCA*

When a UE is configured for NR-DC operation, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per slot that corresponds to downlink cells for the MCG where is provided by *pdcch-BlindDetection* for the MCG and determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per slot that corresponds to downlink cells for the SCG where is provided by *pdcch-BlindDetection* for the SCG. When the UE is configured for carrier aggregation operation over more than 4 cells, or for a cell group when the UE is configured for NR-DC operation, the UE does not expect to monitor per slot a number of PDCCH candidates or a number of non-overlapped CCEs that is larger than the maximum number as derived from the corresponding value of .

When a UE is configured for NR-DC operation with a total of downlink cells on both the MCG and the SCG, the UE expects to be provided *pdcch-BlindDetection* for the MCG and *pdcch-BlindDetection* for the SCG with values that satisfy

- *pdcch-BlindDetection* for the MCG + *pdcch-BlindDetection* for the SCG <= *pdcch-BlindDetectionCA*, if the UE reports *pdcch-BlindDetectionCA*, or

- *pdcch-BlindDetection* for the MCG + *pdcch-BlindDetection* for the SCG <= , if the UE does not report *pdcch-BlindDetectionCA*.

For NR-DC operation, the UE may indicate, through *pdcch-BlindDetectionMCG-UE* and *pdcch-BlindDetectionSCG-UE*, respective maximum values for *pdcch-BlindDetection* for the MCG and *pdcch-BlindDetection* for the SCG.

If the UE reports *pdcch-BlindDetectionCA*,

- the value range of *pdcch-BlindDetectionMCG-UE* or of *pdcch-BlindDetectionSCG-UE* is [1, …, *pdcch-BlindDetectionCA*-1], and

- *pdcch-BlindDetectionMCG-UE* + *pdcch-BlindDetectionSCG-UE* >= *pdcch-BlindDetectionCA*.

Otherwise, if  is a maximum total number of downlink cells that the UE can be configured on both the MCG and the SCG for NR-DC as indicated in *UE-NR-Capability*,

- the value range of *pdcch-BlindDetectionMCG-UE* or of *pdcch-BlindDetectionSCG-UE* is [1, 2, 3], and

- *pdcch-BlindDetectionMCG-UE* + *pdcch-BlindDetectionSCG-UE* >= .

If a UE indicates in *UE-NR-Capability* a carrier aggregation capability larger than two downlink cells, the UE includes in *UE-NR-Capability* an indication for a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs that the UE can monitor per span when the UE is configured for carrier aggregation operation over more than two downlink cells with *monitoringCapabilityConfig* = *r16monitoringcapability*. When a UE is not configured for NR-DC operation and the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for all downlink cell where the UE monitors PDCCH, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per span that corresponds to downlink cells, where

- is the number of configured downlink cells if the UE does not provide *pdcch-MonitoringCA*

- otherwise, is the value of *pdcch-MonitoringCA*

When a UE is configured for NR-DC operation and the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for all downlink cells where the UE monitors PDCCH, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per span that corresponds to

- downlink cells for the MCG where is provided by *pdcch-BlindDetection2* for the MCG, and

- downlink cells for the SCG where is provided by *pdcch-BlindDetection2* for the SCG

When the UE is configured for carrier aggregation operation over more than 2 cells, or for a cell group when the UE is configured for NR-DC operation, the UE does not expect to monitor per span a number of PDCCH candidates or a number of non-overlapped CCEs that is larger than the maximum number as derived from the corresponding value of .

When a UE is configured for NR-DC operation with a total of downlink cells on both the MCG and the SCG and the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for all downlink cells where the UE monitors PDCCH, the UE expects to be provided *pdcch-BlindDetection* for the MCG and *pdcch-BlindDetection* for the SCG with values that satisfy

- *pdcch-BlindDetection2* for the MCG + *pdcch-BlindDetection2* for the SCG <= *pdcch-MonitoringCA*, if the UE reports *pdcch-MonitoringCA*, or

- *pdcch-BlindDetection2* for the MCG + *pdcch-BlindDetection2* for the SCG <= , if the UE does not report *pdcch-MonitoringCA*

When a UE is configured for NR-DC operation and the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* for all downlink cells where the UE monitors PDCCH, the UE may indicate, through *pdcch-BlindDetectionMCG-UE-r16* and *pdcch-BlindDetectionSCG-UE-r16*, respective maximum values for *pdcch-BlindDetection* for the MCG and *pdcch-BlindDetection* for the SCG.

If the UE reports *pdcch-MonitoringCA*,

- the value range of *pdcch-BlindDetectionMCG-UE-r16* or of *pdcch-BlindDetectionSCG-UE-r16* is [1, …, *pdcch-MonitoringCA*-1], and

- *pdcch-BlindDetectionMCG-UE-r16* + *pdcch-BlindDetectionSCG-UE-r16* >= *pdcch-MonitoringCA.*

Otherwise, if is a maximum total number of downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* and the UE is configured on both the MCG and the SCG for NR-DC as indicated in *UE-NR-Capability*

- the value of *pdcch-BlindDetectionMCG-UE-r16* or of *pdcch-BlindDetectionSCG-UE-r16* is 1,

- *pdcch-BlindDetectionMCG-UE-r16* + *pdcch-BlindDetectionSCG-UE-r16* >= .

If a UE indicates in *UE-NR-Capability* a carrier aggregation capability larger than one downlink cell with *monitoringCapabilityConfig* = *r15monitoringcapability* or larger than one downlink cell with *monitoringCapabilityConfig* = *r16monitoringcapability*, the UE includes in *UE-NR-Capability* an indication for a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs the UE can monitor for downlink cells with *monitoringCapabilityConfig* = *r15monitoringcapability* or for downlink cells with *monitoringCapabilityConfig* = *r16monitoringcapability* when the UE is configured for carrier aggregation operation over more than two downlink cells with at least one downlink cell with *monitoringCapabilityConfig* = *r15monitoringcapability* and at least one downlink cell with *monitoringCapabilityConfig* = *r16monitoringcapability*. When a UE is not configured for NR-DC operation, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs per slot or per span that corresponds to downlink cells or to downlink cells, respectively, where

- is the number of configured downlink cells if the UE does not provide *pdcch-BlindDetectionCA1*

- otherwise,

- if the UE reports only one combination of (*pdcch-BlindDetectionCA1*, *pdcch-BlindDetectionCA2*), is the value of *pdcch-BlindDetectionCA1*

- else, is the value of *pdcch-BlindDetectionCA1* from a combination of (*pdcch-BlindDetectionCA1, pdcch-BlindDetectionCA2*) that is provided by *pdcch-BlindDetectionCA-CombIndicator*

and

- is the number of configured downlink cells if the UE does not provide *pdcch-BlindDetectionCA2*

- otherwise,

- if the UE reports only one combination of (*pdcch-BlindDetectionCA1, pdcch-BlindDetectionCA2*), is the value of *pdcch-BlindDetectionCA2*

- else, is the value of *pdcch-BlindDetectionCA2* from a combination of (*pdcch-BlindDetectionCA1, pdcch-BlindDetectionCA2*) that is provided by *pdcch-BlindDetectionCA-CombIndicator*

When a UE is configured for NR-DC operation and is provided *monitoringCapabilityConfig* = *r15monitoringcapability* for at least one downlink cell and *monitoringCapabilityConfig* = *r16monitoringcapability* for at least one downlink cell where the UE monitors PDCCH, the UE determines a capability to monitor a maximum number of PDCCH candidates and a maximum number of non-overlapped CCEs that corresponds to

- downlink cells for the MCG where is provided by *pdcch-BlindDetection3* for the MCG,

- downlink cells for the SCG where is provided by *pdcch-BlindDetection3* for the SCG, and

- downlink cells for the MCG where is provided by *pdcch-BlindDetection2* for the MCG,

- downlink cells for the SCG where is provided by *pdcch-BlindDetection2* for the SCG

When the UE is configured for carrier aggregation operation over more than two downlink cells with at least one downlink cell with *monitoringCapabilityConfig* = *r15monitoringcapability* and at least one downlink cell with *monitoringCapabilityConfig* = *r16monitoringcapability*, or for a cell group when the UE is configured for NR-DC operation, the UE does not expect to

- monitor per slot a number of PDCCH candidates or a number of non-overlapped CCEs that is larger than the maximum number as derived from the corresponding value of , and

- monitor per span a number of PDCCH candidates or a number of non-overlapped CCEs that is larger than the maximum number as derived from the corresponding value of

When a UE is configured for NR-DC operation with a total of downlink cells on both the MCG and the SCG and the UE is provided *monitoringCapabilityConfig* = *r15monitoringcapability* for downlink cells and *monitoringCapabilityConfig* = *r16monitoringcapability* for downlink cells where the UE monitors PDCCH, the UE expects to be provided *pdcch-BlindDetection3* and *pdcch-BlindDetection2* for the MCG, and *pdcch-BlindDetection3* and *pdcch-BlindDetection2* for the SCG with values that satisfy

- *pdcch-BlindDetection3* for the MCG + *pdcch-BlindDetection3* for the SCG <= *pdcch-BlindDetectionCA1*, if the UE reports *pdcch-BlindDetectionCA1*, or

- *pdcch-BlindDetection3* for the MCG + *pdcch-BlindDetection3* for the SCG <= , if the UE does not report *pdcch-BlindDetectionCA1*

and

- *pdcch-BlindDetection2* for the MCG + *pdcch-BlindDetection2* for the SCG <= *pdcch-BlindDetectionCA2*, if the UE reports *pdcch-BlindDetectionCA2*, or

- *pdcch-BlindDetection2* for the MCG + *pdcch-BlindDetection2* for the SCG <= , if the UE does not report *pdcch-BlindDetectionCA2*

When a UE is configured for NR-DC operation and is provided *monitoringCapabilityConfig* = *r15monitoringcapability* for at least one downlink cell and *monitoringCapabilityConfig* = *r16monitoringcapability* for at least one downlink cell where the UE monitors PDCCH, the UE may indicate, through *pdcch-BlindDetectionMCG-UE1* and *pdcch-BlindDetectionSCG-UE1*, respective maximum values for *pdcch-BlindDetection3* for the MCG and *pdcch-BlindDetection3* for the SCG, and through *pdcch-BlindDetectionMCG-UE2* and *pdcch-BlindDetectionSCG-UE2* respective maximum values for *pdcch-BlindDetection2* for the MCG and *pdcch-BlindDetection2* for the SCG.

If the UE reports *pdcch-BlindDetectionCA1*,

- the value range of *pdcch-BlindDetectionMCG-UE1* or of *pdcch-BlindDetectionSCG-UE1* is [0, 1, …, *pdcch-BlindDetectionCA1*], and

- *pdcch-BlindDetectionMCG-UE1* + *pdcch-BlindDetectionSCG-UE1* >= *pdcch-BlindDetectionCA1*.

Otherwise, if is a maximum total number of downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r15monitoringcapability* and the UE is configured on both the MCG and the SCG for NR-DC as indicated in *UE-NR-Capability*

- the value range of *pdcch-BlindDetectionMCG-UE1* or of *pdcch-BlindDetectionSCG-UE1* is [0, 1, 2],

- *pdcch-BlindDetectionMCG-UE1* + *pdcch-BlindDetectionSCG-UE1* >= .

If the UE reports *pdcch-BlindDetectionCA2*

- the value range of *pdcch-BlindDetectionMCG-UE2* or of *pdcch-BlindDetectionSCG-UE2* is [0, 1, …, *pdcch-BlindDetectionCA2*], and

- *pdcch-BlindDetectionMCG-UE2* + *pdcch-BlindDetectionSCG-UE2* >= *pdcch-BlindDetectionCA2.*

Otherwise, if is a maximum total number of downlink cells for which the UE is provided *monitoringCapabilityConfig* = *r16monitoringcapability* and the UE is configured on both the MCG and the SCG for NR-DC as indicated in *UE-NR-Capability*

- the value range of *pdcch-BlindDetectionMCG-UE2* or of *pdcch-BlindDetectionSCG-UE2* is [0, 1],

- *pdcch-BlindDetectionMCG-UE2* + *pdcch-BlindDetectionSCG-UE2* >= .

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

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

- a Type0-PDCCH CSS set configured by *pdcch-ConfigSIB1* in *MIB* or by *searchSpaceSIB1* in *PDCCH-ConfigCommon* or by *searchSpaceZero* in *PDCCH-ConfigCommon* for a DCI format with CRC scrambled by a SI-RNTI on the primary cell of the MCG

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

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

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

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

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

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

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

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

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

If a UE is provided a zero value for *searchSpaceID* in *PDCCH-ConfigCommon* for a Type0/0A/2-PDCCH CSS set, the UE determines monitoring occasions for PDCCH candidates of the Type0/0A/2-PDCCH CSS set as described in clause 13, and the UE is provided a C-RNTI, the UE monitors PDCCH candidates only at monitoring occasions associated with a SS/PBCH block, where the SS/PBCH block is determined by the most recent of

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

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

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

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

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

If a UE is provided

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

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

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

If a UE is provided

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- an antenna port quasi co-location, from a set of antenna port quasi co-locations provided by *TCI-State*, indicating quasi co-location information of the DM-RS antenna port for PDCCH reception;- an indication for a presence or absence of a transmission configuration indication (TCI) field for a DCI format, other than DCI format 1\_0, that schedules PDSCH receptions or has associated HARQ-ACK information without scheduling PDSCH and is provided by a PDCCH in CORESET , by *tci-PresentInDCI* or tci-PresentDCI-1-2.

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

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

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

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

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

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

For a CORESET other than a CORESET with index 0,

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

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

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

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

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

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

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

For a CORESET associated with a USS set, if a UE is provided *tci-StateId-r17* indicating a unified TCI state,

- a DM-RS antenna port for PDCCH receptions in the CORESET and a DM-RS antenna port for PDSCH receptions scheduled by DCI formats provided by PDCCH receptions in the CORESET are quasi co-located with reference signals provided by the unified TCI state [6, TS 38.214]

- a DM-RS antenna port for PUCCH transmissions or for PUSCH transmissions scheduled by DCI formats provided by PDCCH receptions in the CORESET uses a spatial filter provided by the unified TCI state

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

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

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

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

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

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

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

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

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

- if search space set is a CSS set

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

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

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

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

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

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

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

- if search space set is a first Type-3 PDCCH CSS set or a first USS set, a search space set index for a second Type-3 PDCCH CSS set or a second USS set, respectively, that is linked to search space set is provided by *searchSpaceLinking*.

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

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

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

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

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

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

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

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

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

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

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

where

for any CSS, ;

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

;

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

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

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

for any CSS, ;

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

the RNTI value used for is the C-RNTI.

For search space sets and that include *searchSpaceLinking* with value and , respectively, the UE monitors, in monitoring occasions with same index according to search space sets and , PDCCH candidates and , with , for detection of a DCI format. The UE expects , , , and a same number of non-overlapping PDCCH monitoring occasions per slot based on corresponding *monitoringSymbolsWithinSlot*, for search space sets and . For CORESET associated with the search space set and for CORESET associated with the search space set , the UE is provided *tci-PresentInDCI* or tci-PresentDCI-1-2 for either none or both of CORESETs and . The UE can indicate by countLinkedCandidates a capability for counting PDCCH candidates and either as 2 PDCCH candidates or as 3 PDCCH candidates. For detection of DCI formats with same size, the UE expects different CCEs in a CORESET for any of first PDCCH candidates and , with , and any of second PDCCH candidates and , with .

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

A UE that

- is configured for operation with carrier aggregation, and

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

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

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

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

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

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

For search space sets and that include *searchSpaceLinking* with values and , and for search space set that does not include *searchSpaceLinking*, when a UE

- monitors PDCCH candidates and in a slot for detection of a first DCI format,

- monitors PDCCH candidate in the slot for detection of a second DCI format having a same size as the first DCI format,

- the PDCCH candidate , or the PDCCH candidate , and the PDCCH candidate have identical scrambling and use a same set of CCEs in a CORESET on the active DL BWP of a scheduling cell,

the PDCCH candidate is not counted for monitoring and the UE assumes that a detected DCI format is the first DCI format. A UE may monitor PDCCH candidate depending on a corresponding capability [16, TS 38.306].Table 10.1-2 provides the maximum number of monitored PDCCH candidates, , per slot for a UE in a DL BWP with SCS configuration for operation with a single serving cell.

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

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

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

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

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

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

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

- different CORESET indexes, or

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

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

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

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

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

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

If a UE

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

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

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

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

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

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

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

If a UE

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Set

Set

Set

while AND

allocate PDCCH candidates for monitoring to USS set

;

;

;

end while

If a UE

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

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

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

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

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

If a UE

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

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

- indicates a capability for time-overlapping PDCCH receptions in CORESETs with *qcl-Type* set to two different 'typeD' properties and is provided *two-QCLTypeDforPDCCHRepetition*

the UE monitors PDCCHs only in a first CORESET with *qcl-Type* set to first 'typeD' properties and, if any, in a second CORESET with *qcl-Type* set to second 'typeD' properties that are different than the first 'typeD' properties, and in any other CORESET from the multiple CORESETs with corresponding *qcl-Type* set to the first 'typeD' properties or to the second 'typeD' properties

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

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

- the second CORESET corresponds to a CSS set or a USS set, if any, that includes *searchSpaceLinking* with a value indicating, respectively, the CSS set of the USS set with the lowest index in the cell with the lowest index

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

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

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

The number of active TCI states is determined from the multiple CORESETs.

If a UE

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

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

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

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

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

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

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

the UE expects to have respectively received at most PDCCHs for

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

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

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

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

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

the UE expects to have respectively received at most PDCCHs for

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

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

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

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

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

the UE expects to have respectively received

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

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

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

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

If a UE

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

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

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

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

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

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

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

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

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

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

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

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

# 11 UE-group common signalling

If the 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.

In the remaining of this clause, unless stated otherwise, when a PDCCH reception by a UE includes two PDCCH candidates from corresponding search space sets, as described in clause 10.1

- a PDCCH monitoring occasion is the union of the PDCCH monitoring occasions for the two PDCCH candidates

- the start of the PDCCH reception is the start of the earlier PDCCH candidate

- the end of the PDCCH reception in the end of the later PDCCH candidate

The PDCCH reception includes the two PDCCH candidates also when the UE is not required to monitor one of the two PDCCH candidates as described in clause 10, clause 11.1, and clause 11.1.1.

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

## 11.2A Cancellation indication

If a UE is provided *UplinkCancellation*, the UE is provided, in one or more serving cells, search space sets for monitoring the first PDCCH candidate with a CCE aggregation level of CCEs of each search space set for detection of a DCI format 2\_4 [5, TS 38.212] with a CI-RNTI provided by *ci-RNTI* as described in clause 10.1. *UplinkCancellation* additionally provides to the UE

- a set of serving cells, by *ci-ConfigurationPerServingCell*,that includes a set of serving cell indexes and a corresponding set of locations for fields in DCI format 2\_4 by *positionInDCI*

- a number of fields in DCI format 2\_4, by *positionInDCI-forSUL*, for each serving cell for a SUL carrier, if the serving cell is configured with a SUL carrier

- an information payload size for DCI format 2\_4 by *dci-PayloadSize-ForCI*

- an indication for time-frequency resources by *timeFrequencyRegion*

For a serving cell having an associated field in a DCI format 2\_4, for the field denote by

- a number of bits provided by *ci-PayloadSize*

- a number of PRBs provided by *frequencyRegionforCI* in *timeFrequencyRegion*

- a number of symbols, excluding symbols for reception of SS/PBCH blocks and DL symbols indicated by *tdd-UL-DL-ConfigurationCommon*, from a number of symbols that

- is provided by *timeDurationforCI* in *timeFrequencyRegion*, if the PDCCH monitoring periodicity for the search space set with the DCI format 2\_4 is one slot and there are more than one PDCCH monitoring occasions in a slot, or

- is equal to the PDCCH monitoring periodicity, otherwise.

- a number of partitions for the symbols provided by *timeGranularityforCI* in *timeFrequencyRegion*

sets of bits from the MSB of the bits have a one-to-one mapping with groups of symbols where each of the first groups includes symbols and each of the remaining groups includes symbols. A UE determines a symbol duration with respect to a SCS configuration of an active DL BWP where the UE monitors PDCCH for DCI format 2\_4 detection.

For a group of symbols, bits from MSB of each set of bits have a one-to-one mapping with groups of PRBs where each of the first groups includes PRBs and each of the remaining groups includes PRBs. A UE determines a first PRB index as and a number of contiguous RBs as from *frequencyRegionforCI* that indicates an offset and a length as RIV according to [6, TS 38.214], and from *offsetToCarrier* in FrequencyInfoUL-SIB or FrequencyInfoUL that indicates for a SCS configuration of an active DL BWP where the UE monitors PDCCH for DCI format 2\_4 detection.

An indication by a DCI format 2\_4 for a serving cell is applicable to a PUSCH transmission or an SRS transmission on the serving cell. If the PUSCH transmission or the SRS transmission is scheduled by a DCI format, the indication by the DCI format 2\_4 is applicable to the PUSCH transmission or SRS transmission only if the last symbol of the PDCCH reception providing the DCI format is earlier than the first symbol of the PDCCH reception providing the DCI format 2\_4. If the UE detects the DCI format 2\_4 from two PDCCH receptions in search space sets and that include *searchSpaceLinking* with value and , respectively, as described in clause 10.1, the UE considers the PDCCH reception providing the DCI format 2\_4 to be the one from the two PDCCH receptions that starts earlier.

For the serving cell, the UE determines the first symbol of the symbols to be the first symbol that is after from the end of a PDCCH reception where the UE detects the DCI format 2\_4, where is obtained from for PUSCH processing capability 2 [6, TS 38.214] assuming where is provided by *delta\_Offset*, being the smallest SCS configuration between the SCS configuration of the PDCCH and the smallest SCS configuration provided in *scs-SpecificCarrierList* of *FrequencyInfoUL* or *FrequencyInfoUL-SIB*. The UE does not expect to cancel the PUSCH transmission or the SRS transmission before a corresponding symbol that is assuming that after a last symbol of the PDCCH reception where the UE detects the DCI format 2\_4.

A UE that detects a DCI format 2\_4 for a serving cell cancels a PUSCH transmission or an actual repetition of a PUSCH transmission [6, TS 38.214] if the PUSCH transmission is with repetition Type B, as determined in clauses 9 and 9.2.5 or in clause 6.1 of [6, TS 38.214], or an SRS transmission on the serving cell if, respectively,

- the transmission is PUSCH with priority 0, if the UE is provided *uplinkCancellationPriority*,

- a group of symbols, from the symbols, has at least one bit value of '1' in the corresponding set of bits in the DCI format 2\_4 and includes a symbol of the (repetition of the) PUSCH transmission or of the SRS transmission, and

- a group of PRBs, from the PRBs, has a corresponding bit value of '1' in the set of bits corresponding to the group of symbols in the DCI format 2\_4 and includes a PRB of the (repetition of the) PUSCH transmission or of the SRS transmission,

where

- the cancellation of the (repetition of the) PUSCH transmission includes all symbols from the earliest symbol of the (repetition of the) PUSCH transmission that is in a group of symbols having corresponding bit values of '1' in the DCI format 2\_4;

- the cancellation of the SRS transmission includes only symbols that are in one or more groups of symbols having corresponding bit values of '1' in the DCI format 2\_4.

If, based on an indication by a DCI format 2\_4, a UE cancels a PUSCH transmission or an SRS transmission, the UE does not expect to be scheduled by a second DCI format to transmit a PUSCH or an SRS over symbols that include symbols of the cancelled PUSCH transmission or SRS transmission, where the last symbol of the PDCCH reception providing the second DCI format is later than the first symbol of the PDCCH reception providing the DCI format 2\_4.

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

# 12 Bandwidth part operation

If the 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.

A UE configured for operation in bandwidth parts (BWPs) of a serving cell, is configured by higher layers for the serving cell a set of at most four bandwidth parts (BWPs) for receptions by the UE (DL BWP set) in a DL bandwidth by parameter *BWP-Downlink* or by parameter *initialDownlinkBWP* with a set of parameters configured by *BWP-DownlinkCommon* and *BWP-DownlinkDedicated*, and a set of at most four BWPs for transmissions by the UE (UL BWP set) in an UL bandwidth by parameter *BWP-Uplink* or by parameter *initialUplinkBWP* with a set of parameters configured by *BWP-UplinkCommon* and *BWP-UplinkDedicated*.

For operation with shared spectrum channel access, a UE expects that the BWP configured by the parameter *initialUplinkBWP* provided in *UplinkConfigCommonSIB* is mapped to only a single RB set.

If a UE is not provided *initialDownlinkBWP*, an initial DL BWP is defined by a location and number of contiguous PRBs, starting from a PRB with the lowest index and ending at a PRB with the highest index among PRBs of a CORESET for Type0-PDCCH CSS set, and a SCS and a cyclic prefix for PDCCH reception in the CORESET for Type0-PDCCH CSS set; otherwise, the initial DL BWP is provided by *initialDownlinkBWP*. For operation on the primary cell or on a secondary cell, a UE is provided an initial UL BWP by *initialUplinkBWP*. If the UE is configured with a supplementary UL carrier, the UE can be provided an initial UL BWP on the supplementary UL carrier by *initialUplinkBWP*.

If a UE has dedicated BWP configuration, the UE can be provided by *firstActiveDownlinkBWP-Id* a first active DL BWP for receptions and by *firstActiveUplinkBWP-Id* a first active UL BWP for transmissions on a carrier of the primary cell.

For each DL BWP or UL BWP in a set of DL BWPs or UL BWPs, respectively, the UE is provided the following parameters for the serving cell as defined in [4, TS 38.211] or [6, TS 38.214]:

- a SCS by *subcarrierSpacing*

- a cyclic prefix by *cyclicPrefix*

- a common RB and a number of contiguous RBs provided by *locationAndBandwidth* that indicates an offset and a length as RIV according to [6, TS 38.214], setting , and a value provided by *offsetToCarrier* for the *subcarrierSpacing*

- an index in the set of DL BWPs or UL BWPs by respective *BWP-Id*

- a set of BWP-common and a set of BWP-dedicated parameters by *BWP-DownlinkCommon* and *BWP-DownlinkDedicated* for the DL BWP, or *BWP-UplinkCommon* and *BWP-UplinkDedicated* for the UL BWP [12, TS 38.331]

For unpaired spectrum operation, a DL BWP from the set of configured DL BWPs with index provided by *BWP-Id* is linked with an UL BWP from the set of configured UL BWPs with index provided by *BWP-Id* when the DL BWP index and the UL BWP index are same. For unpaired spectrum operation, a UE does not expect to receive a configuration where the center frequency for a DL BWP is different than the center frequency for an UL BWP when the *BWP-Id* of the DL BWP is same as the *BWP-Id* of the UL BWP.

For each DL BWP in a set of DL BWPs of the PCell, a UE can be configured CORESETs for every type of CSS sets and for USS as described in clause 10.1. The UE does not expect to be configured without a CSS set on the PCell in the active DL BWP.

If a UE is provided *controlResourceSetZero* and *searchSpaceZero* in *PDCCH-ConfigSIB1* or *PDCCH-ConfigCommon*, the UE determines a CORESET for a search space set from *controlResourcesetZero* as described in clause 13 and for Tables 13-1 through 13-10, and determines corresponding PDCCH monitoring occasions as described in clause 13 and for Tables 13-11 through 13-15. If the active DL BWP is not the initial DL BWP, the UE determines PDCCH monitoring occasions for the search space set only if the CORESET bandwidth is within the active DL BWP and the active DL BWP has same SCS configuration and same cyclic prefix as the initial DL BWP.

For each UL BWP in a set of UL BWPs of the PCell or of the PUCCH-SCell, the UE is configured resource sets for PUCCH transmissions as described in clause 9.2.1.

A UE receives PDCCH and PDSCH in a DL BWP according to a configured SCS and CP length for the DL BWP. A UE transmits PUCCH and PUSCH in an UL BWP according to a configured SCS and CP length for the UL BWP.

If a bandwidth part indicator field is configured in a DCI format, the bandwidth part indicator field value indicates the active DL BWP, from the configured DL BWP set, for DL receptions as described in [5, TS 38.212]. If a bandwidth part indicator field is configured in a DCI format, the bandwidth part indicator field value indicates the active UL BWP, from the configured UL BWP set, for UL transmissions as described in [5, TS 38.212]. If a bandwidth part indicator field is configured in a DCI format and indicates an UL BWP or a DL BWP different from the active UL BWP or DL BWP, respectively, the UE shall

- for each information field in the DCI format

- if the size of the information field is smaller than the one required for the DCI format interpretation for the UL BWP or DL BWP that is indicated by the bandwidth part indicator, the UE prepends zeros to the information field until its size is the one required for the interpretation of the information field for the UL BWP or DL BWP prior to interpreting the DCI format information fields, respectively

- if the size of the information field is larger than the one required for the DCI format interpretation for the UL BWP or DL BWP that is indicated by the bandwidth part indicator, the UE uses a number of least significant bits of the DCI format equal to the one required for the UL BWP or DL BWP indicated by bandwidth part indicator prior to interpreting the DCI format information fields, respectively

- set the active UL BWP or DL BWP to the UL BWP or DL BWP indicated by the bandwidth part indicator in the DCI format

If a bandwidth part indicator field is configured in a DCI format 0\_1 and indicates an active UL BWP with different SCS configuration , or with different number of RB sets, than a current active UL BWP, the UE determines an uplink frequency domain resource allocation Type 2 based on bits and bits that are generated by independently truncating or padding the MSBs and the LSBs [6, TS 38.214] of the frequency domain resource assignment field of DCI format 0\_1, where truncation starts from the MSBs of the X bits or the Y bits, zero-padding prepends zeros to the X bits or the Y bits, and

- if the indicated active UL BWP has SCS configuration and the current active BWP has SCS configuration , the MSBs are truncated to bits, or

- if the indicated active UL BWP has SCS configuration and the current active BWP has SCS configuration , the MSBs are zero-padded to bits

- otherwise, the MSBs are unchanged

and

- the LSBs are truncated or zero-padded to bits where is a number of RB sets configured for the indicated active UL BWP

A UE does not expect to detect a DCI format with a BWP indicator field that indicates an active DL BWP or an active UL BWP change with the corresponding time domain resource assignment field providing a slot offset value for a PDSCH reception or PUSCH transmission that is smaller than a delay required by the UE for an active DL BWP change or UL BWP change, respectively [10, TS 38.133].

If a UE detects a DCI format with a BWP indicator field that indicates an active DL BWP change for a cell, the UE is not required to receive or transmit in the cell during a time duration from the end of the third symbol of a slot where the UE receives the PDCCH that includes the DCI format in a scheduling cell until the beginning of a slot indicated by the slot offset value of the time domain resource assignment field in the DCI format.

If a UE detects a DCI format with SCell dormancy indication that indicates an active DL BWP change for an Scell in slot *n* of primary cell, the UE is not required to receive or transmit in the SCell during a time duration specified in [10, TS 38.133].

If a UE detects a DCI format indicating an active UL BWP change for a cell, the UE is not required to receive or transmit in the cell during a time duration from the end of the third symbol of a slot where the UE receives the PDCCH that includes the DCI format in the scheduling cell until the beginning of a slot indicated by the slot offset value of the time domain resource assignment field in the DCI format.

A UE does not expect to detect a DCI format indicating an active DL BWP change or an active UL BWP change for a scheduled cell within FR1 (or FR2) in a slot other than the first slot of a set of slots for the DL SCS of the scheduling cell that overlaps with a time duration where the UE is not required to receive or transmit, respectively, for an active BWP change in a different cell from the scheduled cell within FR1 (or FR2).

A UE expects to detect a DCI format with a BWP indicator field that indicates an active UL BWP change or an active DL BWP change only if a corresponding PDCCH is received within the first 3 symbols of a slot. If the UE detects the DCI format from two PDCCH receptions in search space sets and that include *searchSpaceLinking* with value and , respectively, as described in clause 10.1, the UE considers the PDCCH reception where the UE detects the DCI format to be the one from the two PDCCH receptions that ends later.

For a serving cell, a UE can be provided by *defaultDownlinkBWP-Id* a default DL BWP among the configured DL BWPs. If a UE is not provided a default DL BWP by *defaultDownlinkBWP-Id*, the default DL BWP is the initial DL BWP.

If a UE is provided by *bwp-InactivityTimer* a timer value for the serving cell [11, TS 38.321] and the timer is running, the UE decrements the timer at the end of a subframe for FR1 or at the end of a half subframe for FR2 if the restarting conditions in [11, TS 38.321] are not met during the interval of the subframe for FR1 or of the half subframe for FR2.

For a cell where a UE changes an active DL BWP due to a BWP inactivity timer expiration and for accommodating a delay in the active DL BWP change or the active UL BWP change required by the UE [10, TS 38.133], the UE is not required to receive or transmit in the cell during a time duration from the beginning of a subframe for FR1, or of half of a subframe for FR2, that is immediately after the BWP inactivity timer expires until the beginning of a slot where the UE can receive or transmit.

When a UE's BWP inactivity timer for a cell within FR1 (or FR2) expires within a time duration where the UE is not required to receive or transmit for an active UL/DL BWP change in the cell or in a different cell within FR1 (or FR2), the UE delays the active UL/DL BWP change triggered by the BWP inactivity timer expiration until a subframe for FR1 or half a subframe for FR2 that is immediately after the UE completes the active UL/DL BWP change in the cell or in the different cell within FR1 (or FR2).

If a UE is provided by *firstActiveDownlinkBWP-Id* a first active DL BWP and by *firstActiveUplinkBWP-Id* a first active UL BWP on a carrier of a secondary cell, the UE uses the indicated DL BWP and the indicated UL BWP as the respective first active DL BWP on the secondary cell and first active UL BWP on the carrier of the secondary cell.

A UE does not expect to monitor PDCCH when the UE performs RRM measurements [10, TS 38.133] over a bandwidth that is not within the active DL BWP for the UE.

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