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

**Toulouse, France, August 21st – 25th, 2023**

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| *CR-Form-v12.2* |
| **DRAFT CHANGE REQUEST** |
|  |
|  | **38.214** | **CR** | **-** | **rev** | **-** | **Current version:** | **17.6.0** |  |
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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:***  |

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| Introduction of multi-cell PDSCH / PUSCH scheduling |
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| ***Source to WG:*** | Nokia |
| ***Source to TSG:*** | R1 |
|  |  |
| ***Work item code:*** | NR\_MC\_enh-Core |  | ***Date:*** | 2023-09-08 |
|  |  |  |  |  |
| ***Category:*** | **B** |  | ***Release:*** | Rel-18 |
|  | *Use one of the following categories:****F*** *(correction)****A*** *(mirror corresponding to a change in an earlier release)****B*** *(addition of feature),* ***C*** *(functional modification of feature)****D*** *(editorial modification)*Detailed explanations of the above categories canbe found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | *Use one of the following releases:Rel-8 (Release 8)Rel-9 (Release 9)Rel-10 (Release 10)Rel-11 (Release 11)…Rel-16 (Release 16)Rel-17 (Release 17)Rel-18 (Release 18)Rel-19 (Release 19)* |
|  |  |
| ***Reason for change:*** | Introduction of multi-cell PDSCH / PUSCH scheduling using DCI format 0\_3 & 1\_3 |
|  |  |
| ***Summary of change:*** | Introduction of multi-cell PUSCH scheduling using DCI format 0\_3 in clauses Introduction of multi-cell PDSCH scheduling using DCI format 1\_3 in clauses |
|  |  |
| ***Consequences if not approved:*** | Multi-cell PDSCH / PUSCH scheduling using DCI format 0\_3 & 1\_3 not supported |
|  |  |
| ***Clauses affected:*** | 5.1, 5.1.2.1, 5.1.2.1.1, 5.1.2.2, 5.1.2.2.1, 5.1.2.2.2, 5.1.2.3, 5.1.3, 5.1.3.1, 5.1.3.2, 5.1.4.1, 5.1.4.2. 5.1.5, 5.1.6.2, 5.1.6.3, 5.1.7, 5.2.1, 5.2.1.4, 5.2.3, 5.3.16.1, 6.1.1, 6.1.1.1, 6.1.1.2, 6.1.2.1, 6.1.2.1.1, 6.1.2.2, 6.1.2.2.1, 6.1.2.2.2, 6.1.2.3.1, 6.1.2.3.2, 6.1.4, 6.1.4.1, 6.1.4.2, 6.1.5, 6.1.7, 6.2.1, 6.2.2, 6.2.3, 6.2.3.1, 6.3.1 |
|  |  |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  |  Other core specifications  | TS 38.211, TS 38.212, TS 38.213  |
| ***affected:*** |  | **X** |  Test specifications |  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications |  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

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5 Physical downlink shared channel related procedures

5.1 UE procedure for receiving the physical downlink shared channel

For downlink, a maximum of 16 HARQ processes per cell are supported by the UE, or subject to UE capability, a maximum of 32 HARQ processes per cell as defined in [13, TS 38.306]. The number of processes the UE may assume will at most be used for the downlink is configured to the UE for each cell separately by higher layer parameter *nrofHARQ-ProcessesForPDSCH* or *nrofHARQ-ProcessesForPDSCH-v1700*, and when no configuration is provided the UE may assume a default number of 8 processes.

A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1, 1\_2, 1\_3, 4\_0, 4\_1 or 4\_2 decode the corresponding PDSCHs as indicated by that DCI. When the UE is scheduled with multiple PDSCHs on a serving cell by a DCI, HARQ process ID indicated by this DCI applies to the first PDSCH not overlapping with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, HARQ process ID is then incremented by 1 for each subsequent PDSCH(s) in the scheduled order, with modulo operation of *nrofHARQ-ProcessesForPDSCH* applied if *nrofHARQ-ProcessesForPDSCH* is provided, or with modulo operation of *nrofHARQ-ProcessesForPDSCH-v1700* applied if or *nrofHARQ-ProcessesForPDSCH-v1700* is provided, or with modulo operation of 8 applied, otherwise. HARQ process ID is not incremented for PDSCH(s) not received if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided. When a UE is configured by the higher layer parameter *repetitionScheme* set to 'tdmSchemeA’, the PDSCH includes two PDSCH transmission occasions. For each PDSCH, if either PDSCH occasion overlaps with a UL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, the PDSCH is not received and HARQ process ID is not increment for the PDSCH. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH if the UE is not capable of receiving FDMed unicast and multicast PDSCH per slot per carrier. When HARQ feedback for the HARQ process ID is not disabled, or for the HARQ process associated with the first SPS PDSCH when *HARQ-feedbackEnablingforSPSactive* is provided and enabled, the UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6, TS 38.213]. For HARQ-ACK subject to HARQ-ACK deferral described in Clause 9.2.5.4 of [6 TS 38.213], the expected transmission of HARQ-ACK corresponds to the expected transmission HARQ-ACK in a first slot. When HARQ feedback for the HARQ process ID is disabled, the UE is not expected to receive another PDCCH carrying a DCI scheduling a PDSCH or set of slot-aggregated PDSCH scheduled for the given HARQ process or to receive another PDSCH without corresponding PDCCH for the given HARQ process that starts until Tproc,1 after the end of the reception of the last PDSCH or slot-aggregated PDSCH for that HARQ process. Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* and PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,* in a given scheduled cell, the UE is not expected to receive a first PDSCH and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH, where the two resources are in different slots for the associated HARQ-ACK transmissions, each slot is composed of symbols [4] or a number of symbols indicated by *subslotLengthForPUCCH* if provided, and the HARQ-ACK for the two PDSCHs are associated with the HARQ-ACK codebook of the same priority. Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* and PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,* in a given scheduled cell, the UE is not expected to receive a first PDSCH, and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH if the HARQ-ACK for the two PDSCHs are associated with HARQ-ACK codebooks of different priorities. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol *j* by a PDCCH ending in symbol *i* on a scheduling cell, the UE is not expected to be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH that ends later than symbol *i* of a scheduling cell,. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], the PDCCH ending in symbol *i* is determined based on the PDCCH candidate that ends later in time. In a given scheduled cell, for any PDSCH corresponding to SI-RNTI, the UE is not expected to decode a re-transmission of an earlier PDSCH with a starting symbol less than *N* symbols after the last symbol of that PDSCH, where the value of *N* depends on the PDSCH subcarrier spacing configuration *μ,* with *N*=13 for *μ*=0, *N*=13 for *μ*=1, *N*=20 for *μ*=2, *N*=24 for *μ*=3, *N*=96 for *m*=5, and *N*=192 for *m*=6.

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When a UE is not indicated with a DCI that DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, and it is indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* and DM-RS port(s) within two CDM groups in the DCI field '*Antenna Port(s)'* and it is not configured with higher layer parameter *sfnSchemePdsch*, the UE may expect to receive a single PDSCH where the association between the DM-RS ports and the TCI states are as defined in Clause 5.1.6.2.

When a UE is not indicated with a DCI that DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, and it is indicated with one TCI states in a codepoint of the DCI field *'Transmission Configuration Indication',* the UE procedure for receiving the PDSCH upon detection of a PDCCH follows Clause 5.1.

When a UE is configured with higher layer parameter *sfnSchemePdsch* set to either *'*sfnSchemeA*'* or *'*sfnSchemeB*'* and

- if the UE reports its capability of *sfn-SchemeA-DynamicSwitching-r17* or *sfn-SchemeB-DynamicSwitching-r17*, the UE is indicated with one or two TCI state(s) in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, or

- otherwise, the UE is not expected to be indicated with one TCI state per any of TCI codepoint by MAC CE, and the UE is indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* in DCI format 1\_1/1\_2, and

the UE procedure for receiving the PDSCH upon detection of a PDCCH follows clause 5.1 and the QCL assumption for the PDSCH as defined in clause 5.1.5.

When a UE is configured with both *sfnSchemePdsch* and *sfnSchemePdcch*, the UE shall expect that *sfnSchemePdsch* and *sfnSchemePdcch* are set to the same scheme, either *'*sfnSchemeA*'* or *'*sfnSchemeB*'*.

If a UE is configured with *sfnSchemePdcch* set to 'sfnSchemeA' and activated with two TCI states by MAC CE, and the UE does not report its capability of *sfn-SchemeA-PDCCH-only*, the UE is expected to be configured with *sfnSchemePdsch* set to *'sfnSchemeA'* and indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication',* if the PDSCH is scheduled by DCI format 1\_1/1\_2.

If a UE is configured with *sfnSchemePdcch* set to 'sfnSchemeB' and activated with two TCI states by MAC CE, the UE is expected to be configured with *sfnSchemePdsch* set to *'sfnSchemeB'* and indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication',* if the PDSCH is scheduled by DCI format 1\_1/1\_2.

When a UE is configured with *sfnSchemePdsch* and/or *sfnSchemePdcch*, the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same within a CC, and the UE shall expect that the *sfnSchemePdsch* and/or *sfnSchemePdcch* configuration are the same in all CCs in a same frequency band if the UE is configured with CA, where the UE does not expect to be configured with *sfnSchemePdsch* and/or *sfnSchemePdcch* in initial BWP in each CC.

If more than one PDSCH on a serving cell each without a corresponding PDCCH transmission are in a slot, after resolving overlapping with symbols in the slot indicated as uplink by *tdd-UL-DL-ConfigurationCommon*, or by *tdd-UL-DL-ConfigurationDedicated*, a UE receives one or more PDSCHs without corresponding PDCCH transmissions in the slot as specified below.

‒ Step 0: set *j=0*, where *j* is thenumber of selected PDSCH(s) for decoding. *Q* is the set of activated PDSCHs without corresponding PDCCH transmissions within the slot

‒ Step 1: A UE receives one PDSCH with the lowest configured *sps-ConfigIndex* within *Q*, set *j=j+1*. Designate the received PDSCH as survivor PDSCH.

‒ Step 2: The survivor PDSCH in step 1 and any other PDSCH(s) overlapping (even partially) with the survivor PDSCH in step 1 are excluded from *Q*.

‒ Step 3: Repeat step 1 and 2 until *Q* is empty or *j* is equal to the number of unicast/multicast PDSCHs in a slot supported by the UE

<omitted text>

5.1.2 Resource allocation

5.1.2.1 Resource allocation in time domain

When the UE is scheduled to receive PDSCH by a DCI, the *Time domain resource assignment* field value *m* for the scheduled PDSCH on the serving cell provides a row index *m* + 1 to a resource allocation table. The determination of the used resource allocation table is defined in Clause 5.1.2.1.1. The indexed row defines the slot offset *K0*, the start and length indicator *SLIV*, or directly the start symbol *S* and the allocation length *L*, and the PDSCH mapping type to be assumed in the PDSCH reception.

<omitted text>

When receiving PDSCH scheduled by DCI format 1\_1, 1\_2 or 1\_3 in PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, or scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by CS-RNTI with NDI=1, if the UE is configured with *pdsch-AggregationFactor* in *pdsch-config*, the same symbol allocation is applied across the *pdsch-AggregationFactor* consecutive slots. When receiving PDSCH scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by CS-RNTI with NDI=0, or PDSCH scheduled without corresponding PDCCH transmission using *sps-Config* and activated by DCI format 1\_1 or 1\_2, the same symbol allocation is applied across the *pdsch-AggregationFactor*, in *sps-Config* if configured, or across the *pdsch-AggregationFactor* in *pdsch-config* otherwise, consecutive slots. The UE may expect that the TB is repeated within each symbol allocation among each of the *pdsch-AggregationFactor* consecutive slots and the PDSCH is limited to a single transmission layer. For PDSCH scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by CS-RNTI with NDI=0, or PDSCH scheduled without corresponding PDCCH transmission using *sps-Config* and activated by DCI format 1\_1 or 1\_2, the UE is not expected to be configured with the time duration for the reception of *pdsch-AggregationFactor* repetitions, in *sps-Config* if configured, or across the *pdsch-AggregationFactor* in *pdsch-config* otherwise, larger than the time duration derived by the periodicity P obtained from the corresponding *sps-Config*. The redundancy version to be applied on the *n*th transmission occasion of the TB, where *n* = 0, 1, …*pdsch-AggregationFactor* -1, is determined according to table 5.1.2.1-2 and "*rvid* indicated by the DCI scheduling the PDSCH" in table 5.1.2.1-2 is assumed to be 0 for PDSCH scheduled without corresponding PDCCH transmission using *sps-Config* and activated by DCI format 1\_1 or 1\_2.

<omitted text>

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH* in which one or more rows contain multiple SLIVs for PDSCH, the UE does not expect to be configured with higher layer parameter *repetitionNumber* in *pdsch-TimeDomainAllocationListForMultiPDSCH*.

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH* in which one or more rows contain multiple SLIVs for PDSCH on a DL BWP of a serving cell, the UE does not apply *pdsch-AggregationFactor* in *PDSCH-config*, if configured, to DCI format 1\_1 on the DL BWP of the serving cell.

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH* in which one or more rows contain multiple *SLIV*s for PDSCH on a DL BWP of a serving cell, when any two DL DCIs end in the same symbol and at least one of the DCIs schedules multiple PDSCHs, the UE does not expect that the scheduled PDSCH(s) by the two DCIs have overlapping spans, where the span associated with a DCI is defined from the beginning of the first scheduled PDSCH or up to the end of the last scheduled PDSCH.

If a UE is configured with *pdsch-TimeDomainAllocationListForMultiPDSCH* in which one or more rows contain multiple SLIVs for PDSCH on a DL BWP of a serving cell within a PUCCH group, the UE does not expect to be configured with higher layer parameter *ScheduledCell-ListDCI-1-3* on any serving cell within the PUCCH group.

<omitted text>

When the UE is configured with *minimumSchedulingOffsetK0* in an active DL BWP it applies a minimum scheduling offset restriction indicated by the 'Minimum applicable scheduling offset indicator'field in DCI format 0\_1, 0\_3, 1\_1, 1\_3, if the same field is available. When the UE is configured with *minimumSchedulingOffsetK0* in an active DL BWP and it has not received 'Minimum applicable scheduling offset indicator' field in DCI format 0\_1, 0\_3, 1\_1 or 1\_3, the UE shall apply a minimum scheduling offset restriction indicated based on 'Minimum applicable scheduling offset indicator' value '0'. When the minimum scheduling offset restriction is applied the UE is not expected to be scheduled with a DCI in slot *n* to receive a PDSCH scheduled with C-RNTI, CS-RNTI or MCS-C-RNTI with *K*0 smaller than , where *K*0minand are the applied minimum scheduling offset restriction and the numerology of the active DL BWP of the scheduled cell when receiving the DCI in slot *n,* respectively, and is the numerology of the new active DL BWP in case of active DL BWP change in the scheduled cell and is equal to , otherwise. The minimum scheduling offset restriction is not applied when PDSCH transmission is scheduled with C-RNTI, CS-RNTI or MCS-C-RNTI in common search space associated with CORESET0 and default PDSCH time domain resource allocation is used, in the search space set provided by *recoverySearchSpaceId* when monitoring PDCCH as described in [6, TS 38.213] or when PDSCH transmission is scheduled with SI-RNTI, MSGB-RNTI or RA-RNTI. The application delay of the change of the minimum scheduling offset restriction is determined in Clause 5.3.1.

<omitted text>

5.1.2.1.1 Determination of the resource allocation table to be used for PDSCH

Table 5.1.2.1.1-1 and Table 5.1.2.1.1-1A define which PDSCH time domain resource allocation configuration to apply. Either a default PDSCH time domain allocation A, B or C according to tables 5.1.2.1.1-2, 5.1.2.1.1-3, 5.1.2.1.1-4 and 5.1.2.1.1-5 is applied, or the higher layer configured *pdsch-TimeDomainAllocationList* or *pdsch-TimeDomainAllocationListForMultiPDSCH* or *pdsch-TimeDomainAllocationListDCI-1-2* is applied. For operation with shared spectrum channel access in frequency range 1, as described in [16, TS 37.213], UE reinterprets *S* and *L* in row 9 of Table 5.1.2.1.1-2 as *S=6* and *L=7*.

**Table 5.1.2.1.1-1: Applicable PDSCH time domain resource allocation for DCI formats 1\_0, 1\_1, 1\_3, 4\_0, 4\_1 and 4\_2**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **RNTI** | **PDCCH search space** | **SS/PBCH block and CORESET multiplexing pattern** | ***PDSCH-ConfigCommon* includes *pdsch-TimeDomainAllocationList*** | ***PDSCH-Config* includes *pdsch-TimeDomainAllocationList*** | ***pdsch-ConfigMCCH / pdsch-ConfigMTCH*  includes *pdsch-TimeDomainAllocationList******Or*** ***pdsch-ConfigMulticast* includes *pdsch-TimeDomainAllocationList*** | ***PDSCH-Config* includes *pdsch-TimeDomainAllocationListForMultiPDSCH*** | **PDSCH time domain resource allocation to apply** |
| SI-RNTI | Type0 common | 1 | - | - | - | - | Default A for normal CP |
| 2 | - | - | - | - | Default B |
| 3 | - | - | - | - | Default C |
| SI-RNTI | Type0A common | 1 | No | - | - | - | Default A |
| 2 | No | - | - | - | Default B |
| 3 | No | - | - | - | Default C |
| 1,2,3 | Yes | - | - | - | *Pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| RA-RNTI, MSGB-RNTI, TC-RNTI | Type1 common | 1,2,3 | No | - | - | - | Default A |
| 1,2,3 | Yes | - | - | - | *Pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| P-RNTI | Type2 common | 1 | No | - | - | - | Default A |
| 2 | No | - | - | - | Default B |
| 3 | No | - | - | - | Default C |
| 1,2,3 | Yes | - | - | - | *Pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| MCCH-RNTI  | Type 0/0B common for broadcast | 1 | No | - | No | *-* | Default A |
| 2 | No | - | No | *-* | Default B |
| 3 | No | - | No | *-* | Default C |
| 1,2,3 | Yes | - | No | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| 1,2,3 | No/Yes | - | Yes | *-* | *pdsch-TimeDomainAllocationList provided in pdsch-ConfigMCCH* |
| G-RNTI for broadcast | Type 0/0B common for broadcast | 1 | No | - | No | *-* | Default A |
| 2 | No | - | No | *-* | Default B |
| 3 | No | - | No | *-* | Default C |
| 1,2,3 | Yes | - | No | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| 1,2,3 | No/Yes | - | Yes | *-* | *pdsch-TimeDomainAllocationList* provided in *pdsch-ConfigMTCH,* if configured, otherwise *TimeDomainAllocationList* provided in *pdsch-ConfigMCCH* |
| C-RNTI, MCS-C-RNTI, CS-RNTI | Any common search space associated with CORESET 0 | 1, 2, 3 | No | - | - | - | Default A |
| 1, 2, 3 | Yes | - | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon* |
| C-RNTI, MCS-C-RNTI, CS-RNTI | Any common search space not associated with CORESET 0UE specific search space | 1,2,3 | No | No | - | - | Default A |
| 1,2,3 | Yes | No | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon*  |
| 1,2,3 | No/Yes | Yes | - | *-* | *pdsch-TimeDomainAllocationList* provided in *PDSCH-Config* |
| 1,2,3 | No/Yes | - | - | Yes | *pdsch-TimeDomainAllocationListForMultiPDSCH-r17* provided in *PDSCH-Config (Note 2)* |
| G-RNTI for multicast, G-CS-RNTI  | Type 3 common search space for multicast | 1,2,3 | No | - | No | - | *Default A* |
| 1,2,3 | Yes | - | No | - | *pdsch-TimeDomainAllocationList* provided in *PDSCH-ConfigCommon (Note 1)* |
| 1,2,3 | No/Yes | - | Yes | - | *pdsch-TimeDomainAllocationList* provided in *pdsch-ConfigMulticast**(Note 1)* |
| Note 1: For a UE that supports multicast, the same TDRA table applies to all G-RNTIs and G-CS-RNTIs (configured for multicast) if configured on a given serving cell.Note 2: If *pdsch-TimeDomainAllocationListForMultiPDSCH* is provided, it is applicable to DCI format 1\_1 only. |

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5.1.2.2 Resource allocation in frequency domain

Two downlink resource allocation schemes, type 0 and type 1, are supported. The UE shall assume that when the scheduling grant is received with DCI format 1\_0, 4\_0 or 4\_1 then downlink resource allocation type 1 is used.

If the scheduling DCI is configured to indicate the downlink resource allocation type as part of the '*Frequency domain resource assignment'* field by setting a higher layer parameter *resourceAllocation* in *PDSCH-Config* to 'dynamicSwitch', for DCI format 1\_1 or setting a higher layer parameter *resourceAllocationDCI-1-2* in *PDSCH-Config* to 'dynamicSwitch' for DCI format 1\_2 or setting a higher layer parameter *resourceAllocationDCI-1-3* in *PDSCH-Config* to 'dynamicSwitch' for DCI format 1\_3 or setting a higher layer parameter *resourceAllocation* in *pdsch-ConfigMulticast* to 'dynamicSwitch' for DCI format 4\_2, the UE shall use downlink resource allocation type 0 or type 1 as defined by this DCI field. Otherwise the UE shall use the downlink frequency resource allocation type as defined by the higher layer parameter *resourceAllocation* in *PDSCH-Config* for DCI format 1\_1 or by the higher layer parameter *resourceAllocationDCI-1-2* for DCI format 1\_2 or by the higher layer parameter *resourceAllocationDCI-1-3* for DCI format 1\_3 or by the higher layer parameter *resourceAllocation* in *pdsch-ConfigMulticast* for DCI format 4\_2.

If a bandwidth part indicator field is not configured in the scheduling DCI or the UE does not support active BWP change via DCI, the RB indexing for downlink type 0 and type 1 resource allocation is determined within the UE's active bandwidth part. If a bandwidth part indicator field is configured in the scheduling DCI and the UE supports active BWP change via DCI, the RB indexing for downlink type 0 and type 1 resource allocation is determined within the UE's bandwidth part indicated by bandwidth part indicator field value in the DCI. The UE shall upon detection of PDCCH intended for the UE determine first the downlink bandwidth part and then the resource allocation within the bandwidth part.

For a PDSCH scheduled with a DCI format 1\_0 in any type of PDCCH common search space, regardless of which bandwidth part is the active bandwidth part, RB numbering starts from the lowest RB of the CORESET in which the DCI was received; otherwise RB numbering starts from the lowest RB in the determined downlink bandwidth part. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the downlink RB set of a PDSCH when scheduled by DCI format 1\_0, the CORESET with lower ID among two CORESETs associated with two PDCCH candidates is used.

5.1.2.2.1 Downlink resource allocation type 0

In downlink resource allocation of type 0, the resource block assignment information includes a bitmap indicating the Resource Block Groups (RBGs) that are allocated to the scheduled UE where a RBG is a set of consecutive virtual resource blocks defined by higher layer parameter *rbg-Size* configured by *PDSCH-Config* for DCI format 1\_1 or 1\_2 or by higher layer parameter *rbg-SizeDCI-1-3* configured by *PDSCH-Config* for DCI format 1­\_3 and the size of the bandwidth part as defined in Table 5.1.2.2.1-1.

**Table 5.1.2.2.1-1: Nominal RBG size *P***

|  |  |  |  |
| --- | --- | --- | --- |
| **Bandwidth Part Size** | **Configuration 1** | **Configuration 2** | **Configuration 3** |
| 1 – 36 | 2 | 4 | 8 |
| 37 – 72 | 4 | 8 | 16 |
| 73 – 144 | 8 | 16 | 32 |
| 145 – 275 | 16 | 16 | 32 |

The total number of RBGs () for a downlink bandwidth part *i* of size PRBs is given by , where

- the size of the first RBG is ,

- the size of last RBG is if and *P* otherwise,

- the size of all other RBGs is *P*.

In downlink resource allocation of type 0 scheduled using a DCI with CRC scrambled by G-RNTI for multicast or G-CS-RNTI, the resource block assignment information bitmap is calculated based on the description above with the following changes: the parameter is the starting PRB of the CFR, is the size of the common frequency resource (CFR) and the value of the higher layer parameter *rbg-Size* is configured by *pdsch-ConfigMulticast*.

The bitmap is of size bits with one bitmap bit per RBG such that each RBG is addressable. The RBGs shall be indexed in the order of increasing frequency and starting at the lowest frequency of the bandwidth part. The order of RBG bitmap is such that RBG 0 to RBG are mapped from MSB to LSB. The RBG is allocated to the UE if the corresponding bit value in the bitmap is 1, the RBG is not allocated to the UE otherwise.

5.1.2.2.2 Downlink resource allocation type 1

In downlink resource allocation of type 1, the resource block assignment information indicates to a scheduled UE a set of contiguously allocated non-interleaved or interleaved virtual resource blocks within the active bandwidth part of size  PRBs except for the case when DCI format 1\_0 is decoded in any common search space in which case the size of CORESET 0 shall be used if CORESET 0 is configured for the cell and the size of initial DL bandwidth part shall be used if CORESET 0 is not configured for the cell.

A downlink type 1 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting virtual resource block () and a length in terms of contiguously allocated resource blocks. The resource indication value is defined by

if  then



else



where≥ 1 and shall not exceed .

When the DCI size for DCI format 1\_0 in USS is derived from the size of DCI format 1\_0 in CSS but applied to an active BWP with size of , a downlink type 1 resource block assignment field consists of a resource indication value (*RIV*) corresponding to a starting resource block and a length in terms of virtually contiguously allocated resource blocks , where  is given by

- the size of CORESET 0 if CORESET 0 is configured for the cell;

- the size of initial DL bandwidth part if CORESET 0 is not configured for the cell.

The resource indication value is defined by:

if  then



else



where, and where shall not exceed .

If , *K* is the maximum value from set {1, 2, 4, 8} which satisfies ; otherwise *K* = 1.

When the scheduling grant is received with DCI format 1\_2 or 1\_3, a downlink type 1 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting resource block group *RBGstart*=0, 1, …, *NRBG*-1 and a length in terms of virtually contiguously allocated resource block groups *LRBGs*=1, …, *NRBG*, where the resource block groups are defined as in 5.1.2.2.1 with *P* defined by *resourceAllocationType1GranularityDCI-1-2* for DCI format 1\_2 and *resourceAllocationType1GranularityDCI-1-3* for DCI format 1\_3 if the UE is configured with higher layer parameter *resourceAllocationType1GranularityDCI-1-2* or *resourceAllocationType1GranularityDCI-1-3*, and *P*=1 otherwise*.* The resource indication value is defined by

if  then



else



where≥ 1 and shall not exceed .

<omitted text>

5.1.2.3 Physical resource block (PRB) bundling

The PRB bundling procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying the parameters of *prb-BundlingTypeDCI-1-2* instead of *prb-BundlingType* as well as *vrb-ToPRB-InterleaverDCI-1-2* instead of *vrb-ToPRB-Interleaver*. The PRB bundling procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_3. The PRB bundling procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_2, by applying the parameters of *prb-BundlingType* given by *pdsch-ConfigMulticast* as well as *vrb-ToPRB-Interleaver* given by *pdsch-ConfigMulticast*.

<omitted text>

5.1.3 Modulation order, target code rate, redundancy version and transport block size determination

To determine the modulation order, target code rate, and transport block size(s) in the physical downlink shared channel, the UE shall first

- read the 5-bit modulation and coding scheme field (*IMCS*) in the DCI to determine the modulation order (*Qm*) and target code rate (*R*) based on the procedure defined in Clause 5.1.3.1, and

- read '*redundancy version'* field (*rv*) in the DCI to determine the redundancy version.

and second

- the UE shall use the number of layers (ʋ), the total number of allocated PRBs before rate matching (*nPRB*) to determine to the transport block size based on the procedure defined in Clause 5.1.3.2.

The UE may skip decoding a transport block in an initial transmission if the effective channel code rate is higher than 0.95, where the effective channel code rate is defined as the number of downlink information bits (including CRC bits) divided by the number of physical channel bits on PDSCH.

When the UE is scheduled with multiple PDSCHs on a serving cell by a DCI, as described in clause 5.1.2.1, the bits of *rv* field and NDI field, respectively, in the DCI are one-to-one mapped to the scheduled PDSCH(s) indicated by the TDRA information field with the corresponding transport block(s) in the scheduled order, where the LSB bits of the *rv* field and NDI field, respectively, correspond to the last scheduled PDSCH indicated by the TDRA information field.

The UE is not expected to handle any transport blocks (TBs) in a 14 consecutive-symbol duration for normal CP (or 12 for extended CP) ending at the last symbol of the latest PDSCH transmission within an active BWP on a serving cell whenever

where, for the serving cell,

- S is the set of TBs belonging to PDSCH(s) that are partially or fully contained in the consecutive-symbol duration

- for the *i*th TB

*- Ci'* is the number of scheduled code blocks for as defined in [5, 38.212].

*- Li* is the number of OFDM symbols assigned to the PDSCH

*- xi* is the number of OFDM symbols of the PDSCH contained in the consecutive-symbol duration

- based on the values defined in Clause 5.4.2.1 [5, TS 38.212]

- is the starting location of RV for the th transmission

- of the scheduled code blocks for the transmission

- is the circular buffer length

- is the current (re)transmission for the *i*th TB

- corresponds to the subcarrier spacing of the BWP (across all configured BWPs of a carrier) that has the largest configured number of PRBs

- in case there is more than one BWP corresponding to the largest configured number of PRBs, *µ'* follows the BWP with the largest subcarrier spacing.

- corresponds to the subcarrier spacing of the active BWP

- RLBRM = 2/3 as defined in Clause 5.4.2.1 [5, TS 38.212]

- TBSLBRM as defined based on the parameters for unicast in Clause 5.4.2.1 [5, TS 38.212]

- X as defined for downlink max MIMO layer for unicast in Clause 5.4.2.1 [5, TS 38.212].

If the UE skips decoding, the physical layer indicates to higher layer that the transport block is not successfully decoded.

Within a cell group, a UE is not required to handle PDSCH(s) transmissions including unicast and/or multicast/broadcast in slot *sj* in serving cell-*j*, and for *j* = 0,1,2.. *J-1*, slot *sj* overlapping with any given point in time, if the following condition is not satisfied at that point in time:

where,

- *J* is the number of configured serving cells belonging to a frequency range

- for the *j-th* serving cell,

*- M* is the number of TB(s) transmitted in slot *sj*. If there are two PDSCH transmission occasions of the same TB (in time domain or in frequency domain) in the slot *sj*, each transmission occasion is counted separately.

*- Tslotμ(j)* =10-3/2*μ(j)*, where *μ(j)* is the numerology for PDSCH(s) in slot *sj* of the *j*-th serving cell.

- for the *m*-th TB,

*- A* is the number of bits in the transport block as defined in Clause 7.2.1 [5, TS 38.212]

*- C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212].

*-*  is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]

- [Mbps] is computed as the maximum data rate summed over all the carriers in the frequency range for any signaled band combination and feature set consistent with the configured servings cells, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*

For a *j-*th serving cell, if higher layer parameter *processingType2Enabled* of *PDSCH-ServingCellConfig* is configured for the serving cell and set to '*enable',* or if at least one *IMCS >* *W* for a PDSCH for unicast or multicast, where *W* = 28 for MCS tables 5.1.3.1-1 and 5.1.3.1-3, and *W* = 27 for MCS table 5.1.3.1-2, and *W* = 26 for MCS table 5.1.3.1-4, or for a j-th serving cell where UE supports FDM-ed unicast and MBS PDSCH, the UE is not required to handle PDSCH transmissions, if the following condition is not satisfied:

where

- is the number of symbols assigned to the PDSCH(s). For a PDSCH that consists of two PDSCH transmission occasions in time domain in one slot, is the number of symbols of one transmission occasion. For FDMed unicast and MBS PDSCHs in one slot, is the total number of symbols of the unicast and MBS PDSCHs with fully or partially-overlapped in time domain.

- M is the number of TB(s) in the PDSCH(s)

- where *μ* is the numerology of the PDSCH(s)

- for the *m*-th TB,

*- A* is the number of bits in the transport block as defined in Clause 7.2.1 [5, TS 38.212]

*- C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212]

*-*  is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]

- [Mbps] is computed as the maximum data rate for a carrier in the frequency band of the serving cell for any signaled band combination and feature set consistent with the serving cell, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*

5.1.3.1 Modulation order and target code rate determination

For the PDSCH scheduled by a PDCCH with DCI format 1\_0, format 1\_1, format 1\_2, format 1\_3, format 4\_0, format 4\_1 or format 4\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, SI-RNTI, RA-RNTI, MSGB-RNTI, G-RNTI, G-CS-RNTI, MCCH-RNTI or P-RNTI, or for the PDSCH scheduled without corresponding PDCCH transmissions using the higher-layer-provided PDSCH configuration *SPS-Config*,

if the higher layer parameter *mcs-Table-r17* given by *PDSCH-Config* is set to 'qam1024', and the PDSCH is scheduled by a PDCCH with DCI format 1\_1 or 1\_3 with CRC scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-4 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif *mcs-TableDCI-1-2-r17* given by *PDSCH-Config* is set to 'qam1024', and the PDSCH is scheduled by a PDCCH with DCI format 1\_2 with CRC scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-4 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the higher layer parameter *mcs-TableDCI-1-2* given by *PDSCH-Config* is set to 'qam256', and the PDSCH is scheduled by a PDCCH with DCI format 1\_2 with CRC scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with MCS-C-RNTI, the higher layer parameter *mcs-TableDCI-1-2* given by *PDSCH-Config* is set to 'qam64LowSE', and the PDSCH is scheduled by a PDCCH with DCI format 1\_2 scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the higher layer parameter *mcs-Table* given by *PDSCH-Config* is set to 'qam256', and the PDSCH is scheduled by a PDCCH with DCI format 1\_1 or 1\_3 with CRC scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the higher layer parameter *mcs-Table* given by *pdsch-ConfigMulticast* is set to 'qam256', and the PDSCH is scheduled by a PDCCH with DCI format 4\_1 or 4\_2 with CRC scrambled by G-RNTI for multicast

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the higher layer parameter *mcs-Table* given by *pdsch-ConfigMCCH and pdsch-ConfigMTCH* is set to 'qam256', and the PDSCH is scheduled by a PDCCH with DCI format 4\_0 with CRC scrambled by MCCH-RNTI or G-RNTI for broadcast

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the higher layer parameter *mcs-Table* given by *pdsch-ConfigMulticast* is set to 'qam64LowSE', and the PDSCH is scheduled by a PDCCH with DCI format 4\_1 or 4\_2 with CRC scrambled by G-RNTI for multicast

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with MCS-C-RNTI, the higher layer parameter *mcs-Table* given by *PDSCH-Config* is set to 'qam64LowSE', and the PDSCH is scheduled by a PDCCH with a DCI format other than DCI format 1\_2 in a UE-specific search space with CRC scrambled by C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is configured with MCS-C-RNTI, and the PDSCH is scheduled by a PDCCH with CRC scrambled by MCS-C-RNTI

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with the higher layer parameter *mcs-Table* given by *SPS-config*, and the higher layer parameter *mcs-Table-r17* given by *PDSCH-Config* is set to 'qam1024',

- if the PDSCH is scheduled by a PDCCH with DCI format 1\_1 with CRC scrambled by CS-RNTI or

- if the PDSCH with SPS activated by DCI format 1\_1 is scheduled without corresponding PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-4 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with the higher layer parameter *mcs-Table* given by *SPS-config*, and the higher layer parameter *mcs-TableDCI-1-2-r17* given by *PDSCH-Config* is set to 'qam1024',

- if the PDSCH is scheduled by a PDCCH with DCI format 1\_2 with CRC scrambled by CS-RNTI or

- if the PDSCH with SPS activated by DCI format 1\_2 is scheduled without corresponding PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-4 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with the higher layer parameter *mcs-Table* given by *SPS-config*, and the higher layer parameter *mcs-TableDCI-1-2* given by *PDSCH-Config* is set to 'qam256',

- if the PDSCH is scheduled by a PDCCH with DCI format 1\_2 with CRC scrambled by CS-RNTI or

- if the PDSCH with SPS activated by DCI format 1\_2 is scheduled without corresponding PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is not configured with the higher layer parameter *mcs-Table* given by *SPS-Config*, and the higher layer parameter *mcs-Table* given by *PDSCH-Config* is set to 'qam256',

- if the PDSCH is scheduled by a PDCCH with DCI format 1\_1 with CRC scrambled by CS-RNTI or

- if the PDSCH with SPS activated by DCI format 1\_1 is scheduled without corresponding PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is configured with the higher layer parameter *mcs-Table* given by *SPS-Config* set to 'qam64LowSE'

- if the PDSCH is scheduled by a PDCCH with CRC scrambled by CS-RNTI or

- if the PDSCH is scheduled without corresponding PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

elseif the UE is configured with the higher layer parameter *mcs-Table* given by *SPS-Config* or *mcs-Table* of *pdsch-ConfigMulticast* in the same *CFR-ConfigMulticast* set to 'qam64LowSE'

- if the GC-PDSCH is scheduled by a GC-PDCCH with CRC scrambled by G-CS-RNTI or

- if the GC-PDSCH is scheduled without corresponding GC-PDCCH transmission using *SPS-Config*,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

else

- the UE shall use *IMCS* and Table 5.1.3.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical downlink shared channel.

end

The UE is not expected to decode a PDSCH scheduled with P-RNTI, RA-RNTI, SI-RNTI and *Qm* > 2

For a UE configured with the higher layer parameter *repetitionScheme* set to 'fdmSchemeB', and when the UE is indicated with two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* and DM-RS port(s) within one CDM group in the DCI field '*Antenna Port(s)*', the determined modulation order of PDSCH transmission occasion associated with the first TCI state is applied to the PDSCH transmission occasion associated with the second TCI state.

<omitted text>

5.1.3.2 Transport block size determination

In case the higher layer parameter *maxNrofCodeWordsScheduledByDCI* in *PDSCH-config* indicates that two codeword transmission is enabled, then one of the two transport blocks is disabled by DCI format 1\_1 or 1\_3 if *IMCS* = 26 and if *rvid* = 1 for the corresponding transport block. In case the higher layer parameter *maxNrofCodeWordsScheduledByDCI* in *pdsch-ConfigMulticast* indicates that two codeword transmission is enabled, then one of the two transport blocks is disabled by DCI format 4\_2 if *IMCS* = 26 and if *rvid* = 1 for the corresponding transport block. When the UE is configured with higher layer parameter *pdsch-TimeDomainAllocationListForMultiPDSCH*, either the first or the second transport block of all scheduled PDSCHs is disabled by the DCI format 1\_1 if *IMCS* = 26 and if *rvid* = 2 for the corresponding transport block of all scheduled PDSCHs. If both transport blocks are enabled, transport block 1 and 2 are mapped to codeword 0 and 1 respectively. If only one transport block is enabled, then the enabled transport block is always mapped to the first codeword.

For the PDSCH assigned by a PDCCH with DCI format 1\_0, 1\_1, 1\_2, 1\_3, 4\_0, 4\_1 or 4\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, G-RNTI, G-CS-RNTI, MCCH-RNTI or SI-RNTI, if Table 5.1.3.1-2 is used and *,* else if Table 5.1.3.1-4 is used and or a table other than Table 5.1.3.1-2 and Table 5.1.3.1-4 is usedand *,* the UE shall, except if the transport block is disabled in DCI format 1\_1 or 1\_3, first determine the TBS as specified below:

1) The UE shall first determine the number of REs (*NRE*) within the slot.

- A UE first determines the number of REs allocated for PDSCH within a PRB () by , where is the number of subcarriers in a physical resource block,  is the number of symbols of the PDSCH allocation within the slot,  is the number of REs for DM-RS per PRB in the scheduled duration including the overhead of the DM-RS CDM groups without data, as indicated by DCI format 1\_1, 1\_2 or 1\_3 or as described for format 1\_0 in Clause 5.1.6.2, and  is the overhead configured by higher layer parameter *xOverhead* in *PDSCH-ServingCellConfig*. If the *xOverhead* in *PDSCH-ServingCellconfig* is not configured (a value from 6, 12, or 18), the  is set to 0. If the PDSCH is scheduled by PDCCH with a CRC scrambled by SI-RNTI, RA-RNTI, MSGB-RNTI or P-RNTI, is assumed to be 0. If the PDSCH is scheduled by PDCCH with a CRC scrambled by G-RNTI for multicast or G-CS-RNTI or PDSCH without PDCCH is activated by PDCCH with a CRC scrambled by G-CS-RNTI, is the overhead configured by higher layer parameter *xOverhead-Multicast* in *pdsch-ConfigMulticast*. If the *xOverhead-Multicast* in *pdsch-ConfigMulticast* is not configured, the is set to 0.

- A UE determines the total number of REs allocated for PDSCH () by , where *nPRB* is the total number of allocated PRBs for the UE.

<omitted text>

5.1.4 PDSCH resource mapping

<omitted text>

5.1.4.1 PDSCH resource mapping with RB symbol level granularity

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying only the parameters of *rateMatchPatternGroup1DCI-1-2*, *rateMatchPatternGroup2DCI-1-2* instead of *rateMatchPatternGroup1* and *rateMatchPatternGroup2*. The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_3. The procedures for PDSCH scheduled by PDCCH with DCI format 1\_0 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_0, by applying only the parameters of *rateMatchPatternToAddModList* configured in *pdsch-ConfigMCCH* or *pdsch-ConfigMTCH*.

<omitted text>

5.1.4.2 PDSCH resource mapping with RE level granularity

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying the parameters of *aperiodicZP-CSI-RS-ResourceSetsToAddModListDCI-1-2* instead of *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList*. The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_3.

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_0 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_1 and the procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_2, by applying the parameters of *aperiodicZP-CSI-RS-ResourceSetsToAddModList in pdsch-ConfigMulticast* instead of *aperiodic-ZP-CSI-RS-ResourceSetsToAddModList in PDSCH-Config*.

<omitted text>

5.1.5 Antenna ports quasi co-location

The UE can be configured with a list of up to *M* *TCI-State* configurations within the higher layer parameter *PDSCH-Config* to decode PDSCH according to a detected PDCCH with DCI intended for the UE and the given serving cell, where M depends on the UE capability *maxNumberConfiguredTCIstatesPerCC*. Each *TCI-State* contains parameters for configuring a quasi co-location relationship between one or two downlink reference signals and the DM-RS ports of the PDSCH, the DM-RS port of PDCCH or the CSI-RS port(s) of a CSI-RS resource. The quasi co-location relationship is configured by the higher layer parameter *qcl-Type1* for the first DL RS, and *qcl-Type2* for the second DL RS(if configured). For the case of two DL RSs, the QCL types shall not be the same, regardless of whether the references are to the same DL RS or different DL RSs. The quasi co-location types corresponding to each DL RS are given by the higher layer parameter *qcl-Type* in *QCL-Info* and may take one of the following values:

- 'typeA': {Doppler shift, Doppler spread, average delay, delay spread}

- 'typeB': {Doppler shift, Doppler spread}

- 'typeC': {Doppler shift, average delay}

- 'typeD': {Spatial Rx parameter}

The UE can be configured with a list of up to *128* *TCI-State* configurations, within the higher layer parameter *dl-OrJointTCI-StateList* in *PDSCH-Config* for providing a reference signal for the quasi co-location for DM-RS of PDSCH and DM-RS of PDCCH in a BWP/CC, for CSI-RS, and to provide a reference, if applicable, for determining UL TX spatial filter for dynamic-grant and configured-grant based PUSCH and PUCCH resource in a BWP/CC, and SRS.

If the *TCI-State* or *TCI-UL-State* configurations are absent in a BWP of the CC, the UE can apply the *TCI-State* or *TCI-UL-State* configurations from a reference BWP of a reference CC. The UE is not expected to be configured with *tci-StatesToAddModList*, *SpatialRelationInfo* or *PUCCH-SpatialRelationInfo*, except *SpatialRelationInfoPos* in a CC in a band, if the UE is configured with *dl-OrJointTCI-StateList* or *ul-TCI-StateList* in any CC in the same band. The UE can assume that when the UE is configured with *tci-StatesToAddModList* in any CC in the CC list configured by *simultaneousTCI-UpdateList1-r16, simultaneousTCI-UpdateList2-r16,* *simultaneousSpatial-UpdatedList1-r16, or simultaneousSpatial-UpdatedList2-r16,* the UE is not configured with *dl-OrJointTCI-StateList* or *ul-TCI-StateList* in any CC within the same band in the CC list.

The UE receives an activation command, as described in clause 6.1.3.14 of [10, TS 38.321] or 6.1.3.47 of [10, TS 38.321], used to map up to 8 TCI states and/or pairs of TCI states, with one TCI state for DL channels/signals and/or one TCI state for UL channels/signals to the codepoints of the DCI field *'Transmission Configuration Indication'* for one or for a set of CCs/DL BWPs, and if applicable, for one or for a set of CCs/UL BWPs. When a set of TCI state IDs are activated for a set of CCs/DL BWPs and if applicable, for a set of CCs/UL BWPs, where the applicable list of CCs is determined by the indicated CC in the activation command, the same set of TCI state IDs are applied for all DL and/or UL BWPs in the indicated CCs. If the activation command maps *TCI-State* and/or *TCI-UL-State* to only one TCI codepoint, the UE shall apply the indicated *TCI-State* and/or *TCI-UL-State* to one or to a set of CCs /DL BWPs, and if applicable, to one or to a set of CCs /UL BWPs once the indicated mapping for the one single TCI codepoint is applied as described in [11, TS 38.133].

When the *bwp-id* or *cell* for QCL-TypeA/D source RS in a QCL-Info of the TCI state is not configured, the UE assumes that QCL-TypeA/D source RS is configured in the CC/DL BWP where TCI state applies.

When *tci-PresentInDCI* is set as 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET, a UE configured with *dl-OrJointTCI-StateList* with activated *TCI-State* or *ul-TCI-StateList* with activated *TCI-UL-State* receives DCI format 1\_1/1\_2/1\_3 providing indicated *TCI-State* and/or *TCI-UL-State* for a CC or all CCs in the same CC list configured by *simultaneousU-TCI-UpdateList1-r17, simultaneousU-TCI-UpdateList2-r17, simultaneousU-TCI-UpdateList3-r17, simultaneousU-TCI-UpdateList4-r17*. The DCI format 1\_1/1\_2 can be with or without, if applicable, DL assignment. If the DCI format 1\_1/1\_2/ is without DL assignment, the UE can assume the following:

- CS-RNTI is used to scramble the CRC for the DCI

- The values of the following DCI fields are set as follows:

- RV = all '1's

- MCS = all '1's

- NDI = 0

- Set to all '0's for FDRA Type 0, or all '1's for FDRA Type 1, or all '0's for dynamicSwitch (same as in Table 10.2-4 of [6, TS 38.213]).

<omitted text>

When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command, the indicated mapping between TCI states and codepoints of the DCI field *'Transmission Configuration Indication'* should be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH and is the subcarrier spacing configuration for with a value of 0 for frequency range 1, and is provided by *K-Mac* or if *K-Mac* is not provided. If *tci-PresentInDCI* is set to 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET scheduling the PDSCH, and the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than *timeDurationForQCL* if applicable, after a UE receives an initial higher layer configuration of TCI states and before reception of the activation command, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the SS/PBCH block determined in the initial access procedure with respect to *qcl-Type* set to 'typeA', and when applicable, also with respect to *qcl-Type* set to 'typeD'.

If a UE is configured with the higher layer parameter *tci-PresentInDCI* that is set as 'enabled'for the CORESET scheduling a PDSCH, the UE assumes that the TCI field is present in the DCI format 1\_1 or format 1\_3 of the PDCCH transmitted on the CORESET. If a UE is configured with the higher layer parameter *tci-PresentDCI-1-2* for the CORESET scheduling the PDSCH, the UE assumes that the TCI field with a DCI field size indicated by *tci-PresentDCI-1-2* is present in the DCI format 1\_2 of the PDCCH transmitted on the CORESET. If a UE is configured with the higher layer parameter *tci-PresentInDCI* that is set as 'enabled'for the CORESET scheduling the multicast PDSCH, the UE assumes that the TCI field is present in the DCI format 4\_2 of the PDCCH transmitted on the CORESET. If the PDSCH is scheduled by a DCI format not having the TCI field present, and the time offset between the reception of the DL DCI and the corresponding PDSCH of a serving cell is equal to or greater than a threshold *timeDurationForQCL* if applicable, where the threshold is based on reported UE capability [13, TS 38.306], for determining PDSCH antenna port quasi co-location, the UE assumes that the TCI state or the QCL assumption for the PDSCH is identical to the TCI state or QCL assumption whichever is applied for the CORESET used for the PDCCH transmission within the active BWP of the serving cell.

When a UE is configured with both *sfnSchemePdcch* and *sfnSchemePdsch* scheduled by DCI format 1\_0 or by DCI format 1\_1/1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH of a serving cell is equal to or greater than a threshold *timeDurationForQCL* if applicable:

- if the UE supports *sfn-DefaultDL-BeamSetup-r17* for DCI scheduling without TCI field, the UE assumes that the TCI state(s) or the QCL assumption(s) for the PDSCH is identical to the TCI state(s) or QCL assumption(s) whichever is applied for the CORESET used for the reception of the DL DCI within the active BWP of the serving cell regardless of the number of active TCI states of the CORESET. If the UE does not support *sfn-SchemeA-DynamicSwitching-r17* or *sfn-SchemeB-DynamicSwitching-r17*, the UE should be activated with the CORESET with two TCI states.

- else if the UE does not support *sfn-DefaultDL-BeamSetup-r17* for DCI scheduling without TCI field, the UE shall expect TCI field present when scheduled by DCI format 1\_1/1\_2.

When a UE is configured with *sfnSchemePdsch* and *sfnSchemePdcch* is not configured, when scheduled by DCI format 1\_1/1\_2, if the time offset between the reception of the DL DCI and the corresponding PDSCH of a serving cell is equal to or greater than a threshold *timeDurationForQCL* if applicable, the UE shall expect TCI field present.

For PDSCH scheduled by DCI format 1\_0, 1\_1, 1\_2, when a UE is configured with *sfnSchemePdcch* set to 'sfnSchemeA' and *sfnSchemePdsch* is not configured, and there is no TCI codepoint with two TCI states in the activation command, and if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal or larger than the threshold *timeDurationForQCL* if applicable and the CORESET which schedules the PDSCH is indicated with two TCI states, the UE assumes that the TCI state or the QCL assumption for the PDSCH is identical to the first TCI state or QCL assumption which is applied for the CORESET used for the PDCCH transmission within the active BWP of the serving cell.

If a PDSCH is scheduled by a DCI format having the TCI field present, the TCI field in DCI in the scheduling component carrier points to the activated TCI states in the scheduled component carrier or DL BWP, the UE shall use the *TCI-State* according to the value of the '*Transmission Configuration Indication*' field in the detected PDCCH with DCI for determining PDSCH antenna port quasi co-location. The UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL type parameter(s) given by the indicated TCI state if the time offset between the reception of the DL DCI and the corresponding PDSCH is equal to or greater than a threshold *timeDurationForQCL*, where the threshold is based on reported UE capability [13, TS 38.306]. For a single slot PDSCH, the indicated TCI state(s) should be based on the activated TCI states in the slot with the scheduled PDSCH. For a multi-slot PDSCH or the UE is configured with higher layer parameter *pdsch-TimeDomainAllocationListForMultiPDSCH*, the indicated TCI state(s) should be based on the activated TCI states in the first slot with the scheduled PDSCH(s), and UE shall expect the activated TCI states are the same across the slots with the scheduled PDSCH(s). When the UE is configured with CORESET associated with a search space set for cross-carrier scheduling and the UE is not configured with *enableDefaultBeamForCCS*, the UE expects *tci-PresentInDCI* is set as 'enabled' or *tci-PresentDCI-1-2* is configured for the CORESET, and if one or more of the TCI states configured for the serving cell scheduled by the search space set contains *qcl-Type* set to 'typeD', the UE expects the time offset between the reception of the detected PDCCH in the search space set and a corresponding PDSCH is larger than or equal to the threshold *timeDurationForQCL.*

Independent of the configuration of *tci-PresentInDCI* and *tci-PresentDCI-1-2* in RRC connected mode, if the UE is not provided *dl-OrJointTCI-StateList-r17*, and if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL* and at least one configured TCI state for the serving cell of scheduled PDSCH contains *qcl-Type* set to 'typeD',

- the UE may assume that the DM-RS ports of PDSCH(s) of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the CORESET associated with a monitored search space with the lowest *controlResourceSetId* in the latest slot in which one or more CORESETs within the active BWP of the serving cell are monitored by the UE. In this case, if the *qcl-Type* is set to 'typeD' of the PDSCH DM-RS is different from that of the PDCCH DM-RS with which they overlap in at least one symbol, the UE is expected to prioritize the reception of PDCCH associated with that CORESET. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers).

- If a UE is configured with *enableDefaultTCI-StatePerCoresetPoolIndex* and the UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in different *ControlResourceSets,*

- the UE may assume that the DM-RS ports of PDSCH associated with a value of *coresetPoolIndex* of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the CORESET associated with a monitored search space with the lowest *controlResourceSetId* among CORESETs, which are configured with the same value of *coresetPoolIndex* as the PDCCH scheduling that PDSCH, in the latest slot in which one or more CORESETs associated with the same value of *coresetPoolIndex* as the PDCCH scheduling that PDSCH within the active BWP of the serving cell are monitored by the UE. In this case, if the 'QCL-TypeD' of the PDSCH DM-RS is different from that of the PDCCH DM-RS with which they overlap in at least one symbol and they are associated with same value of *coresetPoolIndex*, the UE is expected to prioritize the reception of PDCCH associated with that CORESET. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers).

- If a UE is configured with *enableTwoDefaultTCI-States*, and at least one TCI codepoint indicates two TCI states, the UE may assume that the DM-RS ports of PDSCH or PDSCH transmission occasions of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) associated with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states. When the UE is configured by higher layer parameter *repetitionScheme* set to 'tdmSchemeA' or is configured with higher layer parameter *repetitionNumber*, and the offset between the reception of the DL DCI and the first PDSCH transmission occasion is less than the threshold *timeDurationForQCL,* the mapping of the TCI states to PDSCH transmission occasions is determined according to clause 5.1.2.1 by replacing the indicated TCI states with the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states based on the activated TCI states in the slot with the first PDSCH transmission occasion. In this case, if the 'QCL-TypeD' in both of the TCI states corresponding to the lowest codepoint among the TCI codepoints containing two different TCI states is different from that of the PDCCH DM-RS with which they overlap in at least one symbol, the UE is expected to prioritize the reception of PDCCH associated with that CORESET. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers)

- If a UE is not configured with *sfnSchemePdsch*, and the UE is configured with *sfnSchemePdcch* set to 'sfnSchemeA' and there is no TCI codepoint witih two TCI states in the activation command and the CORESET with the lowest ID in the latest slot is indicated with two TCI states, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) associated with the first TCI state of two TCI states indicated for the CORESET. In this case, if the *qcl-Type* is set to 'typeD' of the PDSCH DM-RS is different from that of the PDCCH DM-RS with which they overlap in at least one symbol, the UE is expected to prioritize the reception of PDCCH associated with that CORESET with single active TCI state. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers).

- In all cases above, if none of configured TCI states for the serving cell of scheduled PDSCH is configured with *qcl-Type* set to 'typeD', the UE shall obtain the other QCL assumptions from the indicated TCI state(s) for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.

Independent of the configuration of *tci-PresentInDCI* and *tci-PresentDCI-1-2* in RRC connected mode, if the UE is provided *dl-OrJointTCI-StateList-r17*, and if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL* and at least one configured TCI state for the serving cell of scheduled PDSCH contains *qcl-Type* set to 'typeD', regardless of configuration of *followUnifiedTCI-State*,

- if the indicated TCI state is associated with the PCI of the serving cell, the indicated TCI state is applied to PDSCH reception.

- if the indicated TCI state is associated with a PCI different from the serving cell, the UE may assume that the DM-RS ports of PDSCH(s) of a serving cell are quasi co-located with the RS(s) with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the CORESET associated with a monitored search space with the lowest *controlResourceSetId* in the latest slot in which one or more CORESETs within the active BWP of the serving cell are monitored by the UE. In the CA case, if the 'QCL-TypeD' of the PDSCH DM-RSs from respective CCs in a band are different in a slot, the QCL-TypeD assumption of the PDSCH DM-RS in the CC with lowest CC ID in the band is applied to all the PDSCH DM-RSs in the CCs in the band. In this case, if the *qcl-Type* is set to 'typeD' of the PDSCH DM-RS is different from that of the PDCCH DM-RS with which they overlap in at least one symbol, the UE is expected to prioritize the reception of PDCCH associated with that CORESET. This also applies to the intra-band CA case (when PDSCH and the CORESET are in different component carriers).

If the PDCCH carrying the scheduling DCI is received on one component carrier, and a PDSCH scheduled by that DCI is on another component carrier:

- The *timeDurationForQCL* is determined based on the subcarrier spacing of the scheduled PDSCH. If µPDCCH < µPDSCH an additional timing delay is added to the *timeDurationForQCL*, where *d* is defined in 5.2.1.5.1a-1, otherwise *d* is zero;

- When the UE is configured with *enableDefaultBeamForCCS*, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *timeDurationForQCL,* or if the DL DCI does not have the TCI field present, the UE obtains its QCL assumption for the scheduled PDSCH from the activated TCI state with the lowest ID applicable to PDSCH in the active BWP of the scheduled cell.

A UE that has indicated a capability *beamCorrespondenceWithoutUL-BeamSweeping* set to 'supported', as described in [13, TS 38.306], can determine a spatial domain filter to be used while performing the applicable channel access procedures described in [16, TS 37.213] prior to a UL transmission on the channel as follows:

- if UE is indicated with an SRI corresponding to the UL transmission, the UE may use a spatial domain filter that is same as the spatial domain transmission filter associated with the indicated SRI,

- if UE is configured with *SRS-spatialRelationInfo* for the UL transmission, the UE may use a spatial domain filter that is same as the spatial domain filter associated with *referenceSignal* in the corresponding *SRS-spatialRelationInfo*,

- if UE is configured with *TCI-State* in *dl-OrJointTCI-StateList* or *TCI-UL-State* in *ul-TCI-StateList*, the UE may use a spatial domain filter that is same as the spatial domain receive filter the UE may use to receive the DL reference signal associated with the indicated TCI state.

When the PDCCH reception includes two PDCCH from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the time offset between the reception of the DL DCI and the corresponding PDSCH, the PDCCH candidate that ends later in time is used. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the configuration of *tci-PresentInDCI* or *tci-PresentDCI-1-2*, the UE expects the same configuration in the first and second CORESETs associated with the two PDCCH candidates; and if the PDSCH is scheduled by a DCI format not having the TCI field present and if the scheduling offset is equal to or larger than *timeDurationForQCL,* if applicable, PDSCH QCL assumption is based on the CORESET with lower ID among the first and second CORESETs associated with the two PDCCH candidates.

<omitted text>

5.1.6 UE procedure for receiving reference signals

<omitted text>

5.1.6.2 DM-RS reception procedure

The DM-RS reception procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying the parameters of *dmrs-DownlinkForPDSCH-MappingTypeA-DCI-1-2* and *dmrs-DownlinkForPDSCH-MappingTypeB-DCI-1-2* instead of *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB*. The DM-RS reception procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_3.

The DM-RS reception procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 4\_2, by applying the parameters of *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB* in *pdsch-ConfigMulticast* instead of *dmrs-DownlinkForPDSCH-MappingTypeA* and *dmrs-DownlinkForPDSCH-MappingTypeB in PDSCH-Config*.

When receiving PDSCH scheduled by DCI format 1\_0, 4\_0, or 4\_1, or receiving PDSCH before dedicated higher layer configuration of any of the parameters *dmrs-AdditionalPosition*, *maxLength* and *dmrs-Type,* the UE shall assume that the PDSCH is not present in any symbol carrying DM-RS except for PDSCH with allocation duration of 2 symbols with PDSCH mapping type B (described in clause 7.4.1.1.2 of [4, TS 38.211]), and a single symbol front-loaded DM-RS of configuration type 1 on DM-RS port 1000 is transmitted, and that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE and in addition

- For PDSCH with mapping type A and type B, the UE shall assume *dmrs-AdditionalPosition*='pos2' and up to two additional single-symbol DM-RS present in a slot according to the PDSCH duration indicated in the DCI as defined in Clause 7.4.1.1 of [4, TS 38.211], and

- For PDSCH with allocation duration of 2 symbols with mapping type B, the UE shall assume that the PDSCH is present in the symbol carrying DM-RS.

When receiving PDSCH scheduled by DCI format 1\_1 or 1\_3 by PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI or DCI format 4\_2 by PDCCH with CRC scrambled by G-RNTI for multicast or G-CS-RNTI,

- the UE may be configured with the higher layer parameter *dmrs-Type*, and the configured DM-RS configuration type is used for receiving PDSCH in as defined in Clause 7.4.1.1 of [4, TS 38.211].

- the UE may be configured with the maximum number of front-loaded DM-RS symbols for PDSCH by higher layer parameter *maxLength* given by *DMRS-DownlinkConfig..*

- if *maxLength* is set to 'len1', single-symbol DM-RS can be scheduled for the UE by DCI, and the UE can be configured with a number of additional DM-RS for PDSCH by higher layer parameter *dmrs-AdditionalPosition,* which can be set to 'pos0', 'pos1', 'pos2' or 'pos3'.

- if *maxLength* is set to 'len2', both single-symbol DM-RS and double symbol DM-RS can be scheduled for the UE by DCI, and the UE can be configured with a number of additional DM-RS for PDSCH by higher layer parameter *dmrs-AdditionalPosition,* which can be set to 'pos0' or 'pos1'.

- and the UE shall assume to receive additional DM-RS as specified in Table 7.4.1.1.2-3 and Table 7.4.1.1.2-4 as described in Clause 7.4.1.1.2 of [4, TS 38.211].

For the UE-specific reference signals generation as defined in Clause 7.4.1.1 of [4, TS 38.211], a UE can be configured by higher layers with one or two scrambling identity(s), *i* = 0,1 which are the same for both PDSCH mapping Type A and Type B.

A UE may be scheduled with a number of DM-RS ports by the antenna port index in DCI format 1\_1 as described in Clause 7.3.1.2 of [5, TS 38.212].

For DM-RS configuration type 1,

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 30} in Table 7.3.1.2.2-1 and Table 7.3.1.2.2-2 of Clause 7.3.1.2 of [5, TS 38.212], or

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 9, 10, 11 or 12} in Table 7.3.1.2.2-1A and {2, 9, 10, 11, 30 or 31} in Table 7.3.1.2.2-2A of Clause 7.3.1.2 of [5, TS 38.212], or

- if a UE is scheduled with two codewords,

the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE.

For DM-RS configuration type 2,

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10 or 23} in Table 7.3.1.2.2-3 and Table 7.3.1.2.2-4 of Clause 7.3.1.2 of [5, TS38.212], or

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of {2, 10, 23 or 24} in Table 7.3.1.2.2-3A and {2, 10, 23 or 58} in Table 7.3.1.2.2-4A of Clause 7.3.1.2 of [5, TS 38.212], or

- if a UE is scheduled with two codewords,

the UE may assume that all the remaining orthogonal antenna ports are not associated with transmission of PDSCH to another UE.

If a UE receiving PDSCH scheduled by DCI format 1\_2 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA-DCI-1-2* or *dmrs-DownlinkForPDSCH-MappingTypeB-DCI-1-2* or a UE receiving PDSCH scheduled by DCI format 1\_0, 1\_1 or 1\_3 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA* or *dmrs-DownlinkForPDSCH-MappingTypeB*, the UE may assume that the following configurations are not occurring simultaneously for the received PDSCH:

- any DM-RS ports among 1004-1007 or 1006-1011 for DM-RS configurations type 1 and type 2, respectively are scheduled for the UE and the other UE(s) sharing the DM-RS REs on the same CDM group(s), and

- PT-RS is transmitted to the UE.

<omitted text>

5.1.6.3 PT-RS reception procedure

The procedures on PT-RS reception described in this clause apply to a UE receiving PDSCH scheduled by DCI format 1\_2 configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA-DCI-1-2* or *dmrs-DownlinkForPDSCH-MappingTypeB-DCI-1-2* and to a UE receiving PDSCH scheduled by DCI format 1\_0, 1\_1 or 1\_3 configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA* or *dmrs-DownlinkForPDSCH-MappingTypeB*. The procedures on PT-RS reception described in this clause apply to a UE receiving PDSCH scheduled by DCI format 4\_1 or 4\_2 configured with the higher layer parameter *phaseTrackingRS* in *dmrs-DownlinkForPDSCH-MappingTypeA* or *dmrs-DownlinkForPDSCH-MappingTypeB* in *pdsch-ConfigMulticast*.

<omitted text>

5.1.6.5 PRS reception procedure

<omitted text>

The UE is expected to measure the DL PRS outside the measurement gap, subject to UE capability, if the DL PRS is inside the active DL BWP and has the same numerology as the active DL BWP and is within the DL PRS processing window indicated by higher layer parameter *DL-PPW-PreConfig*. The UE is not expected to measure the DL PRS outside the measurement gap if the expected received timing difference between the DL PRS from the non-serving cell and that from the serving cell, determined by the higher layer parameters *nr-DL-PRS-ExpectedRSTD* and *nr-DL-PRS-ExpectedRSTD-Uncertainty,* is larger than maximum Rx timing difference provided by UE capability*.* For receiving the DL PRS outside the measurement gap and within the DL PRS processing window, the priority between DL PRS and SSB is defined in [11, TS 38.133] and the UE determines the DL PRS priority as indicated by higher layer parameter *priority* subject to UE capability or as implied by UE capability, except for SSB:

- with value *'st1'* where the DL PRS is higher priority than all the DL signals and channels, or

- with value *'st2'* where the DL PRS is lower priority than PDCCH and the PDSCH scheduled by DCI formats 1\_1, 1\_2 or 1\_3 with the priority indicator field in the corresponding DCI format set to 1, and is higher priority than other DL signals and channels, or

- with value *'st3'* where the DL PRS is lower priority than all the DL signals and channels.

Inside one *DL-PPW-PreConfig* the UE is only expected to measure a single DL PRS positioning frequency layer.

<omitted text>

5.1.7 Code block group based PDSCH transmission

If a UE is configured to receive code block group (CBG) based transmissions by receiving the higher layer parameter *PDSCH-CodeBlockGroupTransmission* in *PDSCH-ServingCellConfig* on a serving cell in a PUCCH group, the UE does not expect to be configured with higher layer parameter *ScheduledCell-ListDCI-1-3* on any serving cell within the PUCCH group.<omitted text>

5.2 UE procedure for reporting channel state information (CSI)

5.2.1 Channel state information framework

The procedures on aperiodic CSI reporting described in this clause assume that the CSI reporting is triggered by DCI format 0\_1, but they equally apply to CSI reporting triggered by DCI format 0\_2, by applying the higher layer parameter *reportTriggerSizeDCI-0-2* instead of *reportTriggerSize*. The procedures on aperiodic CSI reporting described in this clause assume that the CSI reporting is triggered by DCI format 0\_1, but they equally apply to CSI reporting triggered by DCI format 0\_3.

The time and frequency resources that can be used by the UE to report CSI are controlled by the gNB. CSI may consist of Channel Quality Indicator (CQI), precoding matrix indicator (PMI), CSI-RS resource indicator (CRI), SS/PBCH Block Resource indicator (SSBRI), layer indicator (LI), rank indicator (RI), L1-RSRP, L1-SINR or CapabilityIndex.

For CQI, PMI, CRI, SSBRI, LI, RI, L1-RSRP, L1-SINR, CapabilityIndex a UE is configured by higher layers with N≥1 *CSI-ReportConfig* Reporting Settings, M≥1 *CSI-ResourceConfig* Resource Settings, and one or two list(s) of trigger states (given by the higher layer parameters *CSI-AperiodicTriggerStateList* and *CSI-SemiPersistentOnPUSCH-TriggerStateList*). Each trigger state in *CSI-AperiodicTriggerStateList* contains a list of associated *CSI-ReportConfigs* indicating the Resource Set IDs for channel and optionally for interference. Each trigger state in *CSI-SemiPersistentOnPUSCH-TriggerStateList* contains one associated *CSI-ReportConfig*.

<omitted text>

5.2.1.4 Reporting configurations

<omitted text>

For a semi-persistent or aperiodic CSI report on PUSCH, the allowed slot offsets are configured by the following higher layer parameters:

- if triggered/activated by DCI format 0\_2 and the higher layer parameter *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17* is configured, the allowed slot offsets are configured by *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17*, and

- if triggered/activated by DCI format 0\_1 or 0\_3 and the higher layer parameter *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17* is configured, the allowed slot offsets are configured by *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17,* and

- otherwise, the allowed slot offsets are configured by the higher layer parameter *reportSlotOffsetList* or *reportSlotOffsetList-r17.*

The offset is selected in the activating/triggering DCI.

For CSI reporting, a UE can be configured via higher layer signaling with one out of two possible subband sizes, where a subband is defined as  contiguous PRBs and depends on the total number of PRBs in the bandwidth part according to Table 5.2.1.4-2.

**Table 5.2.1.4-2: Configurable subband sizes**

|  |  |
| --- | --- |
| **Bandwidth part (PRBs)** | **Subband size (PRBs)** |
| 24 – 72 | 4, 8 |
| 73 – 144 | 8, 16 |
| 145 – 275 | 16, 32 |

The *reportFreqConfiguration* contained in a *CSI-ReportConfig* indicates the frequency granularity of the CSI Report. A CSI Reporting Setting configuration defines a CSI reporting band as a subset of subbands of the bandwidth part, where the *reportFreqConfiguration* indicates:

- the *csi-ReportingBand* as a contiguous or non-contiguous subset of subbands in the bandwidth part for which CSI shall be reported.

- A UE is not expected to be configured with *csi-ReportingBand* which contains a subband where a CSI-RS resource linked to the CSI Report setting has the frequency density of each CSI-RS port per PRB in the subband less than the configured density of the CSI-RS resource.

- If a CSI-IM resource is linked to the CSI Report Setting, a UE is not expected to be configured with *csi-ReportingBand* which contains a subband where not all PRBs in the subband have the CSI-IM REs present.

- wideband CQI or subband CQI reporting, as configured by the higher layer parameter *cqi-FormatIndicator*. When wideband CQI reporting is configured, a wideband CQI is reported for each codeword for the entire CSI reporting band. When subband CQI reporting is configured, one CQI for each codeword is reported for each subband in the CSI reporting band.

- wideband PMI or subband PMI reporting as configured by the higher layer parameter *pmi-FormatIndicator*. When wideband PMI reporting is configured, a wideband PMI is reported for the entire CSI reporting band. When subband PMI reporting is configured, except with 2 antenna ports, a single wideband indication (*i1* in Clause 5.2.2.2) is reported for the entire CSI reporting band and one subband indication (*i2* in clause 5.2.2.2) is reported for each subband in the CSI reporting band. When subband PMIs are configured with 2 antenna ports, a PMI is reported for each subband in the CSI reporting band.

- a UE is not expected to be configured with *pmi-FormatIndicator* if *codebookType* is set to 'typeII-r16' or 'typeII-PortSelection-r16' or 'typeII-PortSelection-r17'.

A CSI Reporting Setting is said to have a wideband frequency-granularity if

- *reportQuantity* is set to 'cri-RI-PMI-CQI', or 'cri-RI-LI-PMI-CQI', *cqi-FormatIndicator* is set to 'widebandCQI' and *pmi-FormatIndicator* is set to 'widebandPMI', or

- *reportQuantity* is set to 'cri-RI-PMI-CQI', *codebookType* is set to 'typeII-PortSelection-r17' with and *cqi-FormatIndicator* is set to 'widebandCQI', or

- *reportQuantity* is set to 'cri-RI-i1' or

- *reportQuantity* is set to 'cri-RI-CQI' or 'cri-RI-i1-CQI' and *cqi-FormatIndicator* is set to 'widebandCQI', or

- *reportQuantity* is set to 'cri-RSRP' or 'ssb-Index-RSRP' or 'cri-SINR', or 'ssb-Index-SINR' or 'cri-RSRP-Index' or 'ssb-Index-RSRP-Index' or 'cri-SINR-Index', or 'ssb-Index-SINR-Index'

otherwise, the CSI Reporting Setting is said to have a subband frequency-granularity.

A CSI Reporting Setting with *codebookType* set to 'typeI-SinglePanel' and the corresponding CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, as described in clause 5.2.1.4.1, can be configured with wideband frequency-granularity only if *csi-ReportMode* is set to 'Mode1' and *numberOfSingleTRP-CSI-Mode1* is set to , as described in clause 5.2.1.4.2.

If the UE is configured with a CSI Reporting Setting for a bandwidth part with fewer than 24 PRBs, the CSI reporting setting is expected to have a wideband frequency-granularity, and, if applicable, the higher layer parameter *codebookType* is set to 'typeI-SinglePanel'.

The first subband size is given by  and the last subband size given by  if  and if 

If a UE is configured with semi-persistent CSI reporting, the UE shall report CSIwhen both CSI-IM and NZP CSI-RS resources are configured as periodic or semi-persistent. If a UE is configured with aperiodic CSI reporting, the UE shall report CSIwhen both CSI-IM and NZP CSI-RS resources are configured as periodic, semi-persistent or aperiodic.

A UE configured with DCI format 0\_1, 0\_2 or 0\_3 does not expect to be triggered with multiple CSI reports with the same *CSI-ReportConfigId*.

<omitted text>

5.2.3 CSI reporting using PUSCH

A UE shall perform aperiodic CSI reporting using PUSCH on serving cell c upon successful decoding of a DCI format 0\_1 or DCI format 0\_2 which triggers an aperiodic CSI trigger state. A UE shall perform aperiodic CSI reporting using PUSCH on the serving cell with the smallest serving cell index scheduled by DCI format 0\_3 which triggers an aperiodic CSI trigger state.

When a DCI format 0\_1 schedules two PUSCH allocations, the aperiodic CSI report is carried on the second scheduled PUSCH. When a DCI format 0\_1 schedules more than two PUSCH allocations, the aperiodic CSI report is carried on the penultimate scheduled PUSCH.

An aperiodic CSI report carried on the PUSCH supports wideband, and sub-band frequency granularities. An aperiodic CSI report carried on the PUSCH supports Type I, Type II, Enhanced Type II and Further Enhanced Type II Port Selection CSI.

A UE shall perform semi-persistent CSI reporting on the PUSCH upon successful decoding of a DCI format 0\_1 or DCI format 0\_2 which activates a semi-persistent CSI trigger state. DCI format 0\_1 and DCI format 0\_2 contains a CSI request field which indicates the semi-persistent CSI trigger state to activate or deactivate. Semi-persistent CSI reporting on the PUSCH supports Type I, Type II with wideband, and sub-band frequency granularities, Enhanced Type II and Further Enhanced Type II Port Selection CSI. The PUSCH resources and MCS shall be allocated semi-persistently by an uplink DCI.

<omitted text>

5.3 UE PDSCH processing procedure time

<omitted text>

5.3.1 Application delay of the minimum scheduling offset restriction

When the UE is scheduled with DCI format 0\_1, 0\_3, 1\_1 or 1\_3 with a '*Minimum applicable scheduling offset indicator*'field in slot *n*, it shall determine the *K*0min and *K*2min values, if configured respectively, to be applied, while the previously applied *K*0min and/or *K*2min values are applied until the new values take effect. If the DCI in slot *n* also indicates an active DL (UL) BWP change for a serving cell, the indicated *K*0min (*K*2min) value in the new active DL (UL) BWP, if configured, is applied from the slot indicated by the slot offset value of the time domain resource assignment field in the DCI. Otherwise, change of applied minimum scheduling offset restriction indication carried by DCI in slot *n*, shall be applied in slot *n*+*X* of the scheduling cell. The UE does not expect to be scheduled with DCI format 0\_1, 0\_3, 1\_1 or 1\_3 with '*Minimum applicable scheduling offset indicator*' field indicating another change to *K*0min or *K*2min for the same active BWP of the scheduled cell before slot *n+X* of the scheduling cell.

When the DCI format 0\_1, 0\_3, 1\_1 or 1\_3 with '*Minimum applicable scheduling offset indicator*'field indicating a change to the applied *K*0min or *K*2min is contained within the first three symbols of slot *n*, the value of application delay *X* is determined by, where *K*0minOld is the currently applied *K*0min value of the active DL BWP in the scheduled cell and is zero, if *minimumSchedulingOffsetK0* is not configured for the active DL BWP in the scheduled cell, *Zµ* is determined by the subcarrier spacing of the active DL BWP in the scheduling cell in slot *n*, and given in Table 5.3.1-1, and *µ*PDCCH and *µ*PDSCH are the sub-carrier spacing configurations for PDCCH of the active DL BWP in the scheduling cell and PDSCH of the active DL BWP in the scheduled cell, respectively, in slot *n*. After indication of a change to the applied *K*0min or *K*2min of the scheduled cell in slot *n* of the scheduling cell, if there is an active DL BWP change in the scheduling cell before slot *n+X*, the new *K*0min and/or *K*2min values are applied from the first slot no earlier than the start of slot *n+X* based on the sub-carrier spacing configuration of the active DL BWP in the scheduling cell in slot *n*.

When the DCI format 0\_1, 0\_3, 1\_1 or 1\_3 with '*Minimum applicable scheduling offset indicator*'field is received outside the first three symbols of the slot, value of *Zµ* from Table 5.3.1-1 is incremented by one before determining the application delay *X*. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining '*Minimum applicable scheduling offset indicator*'field is received outside the first three symbols of the slot, the PDCCH candidate that ends later in time is used.

**Table 5.3.1-1: Definition of *Zµ***

|  |  |
| --- | --- |
| ***µ*** | ***Zµ*** |
| 0 | 1 |
| 1 | 1 |
| 2 | 2 |
| 3 | 2 |
| 5 | 8 |
| 6 | 16 |

<omitted text>

6 Physical uplink shared channel related procedure

6.1 UE procedure for transmitting the physical uplink shared channel

PUSCH transmission(s) can be dynamically scheduled by an UL grant in a DCI, or the transmission can correspond to a configured grant Type 1 or Type 2. The configured grant Type 1 PUSCH transmission is semi-statically configured to operate upon the reception of higher layer parameter of *configuredGrantConfig* including *rrc-ConfiguredUplinkGrant* without the detection of an UL grant in a DCI. The configured grant Type 2 PUSCH transmission is semi-persistently scheduled by an UL grant in a valid activation DCI according to clause 10.2 of [6, TS 38.213] after the reception of higher layer parameter *configuredGrantConfig* not including *rrc-ConfiguredUplinkGrant*. If *configuredGrantConfigToAddModList* is configured, more than one configured grant configuration of configured grant Type 1 and/or configured grant Type 2 may be active at the same time on an active BWP of a serving cell.

The UE can be configured with a list of up to 64 *TCI-UL-State* configurations within the higher layer parameter *BWP-UplinkDedicated.* Each *TCI-UL-State* configuration contains a parameter for configuring one reference signal, if applicable, for determining UL TX spatial filter for dynamic-grant and configured-grant based PUSCH and PUCCH resource in a CC, and SRS.

For the PUSCH transmission corresponding to a Type 1 configured grant or a Type 2 configured grant activated by DCI format 0\_0 or 0\_1, the parameters applied for the transmission are provided by *configuredGrantConfig* except for *dataScramblingIdentityPUSCH*, *txConfig*, *codebookSubset*, *maxRank*, *scaling* of *UCI-OnPUSCH,* which are provided by *pusch-Config*. For the PUSCH transmission corresponding to a Type 2 configured grant activated by DCI format 0\_2, the parameters applied for the transmission are provided by *configuredGrantConfig* except for *dataScramblingIdentityPUSCH*, *txConfig*, *codebookSubsetDCI-0-2*, *maxRankDCI-0-2*, *scaling* of *UCI-OnPUSCH*, *resourceAllocationType1GranularityDCI-0-2* provided by *pusch-Config*.If the UE is provided with *transformPrecoder* in *configuredGrantConfig*, the UE applies the higher layer parameter *tp-pi2BPSK*, if provided in *pusch-Config*, according to the procedure described in clause 6.1.4 for the PUSCH transmission corresponding to a configured grant. When the UE is configured *dl-OrJointTCI-StateList* or *ul-TCI-StateList*, the UE shall perform PUSCH transmission corresponding to a Type 1 configured grant or a Type 2 configured grant or a dynamic grant according to the spatial relation, if applicable, with a reference to the RS for determining UL Tx spatial filter. The RS is determined based on an RS configured with *qcl-Type* set to 'typeD' of the indicated *TCI-State* or an RS in the indicated *TCI-UL-State*. The reference RS in the indicated *TCI-State* can be a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info.* The reference RS in the indicated *TCI-UL-State* can be a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info*, an SRS resource in an SRS resource set with the higher layer parameter *usage* set to 'beamManagement', or SS/PBCH block associated with the same or different PCI from the PCI of the serving cell.

For the PUSCH retransmission scheduled by a PDCCH with CRC scrambled by CS-RNTI with NDI=1, the parameters in *pusch-Config* are applied for the PUSCH transmission except for *p0-NominalWithoutGrant, p0-PUSCH-Alpha, powerControlLoopToUse,* *pathlossReferenceIndex* described in clause 7.1 of [6, TS 38.213], *mcs-Table, mcs-TableTransformPrecoder* described in clause 6.1.4.1 and *transformPrecoder* described in clause 6.1.3.

For a UE configured with two uplinks in a serving cell, PUSCH retransmission for a TB on the serving cell is not expected to be on a different uplink than the uplink used for the PUSCH initial transmission of that TB.

A UE shall upon detection of a PDCCH with a configured DCI format 0\_0, 0\_1, 0\_2 or 0\_3 transmit the corresponding PUSCH as indicated by that DCI unless the UE does not generate a transport block as described in [10, TS38.321]. Upon detection of a DCI format 0\_1 or 0\_2 with '*UL-SCH indicator*' set to '0' and with a non-zero '*CSI request*' where the associated *reportQuantity* in *CSI-ReportConfig* set to '*none*' for all CSI report(s) triggered by '*CSI request*' in this DCI format 0\_1 or 0\_2, the UE ignores all fields in this DCI except the '*CSI request*' and the UE shall not transmit the corresponding PUSCH as indicated by this DCI format 0\_1 or 0\_2. Upon detection of a DCI format 0\_3 with '*UL-SCH indicator*' set to '0' and with a non-zero '*CSI request*' where the associated *reportQuantity* in *CSI-ReportConfig* set to '*none*' for all CSI report(s) triggered by '*CSI request*' in this DCI format 0\_3, the UE ignores all fields for the scheduled cell with the smallest serving cell index in this DCI except the '*CSI request*' and the UE shall not transmit the corresponding PUSCH on the serving cell with the smallest serving cell index as indicated by this DCI format 0\_3. When the UE is scheduled with multiple PUSCHs on a serving cell by a DCI, HARQ process ID indicated by this DCI applies to the first PUSCH not overlapping with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*, HARQ process ID is then incremented by 1 for each subsequent PUSCH(s) in the scheduled order, with modulo operation of *nrofHARQ-ProcessesForPUSCH* applied if *nrofHARQ-ProcessesForPUSCH* is provided, or with modulo operation of *nrofHARQ-ProcessesForPUSCH-r17* applied if *nrofHARQ-ProcessesForPUSCH-r17* is provided, or with modulo operation of 16 applied, otherwise. HARQ process ID is not incremented for PUSCH(s) not transmitted if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to transmit a PUSCH that overlaps in time with another PUSCH. Except for the case when a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two non-overlapping in time domain PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,* for any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start a first PUSCH transmission starting in symbol *j* by a PDCCH ending in symbol *i* on a scheduling cell,, the UE is not expected to be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH that ends later than symbol *i* of the scheduling cell. When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the PDCCH ending in symbol *i*, the PDCCH candidate that ends later in time is used. The UE is not expected to be scheduled to transmit another PUSCH by a DCI format 0\_0 with CRC scrambled by TC-RNTI, for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI format 0\_0 with CRC scrambled by TC-RNTI or by an UL grant in RA Response. The UE is not expected to be scheduled to transmit another PUSCH by DCI format 0\_0, 0\_1, 0\_2 or 0\_3 scrambled by C-RNTI, CS-RNTI or MCS-C-RNTI for a given HARQ process with the DCI received before the end of the expected transmission of the last PUSCH for that HARQ process if the latter is scheduled by a DCI with CRC scrambled by C-RNTI, CS-RNTI or MCS-C-RNTI.

<omitted text>

6.1.1 Transmission schemes

Two transmission schemes are supported for PUSCH: codebook based transmission and non-codebook based transmission. The UE is configured with codebook based transmission when the higher layer parameter *txConfig* in *pusch-Config* is set to 'codebook', the UE is configured non-codebook based transmission when the higher layer parameter *txConfig* is set to 'nonCodebook'. If the higher layer parameter *txConfig* is not configured, the UE is not expected to be scheduled by DCI format 0\_1, 0\_2 or 0\_3. If PUSCH is scheduled by DCI format 0\_0, the PUSCH transmission is based on a single antenna port. Except if the higher layer parameter *enableDefaultBeamPL-ForPUSCH0-0* is set 'enabled', the UE shall not expect PUSCH scheduled by DCI format 0\_0 in a BWP without configured PUCCH resource with *PUCCH-SpatialRelationInfo* in frequency range 2 in RRC connected mode.

6.1.1.1 Codebook based UL transmission

For codebook based transmission, PUSCH can be scheduled by DCI format 0\_0, DCI format 0\_1, DCI format 0\_2, DCI format 0\_3 or semi-statically configured to operate according to Clause 6.1.2.3. If this PUSCH is scheduled by DCI format 0\_1, DCI format 0\_2, or semi-statically configured to operate according to Clause 6.1.2.3, the UE determines its PUSCH transmission precoder(s) based on SRI(s), TPMI(s) and the transmission rank, where the SRI(s), TPMI(s) and the transmission rank are given by DCI fields of one or two SRS resource indicators and one or two Precoding information and number of layers in clause 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212] for DCI format 0\_1 and 0\_2 or given by *srs-ResourceIndicator* and *precodingAndNumberOfLayers* according to clause 6.1.2.3 or given by *srs-ResourceIndicator, srs-ResourceIndicator2,* *precodingAndNumberOfLayers, and precodingAndNumberOfLayers2* according to clause 6.1.2.3. If this PUSCH is scheduled by DCI format 0\_3, the UE determines its PUSCH transmission precoder based on SRI, TPMI and the transmission rank, where the SRI, TPMI and the transmission rank are given by DCI fields of one SRS resource indicator and one Precoding information and number of layers in clause 7.3.1.1.4 of [5, TS 38.212] for DCI format 0\_3. The *SRS-ResourceSet(s)* applicable for PUSCH scheduled by DCI format 0\_1 and DCI format 0\_2 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* and *srs-ResourceSetToAddModListDCI-0-2* in *SRS-config*, respectively. Only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook', and only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook'.

When only one SRS resource set is configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook', SRI and TPMI are given by the DCI fields of one SRS resource indicator and one Precoding information and number of layers in clause 7.3.1.1.2, 7.3.1.1.3 and 7.3.1.1.4 of [5, TS 38.212] for DCI format 0\_1. 0\_2 and 0\_3 or given by *srs-ResourceIndicator* and *precodingAndNumberOfLayers* according to clause 6.1.2.3. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook', SRI and TPMI are given by the DCI fields of one SRS resource indicator and one Precoding information and number of layers in clause 7.3.1.1.4 of [5, TS 38.212] for DCI format 0\_3 and the UE applies the indicated SRI and TPMI to one or more PUSCH repetitions according to the first SRS resource set. The TPMI is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource selected by the SRI when multiple SRS resources are configured, or if a single SRS resource is configured TPMI is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource. The transmission precoder is selected from the uplink codebook that has a number of antenna ports equal to higher layer parameter *nrofSRS-Ports* in SRS-Config, as defined in Clause 6.3.1.5 of [4, TS 38.211]. When the UE is configured with the higher layer parameter *txConfig* set to 'codebook', the UE is configured with at least one SRS resource. The indicated SRI in slot *n* is associated with the most recent transmission of SRS resource identified by the SRI, where the SRS resource is prior to the PDCCH carrying the SRI.

When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook', one or two SRI(s), and one or two TPMI(s) are given by the DCI fields of two SRS resource indicator and two Precoding information and number of layers in clause 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212] for DCI format 0\_1 and 0\_2. The UE applies the indicated SRI(s) and TPMI(s) to one or more PUSCH repetitions according to the associated SRS resource set of a PUSCH repetition according to clause 6.1.2.1. Each TPMI, based on indicated codepoint of *SRS Resource Set* *indicator*, is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource selected by the corresponding SRI when multiple SRS resources are configured for the applicable SRS resource set, or if a single SRS resource is configured for the applicable SRS resource set TPMI is used to indicate the precoder to be applied over the layers {0…*ν*-1} and that corresponds to the SRS resource. For one or two TPMI(s), the transmission precoder is selected from the uplink codebook that has a number of antenna ports equal to the higher layer parameter *nrofSRS-Ports* in SRS-Config for the indicated SRI(s), as defined in Clause 6.3.1.5 of [4, TS 38.211]. When two SRIs are indicated, the UE shall expect the *nrofSRS-Ports* for the two indicated SRS resources to be the same. When the UE is configured with the higher layer parameter *txConfig* set to 'codebook', the UE is configured with at least one SRS resource. Each of the indicated one or two SRI(s) in slot *n* is associated with the most recent transmission of SRS resource of associated SRS resource set identified by the SRI, where the SRS resource is prior to the PDCCH carrying the SRI. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook', the UE is not expected to be configured with different number of SRS resources in the two SRS resource sets.

When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the most recent transmission of SRS resource identified by the SRI, the PDCCH candidate that starts earlier in time is used.

For codebook based transmission, the UE determines its codebook subsets based on TPMI(s) and upon the reception of higher layer parameter *codebookSubset* in *pusch-Config* for PUSCH associated with DCI format 0\_1 or 0\_3 and *codebookSubsetDCI-0-2* in *pusch-Config* for PUSCH associated with DCI format 0\_2 which may be configured with *'*fullyAndPartialAndNonCoherent*'*, or *'*partialAndNonCoherent*'*, or 'nonCoherent' depending on the UE capability. When higher layer parameter *ul-FullPowerTransmission* is set to '*fullpowerMode2'* and the higher layer parameter *codebookSubset* or the higher layer parameter *codebookSubsetDCI-0-2* is set to *'*partialAndNonCoherent', and when the SRS-resourceSet with usage set to "codebook" includes at least one SRS resource with 4 ports and one SRS resource with 2 ports, the codebookSubset associated with the 2-port SRS resource is 'nonCoherent'. The maximum transmission rank may be configured by the higher layer parameter *maxRank* in *pusch-Config* for PUSCH scheduled with DCI format 0\_1 or 0\_3 and *maxRankDCI-0-2* for PUSCH scheduled with DCI format 0\_2*.*

A UE reporting its UE capability of 'partialAndNonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetDCI-0-2* with 'fullyAndPartialAndNonCoherent*'*.

A UE reporting its UE capability of 'nonCoherent' transmission shall not expect to be configured by either *codebookSubset* or *codebookSubsetDCI-0-2* with *'*fullyAndPartialAndNonCoherent*'* or with *'*partialAndNonCoherent'.

A UE shall not expect to be configured with the higher layer parameter *codebookSubset* or the higher layer parameter *codebookSubsetDCI-0-2* set to *'*partialAndNonCoherent' when higher layer parameter *nrofSRS-Ports* in an *SRS-ResourceSet* with *usage* set to 'codebook' indicates that the maximum number of the configured SRS antenna ports in the *SRS-ResourceSet* is two.

For codebook based transmission, only one SRS resource can be indicated based on the SRI from within the SRS resource set. Except when higher layer parameter *ul-FullPowerTransmission* is set to 'fullpowerMode2', the maximum number of configured SRS resources for codebook based transmission is 2. If aperiodic SRS is configured for a UE, the SRS request field in DCI triggers the transmission of aperiodic SRS resources.

A UE shall not expect to be configured with higher layer parameter *ul-FullPowerTransmission* set to 'fullpowerMode1*'* and *codebookSubset* or *codebookSubsetDCI-0-2* set to *'*fullAndPartialAndNonCoherent*'* simultaneously.

The UE shall transmit PUSCH using the same antenna port(s) as the SRS port(s) in the SRS resource indicated by the DCI format 0\_1, 0\_2 or 0\_3 or by *configuredGrantConfig* according to clause 6.1.2.3.

The DM-RS antenna ports  in Clause 6.4.1.1.3 of [4, TS38.211] are determined according to the ordering of DM-RS port(s) given by Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 in Clause 7.3.1.1.2 of [5, TS 38.212].

Except when higher layer parameter *ul-FullPowerTransmission* is set to 'fullpowerMode2', when multiple SRS resources are configured by *SRS-ResourceSet* with *usage* set to 'codebook', the UE shall expect that higher layer parameters *nrofSRS-Ports* in *SRS-Resource* in *SRS-ResourceSet* shall be configured with the same value for all these SRS resources.

When higher layer parameter *ul-FullPowerTransmission* is set to 'fullpowerMode2',

- the UE can be configured with one SRS resource or multiple SRS resources with same or different number of SRS ports within an SRS resource set with *usage* set to 'codebook'.

- up to 2 different spatial relations can be configured for all SRS resources in the SRS resource set with *usage* set to 'codebook' when multiple SRS resources are configured in the SRS resource set.

- subject to UE capability, a maximum of 2 or 4 SRS resources are supported in an SRS resource set with *usage* set to 'codebook'.

6.1.1.2 Non-Codebook based UL transmission

For non-codebook based transmission, PUSCH can be scheduled by DCI format 0\_0, DCI format 0\_1, DCI format 0\_2, DCI format 0\_3 or semi-statically configured to operate according to Clause 6.1.2.3. If this PUSCH is scheduled by DCI format 0\_1, DCI format 0\_2, DCI format 0\_3 or semi-statically configured to operate according to Clause 6.1.2.3, the UE can determine its PUSCH precoder(s) and transmission rank based on the SRI(s) when multiple SRS resources are configured, where the SRI(s) is given by one or two SRS resource indicator(s) in DCI according to clause 7.3.1.1.2, and 7.3.1.1.3 of [5, 38.212] for DCI format 0\_1 and DCI format 0\_2, or the SRI is given by one SRS resource indicator in DCI according to clause 7.3.1.1.4 of [5, 38.212] for DCI format 0\_3, or the SRI is given by *srs-ResourceIndicator* according to clause 6.1.2.3, or SRIs given by *srs-ResourceIndicator* and *srs-ResourceIndicator2* according to clause 6.1.2.3.. The *SRS-ResourceSet(s)* applicable for PUSCH scheduled by DCI format 0\_1 and DCI format 0\_2 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* and *srs-ResourceSetToAddModListDCI-0-2* in *SRS-config*, respectively. The UE shall use one or multiple SRS resources for SRS transmission, where, in a SRS resource set, the maximum number of SRS resources which can be configured to the UE for simultaneous transmission in the same symbol and the maximum number of SRS resources are UE capabilities. The SRS resources transmitted simultaneously occupy the same RBs. Only one SRS port for each SRS resource is configured. Only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', and only one or two SRS resource sets can be configured in *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook'. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', SRIs are given by the DCI fields of two SRS resource indicators in clause 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212] for DCI format 0\_1 and 0\_2 and the UE applies the indicated SRI(s) to one or more PUSCH repetitions according to the associated SRS resource set of a PUSCH repetition according to clause 6.1.2.1. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', SRI is given by the DCI field of one SRS resource indicator in clause 7.3.1.1.4 of [5, TS 38.212] for DCI format 0\_3 and the UE applies the indicated SRI to one or more PUSCH repetitions according to the first SRS resource set. The maximum number of SRS resources per SRS resource set that can be configured for non-codebook based uplink transmission is 4. Each of the indicated SRIs in slot *n* is associated with the most recent transmission of SRS resource(s) of associated SRS resource set identified by the SRI, where the SRS transmission is prior to the PDCCH carrying the SRI. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook', the UE is not expected to be configured with different number of SRS resources in the two SRS resource sets.

When the PDCCH reception includes two PDCCH candidates from two respective search space sets, as described in clause 10.1 of [6, TS 38.213], for the purpose of determining the most recent transmission of SRS resource(s) identified by the SRI, the PDCCH candidate that starts earlier in time is used.

For non-codebook based transmission, the UE can calculate the precoder used for the transmission of SRS based on measurement of an associated NZP CSI-RS resource. A UE can be configured with only one NZP CSI-RS resource for each of the SRS resource set(s) with higher layer parameter usage in *SRS-ResourceSet* set to 'nonCodebook' if configured.

- If aperiodic SRS resource set is configured, the associated NZP-CSI-RS is indicated via SRS request field in DCI format 0\_1 and 1\_1, DCI format 0\_2 (if SRS request field is present) and DCI format 1\_2 (if SRS request field is present), as well as DCI format 0\_3 and 1\_3, where *AperiodicSRS-ResourceTrigger* and *AperiodicSRS-ResourceTriggerList* (indicating the association between aperiodic SRS triggering state(s) and SRS resource sets), triggered SRS resource(s) *srs-ResourceSetId*, *csi-RS* (indicating the associated *NZP-CSI-RS-ResourceId*) are higher layer configured in *SRS-ResourceSet*. The *SRS-ResourceSet(s)* associated with the SRS request by DCI format 0\_1, 0\_3, 1\_1 and 1\_3 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* and the *SRS-ResourceSet(s)* associated with the SRS request by DCI format 0\_2 and 1\_2 are defined by the entries of the higher layer parameter *srs-ResourceSetToAddModListDCI-0-2*. A UE is not expected to update the SRS precoding information if the gap from the last symbol of the reception of the aperiodic NZP-CSI-RS resource and the first symbol of the aperiodic SRS transmission is less than 42 OFDM symbols, where the SCS configuration *μ* is the smallest SCS configuration between the NZP-CSI-RS resource and the SRS transmission.

- If the UE configured with aperiodic SRS associated with aperiodic NZP CSI-RS resource, the presence of the associated CSI-RS is indicated by the SRS request field if the value of the SRS request field is not '00' as in Table 7.3.1.1.2-24 of [5, TS 38.212] and if the scheduling DCI is not used for cross carrier or cross bandwidth part scheduling. If UE is configured with *minimumSchedulingOffsetK0* in the active DL BWP and the currently applicable minimum scheduling offset restriction *K0,min* is larger than 0, the UE does not expected to receive the scheduling DCI with the SRS request field value other than '00'. The CSI-RS is located in the same slot as the SRS request field. If the UE configured with aperiodic SRS associated with aperiodic NZP CSI-RS resource, any of the TCI states configured in the scheduled CC shall not be configured with *qcl-Type* set to 'typeD'.

- If periodic or semi-persistent SRS resource set is configured, the *NZP-CSI-RS-ResourceId* for measurement is indicated via higher layer parameter *associatedCSI-RS* in *SRS-ResourceSet*.

The UE shall perform one-to-one mapping from the indicated SRI(s) to the indicated DM-RS ports(s) and their corresponding PUSCH layers {0 … ν-1} given by DCI format 0\_1, 0\_2 or 0\_3 or by *configuredGrantConfig* according to clause 6.1.2.3 in increasing order.

The UE shall transmit PUSCH using the same antenna ports as the SRS port(s) in the SRS resource(s) indicated by SRI(s) given by DCI format 0\_1 or 0\_2 or by *configuredGrantConfig* according to clause 6.1.2.3, where the SRS port in (*i*+1)-th SRS resource in the SRS resource set is indexed as .

The DM-RS antenna ports  in Clause 6.4.1.1.3 of [4, TS 38.211] are determined according to the ordering of DM-RS port(s) given by Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 in Clause 7.3.1.1.2 of [5, TS 38.212].

For non-codebook based transmission, the UE does not expect to be configured with both *spatialRelationInfo* for SRS resource and *associatedCSI-RS* in *SRS-ResourceSet* for SRS resource set.

For non-codebook based transmission, the UE can be scheduled with DCI format 0\_1 or 0\_2 when at least one SRS resource is configured in *SRS-ResourceSet* with *usage* set to 'nonCodebook'.

6.1.2 Resource allocation

6.1.2.1 Resource allocation in time domain

When the UE is scheduled to transmit a transport block and no CSI report by a DCI or by a RAR UL grant or fallbackRAR UL grant, or the UE is scheduled to transmit a transport block and a CSI report(s) on PUSCH by a DCI, the '*Time domain resource assignment'* field value *m* for the scheduled PUSCH on the serving cell of the DCI or the *PUSCH time resource allocation* field value *m* of the RAR UL grant or of the fallbackRAR UL grant provides a row index *m* + 1to a resource allocation table. The determination of the used resource allocation table is defined in Clause 6.1.2.1.1. The indexed row defines the slot offset *K2*, the start and length indicator *SLIV*, or directly the start symbol *S* and the allocation length *L*, the PUSCH mapping type, the number of slots used for TBS determination (if *numberOfSlotsTBoMS* is present in the resource allocation table), and the number of repetitions (if *numberOfRepetitions* is present in the resource allocation table) to be applied in the PUSCH transmission.

When the UE is scheduled to transmit a PUSCH with no transport block and with a CSI report(s) by a '*CSI request'* field on a DCI, the '*Time domain resource assignment'* field value *m* of the DCI provides a row index *m* + 1to the allocated table as defined in Clause 6.1.2.1.1. The indexed row defines the start and length indicator SLIV, or directly the start symbol *S* and the allocation length *L*, and the PUSCH mapping type to be applied in the PUSCH transmission and the *K2* value is determined as , where  are the corresponding list entries of the higher layer parameter

- *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17*, if PUSCH is scheduled by DCI format 0\_2 and *reportSlotOffsetListDCI-0-2* or *reportSlotOffsetListDCI-0-2-r17* is configured;

- *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17*, if PUSCH is scheduled by DCI format 0\_1 or 0\_3 and *reportSlotOffsetListDCI-0-1* or *reportSlotOffsetListDCI-0-1-r17* is configured;

- *reportSlotOffsetList* or *reportSlotOffsetList-r17*, otherwise;

in *CSI-ReportConfig* for the  triggered CSI Reporting Settings and  is the *(m+1)*th entry of .

- The slot *Ks* where the UE shall transmit the PUSCH is determined by *K2* as *Ks* =, if UE is configured with *ca-SlotOffset* for at least one of the scheduled and scheduling cell, , otherwise, where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where is the subcarrier spacing configuration for with a value of 0 for frequency range 1, *n* is the slot with the scheduling DCI, K*2* is based on the numerology of PUSCH,  and  are the subcarrier spacing configurations for PUSCH and PDCCH, respectively, and the scheduling DCI is other than DCI format 0\_0 with CRC scrambled by TC-RNTI.

- and are the and the, respectively, which are determined by higher-layer configured *ca-SlotOffset* for the cell receiving the PDCCH, and are the and the,respectively, which are determined by higher-layer configured *ca-SlotOffset* for the cell transmitting the PUSCH, as defined in clause 4.5 of [4, TS 38.211], and

- for PUSCH scheduled by DCI format 0\_1, if *pusch-RepTypeIndicatorDCI-0-1* is set to 'pusch-RepTypeB', the UE applies PUSCH repetition Type B procedure when determining the time domain resource allocation. For PUSCH scheduled by DCI format 0\_2, if *pusch-RepTypeIndicatorDCI-0-2* is set to 'pusch-RepTypeB', the UE applies PUSCH repetition Type B procedure when determining the time domain resource allocation. Otherwise, the UE applies PUSCH repetition Type A procedure when determining the time domain resource allocation for PUSCH scheduled by PDCCH, by RAR UL grant, or by fallbackRAR UL grant.

- for PUSCH scheduled by DCI format 0\_1 or DCI format 0\_2, if *numberOfSlotsTBoMS* is present and larger than 1, the UE applies TB processing over multiple slots procedure when determining the time domain resource allocation.

- For PUSCH repetition Type A and TB processing over multiple slots, the starting symbol *S* relative to the start of the slot, and the number of consecutive symbols *L* counting from the symbol *S* allocated for the PUSCH are determined from the start and length indicator *SLIV* of the indexed row:

if  then



else



where, and

- For PUSCH repetition Type B, the starting symbol *S* relative to the start of the slot, and the number of consecutive symbols *L* counting from the symbol *S* allocated for the PUSCH are provided by *startSymbol* and *length* of the indexed row of the resource allocation table, respectively.

- For PUSCH repetition Type A and TB processing over multiple slots, the PUSCH mapping type is set to Type A or Type B as defined in Clause 6.4.1.1.3 of [4, TS 38.211] as given by the indexed row.

- For PUSCH repetition Type B, the PUSCH mapping type is set to Type B.

The UE shall consider the *S* and *L* combinations defined in table 6.1.2.1-1 as valid PUSCH allocations

**Table 6.1.2.1-1: Valid *S* and *L* combinations**

|  |  |  |
| --- | --- | --- |
| **PUSCH mapping type** | **Normal cyclic prefix** | **Extended cyclic prefix** |
| ***S*** | ***L*** | ***S+L*** | ***S*** | ***L*** | ***S+L*** |
| Type A (repetition Type A only) | 0 | {4,…,14} | {4,…,14}  | 0 | {4,…,12} | {4,…,12} |
| Type B | {0,…,13} | {1,…,14} | {1,…,14} for repetition Type A, {1,…,27} for repetition Type B | {0,…, 11} | {1,…,12} | {1,…,12} for repetition Type A, {1,…,23} for repetition Type B |

For TB processing over multiple slots, when transmitting PUSCH scheduled by DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1,

- the number of slots used for TBS determination *N* is indicated by *numberOfSlotsTBoMS.*

- the number of repetitions *K* of the number of slots *N* used for TBS determination is determined as

- if *numberOfRepetitions* is present in the resource allocation table, the number of repetitions *K* is equal to *numberOfRepetitions*;

- otherwise, *K=1*.

- when the UE supports repetition of TB processing over multiple slots, the UE does not expect that is larger than 32.

When configured with m= 5 or 6 the UE does not expect to be scheduled with more than one PUSCH in a slot, by a single DCI or multiple DCIs, where multiple DCIs are not associated with CORESETs having different *coresetpoolIndex*.

For PUSCH repetition Type A, when transmitting PUSCH scheduled by DCI format 0\_1, 0\_2 or 0\_3 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or scheduled by DCI format 0\_1 or 0\_2 in PDCCH with CRC scrambled CS-RNTI with NDI=1, the number of repetitions *K* is determined as

- if *numberOfRepetitions* is present in the resource allocation table, the number of repetitions K is equal to *numberOfRepetitions*;

- elseif the UE is configured with *pusch-AggregationFactor*, the number of repetitions *K* is equal to *pusch-AggregationFactor*;

- otherwise *K=1*.

- the number of slots used for TBS determination *N* is equal to 1.

For PUSCH repetition type A, when transmitting PUSCH scheduled by RAR UL grant, the 2 MSBs of the MCS information field of the RAR UL grant provide a codepoint to determine the number of repetitions *K* according to Table 6.1.2.1-1A, based on whether or not the higher layer parameter *numberOfMsg3-RepetitionsList* is configured. The number of slots used for TBS determination N is equal to 1.

For PUSCH repetition type A, when transmitting PUSCH scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, the 2 MSBs of the MCS information field of the DCI format 0\_0 with CRC scrambled by TC-RNTI provide a codepoint to determine the number of repetitions *K* according to Table 6.1.2.1-1A, based on whether or not the higher layer parameter *numberOfMsg3-RepetitionsList* is configured. The number of slots used for TBS determination N is equal to 1.

**Table 6.1.2.1-1A: Number of repetition *K* as a function of 2 MSBs of MCS information field**

|  |  |  |
| --- | --- | --- |
| ***numberOfMsg3-RepetitionsList is configured*** |  | ***numberOfMsg3-RepetitionsList is not configured*** |
| ***Codepoint*** | ***K*** |  | **Codepoint** | ***K*** |
| 00 | First value of *numberOfMsg3-RepetitionsList* |  | 00 | 1 |
| 01 | Second value of *numberOfMsg3-RepetitionsList* |  | 01 | 2 |
| 10 | Third value of *numberOfMsg3-RepetitionsList* |  | 10 | 3 |
| 11 | Fourth value of *numberOfMsg3-RepetitionsList* |  | 11 | 4 |

If a UE is configured with higher layer parameter *pusch-TimeDomainAllocationListForMultiPUSCH*, the UE does not expect to be configured with *pusch-AggregationFactor*.

If a UE is configured with *extendedK2* in *pusch-TimeDomainAllocationListForMultiPUSCH* in which one or more rows contain multiple SLIVs for PUSCH on a UL BWP of a serving cell, the UE does not apply *pusch-AggregationFactor,* if configured, to DCI format 0\_1 on the UL BWP of the serving cell and the UE does not expect to be configured with *numberOfRepetitions* in *pusch-TimeDomainAllocationListForMultiPUSCH*.

If a UE is configured with *extendedK2* in *pusch-TimeDomainAllocationListForMultiPUSCH* in which one or more rows contain multiple *SLIV*s for PUSCH on a UL BWP of a serving cell, when any two UL DCIs end in the same symbol and at least one of the DCIs scheduling multiple PUSCHs, the UE does not expect that the any scheduled multiple PUSCHs have overlapping spans, where the span associated with a DCI is defined from the beginning of the first scheduled PUSCH till the end of the last scheduled PUSCH.

For unpaired spectrum:

- When *AvailableSlotCounting* is enabled, and in case *K>1,* the UE determines slots for a PUSCH transmission of a PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, based on *tdd-UL-DL-ConfigurationCommon*, *tdd-UL-DL-ConfigurationDedicated* *and ssb-PositionsInBurst*, and the TDRA information field value in the DCI format 0\_1 or 0\_2.

- A slot is not counted in the number of slots for PUSCH transmission of a PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2 if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

- Otherwise, the UE determines consecutive slots for a PUSCH transmission of a PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, based on the TDRA information field value in the DCI format 0\_1 or 0\_2.

- The UE determines slots for a PUSCH transmission of TB processing over multiple slots scheduled by DCI format 0\_1 or 0\_2, based on *tdd-UL-DL-ConfigurationCommon*, *tdd-UL-DL-ConfigurationDedicated* and *ssb-PositionsInBurst*, and the TDRA information field value in the DCI format 0\_1 or 0\_2.

- A slot is not counted in the number of slots for a PUSCH transmission of TB processing over multiple slots if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

- The UE determines slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by RAR UL grant, based on *tdd-UL-DL-ConfigurationCommon* and *ssb-PositionsInBurst,* and the TDRA information field value in the RAR UL grant.

- A slot is not counted in the number of slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by RAR UL grant, if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

- The UE determines slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, based on *tdd-UL-DL-ConfigurationCommon* and *ssb-PositionsInBurst* and the TDRA information field value in the DCI scheduling the PUSCH.

- A slot is not counted in the number of slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by DCI format 0\_0 scrambled by TC-RNTI, if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot overlaps with a DL symbol indicated by *tdd-UL-DL-ConfigurationCommon* if provided, or a symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

For paired spectrum and SUL band:

- The UE determines consecutive slots for a PUSCH transmission of a PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or 0\_3 for paired spectrum only, or for a PUSCH transmission of TB processing over multiple slots scheduled by DCI format 0\_1 or 0\_2, based on the TDRA information field value in the DCI format 0\_1, 0\_2 or 0\_3.

- For the case of a reduced capability half-duplex UE, the UE determines slots for a PUSCH transmission of a PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2 when *AvailableSlotCounting* is enabled and K>1, or for a PUSCH transmission of TB processing over multiple slots scheduled by DCI format 0\_1 or 0\_2, based on the TDRA information field value in the DCI format 0\_1 or 0\_2. A slot is not counted in the number of slots if at least one of the symbols indicated by the indexed row of the used resource allocation table in the slot does not start or end at least or , respectively, from the last or first symbol of an SS/PBCH block with index provided by *ssb-PositionsInBurst*.

- The UE determines consecutive slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by RAR UL grant, based on the TDRA information field value in the RAR UL grant.

- The UE determines consecutive slots for a PUSCH transmission of a PUSCH repetition Type A scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI, based on the TDRA information field value in the DCI scheduling the PUSCH.

If a UE would transmit a PUSCH of PUSCH repetition Type A when *AvailableSlotCounting* is enabled and K>1 or a TB processing over multiple slots over slots, and the UE does not transmit the PUSCH of a TB processing over multiple slots or the PUSCH repetition Type A in a slot from the slots, according to Clause 9, Clause 11.1, Clause 11.2A, Clause 15 and Clause 17.2 of [6, TS 38.213], the UE counts the slots in the number of slots.

For PUSCH repetition Type A, in case *K>1*,

- If the PUSCH is scheduled by DCI format 0\_1 or 0\_2

- if *AvailableSlotCounting* is enabled, the same symbol allocation is applied across the slots determined for the PUSCH transmission and the PUSCH is limited to a single transmission layer. The UE shall repeat the TB across the slots determined for the PUSCH transmission, applying the same symbol allocation in each slot.

- Otherwise, the same symbol allocation is applied across the consecutive slots and the PUSCH is limited to a single transmission layer. The UE shall repeat the TB across the consecutive slots applying the same symbol allocation in each slot.

- Else if the PUSCH is scheduled by RAR UL grant or by DCI format 0\_0 with CRC scrambled by TC-RNTI, the same symbol allocation is applied across the slots determined for the PUSCH transmission and the PUSCH is limited to a single transmission layer. The UE shall repeat the TB across the slots determined for the PUSCH transmission, applying the same symbol allocation in each slot.

For TB processing over multiple slots:

- For unpaired spectrum, the same symbol allocation is applied across the slots determined for the PUSCH transmission and the PUSCH is limited to a single transmission layer. The UE shall transmit the TB across the slots determined for the PUSCH transmission, applying the same symbol allocation in each slot.

- For paired spectrum or supplementary uplink band, the same symbol allocation is applied across the consecutive slots and the PUSCH is limited to a single transmission layer. The UE shall transmit the TB across the consecutive slots applying the same symbol allocation in each slot.

- For the case of reduced capability half-duplex UE, the same symbol allocation is applied across the slots determined for the PUSCH transmission and the PUSCH is limited to a single transmission layer. The UE shall transmit the TB across the slots determined for the PUSCH transmission, applying the same symbol allocation in each slot.

For a PUSCH transmission scheduled by DCI format 0\_1, 0\_2 or 0\_3, or 0\_0 with CRC scrambled by TC-RNTI, the redundancy version to be applied on the *n*th transmission occasion of the TB, where n = 0, 1, …-1, is determined according to table 6.1.2.1-2.

For a PUSCH transmission of a PUSCH repetition Type A scheduled by RAR UL grant, the redundancy version to be applied on the *n*th transmission occasion of the TB, where n = 0, 1, …-1, is determined according to the first row of Table 6.1.2.1-2.

**Table 6.1.2.1-2: Redundancy version for PUSCH transmission**

|  |  |
| --- | --- |
| ***rvid* indicated by the DCI scheduling the PUSCH** | ***rvid* to be applied to *n*th transmission occasion (repetition Type A) or TB processing over multiple slots) or *n*th actual repetition (repetition Type B)** |
| ***((n-(n mod N))/N)* mod 4 = 0** | ***((n-(n mod N))/N)* mod 4 = 1** | ***((n-(n mod N))/N)* mod 4 = 2** | ***((n-(n mod N))/N)* mod 4 = 3** |
| 0 | 0 | 2 | 3 | 1 |
| 2 | 2 | 3 | 1 | 0 |
| 3 | 3 | 1 | 0 | 2 |
| 1 | 1 | 0 | 2 | 3 |

When transmitting MsgA PUSCH on a non-initial UL BWP, if the UE is configured with *startSymbolAndLengthMsgA-PO*, the UE shall determine the *S* and *L* from *startSymbolAndLengthMsgA-PO*.

When transmitting MsgA PUSCH, if the UE is not configured with *startSymbolAndLengthMsgA-PO*, and if the TDRA list *PUSCH-TimeDomainResourceAllocationList* is provided in *PUSCH-ConfigCommon*, the UE shall use *msgA-PUSCH-TimeDomainAllocation* to indicate which values are used in the list. If *PUSCH-TimeDomainResourceAllocationList* is not provided in *PUSCH-ConfigCommon*, the UE shall use parameters *S* and *L* from table 6.1.2.1.1-2 or table 6.1.2.1.1-3 where *msgA-PUSCH-TimeDomainAllocation* indicates which values are used in the list. The time offset for PUSCH transmission is described in [6, TS 38.213].

For PUSCH repetition Type A and TB processing over multiple slots, a PUSCH transmission in a slot of a multi-slot PUSCH transmission is omitted according to the conditions in Clause 9, Clause 11.1, Clause 11.2A, Clause 15 and Clause 17.2 of [6, TS 38.213].

For PUSCH repetition Type B, except for PUSCH transmitting CSI report(s) with no transport block, the number of nominal repetitions is given by *numberOfRepetitions*. For the *n*-th nominal repetition, *n* = *0*, …, *numberOfRepetitions* - 1,

- The slot where the nominal repetition starts is given by , and the starting symbol relative to the start of the slot is given by .

- The slot where the nominal repetition ends is given by , and the ending symbol relative to the start of the slot is given by .

Here is the slot where the PUSCH transmission starts, and is the number of symbols per slot as defined in Clause 4.3.2 of [4, TS38.211].

For PUSCH repetition Type B, the UE determines invalid symbol(s) for PUSCH repetition Type B transmission as follows:

- A symbol that is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* is considered as an invalid symbol for PUSCH repetition Type B transmission.

- For operation in unpaired spectrum, symbols indicated by *ssb-PositionsInBurst* in SIB1 or *ssb-PositionsInBurst* in *ServingCellConfigCommon* or by *NonCellDefiningSSB* for reception of SS/PBCH blocks are considered as invalid symbols for PUSCH repetition Type B transmission.

- For a reduced capability half-duplex UE in paired spectrum, symbols that do not start or end at least or , respectively, from the last or first symbol of an SS/PBCH block with index indicated by *ssb-PositionsInBurst* in SIB1 or by *ssb-PositionsInBurst* in *ServingCellConfigCommon* or by *NonCellDefiningSSB*, or by *ssb-PositionsInBurst* in *SSB-MTC-AdditionalPCI* associated to physical cell ID with active TCI states for PDCCH or PDSCH, or for a set of symbols of a slot corresponding to SS/PBCH blocks configured for L1 beam measurement/reporting for reception of SS/PBCH blocks are considered as invalid symbols for PUSCH repetition Type B transmission.

- For operation in unpaired spectrum, symbol(s) indicated by *pdcch-ConfigSIB1* in *MIB* for a CORESET for Type0-PDCCH CSS set are considered as invalid symbol(s) for PUSCH repetition Type B transmission.

- For operation in unpaired spectrum, if *numberOfInvalidSymbolsForDL-UL-Switching* is configured, *numberOfInvalidSymbolsForDL-UL-Switching* symbol(s) after the last symbol that is indicated as downlink in each consecutive set of all symbols that are indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* are considered as invalid symbol(s) for PUSCH repetition Type B transmission. The symbol(s) given by *numberOfInvalidSymbolsForDL-UL-Switching* are defined using the reference SCS configuration *referenceSubcarrierSpacing* provided in *tdd-UL-DL-ConfigurationCommon*.

- For operation with shared spectrum channel access with semi-static channel occupancy, symbols in an idle duration associated with a periodic channel occupancy as described in Clause 4.3.1.1 of [16, 37.213], or in an idle duration in a period associated with an initiated channel occupancy as described in Clause 4.3.2. of [16, TS 37.213] are considered as invalid symbol(s) for PUSCH repetition Type B transmission.

- The UE may be configured with the higher layer parameter *invalidSymbolPattern*, which provides a symbol level bitmap spanning one or two slots (higher layer parameter *symbols* given by *invalidSymbolPattern*). A bit value equal to 1 in the symbol level bitmap *symbols* indicates that the corresponding symbol is an invalid symbol for PUSCH repetition Type B transmission. The UE may be additionally configured with a time-domain pattern (higher layer parameter *periodicityAndPattern* given by *invalidSymbolPattern*), where each bit of *periodicityAndPattern* corresponds to a unit equal to a duration of the symbol level bitmap *symbols*, and a bit value equal to 1 indicates that the symbol level bitmap *symbols* is present in the unit. The *periodicityAndPattern* can be {1, 2, 4, 5, 8, 10, 20 or 40} units long, but maximum of 40 msec. The first symbol of *periodicityAndPattern* every 40 msec/P periods is a first symbol in frame 𝑛𝑓 mod 4 = 0, where P is the duration of *periodicityAndPattern-r16* in units of msec. When *periodicityAndPattern* is not configured, for a symbol level bitmap spanning two slots, the bits of the first and second slots correspond respectively to even and odd slots of a radio frame, and for a symbol level bitmap spanning one slot, the bits of the slot correspond to every slot of a radio frame. If *invalidSymbolPattern* is configured, when the UE applies the invalid symbol pattern is determined as follows:

- if the PUSCH is scheduled by DCI format 0\_1, or corresponds to a Type 2 configured grant activated by DCI format 0\_1, and if *invalidSymbolPatternIndicatorDCI-0-1* is configured,

- if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern;

- otherwise, the UE does not apply the invalid symbol pattern;

- if the PUSCH is scheduled by DCI format 0\_2, or corresponds to a Type 2 configured grant activated by DCI format 0\_2, and if *invalidSymbolPatternIndicatorDCI-0-2* is configured,

- if invalid symbol pattern indicator field is set 1, the UE applies the invalid symbol pattern;

- otherwise, the UE does not apply the invalid symbol pattern;

- otherwise, the UE applies the invalid symbol pattern.

- If the UE

- is configured with multiple serving cells within a cell group and is provided with *directionalCollisionHandling-r16* = 'enabled' for a set of serving cell(s) among the multiple serving cells, and

- indicates support of *half-DuplexTDD-CA-SameSCS-r16* capability, and

- is not configured to monitor PDCCH for detection of DCI format 2-0 on any of the multiple serving cells,

- a symbol indicated to the UE for reception of SS/PBCH blocks in a first cell of the multiple serving cells by *ssb-PositionsInBurst* in *SIB1* or by *ssb-PositionsInBurst* in *ServingCellConfigCommon*, or by *ssb-PositionsInBurst* in *SSB-MTC-AdditionalPCI* associated to physical cell ID with active TCI states for PDCCH or PDSCH, or for a set of symbols of a slot corresponding to SS/PBCH blocks configured for L1 beam measurement/reporting is considered as an invalid symbol for PUSCH repetition Type B transmission in

- any of the multiple serving cells if the UE is not capable of simultaneous transmission and reception as indicated by *simultaneousRxTxInterBandCA* among the multiple serving cells, and

- any one of the cells corresponding to the same band as the first cell, irrespective of any capability indicated by *simultaneousRxTxInterBandCA*

and

- a symbol is considered as an invalid symbol in another cell among the set of serving cell(s) provided with *directionalCollisionHandling-r16* for PUSCH repetition Type B transmission with Type 1 or Type 2 configured grant except for the first Type 2 PUSCH transmission (including all repetitions) after activation if the symbol is indicated as downlink by *tdd-UL-DL-ConfigurationCommon* or *tdd-UL-DL-ConfigurationDedicated* on the reference cell as defined in Clause 11.1 of [6, TS 38.213], or the UE is configured by higher layers to receive PDCCH, PDSCH, or CSI-RS on the reference cell in the symbol.

For PUSCH repetition Type B, after determining the invalid symbol(s) for PUSCH repetition type B transmission for each of the *K* nominal repetitions, the remaining symbols are considered as potentially valid symbols for PUSCH repetition Type B transmission. If the number of potentially valid symbols for PUSCH repetition type B transmission is greater than zero for a nominal repetition, the nominal repetition consists of one or more actual repetitions, where each actual repetition consists of a consecutive set of all potentially valid symbols that can be used for PUSCH repetition Type B transmission within a slot. An actual repetition with a single symbol is omitted except for the case of *L*=1. An actual repetition is omitted according to the conditions in Clause 9, Clause 11.1, Clause 11.2A, Clause 15 and Clause 17.2 of [6, TS 38.213]. The UE shall repeat the TB across actual repetitions. The redundancy version to be applied on the *n*th actual repetition (with the counting including the actual repetitions that are omitted) is determined according to table 6.1.2.1-2, where *N*=1.

For PUSCH repetition Type B, when a UE receives a DCI that schedules aperiodic CSI report(s) or activates semi-persistent CSI report(s) on PUSCH with no transport block by a '*CSI request'* field on a DCI, the number of nominal repetitions is always assumed to be 1, regardless of the value of *numberOfRepetitions*. When the UE is scheduled to transmit a PUSCH repetition Type B with no transport block and with aperiodic or semi-persistent CSI report(s) by a '*CSI request'* field on a DCI, the first nominal repetition is expected to be the same as the first actual repetition. For PUSCH repetition Type B carrying semi-persistent CSI report(s) without a corresponding PDCCH after being activated on PUSCH by a '*CSI request'* field on a DCI, if the first nominal repetition is not the same as the first actual repetition, the first nominal repetition is omitted; otherwise, the first nominal repetition is omitted according to the conditions in Clause 9, Clause 11.1, Clause 11.2A, Clause 15 and Clause 17.2 of [6, TS 38.213].

For PUSCH repetition Type B, when a UE is scheduled to transmit a transport block and aperiodic CSI report(s) on PUSCH by a '*CSI request'* field on a DCI, the CSI report(s) is multiplexed only on the first actual repetition. The UE does not expect that the first actual repetition has a single symbol duration.

For *pusch-TimeDomainAllocationListForMultiPUSCH* in *pusch-Config*, if a row indicates resource allocation for two to eight contiguous PUSCHs and *extendedK2* is not configured, *K2* given by *k2-r16* indicates the slot where UE shall transmit the first PUSCH of the multiple PUSCHs. Each PUSCH has a separate SLIV and mapping type. The number of scheduled PUSCHs is signalled by the number of indicated valid SLIVs in the row of the *pusch-TimeDomainAllocationListForMultiPUSCH* signalled in DCI format 0\_1.

For *pusch-TimeDomainAllocationListForMultiPUSCH* in *pusch-Config,* if a row indicates resource allocation of more than one PUSCH and *extendedK2* is configured, each PUSCH has a separate SLIV, mapping type and *K2* given by *extendedK2*. If a row indicates resource allocation of a single PUSCH, the PUSCH has a single SLIV, mapping type, and *K2*, where *K2* is given by *extendedK2*, if configured, otherwise *K2* is given by *k2-r16*. The number of scheduled PUSCHs is signalled by the number of indicated SLIVs in the row of the *pusch-TimeDomainAllocationListForMultiPUSCH* signalled in DCI format 0\_1.

If a UE is configured with *extendedK2* in *pusch-TimeDomainAllocationListForMultiPUSCH* in which one or more rows contain multiple *SLIV*s for PUSCH on a UL BWP of a serving cell, and the UE is indicated re-transmission of PUSCH by DCI format 0\_1, where the PUSCH is correspond to a configured grant Type 1 or Type 2, the UE does not expect that the number of indicated *SLIV*s in the row of the *pusch-TimeDomainAllocationListForMultiPUSCH* by the DCI is more than one.

When the UE is configured with *minimumSchedulingOffsetK2* in an active UL BWP it applies a minimum scheduling offset restriction indicated by the '*Minimum applicable scheduling offset indicator*' field in DCI format 0\_1, 0\_3, 1\_1 or 1\_3 if the same field is available. When the UE is configured with *minimumSchedulingOffsetK2* in an active UL BWP and it has not received '*Minimum applicable scheduling offset indicator*' field in DCI format 0\_1, 0\_3, 1\_1 or 1\_3, the UE shall apply a minimum scheduling offset restriction indicated based on '*Minimum applicable scheduling offset indicator*' value '0'. When the minimum scheduling offset restriction is applied the UE is not expected to be scheduled with a DCI in slot *n* to transmit a PUSCH scheduled with C-RNTI, CS-RNTI, MCS-C-RNTI or SP-CSI-RNTI with *K*2 smaller than, where *K*2min and are the applied minimum scheduling offset restriction and the numerology of the active UL BWP of the scheduled cell when receiving the DCI in slot *n*, respectively, and is the numerology of the new active UL BWP in case of active UL BWP change in the scheduled cell and is equal to , otherwise. The minimum scheduling offset restriction is not applied when PUSCH transmission is scheduled by RAR UL grant or fallbackRAR UL grant for RACH procedure, or when PUSCH is scheduled with TC-RNTI. The application delay of the change of the minimum scheduling offset restriction is determined in Clause 5.3.1.

When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook' or 'noncodebook', for PUSCH repetition Type A, in case *K>1,* the same symbol allocation is applied across the *K* consecutive slots and the PUSCH is limited to a single transmission layer. The UE shall repeat the TB across the *K* consecutive slots applying the same symbol allocation in each slot, and the association of the first and second SRS resource set in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* toeach slot is determined as follows:

- if a DCI format 0\_3 schedules the PUSCH, the first SRS resource set is associated with all K consecutive slots,

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint "00" for the *SRS resource set indicator*, the first SRS resource set is associated with all K consecutive slots,

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint "01" for the *SRS resource set indicator*, the second SRS resource set is associated with all K consecutive slots,

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint "10" for the *SRS resource set indicator*, the first and second SRS resource set association to K consecutive slots is determined as follows:

- When K = 2, the first and second SRS resource sets are applied to the first and second slot of 2 consecutive slots, respectively.

- When K > 2 and *cyclicMapping* in *PUSCH-Config* is enabled, the first and second SRS resource sets are applied to the first and second slot of K consecutive slots, respectively, and the same SRS resource set mapping pattern continues to the remaining slots of K consecutive slots.

- When K > 2 and *sequentialMapping* in *PUSCH-Config* is enabled, first SRS resource set is applied to the first and second slots of K consecutive slots, and the second SRS resource set is applied to the third and fourth slot of K consecutive slots, and the same SRS resource set mapping pattern continues to the remaining slots of K consecutive slots.

- Otherwise, a DCI format 0\_1 or DCI format 0\_2 indicates codepoint "11" for the *SRS resource set indicator*, and the first and second SRS resource set association to K consecutive slots is determined as follows,

- When K = 2, the second and first SRS resource set are applied to the first and second slot of 2 consecutive slots, respectively.

- When K > 2 and *cyclicMapping* in *PUSCH-Config* is enabled, the second and first SRS resource sets are applied to the first and second slot of K consecutive slots, respectively, and the same SRS resource set mapping pattern continues to the remaining slots of the K consecutive slots.

- When K > 2 and *sequentialMapping* in *PUSCH-Config* is enabled, the second SRS resource set is applied to the first and second slot of K consecutive slots, and the first SRS resource set is applied to the third and fourth slot of K consecutive slots, and the same SRS resource set mapping pattern continues to the remaining slots of the K consecutive slots.

For PUSCH repetition Type B, when two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook' or 'noncodebook', the SRS resource set association to nominal PUSCH repetitions follows the same method as SRS resource set association to slots in PUSCH Type A repetition by considering nominal repetitions instead of slots.

For both PUSCH repetition Type A and PUSCH repetition Type B, when a DCI format 0\_1 or DCI format 0\_2 indicates codepoint "10" or "11" for the *SRS resource set indicator*, the redundancy version to be applied on the *n*th transmission occasion (for PUSCH repetition Type A) of the TB, where n = 0, 1, … *K*-1, or *n*th actual repetition (for PUSCH repetition Type B, with the counting including the actual repetitions that are omitted) is determined according to Table 6.1.2.1-2 and Table 6.1.2.1-3. For all PUSCH repetitions associated with the SRS resource set of the first transmission occasion or actual repetition, the redundancy version to be applied is derived according to Table 6.1.2.1-2, where n is counted only considering PUSCH transmission occasions or actual repetitions associated with the same SRS resource set as the first transmission occasion or actual repetition. The redundancy version for PUSCH transmission occasions or actual repetitions that are associated with an SRS resource set other than the SRS resource set of the first transmission occasion or actual repetition is derived according to Table 6.1.2.1-3, where additional shifting operation for each redundancy version is configured by higher layer parameter *sequenceOffsetforRV* in *PUSCH-Config* and is counted only considering PUSCH transmission occasions or actual repetitions that are not associated with the SRS resource set of the first transmission occasion or actual repetition.

**Table 6.1.2.1-3: Applied redundancy version for the other SRS resource set (SRS resource set not associated with the first transmission occasion or actual repetition) when *sequenceOffsetforRV* is present**

|  |  |
| --- | --- |
| ***rvid* indicated by the DCI scheduling the PUSCH** | ***rvid* to be applied to *n*th transmission occasion (repetition Type A) or *n*th actual repetition (repetition Type B)**  |
| ***n* mod 4 = 0** | ***n* mod 4 = 1** | ***n* mod 4 = 2** | ***n* mod 4 = 3** |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

For PUSCH repetition Type A, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and schedule aperiodic CSI report(s) on PUSCH with transport block by a '*CSI request'* field on a DCI, the CSI report(s) multiplexing is determined as follows

- if higher layer parameter *AP-CSI-MultiplexingMode* in *CSI-AssociatedReportConfigInfo* is enabled and UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is transmitted separately only on the first transmission occasion associated with the first SRS resource set and the first transmission occasion associated with the second SRS resource set.

- otherwise, the CSI report(s) is transmitted only on the first transmission occasion.

For PUSCH transmissions of TB processing over multiple slots, when a DCI format 0\_1 and DCI format 0\_2 schedule aperiodic CSI report(s) on PUSCH with transport block by a 'CSI request' field on a DCI, the CSI report(s) is transmitted only on the first slot of the 𝑁 ∙ 𝐾 slots determined for the PUSCH transmission.

For PUSCH repetition Type B, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and schedule aperiodic CSI report(s) on PUSCH with transport block by a '*CSI request'* field on a DCI, CSI report(s) multiplexing is determined as follows

- if higher layer parameter *AP-CSI-MultiplexingMode* in *CSI-AssociatedReportConfigInfo* is enabled and the first actual repetition associated with the first SRS resource set and the first actual repetition associated with the second SRS resource set have the same number of symbols and UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is multiplexed separately only on the first actual repetition associated with the first SRS resource set and first actual repetition associated with the second SRS resource set.

- otherwise, the CSI report(s) is multiplexed only on the first actual repetition.

The UE does not expect a different number of actual PT-RS ports for the two actual repetitions when the CSI report(s) is transmitted separately on two actual repetitions.

For PUSCH repetition Type A, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and schedule aperiodic CSI report(s) on PUSCH with no transport block by a '*CSI request'* field on a DCI, the number of repetitions is assumed to be 2 regardless of the value of *numberOfRepetitions* or *pusch-AggregationFactor* (if *numberOfRepetitions* is not present in the time domain resource allocation table), and transmission of CSI report(s) is determined as follows

- if higher layer parameter *AP-CSI-MultiplexingMode* in *CSI-AssociatedReportConfigInfo* is enabled and UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is transmitted separately on the first transmission occasion and the second transmission occasion

- otherwise, the CSI report(s) is transmitted only on the first transmission occasion.

For PUSCH repetition Type B, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and schedule aperiodic CSI report(s) or activates semi-persistent CSI report(s) on PUSCH with no transport block by a '*CSI request'* field on a DCI, the number of nominal repetitions is always assumed to be 2 regardless of the value of *numberOfRepetitions*, and the first and second nominal repetitions are expected to be the same as the first and second actual repetitions, and transmission of CSI report(s) is determined as follows:

- if higher layer parameter *AP-CSI-MultiplexingMode* in *CSI-AssociatedReportConfigInfo* is enabled for aperiodic CSI report(s) or higher layer paremeter *SP-CSI-MultiplexingMode* in *CSI-SemiPersistentOnPUSCH-TriggerStateList* is enabled for semi-persistent CSI report(s) and UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is transmitted separately on the first actual repetition and the second actual repetition

- otherwise, the CSI report(s) is transmitted only on the first actual repetition.

The UE does not expect a different number of actual PT-RS ports for the two actual repetitions when the CSI report(s) is transmitted separately on two actual repetitions.

For PUSCH repetition Type A, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and activate semi-persistent CSI report(s) on PUSCH with no transport block by a '*CSI request'* field on a DCI, the number of repetitions is always assumed to be 2 regardless of the value of *numberOfRepetitions* or *pusch-AggregationFactor* (if *numberOfRepetitions* is not present in the time domain resource allocation table), and transmission of CSI report(s) is determined as follows

- if higher layer parameter *SP-CSI-MultiplexingMode* in *CSI-SemiPersistenetOnPUSCH-TriggerStateList* is enabled and UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is transmitted separately on the first transmission occasion and the second transmission occasion

- otherwise, the CSI report(s) is transmitted only on the first transmission occasion.

For PUSCH repetition Type B, when a DCI format 0\_1 and DCI format 0\_2 indicate codepoint "10" or "11" for the *SRS resource set indicator* and the PUSCH repetition Type B carrying semi-persistent CSI report(s) without a corresponding PDCCH after being activated on PUSCH by a '*CSI request'* field on a DCI, the number of nominal repetitions is always assumed to be 2 regardless of the value of *numberOfRepetitions*, and transmission of CSI report(s) is determined as follows

- if higher layer parameter *SP-CSI-MultiplexingMode* in *CSI-SemiPersistenetOnPUSCH-TriggerStateList* is enabled and one of the first or second nominal repetition is the same as corresponding first or second actual repetition, the nominal repetition that is not having same actual repetition is omitted and the CSI report(s) is transmitted on the actual repetition that is not omitted.

- if higher layer parameter *SP-CSI-MultiplexingMode* in *CSI-SemiPersistenetOnPUSCH-TriggerStateList* is enabled and the first and second nominal repetitions are the same as the first and second actual repetitions and the UCI other than CSI report(s) are not multiplexed on PUSCH, the CSI report(s) is transmitted separately on the first actual repetition and the second actual repetition

- otherwise, the CSI report(s) is transmitted only on the first actual repetition.

6.1.2.1.1 Determination of the resource allocation table to be used for PUSCH

Table 6.1.2.1.1-1, Table 6.1.2.1.1-1A, Table 6.1.2.1.1-1B and Table 6.1.2.1.1-1C define which PUSCH time domain resource allocation configuration to apply.

Table 6.1.2.1.1-4 defines the subcarrier spacing specific values *j*. *j* is used in determination of *K2* in conjunction to table 6.1.2.1.1-2, for normal CP or table 6.1.2.1.1.-3 for extended CP, where is the subcarrier spacing configurations for PUSCH.

Table 6.1.2.1.1-5 defines the additional subcarrier spacing specific slot delay value for the first transmission of PUSCH scheduled by the RAR or by the fallbackRAR. When the UE transmits a PUSCH scheduled by RAR or by the fallbackRAR, the *Δ* value specific to the PUSCH subcarrier spacing *µPUSCH* is applied in addition to the *K2* value.

**Table 6.1.2.1.1-1: Applicable PUSCH time domain resource allocation for common search space and DCI format 0\_0 in UE specific search space**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **RNTI** | **PDCCH search space** | ***pusch-ConfigCommon* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationList*** | **PUSCH time domain resource allocation to apply** |
| PUSCH scheduled by MAC RAR as described in clause 8.2 of [6, TS 38.213] or MAC fallbackRAR as described in clause 8.2A of [6, 38.213] or for MsgA PUSCH transmission | No | - | Default A |
| Yes |  | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon* |
| C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI | Any common search space associated with CORESET 0 | No | - | Default A |
| Yes |  | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon* |
| C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI | Any common search space not associated with CORESET 0,DCI format 0\_0 inUE specific search space | No | No | Default A |
| Yes | No | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon*  |
| No/Yes | Yes | *pusch-TimeDomainAllocationList* provided in *pusch-Config* |

**Table 6.1.2.1.1-1A: Applicable PUSCH time domain resource allocation for DCI format 0\_1 in UE specific search space scrambled with C-RNTI, MCS-C-RNTI, CS-RNTI or SP-CSI-RNTI**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***pusch-ConfigCommon* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationListDCI-0-1*** | ***pusch-Config* includes *pusch-TimeDomainAllocationListForMultiPUSCH*** | **PUSCH time domain resource allocation to apply** |
| No | No | No | No | Default A |
| Yes | No | No | No | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon*  |
| No/Yes | Yes | No | No | *pusch-TimeDomainAllocationList* provided in *pusch-Config* |
| No/Yes | No | Yes | - | *pusch-TimeDomainAllocationListDCI-0-1* provided in *pusch-Config* |
| No/Yes | No | - | Yes | *pusch-TimeDomainAllocationListForMultiPUSCH* provided in *pusch-Config* |

**Table 6.1.2.1.1-1B: Applicable PUSCH time domain resource allocation for DCI format 0\_2 in UE specific search space scrambled with C-RNTI, MCS-C-RNTI, CS-RNTI or SP-CSI-RNTI**

|  |  |  |  |
| --- | --- | --- | --- |
| ***pusch-ConfigCommon* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationListDCI-0-2*** | **PUSCH time domain resource allocation to apply** |
| No | No | No | Default A |
| Yes | No | No | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon*  |
| No/Yes | Yes | No | *pusch-TimeDomainAllocationList* provided in *pusch-Config* |
| No/Yes | No | Yes | *pusch-TimeDomainAllocationListDCI-0-2* provided in *pusch-Config* |

**Table 6.1.2.1.1-1C: Applicable PUSCH time domain resource allocation for DCI format 0\_3 in UE specific search space scrambled with C-RNTI or MCS-C-RNTI**

|  |  |  |  |
| --- | --- | --- | --- |
| ***pusch-ConfigCommon* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationList*** | ***pusch-Config* includes *pusch-TimeDomainAllocationListDCI-0-1*** | **PUSCH time domain resource allocation to apply** |
| No | No | No | Default A |
| Yes | No | No | *pusch-TimeDomainAllocationList* provided in *pusch-ConfigCommon*  |
| No/Yes | Yes | No | *pusch-TimeDomainAllocationList* provided in *pusch-Config* |
| No/Yes | No | Yes | *pusch-TimeDomainAllocationListDCI-0-1* provided in *pusch-Config* |

**Table 6.1.2.1.1-2: Default PUSCH time domain resource allocation A for normal CP**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Row index** | **PUSCH mapping type** | ***K2*** | ***S*** | ***L*** |
| 1 | Type A | *j* | 0 | 14 |
| 2 | Type A | *j* | 0 | 12 |
| 3 | Type A | *j* | 0 | 10 |
| 4 | Type B | *j* | 2 | 10 |
| 5 | Type B | *j* | 4 | 10 |
| 6 | Type B | *j* | 4 | 8 |
| 7 | Type B | *j* | 4 | 6 |
| 8 | Type A | *j*+1 | 0 | 14 |
| 9 | Type A | *j*+1 | 0 | 12 |
| 10 | Type A | *j*+1 | 0 | 10 |
| 11 | Type A | *j*+2 | 0 | 14 |
| 12 | Type A | *j*+2 | 0 | 12 |
| 13 | Type A | *j*+2 | 0 | 10 |
| 14 | Type B | *j* | 8 | 6 |
| 15 | Type A | *j*+3 | 0 | 14 |
| 16 | Type A | *j*+3 | 0 | 10 |

**Table 6.1.2.1.1-3: Default PUSCH time domain resource allocation A for extended CP**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Row index** | **PUSCH mapping type** | ***K2*** | ***S*** | ***L*** |
| 1 | Type A | *j* | 0 | 8 |
| 2 | Type A | *j* | 0 | 12 |
| 3 | Type A | *j* | 0 | 10 |
| 4 | Type B | *j* | 2 | 10 |
| 5 | Type B | *j* | 4 | 4 |
| 6 | Type B | *j* | 4 | 8 |
| 7 | Type B | *j* | 4 | 6 |
| 8 | Type A | *j*+1 | 0 | 8 |
| 9 | Type A | *j*+1 | 0 | 12 |
| 10 | Type A | *j*+1 | 0 | 10 |
| 11 | Type A | *j*+2 | 0 | 6 |
| 12 | Type A | *j*+2 | 0 | 12 |
| 13 | Type A | *j*+2 | 0 | 10 |
| 14 | Type B | *j* | 8 | 4 |
| 15 | Type A | *j*+3 | 0 | 8 |
| 16 | Type A | *j*+3 | 0 | 10 |

**Table 6.1.2.1.1-4: Definition of value *j***

|  |  |
| --- | --- |
| ***µPUSCH*** | ***j*** |
| 0 | 1 |
| 1 | 1 |
| 2 | 2 |
| 3 | 3 |
| 5 | 11 |
| 6 | 21 |

**Table 6.1.2.1.1-5: Definition of value *Δ***

|  |  |
| --- | --- |
| ***µPUSCH*** | ***Δ*** |
| 0 | 2 |
| 1 | 3 |
| 2 | 4 |
| 3 | 6 |
| 5 | 24 |
| 6 | 48 |

6.1.2.2 Resource allocation in frequency domain

The UE shall determine the resource block assignment in frequency domain using the resource allocation field in the detected PDCCH DCI except for a PUSCH transmission scheduled by a RAR UL grant or fallbackRAR UL grant, in which case the frequency domain resource allocation is determined according to clause 8.3 of [6, 38.213] or a MsgA PUSCH transmission with frequency domain resource allocation determined according to clause 8.1A of [6, 38.213]. Three uplink resource allocation schemes type 0, type 1 and type 2 are supported. Uplink resource allocation scheme type 0 is supported for PUSCH only when transform precoding is disabled. Uplink resource allocation scheme type 1 and type 2 are supported for PUSCH for both cases when transform precoding is enabled or disabled.

If the scheduling DCI is configured to indicate the uplink resource allocation type as part of the '*Frequency domain resource'* assignment field by setting a higher layer parameter r*esourceAllocation* in *pusch-Config* to 'dynamicSwitch', for DCI format 0\_1 or setting a higher layer parameter *resourceAllocationDCI-0-2* in *pusch-Config* to 'dynamicSwitch' for DCI format 0\_2 or setting a higher layer parameter *resourceAllocationDCI-0-3* in *pusch-Config* to 'dynamicSwitch' for DCI format 0\_3, the UE shall use uplink resource allocation type 0 or type 1 as defined by this DCI field. Otherwise the UE shall use the uplink frequency resource allocation type as defined by the higher layer parameter *resourceAllocation* for DCI format 0\_1 or the higher layer parameter *resourceAllocationDCI-0-2* for DCI format 0\_2. The UE shall assume that when the scheduling PDCCH is received with DCI format 0\_1 and *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated* is configured, uplink type 2 resource allocation is used.

The UE shall assume that when the scheduling PDCCH is received with DCI format 0\_0, then uplink resource allocation type 1 is used, except when any of the higher layer parameters *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon* and *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated* is configured in which case uplink resource allocation type 2 is used.

The UE expects that either none or both of *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon* and *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated* is configured.

If a bandwidth part indicator field is not configured in the scheduling DCI or the UE does not support active bandwidth part change via DCI, the RB indexing for uplink type 0, type 1 and type 2 resource allocation is determined within the UE's active bandwidth part. If a bandwidth part indicator field is configured in the scheduling DCI and the UE supports active bandwidh part change via DCI, the RB indexing for uplink type 0, type 1, type 2 resource allocation is determined within the UE's bandwidth part indicated by bandwidth part indicator field value in the DCI. The UE shall upon detection of PDCCH intended for the UE determine first the uplink bandwidth part and then the resource allocation within the bandwidth part. RB numbering starts from the lowest RB in the determined uplink bandwidth part.

6.1.2.2.1 Uplink resource allocation type 0

In uplink resource allocation of type 0, the resource block assignment information includes a bitmap indicating the Resource Block Groups (RBGs) that are allocated to the scheduled UE where a RBG is a set of consecutive virtual resource blocks defined by higher layer parameter *rbg-Size* for DCI format 0\_1/0\_2 or *rbg-SizeDCI-0-3* for DCI format 0\_3 configured in *pusch-Config* and the size of the bandwidth part as defined in Table 6.1.2.2.1-1.

**Table 6.1.2.2.1-1: Nominal RBG size *P***

|  |  |  |  |
| --- | --- | --- | --- |
| **Bandwidth Part Size** | **Configuration 1** | **Configuration 2** | **Configuration 3** |
| 1 – 36  | *2* | 4 | 8 |
| 37 – 72 | 4 | 8 | 16 |
| 73 – 144 | 8 | 16 | 32 |
| 145 – 275 | 16 | 16 | 32 |

The total number of RBGs () for a uplink bandwidth part *i* of sizePRBs is given by  where

- the size of the first RBG is ,

- the size of the last RBG is if and *P* otherwise.

- the size of all other RBG is *P*.

The bitmap is of size bits with one bitmap bit per RBG such that each RBG is addressable. The RBGs shall be indexed in the order of increasing frequency of the bandwidth part and starting at the lowest frequency. The order of RBG bitmap is such that RBG 0 to RBG are mapped from MSB to LSB of the bitmap. The RBG is allocated to the UE if the corresponding bit value in the bitmap is 1, the RBG is not allocated to the UE otherwise.

In frequency range 1, only 'almost contiguous allocation' defined in [8, TS 38.101-1] is allowed as non-contiguous allocation per component carrier for UL RB allocation for CP-OFDM.

In frequency range 2, non-contiguous allocation per component carrier for UL RB allocation for CP-OFDM is not supported.

6.1.2.2.2 Uplink resource allocation type 1

In uplink resource allocation of type 1, the resource block assignment information indicates to a scheduled UE a set of contiguously allocated non-interleaved virtual resource blocks within the active bandwidth part of size  PRBs except for the case when DCI format 0\_0 is decoded in any common search space in which case the size of the initial UL bandwidth part  shall be used.

An uplink type 1 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting virtual resource block () and a length in terms of contiguously allocated resource blocks. The resource indication value is defined by

if  then



else



where≥ 1 and shall not exceed.

When the DCI size for DCI format 0\_0 in USS is derived from the initial UL BWP with size  but applied to another active BWP with size of , an uplink type 1 resource block assignment field consists of a resource indication value (*RIV*) corresponding to a starting resource block and a length in terms of virtually contiguously allocated resource blocks .

The resource indication value is defined by

if  then



else



where, and where shall not exceed .

If , *K* is the maximum value from set {1, 2, 4, 8} which satisfies ; otherwise *K* = 1.

When the scheduling grant is received with DCI format 0\_2 or 0\_3, an uplink type 1 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting resource block group *RBGstart*=0, 1, …, *NRBG*-1 and a length in terms of virtually contiguously allocated resource block groups *LRBGs*=1, …, *NRBG*, where the resource block groups are defined as in 6.1.2.2.1 with *P* defined by *resourceAllocationType1GranularityDCI-0-2* for DCI format 0\_2 and by *resourceAllocationType1GranularityDCI-0-3* for DCI format 0\_3 if the UE is configured with higher layer parameter *resourceAllocationType1GranularityDCI-0-2* or *resourceAllocationType1GranularityDCI-0-3*, and *P*=1 otherwise*.* The resource indication value is defined by

if  then



else



where≥ 1 and shall not exceed .

<omitted text>

6.1.2.3 Resource allocation for uplink transmission with configured grant

<omitted text>

6.1.2.3.1 Transport Block repetition for uplink transmissions of PUSCH repetition Type A with a configured grant

<omitted text>

For any RV sequence, the repetitions shall be terminated after transmitting *K* repetitions, or at the last transmission occasion among the *K* repetitions within the period *P*, or from the starting symbol of the repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0, 0\_1, 0\_2 or 0\_3, whichever is reached first. In addition, the UE shall terminate the repetition of a transport block in a PUSCH transmission if the UE receives a DCI format 0\_1 with DFI flag provided and set to '1', and if in this DCI the UE detects ACK for the HARQ process corresponding to that transport block.

<omitted text>

6.1.2.3.2 Transport Block repetition for uplink transmissions of PUSCH repetition Type B with a configured grant

<omitted text>

For any RV sequence, the repetitions shall be terminated after transmitting K nominal repetitions, or at the last transmission occasion among the *K* nominal repetitions within the period *P*, or from the starting symbol of an actual repetition that overlaps with a PUSCH with the same HARQ process scheduled by DCI format 0\_0, 0\_1, 0\_2 or 0\_3, whichever is reached first. The UE is not expected to be configured with the time duration for the transmission of *K* nominal repetitions larger than the time duration derived by the periodicity *P*.

<omitted text>

6.1.4 Modulation order, redundancy version and transport block size determination

To determine the modulation order, target code rate, redundancy version and transport block size for the physical uplink shared channel, the UE shall first

- read the 5-bit modulation and coding scheme field in the DCI scheduling PUSCH or provided in a DCI activating a configured grant Type 2 PUSCH, or as provided by *mcsAndTBS* as described in Clause 6.1.2.3 for a configured grant Type 1 PUSCH to determine the modulation order  and target code rate (*R*) based on the procedure defined in Clause 6.1.4.1

- read redundancy version field (*rv*) in the DCI to determine the redundancy version for PUSCH scheduled by DCI, or determine the redundancy version according to Clause 6.1.2.3.1 for configured grant Type 1 and Type 2 PUSCH,

and second

- use the number of layers , the total number of allocated PRBs  to determine the transport block size based on the procedure defined in Clause 6.1.4.2.

When the UE is scheduled with multiple PUSCHs on a serving cell by a DCI, as described in clause 6.1.2.1, the bits of *rv* field and NDI field, respectively, in the DCI are one to one mapped to the scheduled PUSCH(s) indicated by the TDRA information field with the corresponding transport block(s) in the scheduled order where the LSB bits of the *rv* field and NDI field, respectively, correspond to the last scheduled PUSCH indicated by the TDRA information field.

Within a cell group, a UE is not required to handle PUSCH(s) transmissions in slot *sj* in serving cell-*j*, and for *j* = 0,1,2.. *J-1*, slot *sj* overlapping with any given point in time, if the following condition is not satisfied at that point in time:

,

where

*- J* is the number of configured serving cells belong to a frequency range

- for the *j-th* serving cell,

*- M* is the number of TB(s) transmitted in slot-*sj*. For PUSCH repetition Type B, each actual repetition is counted separately.

*- Tslotμ(j)* =10-3/2*μ(j*), where *μ(j)* is the numerology for PUSCH(s) in slot *sj* of the *j*-th serving cell.

- for the *m*-th TB,

*- A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]

*- C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212].

- is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5,38.212]

- [Mbps] is computed as the maximum data rate summed over all the carriers in the frequency range for any signaled band combination and feature set consistent with the configured servings cells, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i).*

For a *j*-th serving cell, if higher layer parameter *processingType2Enabled* of *PUSCH-ServingCellConfig* is configured for the serving cell and set to 'enable'*,* or if at least one *IMCS > W* for a PUSCH, where *W* = 28 for MCS tables 5.1.3.1-1 and 5.1.3.1-3, and *W* = 27 for MCS tables 5.1.3.1-2, 6.1.4.1-1, and 6.1.4.1-2, or if it is an actual repetition for PUSCH repetition Type B, the UE is not required to handle PUSCH transmissions, if the following condition is not satisfied:

where

- is the number of symbols assigned to the PUSCH

- *M* is the number of TB in the PUSCH

- where μ is the numerology of the PUSCH

- for the *m*-th TB,

- *A* is the number of bits in the transport block as defined in Clause 6.2.1 [5, TS 38.212]

- *C* is the total number of code blocks for the transport block defined in Clause 5.2.2 [5, TS 38.212]

- is the number of scheduled code blocks for the transport block as defined in Clause 5.4.2.1 [5, TS 38.212]

- [Mbps] is computed as the maximum data rate for a carrier in the frequency band of the serving cell for any signaled band combination and feature set consistent with the serving cell, where the data rate value is given by the formula in Clause 4.1.2 in [13, TS 38.306], including the scaling factor *f(i)*

- each actual repetition for PUSCH repetition type B is treated as one PUSCH*.*

6.1.4.1 Modulation order and target code rate determination

For a PUSCH scheduled by RAR UL grant or

for a PUSCH scheduled by a fallbackRAR UL grant or

for a MsgA PUSCH transmission, or

for a PUSCH scheduled by a DCI format 0\_0 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or

for a PUSCH scheduled by a DCI format 0\_1 or DCI format 0\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, SP-CSI-RNTI, or

for a PUSCH scheduled by a DCI format 0\_3 with CRC scrambled by C-RNTI, MCS-C-RNTI, or

for a PUSCH with configured grant using CS-RNTI, and

if transform precoding is disabled for this PUSCH transmission according to Clause 6.1.3

- if *mcs-TableDCI-0-2* in *pusch-Config* is set to 'qam256', and PUSCH is scheduled by a PDCCH with DCI format 0\_2 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel;

- elseif the UE is not configured with MCS-C-RNTI, *mcs-TableDCI-0-2* in *pusch-Config* is set to 'qam64LowSE', and the PUSCH is scheduled by a PDCCH by a PDCCH with DCI format 0\_2 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-Table* in *pusch-Config* is set to 'qam256', and PUSCH is scheduled by a PDCCH with DCI format 0\_1 or 0\_3 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE is not configured with MCS-C-RNTI, *mcs-Table* in *pusch-Config* is set to 'qam64LowSE', and the PUSCH is scheduled by a PDCCH with a DCI format other than DCI format 0\_2 in a UE-specific search space with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE is configured with MCS-C-RNTI, and the PUSCH is scheduled by a PDCCH with CRC scrambled by MCS-C-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-Table* in *configuredGrantConfig* is set to 'qam256',

- if PUSCH is scheduled by a PDCCH with CRC scrambled by CS-RNTI or

- if PUSCH is transmitted with configured grant

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-Table* in *configuredGrantConfig* is set to 'qam64LowSE',

- if PUSCH is scheduled by a PDCCH with CRC scrambled by CS-RNTI or

- if PUSCH is transmitted with configured grant,

- the UE shall use *IMCS* and Table 5.1.3.1-3 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif for a MsgA PUSCH transmission,

- the UE shall use higher layer parameter *msgA-MCS* for *IMCS* and Table 5.1.3.1-1 to determine the Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE requests repetition of PUSCH scheduled by RAR UL grant [10, TS 38.321], when transmitting PUSCH scheduled by RAR UL grant,

- the 2 LSBs of the MCS information field of the RAR UL grant provide a codepoint to determine the MCS index *IMCS* according to Table 6.1.4.1-3, based on whether or not the higher layer parameter *mcs-Msg3-Repetitions* is configured. The UE shall use the determined *IMCS* and Table 5.1.3.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE requests repetition of PUSCH scheduled by RAR UL grant [10, TS 38.321], when transmitting PUSCH scheduled by DCI format 0\_0 with CRC scrambled by the TC-RNTI,

- the 3 LSBs of the MCS information field of the DCI format 0\_0 with CRC scrambled by the TC-RNTI provide a codepoint to determine the MCS index *IMCS* according to Table 6.1.4.1-4, based on whether or not the higher layer parameter *mcs-Msg3-Repetitions* is configured. The UE shall use the determined *IMCS* and Table 5.1.3.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- else

- the UE shall use *IMCS* and Table 5.1.3.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

else

- if *mcs-TableTransformPrecoderDCI-0-2* in *pusch-Config* is set to 'qam256', and PUSCH is scheduled by a PDCCH with DCI format 0\_2 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1.-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE is not configured with MCS-C-RNTI, *mcs-TableTransformPrecoderDCI-0-2* in *pusch-Config* is set to 'qam64LowSE', and the PUSCH is scheduled by a PDCCH with DCI format 0\_2 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 6.1.4.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-TableTransformPrecoder* in *pusch-Config* is set to 'qam256', and PUSCH is scheduled by a PDCCH with DCI format 0\_1 or 0\_3 with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 5.1.3.1.-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE is not configured with MCS-C-RNTI, *mcs-TableTransformPrecoder* in *pusch-Config* is set to 'qam64LowSE', and the PUSCH is scheduled by a PDCCH with a DCI format other than DCI format 0\_2 in a UE-specific search space with CRC scrambled by C-RNTI or SP-CSI-RNTI,

- the UE shall use *IMCS* and Table 6.1.4.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE is configured with MCS-C-RNTI, and the PUSCH is scheduled by a PDCCH with CRC scrambled by MCS-C-RNTI,

- the UE shall use *IMCS* and Table 6.1.4.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-TableTransformPrecoder* in *configuredGrantConfig* is set to 'qam256',

- if PUSCH is scheduled by a PDCCH with CRC scrambled by CS-RNTI or

- if PUSCH is transmitted with configured grant,

- the UE shall use *IMCS* and Table 5.1.3.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif *mcs-TableTransformPrecoder* in *configuredGrantConfig* is set to 'qam64LowSE',

- if PUSCH is scheduled by a PDCCH with CRC scrambled by CS-RNTI or

- if PUSCH is transmitted with configured grant,

- the UE shall use *IMCS* and Table 6.1.4.1-2 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif for a MsgA PUSCH transmission,

- the UE shall use higher layer parameter *MsgA-MCS* for *IMCS* and Table 6.1.4.1-1 to determine the Target code rate (*R*) used in the physical uplink shared channel.

- the UE shall use *q=2* for determining modulation order *Qm* in Table 6.1.4.1-1.

- elseif the UE requests repetition of PUSCH scheduled by RAR UL grant [10, TS 38.321], when transmitting PUSCH scheduled by RAR UL grant,

- the 2 LSBs of the MCS information field of the RAR UL grant provide a codepoint to determine the MCS index *IMCS* according to Table 6.1.4.1-3, based on whether or not the higher layer parameter *mcs-Msg3-Repetitions* is configured. The UE shall use the determined *IMCS* and Table 6.1.4.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- elseif the UE requests repetition of PUSCH scheduled by RAR UL grant [10, TS 38.321], when transmitting PUSCH scheduled by DCI format 0\_0 with CRC scrambled by the TC-RNTI,

- the 3 LSBs of the MCS information field of the DCI format 0\_0 with CRC scrambled by the TC-RNTI provide a codepoint to determine the MCS index *IMCS* according to Table 6.1.4.1-4, based on whether or not the higher layer parameter *mcs-Msg3-Repetitions* is configured. The UE shall use the determined *IMCS* and Table 6.1.4.1-1 to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

- else

- the UE shall use *IMCS* and Table 6.1.4.1-1to determine the modulation order (*Qm*) and Target code rate (*R*) used in the physical uplink shared channel.

end

For Table 6.1.4.1-1 and Table 6.1.4.1-2, if higher layer parameter *tp-pi2BPSK* is configured, *q* = 1 otherwise *q*=2.

<omitted text>

6.1.4.2 Transport block size determination

For a PUSCH scheduled by RAR UL grant or

for a PUSCH scheduled by fallbackRAR UL grant or

for a PUSCH scheduled by a DCI format 0\_0 with CRC scrambled by C-RNTI, MCS-C-RNTI, TC-RNTI, CS-RNTI, or

for a PUSCH scheduled by a DCI format 0\_1 or DCI format 0\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, or

for a PUSCH scheduled by a DCI format 0\_3 with CRC scrambled by C-RNTI, MCS-C-RNTI, or

for a PUSCH transmission with configured grant, or

for a MsgA PUSCH transmission,

if

- and transform precoding is disabled and Table 5.1.3.1-2 is used, or

-  and transform precoding is disabled and a table other than Table 5.1.3.1-2 is used, or

-  and transform precoding is enabled, the UE shall first determine the TBS as specified below:

* The UE shall first determine the number of REs (*NRE*) within the slot:

- A UE first determines the number of REs allocated for PUSCH within a PRB  by

- , where is the number of subcarriers in the frequency domain in a physical resource block,  is the number of symbols *L* of the PUSCH allocation according to Clause 6.1.2.1 for scheduled PUSCH or Clause 6.1.2.3 for configured PUSCH,  is the number of REs for DM-RS per PRB in the allocated duration including the overhead of the DM-RS CDM groups without data, as described for PUSCH with a configured grant in Clause 6.1.2.3 or as indicated by DCI format 0\_1, 0\_2 or 0\_3 or as described for DCI format 0\_0 in Clause 6.2.2, and  is the overhead configured by higher layer parameter *xOverhead* in*PUSCH-ServingCellConfig*. If the  is not configured (a value from 6, 12, or 18), the  is assumed to be 0. For Msg3 or MsgA PUSCH transmission the  is always set to 0. In case of PUSCH repetition Type B,  is determined assuming a nominal repetition with the duration of *L* symbols without segmentation.

- A UE determines the total number of REs allocated for PUSCH  as follows

- For TB processing over multiple slots, where  is the total number of allocated PRBs for the UE and *N* is the number of slots used for TBS determination indicated by *numberOfSlotsTBoMS*.

- Otherwise, .

- Next, proceed with steps 2-4 as defined in Clause 5.1.3.2

- For a PUSCH scheduled by fallbackRAR UL grant, UE assumes the TB size determined by the UL grant in the fallbackRAR shall be the same as the TB size used in the corresponding MsgA PUSCH transmission.

else if

-  and transform precoding is disabled and Table 5.1.3.1-2 is used, or

-  and transform precoding is enabled,

- the TBS is assumed to be as determined from the DCI transported in the latest PDCCH for the same transport block using . If there is no PDCCH for the same transport block using , and if the initial PUSCH for the same transport block is scheduled by a RAR UL grant, the TBS shall be determined from the RAR UL grant. If there is no PDCCH for the same transport block using , and if the initial PUSCH for the same transport block is transmitted with configured grant,

- the TBS shall be determined from *configuredGrantConfig* for a configured grant Type 1 PUSCH.

- the TBS shall be determined from the most recent PDCCH scheduling a configured grant Type 2 PUSCH.

else

- the TBS is assumed to be as determined from the DCI transported in the latest PDCCH for the same transport block using . If there is no PDCCH for the same transport block using , and if the initial PUSCH for the same transport block is scheduled by a RAR UL grant, the TBS shall be determined from the RAR UL grant. If there is no PDCCH for the same transport block using , and if the initial PUSCH for the same transport block is transmitted with configured grant,

- the TBS shall be determined from *configuredGrantConfig* for a configured grant Type 1 PUSCH.

- the TBS shall be determined from the most recent PDCCH scheduling a configured grant Type 2 PUSCH.

6.1.5 Code block group based PUSCH transmission

If a UE is configured to transmit code block group (CBG) based transmissions by receiving the higher layer parameter *codeBlockGroupTransmission* in *PUSCH-ServingCellConfig* on a serving cell in a PUCCH group, the UE does not expect to be configured with higher layer parameter *ScheduledCell-ListDCI-0-3* on any serving cell within the PUCCH group.

<omitted text>

6.1.7 UE procedure for determining time domain windows for bundling DM-RS

For PUSCH transmissions of PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2, PUSCH repetition Type A with a configured grant, PUSCH repetition Type B and TB processing over multiple slots, when *pusch-DMRS-Bundling* is enabled, and for PUCCH transmissions of PUCCH repetition, when *PUCCH-DMRS-Bundling* is enabled, the UE determines one or multiple nominal TDWs, as follows:

- For PUSCH transmissions of repetition Type A, PUSCH repetition Type B and TB processing over multiple slots, the duration of each nominal TDW except the last nominal TDW, in number of consecutive slots, is:

- Given by *pusch-TimeDomainWindowLength*, if configured.

- Computed as min (*maxDurationDMRS-Bundling*, M), if *pusch-TimeDomainWindowLength* is not configured, where *maxDurationDMRS-Bundling* is maximum duration for a nominal TDW subject to UE capability [13, TS 38.306], M is the time duration in consecutive slots of PUSCH transmissions, and where:

- For PUSCH transmissions of PUSCH repetition Type A, N=1 and K is the number of repetitions, as defined in Clause 6.1.2.1 or in Clause 6.1.2.3.

- For PUSCH transmissions of PUSCH repetition Type B, N=1 and K is the number of nominal repetitions, as defined in Clause 6.1.2.1 or in Clause 6.1.2.3.

- For PUSCH transmissions of TB processing over multiple slots, N is the number of slots used for TBS determination and K is the number of repetitions of the number of slots N used for TBS determination, as defined in Clause 6.1.2.1 or in Clause 6.1.2.3.

- For PUCCH transmissions of PUCCH repetition, the duration of each nominal TDW except the last nominal TDW, in number of consecutive slots, is:

- Given by *pucch-TimeDomainWindowLength*, if configured.

- Computed as min (*maxDurationDMRS-Bundling*, M), if *pucch-TimeDomainWindowLength* is not configured, where *maxDurationDMRS-Bundling* is maximum duration for a nominal TDW subject to UE capability [13, TS 38.306], M is the time duration in consecutive slots from the first slot determined for PUCCH transmissions of PUCCH repetition to the last slot determined for PUCCH transmissions of PUCCH repetition according to clause 9.2.6 of [6, TS 38.213].

- For PUSCH transmission of a PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2 and PUSCH repetition Type A with a configured grant, when *AvailableSlotCounting* is enabled, and for TB processing over multiple slots:

- The start of the first nominal TDW is the first slot determined for the first PUSCH transmission.

- The end of the last nominal TDW is the last slot determined for the last PUSCH transmission.

- The start of any other nominal TDWs is the first slot determined for PUSCH transmission after the last slot determined for PUSCH transmission of a previous nominal TDW.

- For PUSCH transmissions of a PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2 and PUSCH repetition Type A with a configured grant, when the UE is not configured with *AvailableSlotCounting* or when *AvailableSlotCounting* is disabled, and for PUSCH repetition type B:

- The start of the first nominal TDW is the first slot for the first PUSCH transmission.

- The end of the last nominal TDW is the last slot for the last PUSCH transmission.

- The start of any other nominal TDWs is the first slot after the last slot of a previous nominal TDW.

- For PUCCH transmissions of a PUCCH repetition:

- The start of the first nominal TDW is the first slot determined for the first PUCCH transmission.

- The end of the last nominal TDW is the last slot determined for the last PUCCH transmission.

- The start of any other nominal TDWs is the first slot determined for PUCCH transmission after the last slot determined for PUCCH transmission of a previous nominal TDW.

For PUSCH transmissions of a PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2, PUSCH repetition Type A with a configured grant, PUSCH repetition Type B and TB processing over multiple slots, a nominal TDW consists of one or multiple actual TDWs. The UE determines the actual TDWs as follows:

- The start of the first actual TDW is the first symbol of the first PUSCH transmission in a slot for PUSCH transmission of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots within the nominal TDW.

- The end of an actual TDW is

- The last symbol of the last PUSCH transmission in a slot for PUSCH transmission of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots within the nominal TDW, if the actual TDW reaches the end of the last PUSCH transmission within the nominal TDW.

- The last symbol of a PUSCH transmission before the event, if an event occurs which causes power consistency and phase continuity not to be maintained across PUSCH transmissions of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots within the nominal TDW, and the PUSCH transmission is in a slot for PUSCH transmission of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots.

- When *pusch-WindowRestart* is enabled, the start of a new actual TDW is the first symbol of the PUSCH transmission after the event which causes power consistency and phase continuity not to be maintained across PUSCH transmissions of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots within the nominal TDW, and the PUSCH transmission is in a slot for PUSCH transmission of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots.

For PUCCH transmissions of PUCCH repetition, a nominal TDW consists of one or multiple actual TDWs. The UE determines the actual TDWs as follows:

- The start of the first actual TDW is the first symbol of the first PUCCH transmission in a slot determined for PUCCH transmission within the nominal TDW.

- The end of an actual TDW is

- The last symbol of the last PUCCH transmission in a slot determined for transmission of the PUCCH within the nominal TDW, if the actual TDW reaches the end of the last PUCCH transmission within the nominal TDW.

- The last symbol of a PUCCH transmission before the event, if an event occurs which causes power consistency and phase continuity not be maintained across PUCCH transmissions of PUCCH repetition within the nominal TDW, and the PUCCH transmission is in a slot determined for transmission of the PUCCH.

- When *pucch-WindowRestart* is enabled, the start of a new actual TDW is the first symbol of the PUCCH transmission after the event which causes power consistency and phase continuity not to be maintained across PUCCH transmissions of PUCCH repetition within the nominal TDW, and the PUCCH transmission is in a slot determined for transmission of the PUCCH.

Events which cause power consistency and phase continuity not to be maintained across PUSCH transmissions of PUSCH repetition type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots, or PUCCH transmissions of PUCCH repetition, within the nominal TDW, are:

- A downlink slot or downlink reception or downlink monitoring based on *tdd-UL-DL-ConfigurationCommon* and *tdd-UL-DL-ConfigurationDedicated* for unpaired spectrum.

- The gap between any two consecutive PUSCH transmissions, or the gap between any two consecutive PUCCH transmissions, exceeds 13 symbols for normal cyclic prefix or exceeds 11 symbols for extended cyclic prefix.

- The gap between any two consecutive PUSCH transmissions, or the gap between any two consecutive PUCCH transmissions, does not exceed 13 symbols but other uplink transmissions are scheduled between the two consecutive PUSCH transmissions or the two consecutive PUCCH transmissions.

- For PUSCH transmissions of PUSCH repetition type A, or PUSCH repetition type B or TB processing over multiple slots, a dropping or cancellation of a PUSCH transmission according to clause 9, clause 11.1 and clause 11.2A of [6, TS 38.213].

- For PUCCH transmissions of PUCCH repetition, a dropping or cancellation of a PUCCH transmission according to clause 9, clause 9.2.6 and clause 11.1 of [6, TS 38.213].

- For any two consecutive PUSCH transmissions of PUSCH repetition type A, or PUSCH repetition type B, and when two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook' or 'noncodebook', a different SRS resource set association is used for the two PUSCH transmissions of PUSCH repetition type A, or PUSCH repetition type B, according to Clause 6.1.2.1.

- For any two consecutive PUCCH transmissions of PUCCH repetition, and when a PUCCH resource used for repetitions of a PUCCH transmission by a UE includes first and second spatial relations or first and second sets of power control parameters, as described in [10, TS 38.321] and in clause 7.2.1 of [6, TS 38.213], different spatial relations or different power control parameters are used for the two PUCCH transmissions of PUCCH repetition, according to Clause 9.2.6 of [6, TS 38.213].

- Uplink timing adjustment in response to a timing advance command according to clause 4.2 of [6, TS 38.213].

- Frequency hopping.

- For reduced capability half-duplex UEs,

- a dropping or cancellation of a PUSCH or PUCCH transmission according to clause 17.2 of [6, TS 38.213] or

- an overlapping of the gap between two consecutive PUSCH or two consecutive PUCCH transmissions and any symbol of downlink reception or downlink monitoring

The UE shall maintain power consistency and phase continuity within an actual TDW, across PUSCH transmissions of PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots, or across PUCCH transmissions of PUCCH repetition, in case the actual TDW is created in response to frequency hopping, or in response to the use of a different SRS resource set association for the two PUSCH transmissions of PUSCH repetition type A, or PUSCH repetition type B, or in response to the use of different spatial relations or different power control parameters for the two PUCCH transmissions of PUCCH repetition, or in response to any event not triggered by DCI or MAC-CE. The UE maintains power consistency and phase continuity within an actual TDW, across PUSCH transmissions of PUSCH repetition Type A scheduled by DCI format 0\_1 or 0\_2, or PUSCH repetition Type A with a configured grant, or PUSCH repetition type B or TB processing over multiple slots, or across PUCCH transmissions of PUCCH repetition, in case the actual TDW is created in response to an event triggered by DCI other than frequency hopping or the use of a different SRS resource set association for the two PUSCH transmissions of PUSCH repetition type A, or PUSCH repetition type B, or the use of different spatial relations or different power control parameters for the two PUCCH transmissions of PUCCH repetition, or in response to an event triggered by MAC-CE, subject to UE capability. of *dmrs-BundlingRestart* [13, TS 38.306] and when *pusch-WindowRestart* or *pucch-WindowRestart* is enabled.

<omitted text>

6.2 UE reference signal (RS) procedure

6.2.1 UE sounding procedure

<omitted text>

For a UE configured with one or more SRS resource configuration(s), and when the higher layer parameter *resourceType* in *SRS-Resource* or *SRS-PosResource* is set to 'aperiodic':

- the UE receives a configuration of SRS resource sets,

- the UE receives a downlink DCI, a group common DCI, or an uplink DCI based command where a codepoint of the DCI may trigger one or more SRS resource set(s). For SRS in a resource set with usage set to 'codebook' or 'antennaSwitching', the minimal time interval between the last symbol of the PDCCH triggering the aperiodic SRS transmission and the first symbol of SRS resource is *N2*  symbols and an additional time duration *Tswitch*. Otherwise, the minimal time interval between the last symbol of the PDCCH triggering the aperiodic SRS transmission and the first symbol of SRS resource is *N2* +14 symbols and an additional time duration *Tswitch*. The minimal time interval unit of OFDM symbol is counted based on the minimum subcarrier spacing given by min(*µPDCCH, µUL*) where *µUL* is given by min(*µUL,carrier1, µUL,carrier2, µSRS*) when the UE is configured with the higher layer parameter *uplinkTxSwitchingOption* set to 'dualUL' for uplink carrier aggregation, and by *µSRS*otherwise. *µSRS* and *µPDCCH*are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively.

- *Tswitch*, *µUL,carrier1* and *µUL,carrier2* are defined in clause 6.4.

- A UE reporting its UE capability ‘srs-TriggeringDCI’ can be indicated with DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI as described in clause 7.3.1.1 of [5, TS 38.212]. Otherwise, except for DCI format 0\_1/0\_2 with CRC scrambled by SP-CSI-RNTI, a UE is not expected to receive a DCI format 0\_1/0\_2 with UL-SCH indicator of "0" and CSI request of all zero(s) as described in clause 7.3.1.1 of [5, TS 38.212].

- If the UE receives the DCI triggering aperiodic SRS in slot *n* and at least one resource set is configured with parameter *availableSlotOffset* across all configured BWPs in a component carrier except when SRS is configured with the higher layer parameter *SRS-PosResource*,

- If ca-*SlotOffset* is configured, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (*t* + 1)-th available slot counting from slot ,

- otherwise the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (*t* + 1)-th available slot counting from slot , where

<omitted text>

The SRS request field [5, TS38.212] in DCI format 0\_1, 1\_1, 0\_2 (if SRS request field is present), 1\_2 (if SRS request field is present), 0\_3, 1\_3 indicates the triggered SRS resource set given in Table 7.3.1.1.2-24 of [5, TS 38.212]. The 2-bit SRS request field in DCI format 2\_3 indicates the triggered SRS resource set given in clause 7.3 of [5, TS 38.212] and defined by the entries of the higher layer parameter *srs-ResourceSetToAddModList* if the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* set to 'typeB', or indicates the SRS transmission on a set of serving cells configured by higher layers if the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* set to 'typeA'.

<omitted text>

6.2.2 UE DM-RS transmission procedure

The DM-RS transmission procedures for PUSCH scheduled by PDCCH with DCI format 0\_1 described in this clause equally apply to PUSCH scheduled by PDCCH with DCI format 0\_2, by applying the parameters of *dmrs-UplinkForPUSCH-MappingTypeA-DCI-0-2* and *dmrs-UplinkForPUSCH-MappingTypeB-DCI-0-2* instead of *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*. The DM-RS transmission procedures for PUSCH scheduled by PDCCH with DCI format 0\_1 described in this clause equally apply to PUSCH scheduled by PDCCH with DCI format 0\_3.

When transmitted PUSCH is neither scheduled by DCI format 0\_1/0\_2 with CRC scrambled by C-RNTI, CS-RNTI, SP-CSI-RNTI or MCS-C-RNTI, nor corresponding to a configured grant, nor being a PUSCH for Type-2 random access procedure, the UE shall use single symbol front-loaded DM-RS of configuration type 1 on DM-RS port 0 and the remaining REs not used for DM-RS in the symbols are not used for any PUSCH transmission except for PUSCH with allocation duration of 2 or less OFDM symbols with transform precoding disabled, additional DM-RS can be transmitted according to the scheduling type and the PUSCH duration as specified in Table 6.4.1.1.3-3 of [4, TS38.211] for frequency hopping disabled and as specified in Table 6.4.1.1.3-6 of [4, TS38.211] for frequency hopping enabled, and

If frequency hopping is disabled:

- The UE shall assume *dmrs-AdditionalPosition* equals to 'pos2' and up to two additional DM-RS can be transmitted according to PUSCH duration, or

If frequency hopping is enabled:

- The UE shall assume *dmrs-AdditionalPosition* equals to 'pos1' and up to one additional DM-RS can be transmitted according to PUSCH duration.

When transmitted PUSCH is scheduled by activation DCI format 0\_0 with CRC scrambled by CS-RNTI, the UE shall use single symbol front-loaded DM-RS of configuration type provided by higher layer parameter *dmrs-Type* in *DMRS-UplinkConfig* on DM-RS port 0 and the remaining REs not used for DM-RS in the symbols are not used for any PUSCH transmission except for PUSCH with allocation duration of 2 or less OFDM symbols with transform precoding disabled, and additional DM-RS with *dmrs-AdditionalPosition* from C*onfiguredGrantConfig* can be transmitted according to the scheduling type and the PUSCH duration as specified in Table 6.4.1.1.3-3 of [4, TS38.211] for frequency hopping disabled and as specified in Table 6.4.1.1.3-6 of [4, TS38.211] for frequency hopping enabled.

For the UE-specific reference signals generation as defined in Clause 6.4.1.1 of [4, TS 38.211], a UE can be configured by higher layers with one or two scrambling identity(s), *i* = 0,1 which are the same for both PUSCH mapping Type A and Type B.

When transmitted PUSCH is scheduled by DCI format 0\_1 with CRC scrambled by C-RNTI, CS-RNTI, SP-CSI-RNTI or MCS-C-RNTI, or corresponding to a configured grant, or being a PUSCH for Type-2 random access procedure,

- for a configured-grant based PUSCH transmission in RRC\_INACTIVE state, the UE is provided with a set of DM-RS port(s) by *sdt-DMRSports*. The DM-RS port for the PUSCH is determined by the mapping between SS/PBCH block(s) and a PUSCH occasion and the associated DM-RS resource as described in Clause 19.1 of [6, TS 38.213].

- the UE may be configured with higher layer parameter *dmrs-Type* in *DMRS-UplinkConfig*, and the configured DM-RS configuration type is used for transmitting PUSCH in as defined in Clause 6.4.1.1 of [4, TS 38.211].

- the UE may be configured with the maximum number of front-loaded DM-RS symbols for PUSCH by higher layer parameter *maxLength* in *DMRS-UplinkConfig,* or by higher layer parameter *msgA-MaxLength* in *msgA-DMRS-Config*,

- if *maxLength* is not configured, single-symbol DM-RS can be scheduled for the UE by DCI or configured by the configured grant configuration, and the UE can be configured with a number of additional DM-RS for PUSCH by higher layer parameter *dmrs-AdditionalPosition,* which can be 'pos0', 'pos1', 'pos2', 'pos3'.

- if *maxLength* is configured, either single-symbol DM-RS or double symbol DM-RS can be scheduled for the UE by DCI or configured by the configured grant configuration, and the UE can be configured with a number of additional DM-RS for PUSCH by higher layer parameter *dmrs-AdditionalPosition,* which can be 'pos0' or 'pos1'.

- for MsgA PUSCH for Type-2 random access procedure the UE can be configured with a number of additional DM-RS for PUSCH by higher layer parameter *msgA-DMRS-AdditionalPosition,* which can be 'pos0', 'pos1', 'pos2', 'pos3' for single-symbol DM-RS or 'pos0', 'pos1' for double-symbol DM-RS.

- and, the UE shall transmit a number of additional DM-RS as specified in Table 6.4.1.1.3-3 and Table 6.4.1.1.3-4 in -Clause 6.4.1.1.3 of [4, TS 38.211].

If a UE transmitting PUSCH scheduled by DCI format 0\_2 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA-DCI-0-2* or *dmrs-UplinkForPUSCH-MappingTypeB-DCI-0-2*, or a UE transmitting PUSCH scheduled by DCI format 0\_0, 0\_1 or 0\_3 is configured with the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA* or *dmrs-UplinkForPUSCH-MappingTypeB*, the UE may assume that the following configurations are not occurring simultaneously for the transmitted PUSCH

- any DM-RS ports among 4-7 or 6-11 for DM-RS configurations type 1 and type 2, respectively are scheduled for the UE and PT-RS is transmitted from the UE.

For PUSCH scheduled by DCI format 0\_1, by activation DCI format 0\_1 with CRC scrambled by CS-RNTI, or configured by configured grant Type 1 configuration, the UE shall assume the DM-RS CDM groups indicated in Tables 7.3.1.1.2-6 to 7.3.1.1.2-23 of Clause 7.3.1.1 of [5, TS38.212] are not used for data transmission, where "1", "2" and "3" for the number of DM-RS CDM group(s) correspond to CDM group 0, {0,1}, {0,1,2}, respectively.

For PUSCH scheduled by DCI format 0\_0 or by activation DCI format 0\_0 with CRC scrambled by CS-RNTI, the UE shall assume the number of DM-RS CDM groups without data is 1 which corresponds to CDM group 0 for the case of PUSCH with allocation duration of 2 or less OFDM symbols with transform precoding disabled, the UE shall assume that the number of DM-RS CDM groups without data is 3 which corresponds to CDM group {0,1,2} for the case of PUSCH scheduled by activation DCI format 0\_0 and the *dmrs-Type* in *DMRS-UplinkConfig* equal to 'type2' and the PUSCH allocation duration being more than 2 OFDM symbols, and the UE shall assume that the number of DM-RS CDM groups without data is 2 which corresponds to CDM group {0,1} for all other cases.

For MsgA PUSCH transmission, if the UE is not configured with *msgA-PUSCH-DMRS-CDM-group,* the UEshall assume that 2 DM-RS CDM groups are configured. Otherwise, *msgA-PUSCH-DMRS-CDM-group* indicates which DM-RS CDM group to use from the set of {0,1}.

For MsgA PUSCH transmission, if the UE is not configured with *msgA-PUSCH-NrofPorts,* the UEshall assume that 4 ports are configured per DM-RS CDM group for double-symbol DM-RS. Otherwise, *msgA-PUSCH-NrofPorts* with value of 0 indicates the first port per DM-RS CDM group, while a value of 1 indicates the first two ports per DM-RS CDM group.

For uplink DM-RS with PUSCH, the UE may assume the ratio of PUSCH EPRE to DM-RS EPRE ( [dB]) is given by Table 6.2.2-1 according to the number of DM-RS CDM groups without data. The DM-RS scaling factor  specified in clause 6.4.1.1.3 of [4, TS 38.211] is given by .

**Table 6.2.2-1: The ratio of PUSCH EPRE to DM-RS EPRE**

|  |  |  |
| --- | --- | --- |
| **Number of DM-RS CDM groups without data** | **DM-RS configuration type 1** | **DM-RS configuration type 2** |
| 1 | 0 dB | 0 dB |
| 2 | -3 dB | -3 dB |
| 3 | - | -4.77 dB |

For PUSCH repetition Type B, the DM-RS transmission procedure is applied for each actual repetition separately based on the allocation duration of the actual repetition. A UE is not expected to be indicated with an antenna port configuration that is invalid for the allocated duration of any actual repetition.

6.2.3 UE PT-RS transmission procedure

The procedures on PT-RS transmission described in this clause as well as clauses 6.2.3.1 and 6.2.3.2 apply to a UE PUSCH transmission scheduled by DCI format 0\_2 if the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA-DCI-0-2* or *dmrs-UplinkForPUSCH-MappingTypeB-DCI-0-2* is configured, to PUSCH transmissions scheduled by DCI format 0\_0, 0\_1 or 0\_3 if the higher layer parameter *phaseTrackingRS* in *dmrs-UplinkForPUSCH-MappingTypeA* or *dmrs-UplinkForPUSCH-MappingTypeB* is configured and PUSCH transmissions corresponding to a configured grant if the higher layer parameter *phaseTrackingRS* in *cg-DMRS-Configuration* is configured. If a UE is not configured with the higher layer parameter *phaseTrackingRS* in the respective *DMRS-UplinkConfig*, the UE shall not transmit PT-RS. ThePT-RS is only present on PUSCH scheduled by PDCCH with CRC scrambled by MCS-C-RNTI, C-RNTI, CS-RNTI, SP-CSI-RNTI and on PUSCH corresponding to a configured grant. For PUSCH repetition Type B, the PT-RS transmission procedure is applied for each actual repetition separately based on the allocation duration of the actual repetition.

6.2.3.1 UE PT-RS transmission procedure when transform precoding is not enabled

<omitted text>

For codebook or non-codebook based UL transmission, the association between UL PT-RS port(s) and DM-RS port(s) is signalled by *PTRS-DMRS association* field(s) in DCI format 0\_1, 0\_2 and 0\_3. For a PUSCH corresponding to a configured grant Type 1 transmission, the UE may assume the association between UL PT-RS port(s) and DM-RS port(s) defined by value 0 in Table 7.3.1.1.2-25 or value "00" in Table 7.3.1.1.1.2-26 described in Clause 7.3.1 of [5, TS38.212].

For PUSCH scheduled by DCI format 0\_0 or by activation DCI format 0\_0, the UL PT-RS port is associated to DM-RS port 0.

For non-codebook based UL transmission, the actual number of UL PT-RS port(s) to transmit is determined based on SRI(s) in DCI format 0\_1, 0\_2 or 0\_3 or higher layer parameter *sri-ResourceIndicator* in *rrc-ConfiguredUplinkGrant*. When two SRS resource sets are configured in *srs-ResourceSetToAddModList* or *srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* in *SRS-ResourceSet* set to 'noncodebook', the actual number of UL PT-RS port(s) to transmit corresponding to each SRS resource set is determined based on SRI(s) corresponding to the associated SRS resource set or higher layer parameter *sri-ResourceIndicator or sri-ResourceIndicator2* corresponding to the associated SRS resource set in *rrc-ConfiguredUplinkGrant*. A UE is configured with the PT-RS port index for each configured SRS resource by the higher layer parameter *ptrs-PortIndex* configured by *SRS-Config* if the UE is configured with the higher layer parameter *phaseTrackingRS in DMRS-UplinkConfig*. If the PT-RS port index associated with different SRIs are the same, the corresponding UL DM-RS ports are associated to the one UL PT-RS port.

For partial-coherent and non-coherent codebook-based UL transmission, the actual number of UL PT-RS port(s) is determined based on TPMI(s) and/or number of layers which are indicated by '*Precoding information and number of layers'* field(s) in DCI format 0\_1, 0\_2 or 0\_3 or configured by higher layer parameter *precodingAndNumberOfLayers*:

- if the UE is configured with the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* set to 'n2', the actual UL PT-RS port(s) and the associated transmission layer(s) are derived from indicated TPMI(s) as:

- PUSCH antenna port 1000 and 1002 in indicated TPMI(s) share PT-RS port 0, and PUSCH antenna port 1001 and 1003 in indicated TPMI(s) share PT-RS port 1.

- UL PT-RS port 0 is associated with the UL layer 'x' of layers which are transmitted with PUSCH antenna port 1000 and PUSCH antenna port 1002 in indicated TPMI(s), and UL PT-RS port 1 is associated with the UL layer 'y' of layers which are transmitted with PUSCH antenna port 1001 and PUSCH antenna port 1003 in indicated TPMI(s), where 'x' and/or 'y' are given by DCI parameter '*PTRS-DMRS association'* as shown in DCI format 0\_1, 0\_2 and 0\_3 described in Clause 7.3.1 of [5, TS38.212].

When the UE is scheduled with *Qp*={1,2} PT-RS port(s) in uplink and the number of scheduled layers is ,

<omitted text>

6.3 UE PUSCH frequency hopping procedure

6.3.1 Frequency hopping for PUSCH repetition Type A and for TB processing over multiple slots

For PUSCH repetition Type A other than the PUSCH scheduled by RAR UL grant or fallbackRAR UL grant or by DCI format 0\_0 with CRC scrambled by TC-RNTI and for TB processing over multiple slots (as determined according to procedures defined in Clause 6.1.2.1 for scheduled PUSCH, or Clause 6.1.2.3 for configured PUSCH), a UE is configured for frequency hopping by the higher layer parameter *frequencyHoppingDCI-0-2* in *pusch-Config* for PUSCH transmission scheduled by DCI format 0\_2, and by *frequencyHopping* provided in *pusch-Config* for PUSCH transmission scheduled by a DCI format other than 0\_2*,* and by *frequencyHopping* provided in *configuredGrantConfig* for configured PUSCH transmission. For PUSCH repetition Type A scheduled by RAR UL grant or by DCI format 0\_0 with CRC scrambled by TC-RNTI, a UE is configured for frequency hopping by the frequency hopping flag information field of the RAR UL grant, and by the frequency hopping flag information field of DCI format 0\_0 with CRC scrambled by TC-RNTI, respectively. One of two frequency hopping modes can be configured:

- Intra-slot frequency hopping, applicable to single slot and multi-slot configured PUSCH transmission, multi-slot PUSCH transmission scheduled by DCI format 0\_1, 0\_2 or 0\_3, each of multiple PUSCH transmissions on a serving cell scheduled by a DCI if the higher layer parameter *pusch-TimeDomainAllocationListForMultiPUSCH* is configured and each of multiple configured grant PUSCH transmissions in a configuration where the higher layer parameters *cg-nrofSlots* and *cg-nrofPUSCH-InSlot* are provided.

- Inter-slot frequency hopping, applicable to multi-slot PUSCH transmission.

For operation with shared spectrum channel access in FR1, the UE does not expect that two hops of a PUSCH transmission are in different RB sets.

In case of resource allocation type 2, the UE transmits PUSCH without frequency hopping.

In case of resource allocation type 1, whether or not transform precoding is enabled for PUSCH transmission, the UE may perform PUSCH frequency hopping, if the frequency hopping field in a corresponding detected DCI format or in a random access response UL grant is set to 1, or if for a Type 1 PUSCH transmission with a configured grant the higher layer parameter *frequencyHoppingOffset* is provided, otherwise no PUSCH frequency hopping is performed. When frequency hopping is enabled for PUSCH, the RE mapping is defined in clause 6.3.1.6 of [4, TS 38.211].

For a PUSCH scheduled by RAR UL grant, fallbackRAR UL grant, or by DCI format 0\_0 with CRC scrambled by TC-RNTI, frequency offsets are obtained as described in clause 8.3 of [6, TS 38.213]. Otherwise, for a PUSCH scheduled by DCI format 0\_0/0\_1/0\_3 or a PUSCH based on a Type2 configured UL grant activated by DCI format 0\_0/0\_1 and for resource allocation type 1, frequency offsets are configured by higher layer parameter *frequencyHoppingOffsetLists* in *pusch-Config*. For a PUSCH scheduled by DCI format 0\_2 or a PUSCH based on a Type2 configured UL grant activated by DCI format 0\_2 and for resource allocation type 1, frequency offsets are configured by higher layer parameter *frequencyHoppingOffsetListsDCI-0-2* in *pusch-Config*.

- When the size of the active BWP is less than 50 PRBs, one of two higher layer configured offsets is indicated in the UL grant.

- When the size of the active BWP is equal to or greater than 50 PRBs, one of four higher layer configured offsets is indicated in the UL grant.

<omitted text>