**3GPP TSG-RAN WG1 Meeting #114 *R1-23xxxxx***

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

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| *CR-Form-v12.2* | | | | | | | | |
| **DRAFT CHANGE REQUEST** | | | | | | | | |
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|  | **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:*** | Introduction of specification support for MIMO enhancements on uTCI\_STxMP\_DMRS\_SRS\_8Tx\_2TA | | | | | | |
|  |  | | | | | | |
| ***Source to WG:*** | Nokia | | | | | | |
| ***Source to TSG:*** |  | | | | | | |
|  |  | | | | | | |
| ***Work item code:*** | NR\_MIMO\_evo\_DL\_UL | | |  | ***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 can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
|  |  | | | | | | |
| ***Reason for change:*** | | Introduction of specification support for MIMO Evolution for Downlink and Uplink. | | | | | |
|  | |  | | | | | |
| ***Summary of change:*** | | This document is introducing specification support for unified TCI, STxMP, DM-RS, SRS, 8Tx UL and 2TA. | | | | | |
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| ***Consequences if not approved:*** | Specification does not support MIMO Evolution for Downlink and Uplink. | | | |
|  |  | | | |
| ***Clauses affected:*** | 4.1, 5.1, 5.1.1.1, 5.1.6.2, 5.1.5, 5.2.1.5.1, 6.1, 6.1.1, 6.1.1.1, 6.1.1.2, 6.1.2.1, 6.1.4.2, 6.2.1, 6.2.1.2, 6.2.2, 6.2.3.1 | | | |
|  |  | | | |
|  | **Y** | **N** |  |  |
| ***Other specs*** | **X** |  | Other core specifications | ... |
| ***affected:*** |  | **X** | Test specifications | ... |
| ***(show related CRs)*** |  | **X** | O&M Specifications | ... |
|  |  | | | |
| ***Other comments:*** |  | | | |
|  |  | | | |
| ***This CR's revision history:*** |  | | | |

<omitted text>

# 4 Power control

Throughout this specification, unless otherwise noted, statements using the term "UE" in clauses 4, 5, or 6 are equally applicable to the IAB-MT part of an IAB node.

## 4.1 Power allocation for downlink

The gNB determines the downlink transmit EPRE.

For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume downlink EPRE is constant across the bandwidth. For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume downlink EPRE is constant over SSS carried in different SS/PBCH blocks. For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume that the ratio of SSS EPRE to PBCH DM-RS EPRE is 0 dB.

For the purpose of CSI-RSRP, CSI-RSRQ and CSI-SINR measurements, the UE may assume downlink EPRE of a port of CSI-RS resource configuration is constant across the configured downlink bandwidth and constant across all configured OFDM symbols.

The downlink SS/PBCH SSS EPRE can be derived from the SS/PBCH downlink transmit power given by the parameter *ss-PBCH-BlockPower* provided by higher layers. The downlink SSS transmit power is defined as the linear average over the power contributions (in [W]) of all resource elements that carry the SSS within the operating system bandwidth.

The downlink CSI-RS EPRE can be derived from the SS/PBCH block downlink transmit power given by the parameter *ss-PBCH-BlockPower* and CSI-RS power offset given by the parameter *powerControlOffsetSS* provided by higher layers if the SS/PBCH block is associated with serving cell PCI, or derived from *ss-PBCH-BlockPower-r17* in *SSB-MTC-AdditionalPCI-r17* and *powerControlOffsetSS* provided by higher layersif the SS/PBCH block is associated with additional PCI different from serving cell PCI, where the CSI-RS is QCLed with the SS/PBCH block. The downlink reference-signal transmit power is defined as the linear average over the power contributions (in [W]) of the resource elements that carry the configured CSI-RS within the operating system bandwidth.

For downlink DM-RS associated with PDSCH, the UE may assume the ratio of PDSCH EPRE to DM-RS EPRE ( [dB]) is given by Table 4.1-1 according to the number of DM-RS CDM groups without data as described in Clause 5.1.6.2. The DM-RS scaling factor  specified in Clause 7.4.1.1.2 of [4, TS 38.211] is given by .

Table 4.1-1: The ratio of PDSCH EPRE to DM-RS EPRE

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

When the UE is scheduled with one or two PT-RS ports associated with the PDSCH,

- if the UE is configured with the higher layer parameter *epre-Ratio*, the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port () is given by Table 4.1-2 according to the *epre-Ratio*, the PT-RS scaling factor specified in clause 7.4.1.2.2 of [4, TS 38.211] is given by.

- otherwise, the UE shall assume *epre-Ratio* is set to state '0' in Table 4.1-2 if not configured.

- if the UE is configured with [*enhanced-dmrs-Type\_r18*], the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port () is given by Table 4.1-2A according to the *epre-Ratio.*

Table 4.1-2: PT-RS EPRE to PDSCH EPRE per layer per RE ()

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| *epre-Ratio* | The number of PDSCH layers with DM-RS associated to the PT-RS port | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | 0 | 3 | 4.77 | 6 | 7 | 7.78 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | reserved | | | | | |
| 3 | reserved | | | | | |

Table 4.1-2A: PT-RS EPRE to PDSCH EPRE per layer per RE ()

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *epre-Ratio* | The number of PDSCH layers with DM-RS associated to the PT-RS port | | | | | | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 0 | 0 | 3 | 4.77 | 6 | 7 | 7.78 | 8.45 | 9 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | reserved | | | | | | | |
| 3 | reserved | | | | | | | |

For link recovery, as described in clause 6 of [6, TS 38.213] the ratio of the PDCCH EPRE to NZP CSI-RS EPRE is assumed as 0 dB.

# 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, 4\_0, 4\_1, 4\_2 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. When the UE is scheduled with multiple PDSCHs 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.

When receiving PDSCH scheduled with SI-RNTI, P-RNTI, G-RNTI for broadcast or MCCH-RNTI, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the associated SS/PBCH block with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

When receiving PDSCH scheduled with RA-RNTI, or MSGB-RNTI, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the SS/PBCH block or the CSI-RS resource the UE used for RACH association as applicable, and transmission with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable. When receiving a PDSCH scheduled with RA-RNTI in response to a random access procedure triggered by a PDCCH order which triggers contention-free random access procedure for the SpCell [10, TS 38.321], the UE may assume that the DM-RS port of the received PDCCH order and the DM-RS ports of the corresponding PDSCH scheduled with RA-RNTI are quasi co-located with the same SS/PBCH block or CSI-RS with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable. If a UE is configured with *SSB-MTC-AddtionalPCI* and with *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, and if the UE is configured with [*twoTAGs*]for the SpCell, if the UE attempts to detect the DCI format 1\_0 with CRC scrambled by the corresponding RA-RNTI or when receiving a PDSCH scheduled with RA-RNTI in response to a random access procedure triggered by a PDCCH order which triggers contention-free random access procedure for the SpCell [10, TS 38.321], and if the CORESET used for the PDCCH order transmission is not associated with the serving cell physical cell ID, the UE may assume that the DM-RS port of the PDCCH that includes the DCI format 1\_0 and the DM-RS ports of the received PDSCH are quasi co-located with the DM-RS antenna port associated with PDCCH receptions in the CORESET for Type1-PDCCH CSS set with respect to Doppler shift, Doppler spread, average delay, delay spread, and spatial RX parameters when applicable.

When receiving PDSCH in response to a PUSCH transmission scheduled by a RAR UL grant or corresponding PUSCH retransmission, or when receiving PDSCH in response to a PUSCH for Type-2 random access procedure, or a PUSCH scheduled by a fallbackRAR UL grant or corresponding PUSCH retransmission, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the SS/PBCH block the UE selected for RACH association and transmission with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

If the UE is not configured for PUSCH/PUCCH transmission for at least one serving cell configured with slot formats comprised of DL and UL symbols, and if the UE is not capable of simultaneous reception and transmission on serving cell *c1*and serving cell *c2*, the UE is not expected to receive PDSCH on serving cell *c1* if the PDSCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell *c2* not configured for PUSCH/PUCCH transmission.

The UE is not expected to decode a PDSCH in a serving cell scheduled by a PDCCH with C-RNTI, CS-RNTI, MCS-C-RNTI, G-RNTI, G-CS-RNTI or MCCH-RNTI and one or multiple PDSCH(s) required to be received according to this Clause in the same serving cell without a corresponding PDCCH transmission if the PDSCHs partially or fully overlap in time except if the PDCCH scheduling the PDSCH ends at least 14 symbols before the earliest starting symbol of the PDSCH(s) without the corresponding PDCCH transmission, where *m* and the symbol duration are based on the smallest numerology between the scheduling PDCCH and the PDSCH, in which case the UE shall decode the PDSCH scheduled by the PDCCH. When the PDCCH reception incudes two PDCCH candidates from two respective search space sets, as described in clause 10 of [6, TS 38.213], for the purpose of determining the PDCCH with C-RNTI, CS-RNTI or MCS-C-RNTI scheduling the PDSCH ends at least 14 symbols before the earliest starting symbol of the PDSCH(s) without the corresponding PDCCH transmission, the PDCCH candidate that ends later in time is used.

The UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, G-RNTI for multicast or broadcast, MCCH-RNTI, G-CS-RNTI or CS-RNTI if another PDSCH in the same cell scheduled with RA-RNTI or MSGB-RNTI partially or fully overlap in time.

The UE in RRC\_IDLE and RRC\_INACTIVE modes shall be able to decode two PDSCHs each scheduled with SI-RNTI, P-RNTI, RA-RNTI or TC-RNTI, with the two PDSCHs partially or fully overlapping in time in non-overlapping PRBs.

The UE:

- is expected to decode PDSCH scheduled with MCCH-RNTI and PBCH in PCell that partially or fully overlaps in time in non-overlapping PRBs in PCell.

- is not expected to decode PDSCH scheduled with G-RNTI for broadcast and PBCH in PCell that partially or fully overlaps in time in non-overlapping PRBs in PCell.

- is not expected to decode PDSCH scheduled with G-RNTI for multicast and PBCH in PCell that partially or fully overlaps in time in non-overlapping PRBs in PCell.

On a frequency range 1 cell, the UE shall be able to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI and, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI that partially or fully overlap in time in non-overlapping PRBs, unless the PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI requires Capability 2 processing time according to clause 5.3 in which case the UE may skip decoding of the scheduled PDSCH with C-RNTI, MCS-C-RNTI, or CS-RNTI.

On a frequency range 2 cell, the UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI if in the same cell, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI partially or fully overlap in time.

The UE is expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI during a process of autonomous SI acquisition.

The maximum number of PDSCHs scheduled per slot per component carrier with C-RNTI/CS-RNTI and G-RNTI/G-CS-RNTI/MCCH-RNTI that the UE shall be able to decode is the same as the indicated UE capability for the number of unicast PDSCHs per slot per component carrier. If the UE is capable of receiving FDMed unicast and multicast PDSCH per slot per carrier, the UE shall be able to decode a PDSCH scheduled by a DCI format with C-RNTI or a PDSCH scheduled for a retransmission of a TB by a DCI format with CS-RNTI and a PDSCH scheduled by a DCI format with G-RNTI for multicast or a PDSCH scheduled for a retransmission of a TB by a DCI format with G-CS-RNTI that partially or fully overlap in time in non-overlapping PRBs. If the UE is capable of receiving FDMed unicast and broadcast PDSCH per slot per carrier, the UE shall be able to decode a PDSCH scheduled by a DCI format with C-RNTI or a PDSCH scheduled for a retransmission of a TB by a DCI format with CS-RNTI and a PDSCH scheduled with G-RNTI for broadcast/MCCH-RNTI that partially or fully overlap in time in non-overlapping PRBs.

If the UE is configured by higher layers to decode a PDCCH with its CRC scrambled by a CS-RNTI or G-CS-RNTI, the UE shall receive PDSCH transmissions without corresponding PDCCH transmissions using the higher-layer-provided PDSCH configuration for those PDSCHs.

The UE it is not expected to support reception of FDMed MCCH PDSCH and broadcast MTCH PDSCH in PCell or SCell, or FDMed multiple broadcast MTCH PDSCHs in PCell or SCell, or FDMed MCCH/broadcast MTCH/multicast PDSCH and SIB PDSCH in PCell, or FDMed multicast PDSCHs in PCell or SCell, or FDMed multicast PDSCH and MCCH/broadcast MTCH PDSCH in PCell or SCell, or FDMed MCCH/broadcast MTCH/multicast PDSCH and paging PDSCH.

If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the UE may expect to receive multiple PDCCHs scheduling fully/partially/non-overlapped PDSCHs in time and frequency domain. The UE may expect the reception of full/partially-overlapped PDSCHs in time, only when PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex*. For a *ControlResourceSet* without *coresetPoolIndex*, the UE may assume that the *ControlResourceSet* is assigned with *coresetPoolIndex* as 0. When the UE is configured with *SSB-MTC-AdditionalPCI*, *ControlResourceSets* corresponding to different *coresetPoolIndex* values may be associated with different physical cell IDs via activated TCI states of the *ControlResourceSets*, where *ControlResourceSets* corresponding to one *coresetPoolIndex* is associated with the serving cell physical cell ID and *ControlResourceSets* corresponding to another *coresetPoolIndex* can be associated with another physical cell ID. When the UE is scheduled with full/partially/non-overlapped PDSCHs in time and frequency domain, the full scheduling information for receiving a PDSCH is indicated and carried only by the corresponding PDCCH, the UE is expected to be scheduled with the same active BWP and the same SCS. When the UE is scheduled with full/partially-overlapped PDSCHs in time and frequency domain, the UE can be scheduled with at most two codewords simultaneously. When PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex,* the following operations are allowed:

- 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 associated with a value of *coresetPoolIndex* ending in symbol *i*, the UE can be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*.

- In a given scheduled cell, the UE can receive a first PDSCH in slot *i*, with the corresponding HARQ-ACK assigned to be transmitted in slot *j*, and a second PDSCH associated with a value of *coresetPoolIndex* different from that of the first PDSCH starting later than the first PDSCH with its corresponding HARQ-ACK assigned to be transmitted in a slot before slot *j*.

If PDCCHs that schedule corresponding PDSCHs are associated to the same or different *ControlResourceSets* having the same value of *coresetPoolIndex*, the UE procedure for receiving the PDSCH upon detection of a PDCCH follows Clause 5.1.

A UE does not expect to be configured with *repetitionScheme* if the UE is configured with higher layer parameter *repetitionNumber* for the same PDSCH.

When a UE is configured by higher layer parameter *repetitionScheme* set to one of 'fdmSchemeA*'*, 'fdmSchemeB*'*, 'tdmSchemeA*'*, if 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)'*.

- When two TCI states are indicated in a DCI and the UE is set to 'fdmSchemeA*',* the UE shall receive a single PDSCH transmission occasion of the TB with each TCI state associated to a non-overlapping frequency domain resource allocation as described in Clause 5.1.2.3.

- When two TCI states are indicated in a DCI and the UE is set to 'fdmSchemeB*'*, the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to a PDSCH transmission occasion which has non-overlapping frequency domain resource allocation with respect to the other PDSCH transmission occasion as described in Clause 5.1.2.3.

- When two TCI states are indicated in a DCI and the UE is set to 'tdmSchemeA*'*, the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to a PDSCH transmission occasion which has non-overlapping time domain resource allocation with respect to the other PDSCH transmission occasion and both PDSCH transmission occasions shall be received within a given slot as described in Clause 5.1.2.1.

When a UE is configured by the higher layer parameter *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, the UE may expect to be indicated with one or two TCI states in a codepoint of the DCI field *'Transmission Configuration Indication'* together with the DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation* and DM-RS port(s) within one CDM group in the DCI field '*Antenna Port(s)'*.

- When two TCI states are indicated in a DCI with '*Transmission Configuration Indication*' field, the UE may expect to receive multiple slot level PDSCH transmission occasions of the same TB with two TCI states used across multiple PDSCH transmission occasions in the *repetitionNumber* consecutive slots as defined in Clause 5.1.2.1.

- When one TCI state is indicated in a DCI with '*Transmission Configuration Indication*' field, the UE may expect to receive multiple slot level PDSCH transmission occasions of the same TB with one TCI state used across multiple PDSCH transmission occasions in the *repetitionNumber* consecutive slots as defined in Clause 5.1.2.1.

When a UE is configured with *dl-OrJointTCI-StateList* and is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, and is having two indicated TCI-Stateswhere the first indicated TCI-State corresponds to *coresetPoolIndex* value 0 and the second indicated TCI-State corresponds to *coresetPoolIndex* value 1, the first and second indicated TCI-States are applied to PDSCH transmission occasions scheduled or activated by a PDCCH on a CORESET that is associated with *coresetPoolIndex* values 0 and 1, respectively.

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*'* for a DL BWP 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' for a DL BWP 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' for a DL BWP 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 in all DL BWP within a CC other than initial BWP, 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.

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>

### 5.1.1 Transmission schemes

Only one transmission scheme is defined for the PDSCH, and is used for all PDSCH transmissions.

#### 5.1.1.1 Transmission scheme 1

For transmission scheme 1 of the PDSCH, the UE may assume that a gNB transmission on the PDSCH would be performed with up to 8 transmission layers on antenna ports 1000-1023 as defined in Clause 7.3.1.4 of [4, TS 38.211], subject to the DM-RS reception procedures in Clause 5.1.6.2. <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], 6.1.3.47 of [10, TS 38.321] or 6.1.4.xx 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/] or up to 8 pairs of TCI states or sets of TCI states, where each set is comprised of one or two TCI state(s) for DL channels/signals and/or one or two TCI state(s) 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 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]).

After a UE receives an initial higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* and before application of an indicated TCI state from the configured TCI states:

- The UE assumes that DM-RS of PDSCH and DM-RS of PDCCH and the CSI-RS applying the indicated TCI state are quasi co-located with the SS/PBCH block the UE identified during the initial access procedure

After a UE receives an initial higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* or *ul-TCI-StateList* with more than one *TCI-UL-State* and before application of an indicated TCI state from the configured TCI states:

- The UE assumes that the UL TX spatial filter, if applicable, for dynamic-grant and configured-grant based PUSCH and PUCCH, and for SRS applying the indicated TCI state, is the same as that for a PUSCH transmission scheduled by a RAR UL grant during the initial access procedure

After a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* as part of a Reconfiguration with sync procedure as described in [12, TS 38.331]and before applying an indicated TCI state from the configured TCI states:

- The UE assumes that DM-RS of PDSCH and DM-RS of PDCCH, and the CSI-RS applying the indicated TCI state are quasi co-located with the SS/PBCH block or the CSI-RS resource the UE identified during the random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].

After a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with more than one *TCI-State* or *ul-TCI-StateList* with more than one *TCI-UL-State* as part of a Reconfiguration with sync procedure as described in [12, TS 38.331] and before applying an indicated TCI state from the configured TCI states:

- The UE assumes that the UL TX spatial filter, if applicable, for dynamic-grant and configured-grant based PUSCH and PUCCH, and for SRS applying the indicated TCI state, is the same as that for a PUSCH transmission scheduled by a RAR UL grant during random access procedure initiated by the Reconfiguration with sync procedure as described in [12, TS 38.331].

If a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with a single TCI-State, that can be used as an indicated TCI state, the UE obtains the QCL assumptions from the configured TCI state for DM-RS of PDSCH and DM-RS of PDCCH, and the CSI -RS applying the indicated TCI state.

If a UE receives a higher layer configuration of *dl-OrJointTCI-StateList* with a single TCI-State or *ul-TCI-StateList* with a single *TCI-UL-State*, that can be used as an indicated TCI state, the UE determines an UL TX spatial filter, if applicable, from the configured TCI state for dynamic-grant and configured-grant based PUSCH and PUCCH, and SRS applying the indicated TCI state.

When a UE configured with *dl-OrJointTCI-StateList* would transmit a PUCCH with positive HARQ-ACK or a PUSCH with positive HARQ-ACK corresponding to the DCI carrying the TCI State indication and without DL assignment, or corresponding to the PDSCH scheduled by the DCI carrying the TCI State indication, and if the indicated TCI State(s) is/are different from the previously indicated one(s), the indicatedTCI-State(s) and/or *TCI-UL-State(s)* should be applied starting from the first slot that is at least symbols after the last symbol of the PUCCH or the PUSCH. The first slot and the symbols are both determined on the active BWP with the smallest SCS among the BWP(s) from the CCs applying the indicated *TCI-State(s)* or *TCI-UL-State(s)* that are active at the end of the PUCCH or the PUSCH carrying the positive HARQ-ACK.

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, and the UE is receiving a DCI carrying the *TCI-State* indication and without DL assignment, the UE does not expect that the number of indicated *SLIV*s in the row of the *pdsch-TimeDomainAllocationListForMultiPDSCH* by the DCI is more than one.

If the UE is configured with *SSB-MTC-AddtionalPCI* and with *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the UE receives an activation command for CORESET associated with each *coresetPoolIndex*, as described in clause 6.1.3.14 of [10, TS 38.321] or 6.1.3.xx 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'* in one CC/DL BWP. When a set of TCI state IDs are activated for a *coresetPoolIndex*, the activated TCI states corresponding to one *coresetPoolIndex* is associated with the serving cell physical cell ID and activated TCI states corresponding to another *coresetPoolIndex* can be associated with another physical cell ID.

When a UE supports two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication'* the UE may receive an activation command, as described in clause 6.1.3.24 of [10, TS 38.321], the activation command is used to map up to 8 combinations of one or two TCI states to the codepoints of the DCI field *'Transmission Configuration Indication'*. The UE is not expected to receive more than 8 TCI states in the activation command.

When the DCI field *'Transmission Configuration Indication'* is present in DCI format 1\_2 and when the number of codepoints S in the DCI field *'Transmission Configuration Indication'* of DCI format 1\_2 is smaller than the number of TCI codepoints that are activated by the activation command, as described in clause 6.1.3.14 and 6.1.3.24 of [10, TS38.321], only the first S activated codepoints are applied for DCI format 1\_2.

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 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-r17*, 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 with 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.

For a periodic CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info*, the UE shall expect that a TCI-State indicates one of the following quasi co-location type(s):

- 'typeC' with an SS/PBCH block and, when applicable, 'typeD' with the same SS/PBCH block where SS/PBCH block may have a PCI different from the PCI of the serving cell. The UE can assume center frequency, SCS, SFN offset are the same for SS/PBCH block from the serving cell and SS/PBCH block having a PCI different from the serving cell, or

- 'typeC' with an SS/PBCH block and, when applicable,'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition,* where SS/PBCH block may have a PCI different from the PCI of the serving cell. The UE can assume center frequency, SCS, SFN offset are the same for SS/PBCH block from the serving cell and SS/PBCH block having a PCI different from the serving cell.

For periodic/semi-persistent CSI-RS, if the UE is configured with *dl-OrJointTCI-StateList,* the UE can assume that the indicated *TCI-State* is not applied.

For an aperiodic CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info,* the UE shall expect that a *TCI-State* indicates *qcl-Type* set to 'typeA' with a periodic CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, *qcl-Type* set to 'typeD' with the same periodic CSI-RS resource.

For a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* and without the higher layer parameter *repetition*, the UE shall expect that a TCI-State indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with an SS/PBCH block, where SS/PBCH block may have a PCI different from the PCI of the serving cell. The UE can assume center frequency, SCS, SFN offset are the same for SS/PBCH block from the serving cell and SS/PBCH block having a PCI different from the serving cell, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or

- 'typeB' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* when 'typeD' is not applicable.

For a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition,* the UE shall expect that a TCI-State indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or

- 'typeC' with an SS/PBCH block and, when applicable, 'typeD' with the same SS/PBCH block, the reference RS may additionally be an SS/PBCH block having a PCI different from the PCI of the serving cell. The UE can assume center frequency, SCS, SFN offset are the same for SS/PBCH block from the serving cell and SS/PBCH block having a PCI different from the serving cell.

For the DM-RS of PDCCH, if the UE is not configured with *dl-OrJointTCI-StateList,* the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter trs-Info and without higher layer parameter *repetition* and,when applicable, 'typeD' with the same CSI-RS resource.

When a UE is configured with *sfnSchemePdcch* set to 'sfnSchemeA', and CORESET is activated with two TCI states, the UE shall assume that the DM-RS port(s)of the PDCCH in the CORESET is quasi co-located with the DL-RSs of the two TCI states. When a UE is configured with *sfnSchemePdcch* set to 'sfnSchemeB', and a CORESET is activated with two TCI states, the UE shall assume that the DM-RS port(s)of the PDCCH is quasi co-located with the DL-RSs of the two TCI states except for quasi co-location parameters {Doppler shift, Doppler spread} of the second indicated TCI state.

When a UE is configured by higher layer parameter *cjtSchemePDSCH* and *dl-OrJointTCI-StateList* and is with two indicated TCI-States applied for PDSCH reception and reports [support for two joint TCI states for PDSCH-CJT]:

- if the UE is configured with *[Alt1]*, the UE assumes that PDSCH DM-RS port(s) are QCLed with the DL RSs of both indicated TCI-States with respect to QCL-TypeA.

- if the UE is configured with *[Alt2]*, the UE assumes that PDSCH DM-RS port(s) are QCLed with the DL RSs of both indicated TCI-States with respect to QCL-TypeA except for QCL parameters {Doppler shift, Doppler spread} of the second indicated joint TCI state.

For the DM-RS of PDSCH, if the UE is not configured with *dl-OrJointTCI-StateList,* the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource*,* or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*,or

- typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* and without higher layer parameter *repetition* and, when applicable, 'typeD' with the same CSI-RS resource.

For the DM-RS of PDCCH, if the UE is configured with *dl-OrJointTCI-StateList,* the UE shall expect that an indicated *TCI-State* indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource, or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition.*

For the DM-RS of PDSCH, if the UE is configured with *dl-OrJointTCI-StateList,* the UE shall expect that an indicated *TCI-State* indicates one of the following quasi co-location type(s):

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with the same CSI-RS resource*,* or

- 'typeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'typeD' with a CSI-RS resource in an *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition.*

When a UE is configured with *sfnSchemePdsch* set to 'sfnSchemeA', and the UE is indicated with two TCI states in a codepoint of the DCI field 'Transmission Configuration Indication' in a DCI scheduling a PDSCH, the UE shall assume that the DM-RS port(s)of the PDSCH is quasi co-located with the DL-RSs of the two TCI states. When a UE is configured with *sfnSchemePdsch* set to 'sfnSchemeB', and the UE is indicated with two TCI states in a codepoint of the DCI field 'Transmission Configuration Indication' in a DCI scheduling a PDSCH, the UE shall assume that the DM-RS port(s)of the PDSCH is quasi co-located with the DL-RSs of the two TCI states except for quasi co-location parameters {Doppler shift, Doppler spread} of the second indicated TCI state.

When a UE is configured with *dl-OrJointTCI-StateList* or *TCI-UL-State* and is configured by higher layer parameter *PDCCH-Config* that contains two different values of coresetPoolIndex in *ControlResourceSet*, an indicated TCI state is specific to a coresetPoolIndex value, when it is indicated by the DCI field 'Transmission Configuration Indication' in DCI format 1\_1/1\_2 associated with the coresetPoolIndex value.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated TCI-states, if the UE does not report its capability of *[two default beams for S-DCI based MTRP]* in frequency range 2 and when the offset between the reception of the scheduling/activation DCI format 1\_0/1\_1/1\_2 and the scheduled or activated PDSCH reception is less than *[timeDurationForQCL]* in FR2, the UE shall apply the first indicated TCI-State to the scheduled or activated PDSCH reception.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated TCI-states:

- Regardless of the offset between the reception of the scheduling DCI format 1\_0/1\_1/1\_2 and the scheduled/activated PDSCH reception, if the UE is in frequency range 1, or the UE reports its capability of *[two default beams for S-DCI based MTRP]* in frequency range 2, or

- If the UE does not report its capability of *[two default beams for S-DCI based MTRP]*in frequency range 2 and if the scheduling offset between the reception of the scheduling DCI format 1\_0/1\_1/1\_2 and the scheduled/activated PDSCH reception is equal to or larger than [*timeDurationForQCL]*

- The UE can be configured by higher layer parameter *applyIndicatedTCIState* to indicate whether the first, the second, or both of the indicated TCI-state(s) is/are applied to PDSCH reception scheduled or activated by DCI format 1\_0. The UE can be configured with *applyIndicatedTCIState* with value *both* only when the UE is configured with *cjtSchemePDSCH* and the UE reports [*support for two joint TCI states for PDSCH-CJT*] or the UE is configured with *sfnSchemePdsch*. In that case, the UE shall apply both indicated TCI-states to PDSCH reception scheduled or activated by DCI format 1\_0 on a search space other than Type0/0A/2 CSS on CORESET#0.

- If the UE is not configured with *applyIndicatedTCIState*, the first indicated TCI-state is applied to PDSCH reception scheduled or activated by DCI format 1\_0.

- When the UE is configured with *tciSelection-PresentInDCI* and when the UE receives a DCI format 1\_1/1\_2 that schedules or activates PDSCH reception, the UE shall determine the indicated joint/DL TCI state(s) for the PDSCH reception according to the following:

- If the DCI format 1\_1/1\_2 indicates codepoint "00" for the [TCI selection field], the UE shall apply the first one of two indicated joint/DL TCI states to all PDSCH DM-RS port(s) of corresponding PDSCH transmission occasions(s) scheduled or activated by the DCI format 1\_1/1\_2.

- If the DCI format 1\_1/1\_2 indicates codepoint "01" for the [TCI selection field], the UE shall apply the second one of two indicated joint/DL TCI states to all PDSCH DM-RS port(s) of corresponding PDSCH transmission occasions(s) scheduled or activated by the DCI format 1\_1/1\_2.

- If the DCI format 1\_1/1\_2 indicates codepoint "10" for the [TCI selection field], the UE shall apply both indicated joint/DL TCI states to the PDSCH reception scheduled or activated by the DCI format 1\_1/1\_2.

- If the UE is not configured with *tciSelection-PresentInDCI* and when the UE receives a DCI format 1\_1/1\_2 that schedules/activates PDSCH reception, the UE shall apply both indicated TCI-States to the scheduled or activated PDSCH reception

- the higher layer configuration for indicating whether the first, second, or both of the indicated joint/DL TCI states is/are applied to PDSCH reception scheduled/activated by DCI format 1\_0 can be provided per DL BWP.

<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 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 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/or *enhanced-dmrs-Type\_r18*, 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.

For DM-RS configuration enhanced type 1,

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of [{9, 10, 11 or 30} in Table 7.3.1.2.2-1B and Table 7.3.1.2.2-2B] 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 [{9, 10, 11, 24, 25, 26, 27, 28, 30 or 68} in Table 7.3.1.2.2-1C and Table 7.3.1.2.2-2C] of Clause 7.3.1.2 of [5, TS 38.212], or

the UE may assume that all the remaining orthogonal antenna ports of the CDM groups, form which the antenna ports are indicated to the UE, are not associated with transmission of PDSCH to another UE, 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 enhanced type 2,

- if a UE is scheduled with one codeword and assigned with the antenna port mapping with indices of [{9, 10, 20, 21, 22, 23 or 60} in Table 7.3.1.2.2-3B and Table 7.3.1.2.2-4B] 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 [{9, 10, 20, 21, 22, 23, 42, 43, 44, 45, 46, 47 or 128} in Table 7.3.1.2.2-3C and in Table 7.3.1.2.2-4C] of Clause 7.3.1.2 of [5, TS 38.212], or

the UE may assume that all the remaining orthogonal antenna ports of CDM groups are not associated with transmission of PDSCH to another UE, 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 enhanced type 1, when UE is not indicating UE capability of [*noSchedulingRestriction-r18*], the UE shall assume the number of consecutively scheduled PRBs are even, and the offset of the scheduled PRB from common resource block 0 is even number.

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 or DCI format 1\_1 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 or,

1004-1007 or 1012-1015 for DM-RS configuration enhanced type 1 or

1006-1011 or 1018-1023 for DM-RS configuration enhanced type 2

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.

The UE is not expected to simultaneously be configured with the maximum number of front-loaded DM-RS symbols for PDSCH by higher layer parameter *maxLength* being set equal to ‘len2’ and more than one additional DM-RS symbol as given by the higher layer parameter *dmrs-AdditionalPosition*.

The UE is not expected to assume co-scheduled UE(s) with different DM-RS configuration with respect to the actual number of front-loaded DM-RS symbol(s), the actual number of additional DM-RS, the DM-RS symbol location, and DM-RS configuration type as described in Clause 7.4.1.1 of [4, TS 38.211].

The UE does not expect the precoding of the potential co-scheduled UE(s) in other DM-RS ports of the same CDM group to be different in the PRG-level grid configured to this UE with PRG =2 or 4.

The UE does not expect the resource allocation of the potential co-scheduled UE(s) in other DM-RS ports of the same CDM group to be misaligned in the PRG-level grid to this UE with PRG=2 or 4.

When receiving PDSCH scheduled by DCI format 1\_1, the UE shall assume that the CDM groups indicated in the configured index from Tables 7.3.1.2.2-1, 7.3.1.2.2-1A,[ 7.3.1.2.2-1B, 7.3.1.2.2-1C ], 7.3.1.2.2-2, 7.3.1.2.2-2A,[ 7.3.1.2.2-2B, 7.3.1.2.2-2C ], 7.3.1.2.2-3, 7.3.1.2.2-3A, [ 7.3.1.2.2-3B, 7.3.1.2.2-3C ], 7.3.1.2.2-4, 7.3.1.2.2-4A, [ 7.3.1.2.2-4B, 7.3.1.2.2-4C ] of [5, TS. 38.212] contain potential co-scheduled downlink DM-RS and are not used for data transmission, where "1", "2" and "3" for the number of DM-RS CDM group(s) in Tables 7.3.1.2.2-1, 7.3.1.2.2-1A ,[ 7.3.1.2.2-1B, 7.3.1.2.2-1C ], 7.3.1.2.2-2, 7.3.1.2.2-2A,[ 7.3.1.2.2-2B, 7.3.1.2.2-2C ]7.3.1.2.2-3, 7.3.1.2.2-3A, 7.3.1.2.2-4, 7.3.1.2.2-4A, [ 7.3.1.2.2-4B, 7.3.1.2.2-4C ] of [5, TS. 38.212] correspond to CDM group 0, {0,1}, {0,1,2}, respectively.

When receiving PDSCH scheduled by DCI format 1\_0, 4\_0, or 4\_1, 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 PDSCH with allocation duration of 2 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.

The UE is not expected to receive PDSCH scheduling DCI which indicates CDM group(s) with potential DM-RS ports which overlap with any configured CSI-RS resource(s) for that UE.

If the UE receives the DM-RS for PDSCH and an SS/PBCH block associated with the same PCI in the same OFDM symbol(s), then the UE may assume that the DM-RS and SS/PBCH block are quasi co-located with 'typeD', if 'typeD' is applicable. Furthermore, the UE shall not expect to receive DM-RS in resource elements that overlap with those of the SS/PBCH block associated with the same PCI as the DM-RS, and the UE can expect that the same or different subcarrier spacing is configured for the DM-RS and SS/PBCH block in a CC except for the case of 240 kHz where only different subcarrier spacing is supported. A DM-RS for PDSCH is said to be associated with an additional PCI if the indicated TCI state for the PDSCH is associated with the additional PCI, otherwise a DM-RS for PDSCH is associated with serving cell PCI.

If at least one TCI codepoint indicates two TCI states and the UE receives the DM-RS for PDSCH and an SS/PBCH block in the same OFDM symbol(s), then the UE may assume that at least one DM-RS port for the PDSCH and SS/PBCH block are quasi co-located with 'QCL-TypeD', if 'QCL-TypeD' is applicable.

If the UE is configured by higher layer parameter PDCCH-Config that contains two different values of CORESETPoolIndex in different ControlResourceSets, and the UE receives the DM-RS for PDSCH(s) and an SS/PBCH block in the same OFDM symbol(s), then the UE may assume that at least one DM-RS port for the PDSCH(s) and SS/PBCH block are quasi co-located with 'QCL-TypeD', if 'QCL-TypeD' is applicable.

If a UE is configured by the higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the UE may be scheduled with fully or partially overlapping PDSCHs in the time and frequency domain by multiple PDCCHs with the following restrictions,

- the UE is not expected to assume different DM-RS configuration with respect to the actual number of front-loaded DM-RS symbol(s), the actual number of additional DM-RS symbol(s), the actual DM-RS symbol location, and DM-RS configuration type.

- the UE is not expected to assume DM-RS ports in a CDM group indicated by two TCI states.

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,* the UE is not configured with *sfnSchemePdsch* 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)',*

- the first TCI state corresponds to the CDM group of the first antenna port indicated by the antenna port indication table, and the second TCI state corresponds to the other CDM group.

If a UE is configured with higher layer parameter *dmrs-FD-OCC-DisabledForRank1-PDSCH* and the UE is scheduled with PDSCH with single DM-RS port, the UE may assume that set of orthogonal DM-RS antenna ports from the same CDM group using different set of *w*f(*k*') codes are not associated with the transmission of PDSCH to another UE.

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#### 5.2.1.2 Resource settings

Each CSI Resource Setting *CSI-ResourceConfig* contains a configuration of a list of S≥1 CSI Resource Sets (given by higher layer parameter *csi-RS-ResourceSetList*), where the list is comprised of references to either or both of NZP CSI-RS resource set(s) and SS/PBCH block set(s) or the list is comprised of references to CSI-IM resource set(s). Each CSI Resource Setting is located in the DL BWP identified by the higher layer parameter *BWP-id*, and all CSI Resource Settings linked to a CSI Report Setting have the same DL BWP.

The time domain behavior of the CSI-RS resources within a CSI Resource Setting are indicated by the higher layer parameter *resourceType* and can be set to aperiodic, periodic, or semi-persistent. For periodic and semi-persistent CSI Resource Settings, when the UE is configured with *groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18* , the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1. For periodic and semi-persistent CSI Resource Settings, the configured periodicity and slot offset is given in the numerology of its associated DL BWP, as given by *BWP-id.* When a UE is configured with multiple *CSI-ResourceConfigs* consisting the same NZP CSI-RS resource ID, the same time domain behavior shall be configured for the *CSI-ResourceConfigs*. When a UE is configured with multiple *CSI-ResourceConfigs* consisting the same CSI-IM resource ID, the same time-domain behavior shall be configured for the *CSI-ResourceConfigs*. All CSI Resource Settings linked to a CSI Report Setting shall have the same time domain behavior.

##### 5.2.1.4.1 Resource Setting configuration

For aperiodic CSI, each trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* is associated with one or multiple *CSI-ReportConfig* where the *CSI-ReportConfig* not configured with *groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18* is linked to periodic, or semi-persistent, or aperiodic resource setting(s):

- When one Resource Setting is configured, the Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement for L1-RSRP or for channel and interference measurement for L1-SINR computation.

- When two Resource Settings are configured, the first one Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement and the second one (given by either higher layer parameter *csi-IM-ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) is for interference measurement performed on CSI-IM or on NZP CSI-RS.

- When three Resource Settings are configured, the first Resource Setting (higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement, the second one (given by higher layer parameter *csi-IM-ResourcesForInterference*) is for CSI-IM based interference measurement and the third one (given by higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) is for NZP CSI-RS based interference measurement.

For aperiodic CSI, and for periodic and semi-persistent CSI resource settings, each trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* is associated with one or multiple *CSI-ReportConfig* where the *CSI-ReportConfig* configured with *groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18* is linked to periodic or semi-persistent, setting(s):

- When one Resource Setting is configured, the Resource setting is given by *resourcesForChannelMeasurement* for L1-RSRP measurement. In such a case, the number of configured CSI Resource Sets in the Resource Setting is S=2

For aperiodic CSI, and for aperiodic CSI resource settings, each trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* is associated with one or multiple *CSI-ReportConfig* where the *CSI-ReportConfig* configured with *groupBasedBeamReporting-r17* or *groupBasedBeamReporting-v18* is associated with *resourcesForChannel* and *resourcesForChannel2*, which correspond to first and second resource sets, respectively, for L1-RSRP measurement.

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##### 5.2.1.4.2 Report Quantity Configurations

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If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RSRP', 'ssb-Index-RSRP', 'cri-RSRP- Index' or 'ssb-Index-RSRP- Index',

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'disabled', the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single report *nrofReportedRS* (higher layer configured) different CRI or SSBRI for each report setting.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'enabled', the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single reporting instance two different CRI or SSBRI for each report setting, where CSI-RS and/or SSB resources can be received simultaneously by the UE either with a single spatial domain receive filter, or with multiple simultaneous spatial domain receive filters.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting-r17*, the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single reporting instance *nrofReportedGroups,* if configured, group(s) of two CRIs or SSBRIs selecting one CSI-RS or SSB from each of the two CSI Resource Sets for the report setting, where CSI-RS and/or SSB resources of each group can be received simultaneously by the UE.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting-v18* set to *JointULandDL*, the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single reporting instance *nrofReportedGroups-r18,* if configured, group(s) of two CRIs or SSBRIs selecting one CSI-RS or SSB from each of the two CSI Resource Sets for the report setting, where CSI-RS and/or SSB resources of each group can be received simultaneously and applied for simultaneous transmission with spatial filters by the UE subject to UE capability.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting-v18* set to *ULOnly,* the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single reporting instance *nrofReportedGroups-r18,* if configured, group(s) of two CRIs or SSBRIs selecting one CSI-RS or SSB from each of the two CSI Resource Sets for the report setting, where CSI-RS and/or SSB resources of each group can be applied for simultaneous transmission with spatial filters by the UE subject to UE capability.

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#### 5.2.1.5 Triggering/activation of CSI Reports and CSI-RS

##### 5.2.1.5.1 Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology

For CSI-RS resource sets associated with Resource Settings configured with the higher layer parameter *resourceType* set to 'aperiodic', 'periodic', or 'semi-persistent', trigger states for Reporting Setting(s) (configured with the higher layer parameter *reportConfigType* set to 'aperiodic') and/or Resource Setting for channel and/or interference measurement on one or more component carriers are configured using the higher layer parameter *CSI-AperiodicTriggerStateList*. For aperiodic CSI report triggering, a single set of CSI triggering states are higher layer configured, wherein the CSI triggering states can be associated with any candidate DL BWP. A UE is not expected to receive more than one DCI with non-zero *CSI request* field per slot per cell. A UE is not expected to receive DCI with non-zero *CSI request* field within a cell group in a slot overlapping with any slot receiving DCI with non-zero *CSI request* field in the same cell group. A UE is not expected to be configured with different *TCI-StateId*'s for the same aperiodic CSI-RS resource ID configured in multiple aperiodic CSI-RS resource sets with the same triggering offset in the same aperiodic trigger state. A UE is not expected to receive more than one aperiodic CSI report request for transmission in a given slot per cell. A UE is not expected to receive an aperiodic CSI report request for transmission in a slot overlapping with any slot having an aperiodic CSI report transmission in the same cell group. If a UE does not indicate its capability of *CSItriggerStateContainingNonactiveBWP* the UE is not expected to be triggered with a CSI report for a non-active DL BWP. Otherwise, when a UE is triggered with a CSI report for a DL BWP that is non-active when expecting to receive the most recent occasion, no later than the CSI reference resource, of the associated NZP CSI-RS, the UE is not expected to report the CSI for the non-active DL BWP and the CSI report associated with that BWP is omitted. When a UE is triggered with aperiodic NZP CSI-RS in a DL BWP that is non-active when expecting to receive the NZP CSI-RS, the UE is not expected to measure the aperiodic CSI-RS. In the carrier of the serving cell expecting to receive that associated NZP CSI-RS, if the active DL BWP when receiving the NZP CSI-RS is different from the active DL BWP when receiving the triggering DCI,

- the last symbol of the PDCCH span of the DCI carrying the BWP switching shall be no later than the last symbol of the PDCCH span of the DCI carrying the CSI trigger, irrespective of whether they are in the same carrier of a serving cell or not and irrespective of whether they are in the same SCS or not;

- the UE is not expected to have any other BWP switching in that carrier after the last symbol of the PDCCH span covering the DCI carrying the CSI trigger and before the first symbol of the triggered NZP CSI-RS or CSI-IM.

- 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 span that involves the PDCCH candidate that ends later in time is used.

A trigger state is initiated using the *CSI request* field in DCI.

- When all the bits of *CSI request* field in DCI are set to zero, no CSI is requested.

- When the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , where  is the number of bits in the DCI *CSI request* field, the UE receives a subselection indication, as described in clause 6.1.3.13 of [10, TS 38.321], used to map up to  trigger states to the codepoints of the *CSI request* field in DCI.  is configured by the higher layer parameter *reportTriggerSize* where . When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the subselection indication, the corresponding action in [10, TS 38.321] and UE assumption on the mapping of the selected CSI trigger state(s) to the codepoint(s) of DCI CSI request field shall 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..

- When the number of CSI triggering states in *CSI-AperiodicTriggerStateList* is less than or equal to , the *CSI request* field in DCI directly indicates the triggering state.

- For each aperiodic CSI-RS resource in a CSI-RS resource set associated with each CSI triggering state, the UE is indicated the quasi co-location configuration of quasi co-location RS source(s) and quasi co-location type(s), as described in clause 5.1.5, through higher layer signaling of *qcl-info* which contains a list of references to *TCI-State's* for the aperiodic CSI-RS resources associated with the CSI triggering state. If a *State* referred toin the list is configured with a reference to an RS configured with *qcl-Type* set to 'typeD', that RS may be an SS/PBCH block located in the same or different CC/DL BWP or a CSI-RS resource configured as periodic or semi-persistent located in the same or different CC/DL BWP.

- If the scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in a *NZP-CSI-RS-ResourceSet* configured without higher layer parameter *trs-Info* is smaller than the UE reported threshold *beamSwitchTiming,* as defined in [13, TS 38.306], when the reported value is one of the values of {14, 28, 48} and *enableBeamSwitchTiming* is not provided, or is smaller than 48 when the UE provides *beamSwitchTiming-r16*, *enableBeamSwitchTiming* is provided and the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *repetition* set to 'off' or configured without the higher layer parameter *repetition,* or is smaller than the UE reported threshold *beamSwitchTiming-r16,* when *enableBeamSwitchTiming* is provided and the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *repetition* set to 'on'.

- 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 *ControlResourceSet*

- if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled by a PDCCH associated with the same *coresetPoolIndex* as the PDCCH triggering the aperiodic CSI-RS and scheduled with offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], aperiodic CSI-RS triggered by a PDCCH associated with the same *coresetPoolIndex* as the PDCCH triggering the aperiodic CSI-RS and scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and *enableBeamSwitchTiming* is not provided, aperiodic CSI-RS triggered by a PDCCH associated with the same *coresetPoolIndex* as the PDCCH triggering the aperiodic CSI-RS and scheduled with offset larger than or equal to 48 when the reported value of *beamSwitchTiming-r16* is one of the values {224, 336} and *enableBeamSwitchTiming* is provided, periodic CSI-RS, semi-persistent CSI-RS;

- else, the UE applies the QCL parameter(s) 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 triggering that aperiodic CSI-RS, in the latest slot in which one or more CORESETs are associated with the same value of *coresetPoolIndex* as the PDCCH triggering that aperiodic CSI-RS

- else if a UE is configured with *enableTwoDefaultTCI-States* and at least one TCI codepoint is mapped to two TCI states

- if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], aperiodic CSI-RS scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and *enableBeamSwitchTiming* is not provided, aperiodic CSI-RS scheduled with offset larger than or equal to 48 when the reported value of *beamSwitchTiming-r16* is one of the values {224, 336} and *enableBeamSwitchTiming* is provided, periodic CSI-RS, semi-persistent CSI-RS. If there is a PDSCH indicated with two TCI states in the same symbols as the CSI-RS, the UE applies the first TCI state of the two TCI states when receiving the aperiodic CSI-RS.

- else, the UE applies the first one of two TCI states corresponding to the lowest TCI codepoint among those mapped to two TCI states and applicable to the PDSCH within the active BWP of the cell in which the CSI-RS is to be received when receiving the aperiodic CSI-RS.

- else if a UE is configured with *sfnSchemePdcch* set to *'*sfnSchemeA', it is not configured with *enableTwoDefaultTCI-States,* and the two TCI states are activated for the CORESET by the activation command as described in clause 6.1.3.x of [10, TS 38.321]

- if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with an offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], periodic CSI-RS, semi-persistent CSI-RS, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and when *enableBeamSwitchTiming* is not provided or the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *trs-Info* , aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'off' or configured without the higher layer parameters *repetition* and *trs-Info* scheduled with offset larger than or equal to 48 when the UE provides *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'on' scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided;

- else, the UE applies the first one of two TCI states indicated for the CORESET with the lowest CORESET ID in the latest slot within the active BWP of the cell in which the CSI-RS is to be received when receiving the aperiodic CSI-RS,

- else if there is any other DL signal with an indicated TCI state in the same symbols as the CSI-RS, the UE applies the QCL assumption of the other DL signal also when receiving the aperiodic CSI-RS. The other DL signal refers to PDSCH scheduled with offset larger than or equal to the threshold *timeDurationForQCL,* as defined in [13, TS 38.306], periodic CSI-RS, semi-persistent CSI-RS, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming* when the reported value is one of the values {14,28,48} and when *enableBeamSwitchTiming* is not provided or the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *trs-Info* , aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'off' or configured without the higher layer parameters *repetition* and *trs-Info* scheduled with offset larger than or equal to 48 when the UE provides *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided, aperiodic CSI-RS in a *NZP-CSI-RS-ResourceSet* configuredwith the higher layer parameter *repetition* set to 'on' scheduled with offset larger than or equal to the UE reported threshold *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided;

- else if the UE is not provided *dl-OrJointTCI-StateList*, and if at least one CORESET is configured for the BWP in which the aperiodic CSI-RS is received, when receiving the aperiodic CSI-RS, the UE applies the QCL assumption used for 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;

- else if the UE is provided *dl-OrJointTCI-StateList* and if the indicated TCI state is associated with a PCI different from the serving cell, regardless of configuration of *followUnifiedTCI-State*, and if at least one CORESET is configured for the BWP in which the aperiodic CSI-RS is received, when receiving the aperiodic CSI-RS, the UE applies the QCL assumption used for 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. In the CA case, if the 'QCL-TypeD' of the aperiodic CSI-RSs from respective CCs in a band are different in a slot, the QCL-TypeD assumption of the CSI-RS in the CC with lowest CC ID in the band is applied to all the aperiodic CSI-RSs in the CCs in the band;

- else if the UE is provided *dl-OrJointTCI-StateList* and the indicated TCI state is associated with the PCI of the serving cell, regardless of configuration of *followUnifiedTCI-State*, the indicated TCI state is applied to the aperiodic CSI-RS;

- else if the UE is configured with *enableDefaultBeamForCCS* and when receiving the aperiodic CSI-RS, the UE applies the QCL assumption of the lowest-ID activated TCI state applicable to the PDSCH within the active BWP of the cell in which the CSI-RS is to be received.

- If the scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in a *NZP-CSI-RS-ResourceSet* is equal to or greater than the UE reported threshold *beamSwitchTiming* when the reported value is one of the values of {14,28,48} and *enableBeamSwitchTiming* is not provided and the *NZP-CSI-RS-ResourceSet* is not configured with higher layer parameter *trs-Info*, or is equal to or greater than the UE reported threshold *beamSwitchTiming* when the reported value is one of the values of {14,28,48} and the *NZP-CSI-RS-ResourceSet* is configured with higher layer parameter *trs-Info*, or is equal to or greater than 48 when the UE provides *beamSwitchTiming-r16* and *enableBeamSwitchTiming* is provided and the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *repetition* set to 'off' or configured without the higher layer parameters *repetition* and *trs-Info*, or is equal to or greater than the UE reported threshold *beamSwitchTiming-r16,* when *enableBeamSwitchTiming* is provided and the *NZP-CSI-RS-ResourceSet* is configured with the higher layer parameter *repetition* set to 'on', the UE is expected to apply the QCL assumptions in the indicated TCI states for the aperiodic CSI-RS resources in the CSI triggering state indicated by the CSI trigger field in DCI.

- The UE is not expected to receive aperiodic CSI-RS and PDSCH/aperiodic CSI-RS associated with different values of *coresetPoolIndex* in overlapped symbol(s). The UE is not expected to receive aperiodic CSI-RS and semi-persistent/periodic CSI-RS with different 'QCL-type D' in overlapped symbol(s).

- If configured, the UE may assume that a CSI-RS resource in an aperiodic CSI-RS resource set configured without *trs-Info* is quasi co-located with the RS(s) in the indicated TCI state.

- A non-zero codepoint of the CSI request field in the DCI is mapped to a CSI triggering state according to the order of the associated positions of the up to trigger states in *CSI-AperiodicTriggerStateList* with codepoint '1' mapped to the triggering state in the first position.

For a UE configured with the higher layer parameter *CSI-AperiodicTriggerStateList*, if a Resource Setting linked to a *CSI-ReportConfig* has multiple aperiodic resource sets, only one of the aperiodic CSI-RS resource sets from the Resource Setting is associated with the trigger state, and the UE is higher layer configured per trigger state per Resource Setting to select the one CSI-IM/NZP CSI-RS resource set from the Resource Setting.

When aperiodic CSI-RS is used with aperiodic reporting, the CSI-RS offset is configured per resource set by the higher layer parameter *aperiodicTriggeringOffset* or *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17*. The CSI-RS triggering offset has the values of {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} slots for or {0, 4, 8, 12, …, 60, 64, 96} slots for and , where is the subcarrier spacing configurations for CSI-RS. If the UE is not configured with *minimumSchedulingOffsetK0* for any DL BWP and *minimumSchedulingOffsetK2* for any UL BWP and if all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states, the CSI-RS triggering offset is fixed to zero. The aperiodic triggering offset of the CSI-IM follows offset of the associated NZP CSI-RS for channel measurement. The aperiodic CSI-RS is transmitted in a slot , , if UE is configured with ca-SlotOffset for at least one of the triggered and triggering cell, and in slot , otherwise, and where

*- n* is the slot containing the triggering DCI, *X* is the CSI-RS triggering offset according to the higher layer parameter *aperiodicTriggeringOffset* or *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17*,

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

The UE does not expect that aperiodic CSI-RS is transmitted before the OFDM symbol(s) carrying its triggering DCI. When the minimum scheduling offset restriction is applied, UE is not expected to be triggered by CSI triggering state indicated by the CSI request field in DCI in which CSI-RS triggering offset is smaller than the currently applicable minimum scheduling offset restriction *K*0min.

If interference measurement is performed on aperiodic NZP CSI-RS, a UE is not expected to be configured with a different aperiodic triggering offset of the NZP CSI-RS for interference measurement from the associated NZP CSI-RS for channel measurement.

If the UE is configured with a single carrier for uplink, the UE is not expected to transmit more than one aperiodic CSI report triggered by different DCIs on overlapping OFDM symbols.

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 scheduling offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources, the PDCCH candidate that ends later in time is used, and the UE does not expect that the aperiodic CSI-RS is transmitted before the first symbol of the PDCCH candidate that starts later in time.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated TCI states, a higher layer configuration can be provided to an aperiodic CSI-RS resource set or a CSI-RS resource in an aperiodic CSI-RS resource set to inform that the UE shall apply the first or the second indicated TCI-State to the aperiodic CSI-RS resource set or to the CSI-RS resource in the aperiodic CSI-RS resource set, if the aperiodic CSI-RS resource set for CSI or BM is configured with *followUnifiedTCI-State* and if the offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in the aperiodic CSI-RS resource set is equal to or larger than a threshold.

-If the UE is configured by higher layer parameter PDCCH-Config that contains two different values of CORESETPoolIndex in different ControlResourceSets, the first and the second indicated TCI-States correspond to the indicated TCI-States specific to coresetPoolIndex value 0 and value 1, respectively.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated TCI states and if the offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in the aperiodic CSI-RS resource set is smaller than a threshold:

-If there is no DL signal in the same symbols as the aperiodic CSI-RS

-if the UE is in frequency range 1, or the UE reports its capability of [two default beams for S-DCI based MTRP] in frequency range 2, the UE shall apply the first or the second indicated joint/DL TCI state to the aperiodic CSI-RS according to the higher layer configuration(s) provided to the aperiodic CSI-RS resource or to the aperiodic CSI-RS resource set. If the UE reports its capability of [two default beams for S-DCI based MTRP] in frequency range 2, the UE uses both indicated joint/DL TCI states to buffer the received signal before a threshold.

-Otherwise, the UE shall apply the first indicated joint/DL TCI state to the aperiodic CSI-RS.

When a UE is configured with *dl-OrJointTCI-StateList*, is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in different *ControlResourceSets,* is having two indicated TCI states and if the offset between the last symbol of the PDCCH carrying the triggering DCI and the first symbol of the aperiodic CSI-RS resources in the aperiodic CSI-RS resource set is smaller than a threshold:

-If there is no DL signal in the same symbols as the aperiodic CSI-RS

-if the UE is in frequency range 1, or the UE reports its capability of [default beam per *coresetPoolIndex* for M-DCI based MTRP] in frequency range 2, the UE shall apply the first or the second indicated joint/DL TCI state to the aperiodic CSI-RS according to the higher layer configuration(s) provided to the aperiodic CSI-RS resource or aperiodic CSI-RS resource set. If the UE reports its capability of [default beam per coresetPoolIndex for M-DCI based MTRP] in frequency range 2, the UE uses both indicated joint/DL TCI states to buffer the received signal before a threshold.

-Otherwise, the UE shall apply the indicated joint/DL TCI state specific to *coresetPoolIndex* value 0 to the aperiodic CSI-RS resource set.

<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.

If 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, or if a UE is configured with *SSB-MTC-AddtionalPCI* and with *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, and if the UE is configured with [*twoTAGs*] and is configured with *dl-OrJointTCI-StateList* or *TCI-UL-State* for a serving cell, each *TCI-State* or *TCI-UL-State* is associated with a [*TAG-ID*]for determining timing adjustment for a corresponding UL transmission as described in Clause 4.2 of [6, TS 38.213]. The UE does not expect that *TCI-states* or *TCI-UL-States* associated with one *coresetPoolIndex* to correspond to two TAGs [except if reported by [UE capability]].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 *TCI-UL-State*, 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.

When a UE is configured with *dl-OrJointTCI-StateList* and is having two indicated TCI-States or TCI-UL-States, a UE configured with a PUSCH transmission corresponding to a Type 1 configured grant is expected to be configured with the higher layer parameter *applyIndicatedTCIState* indicating the *first*, the *second* or *both* of the indicated TCI states to be applied for the PUSCH transmission. If ‘both’ TCI states are indicated, the UE should apply the first indicated TCI state to the PUSCH transmission occasion or the PUSCH antenna port associated with the first SRS resource set for CB/NCB transmission, and the second indicated TCI state to the PUSCH transmission occasion or the PUSCH antenna port associated with the second SRS resource set for CB/NCB transmission; otherwise the UE should apply either the ‘first’ or ‘second’ indicated TCI state to all PUSCH transmission occasions.

- If the UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in different *ControlResourceSets*, the first and the second indicated TCI states correspond to the indicated TCI-States or TCI-UL-States specific to coresetPoolIndex value 0 and value 1, respectively.

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 or 0\_2 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. When the UE is scheduled with multiple PUSCHs 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 or 0\_2 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.

If 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 associated with a value of *coresetPoolIndex* ending in symbol *i*, the UE can be scheduled to transmit a PUSCH starting earlier than the end of the first PUSCH by a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol *i*.

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' and higher layer parameter *enableSTx2PofmDCI* is configured and *PDCCH-Config* contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell and PDCCHs that schedule two fully/partially overlapping PUSCHs in time domain and fully/partially/non-overlapping in frequency domain, the PUSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex.*

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' and higher layer parameter *enableSTx2PofmDCI* is configured and *PDCCH-Config* contains two different values of *coresetPoolIndex* in *ControlResourceSet* for the active BWP of a serving cell, the DCI codepoint *SRS Resource Set Indicator* is not present.

Two fully/partially overlapping PUSCH transmissions can be dynamically scheduled by UL grant(s) in DCI(s) and/or transmission(s) corresponding to configured grant(s) Type 1 or Type 2.

A UE is not expected to be scheduled by a PDCCH ending in symbol to transmit a PUSCH on a given serving cell overlapping in time with a transmission occasion, where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321], starting in a symbol on the same serving cell if the end of symbol is not at least symbols before the beginning of symbol , if the UE is not provided *prioLowDG-HighCG* or *prioHighDG-LowCG*, or the UE is provided *prioLowDG-HighCG* or *prioHighDG-LowCG* and the two PUSCHs have the same priority index as described in Clause 9 of [6, TS 38.213]. The value in symbols is determined according to the UE processing capability defined in Clause 6.4, and and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH.

If a UE receives an ACK for a given HARQ process in CG-DFI in a PDCCH ending in symbol *i* to terminate a transport block repetition in a PUSCH transmission with a configured grant on a given serving cell with the same HARQ process after symbol *i*, the UE is expected to terminate the repetition of the transport block in a PUSCH transmission starting from a symbol *j* if the gap between the end of PDCCH of symbol *i* and the start of the PUSCH transmission in symbol *j* is equal to or more than *N2* symbols. The value *N2* in symbols is determined according to the UE processing capability defined in Clause 6.4, and *N2* and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH and the subcarrier spacing of the PDCCH indicating CG-DFI. A UE is not expected to be scheduled by a PDCCH ending in symbol to transmit a PUSCH on a given serving cell for a given HARQ process, if there is a transmission occasion where the UE is allowed to transmit a PUSCH with configured grant according to [10, TS38.321] with the same HARQ process on the same serving cell starting in a symbol after symbol , and if the gap between the end of PDCCH and the beginning of symbol is less than symbols. The value in symbols is determined according to the UE processing capability defined in clause 6.4, and and the symbol duration are based on the minimum of the subcarrier spacing corresponding to the PUSCH with configured grant and the subcarrier spacing of the PDCCH scheduling the PUSCH.

For PUSCH scheduled by DCI format 0\_0 on a cell, the UE shall transmit PUSCH according to the spatial relation, if applicable, corresponding to the dedicated PUCCH resource with the lowest ID within the active UL BWP of the cell, as described in Clause 9.2.1 of [6, TS 38.213]. If the dedicated PUCCH resource with the lowest ID within the active UL BWP of the cell corresponds to two spatial relations, the UE shall transmit the PUSCH according to the spatial relation with the lower ID.

For PUSCH scheduled by DCI format 0\_0 on a cell and if the higher layer parameter *enableDefaultBeamPL-ForPUSCH0-0* is set 'enabled', the UE is not configured with PUCCH resources on the active UL BWP and the UE is in RRC connected mode, the UE shall transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS configured with *qcl-Type* set to 'typeD' corresponding to the QCL assumption of the CORESET with the lowest ID on the active DL BWP of the cell. If the CORESET is indicated with two TCI states, *sfnSchemePdcch* is configured and the UE supports *sfn-DefaultUL-BeamSetup-r17*, the UE shall use the first TCI state as the QCL assumption.

For PUSCH scheduled by DCI format 0\_0 on a cell and if the higher layer parameter *enableDefaultBeamPL-ForPUSCH0-0* is set 'enabled', the UE is configured with PUCCH resources on the active UL BWP where all the PUCCH resource(s) are not configured with any spatial relation and the UE is in RRC connected mode, the UE shall transmit PUSCH according to the spatial relation, if applicable, with a reference to the RS configured with *qcl-Type* set to 'typeD' corresponding to the QCL assumption of the CORESET with the lowest ID on the active DL BWP of the cell in case CORESET(s) are configured on the cell. If the CORESET is indicated with two TCI states, *sfnSchemePdcch* is configured and the UE supports *sfn-DefaultUL-BeamSetup-r17*, the UE shall use the first TCI state as the QCL assumption.

For uplink, 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 uplink is configured to the UE for each cell separately by higher layer parameter *nrofHARQ-ProcessesForPUSCH*, or *nrofHARQ-ProcessesForPUSCH-r17,* and when no configuration is provided the UE may assume a default number of 16 processes.

<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 or 0\_2. 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 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. 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 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. 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 higher layer parameter *multipanelScheme* is set to ‘SDMScheme’ and 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', two SRI(s), and 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:

- When codepoint “10” of *SRS Resource Set* *indicator* is indicated*,* the first TPMI is used to indicate the precoder to be applied over layers {0…v1-1}, where v1 is the number of layers indicated by the first TPMI, 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 single SRS resource is configured for the applicable SRS resource set the first TPMI is used to indicate precoder to be applied over layers {0…v1-1} and the second TPMI is used to indicate the precoder to be applied over layers {v1…. v2+v1-1}, where v2 is the number of layers indicated by the second TPMI, 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 single SRS resource is configured for the applicable SRS resource set the second TPMI is used to indicate precoder to be applied over layers {v1….v2+v1-1}, v1 ≤ *maxRankSdm* andv2 ≤ *maxRankSdm* or *maxRankSdmDCI-0-2* is defining the maximum number of layers applied over the first and the second SRS resource sets, separately..

- When codepoint “00” or “01” of *SRS Resource Set* *indicator* is indicated*,* the second SRI and second TPMI are reserved, the first TPMI is used to indicate the precoder to be applied over layers {0…v-1}, where v ≤ *maxRank,* where *maxRank* is defining the maximum number of layers.

- Codepoint “11” of *SRS Resource Set indicator* is reserved.

- 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 that the number of SRS antenna ports associated with two indicated SRIs would 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 higher layer parameter *multipanelScheme* set to ‘SFNscheme’ and 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', two SRI(s), and 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.

- When codepoint “10” of *SRS Resource Set* *indicator* is indicated*,* the first TPMI is used to indicate precoder to be applied over layers {0…v-1} and the second TPMI is used to indicate the precoder to be applied over layers {0…v-1}, where v ≤ *maxRankSfn* or *maxRankSdmDCI-0-2* definining the maximum number of layers applied over the first SRS resource set and over the second SRS resource set separately.

- When codepoint “00” or “01” of *SRS Resource Set* *indicator* is indicated*,* the second SRI and second TPMI are reserved, the first TPMI is used to indicate precoder to be applied over layers {0…v-1}, where v ≤ *maxRank* and where *maxRank* is defining the maximum number of layers applied over the first SRS resource set or the seoncd SRS resource.

- Codepoint “11” of *SRS Resource Set indicator* is reserved.

- maximum number of layers is up to 2.

- For one or two TPMI(s), the transmission precoder is selected from the uplink codebook that has a number of antenna ports equal to *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 TPMIs are indicated, the UE shall expect that the number of SRS antenna ports associated with two indicated SRIs 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 with two or four antenna ports, 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 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 for two or four antenna ports.

For codebook based transmission with eight antenna ports, the UE determines its codebook based upon the reception of higher layer parameter[s] *CodebookType* and *ULcodebookFC-N1N2* if *CodebookType* is configured with Ng=1in *pusch-Config* for PUSCH associated with DCI format 0\_1 and 0\_2 , 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 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*' for two or four antenna ports*.

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' for two or four antenna ports.

A UE shall not expect to be configured by *CodebookType* with a value of *CodebookType* that does not correspond to one of the values of *UL\_8TX\_Ng* reported in its capability. [A UE shall not expect to be configured by *CodebookType* with a value that does not correspond to the value of *ULcodebookFC-N1N2* reported by the UE in its capability.]

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 or 0\_2 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 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 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 *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. 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. The maximum number of SRS resources per SRS resource set that can be configured for non-codebook based uplink transmission is 1, 2, 4 or 8 depending on UE capability. 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 higher layer parameter *multipanelScheme* is set to ‘SDMScheme’ and 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.

- When codepoint “10” of *SRS Resource Set* *indicator* is indicated*,* the first SRI is used to indicate resource(s) to be associated with layer(s) {0…v1-1}}, where v1 being the number of layers indicated by the first SRI, and the second SRI is used to indicate resource(s) to be associated with layer(s) {v1…. v2+v1-1}, v1 ≤ *Lmax* andv2 ≤ *Lmax* where *Lmax* is defined is defined inclauses 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212].

- When codepoint “00” or “01” of *SRS Resource Set* *indicator* is indicated*,* the second SRI is reserved, the first SRI is used to indicate resource(s) to be associated with layers {0…v-1}, v ≤ *Lmax*.

- Codepoint “11” of *SRS Resource Set indicator* is reserved.

When the higher layer parameter *multipanelScheme* is set to ‘SFNscheme’ and 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', two SRI(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.

- When codepoint “10” of *SRS Resource Set* *indicator* is indicated*,* the first SRI is used to indicate resource(s) to be associated with layer(s) {0…v-1} and the second SRI is used to indicate resource(s) to be associated with layer(s) {0…v-1}, where v ≤ *Lmax* and where *Lmax* is defined in clauses 7.3.1.1.2 and 7.3.1.1.3 of [5, TS 38.212].

- When codepoint “00” or “01” of *SRS Resource Set* *indicator* is indicated*,* the second SRI is reserved, the first SRI is used to indicate resources(s) to be associated with layers {0…v-1}, where v ≤ *Lmax*. When two SRIs are indicated, the UE shall expect that the number of SRS antenna ports associated with two indicated SRIs to be the same.

- Codepoint “11” of *SRS Resource Set indicator* is reserved.

- maximum number of layers is up to 2.

- When the UE is configured with the higher layer parameter *txConfig* set to 'Noncodebook', 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 '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, as well as DCI format 0\_2 (if SRS request field is present) and DCI format 1\_2 (if SRS request field is present), 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 and 1\_1 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 or 0\_2 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* 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 an allocated 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-0-2or *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 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-SlotOffsetfor 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 or 0\_2 in PDCCH with CRC scrambled with C-RNTI, MCS-C-RNTI, or 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 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.

- 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, or 0\_2, 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 or DCI format 1\_1 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 or 1\_1, 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\_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.

When a UE is configured with *dl-OrJointTCI-StateList* or *TCI-UL-State* and is having two indicated TCI-States or TCI-UL-States, and 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 or Type B as described above, or for PUSCH transmission when the higher layer parameter *multipanelScheme* is set to ‘SDMscheme’ or ‘SFNscheme’, the association of the first and second indicated joint/UL TCI states to PUSCH transmission occasions or to corresponding PUSCH antenna ports is determined as follows:

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint “00” or “01” for the *SRS resource set indicator*, the first or second indicated joint/UL TCI state is applied to all PUSCH transmission occasions, respectively.

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint “10” or “11” for the *SRS resource set indicator*, and the *multipanelScheme* is not configured,

- the first indicated joint/UL TCI state is applied to the PUSCH transmission occasion(s) associated with the first SRS resource set and the second indicated joint/UL TCI state is applied to the PUSCH transmission occasion(s) associated with the second SRS resource set, where the association of PUSCH transmission occasions to SRS resource sets is determined for K = 2 and K > 2, and depending on whether *cyclicMapping* or *sequentialMapping* in *PUSCH-Config* is enabled, based on the above description in this Clause.

- if a DCI format 0\_1 or DCI format 0\_2 indicates codepoint “10” for the *SRS resource set indicator* and the higher layer parameters *multipanelScheme* is configured and set to ‘SDMscheme’ or ‘SFNscheme’,

- the first indicated TCI state is applied to the PUSCH antenna port(s), of corresponding PUSCH transmission occasion, associated with the first SRS resource set, and the second indicated TCI state is applied to the PUSCH antenna port(s), of corresponding PUSCH transmission occasion, associated with the second SRS resource set, where the association of PUSCH antenna ports to SRS resource sets is determined according to Clauses 6.1.1.1 and 6.1.1.2.

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.

<omitted text>

#### 6.1.4.2 Transport block size determination

For eight antenna ports PUSCH transmission, when the number of PUSCH transmission layers is greater than 4, two codewords are transmitted.

If the higher layer parameter *maxRank* or *maxMIMO-Layers* in *PUSCH-config* is greater than 4, then one of the two transport blocks is disabled by DCI format 0\_1 if *IMCS* = 26 and if *rvid* = 1 for the corresponding transport block. 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 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 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 or DCI format 0\_2 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 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 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.

<omitted text>

## 6.2 UE reference signal (RS) procedure

### 6.2.1 UE sounding procedure

The UE may be configured with one or more Sounding Reference Signal (SRS) resource sets as configured by the higher layer parameter *SRS-ResourceSet* or *SRS-PosResourceSet*. For each SRS resource set configured by *SRS-ResourceSet*, a UE may be configured with SRS resources (higher layer parameter *SRS-Resource*), where the maximum value of K is indicated by UE capability[13, 38.306]. When SRS resource set is configured with the higher layer parameter *SRS-PosResourceSet,* a UE may be configured with *K* ≥1 SRS resources (higher layer parameter *SRS-PosResource*), where the maximum value of K is 16. The SRS resource set applicability is configured by the higher layer parameter *usage* in *SRS-ResourceSet.* When the higher layer parameter *usage* is set to 'beamManagement'*,* only one SRS resource in each of multiple SRS resource sets may be transmitted at a given time instant, but the SRS resources in different SRS resource sets with the same time domain behaviour in the same BWP may be transmitted simultaneously.

For the SRS resource set(s) configured *in srs-ResourceSetToAddModListDCI-0-2* with higher layer parameter *usage* set to '*antennaSwitching*' or '*beamManagement*', the UE expects the same SRS resource set(s) with the same *usage* being configured in *srs-ResourceSetToAddModList.*

When the UE is configured *dl-OrJointTCI-StateList* or *ul-TCI-StateList,* the UE can assume that SRS resource(s) in any SRS resource set, except SRS resource set for positioning and an SRS resource set configured with *followUnifiedTCI-StateSRS*, can be configured with *TCI-State* or *TCI-UL-State* or updated as described in clause 6.1.3.59 or 6.1.3.60 of [10, TS 38.321]. The reference RS in the *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 *TCI-UL-State*(s) 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 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.

If an SRS resource set, except an SRS resource set for positioning, is configured with *followUnifiedTCI-StateSRS*, the UE shall transmit the target SRS resource(s) within the SRS resource set according to the spatial relation, if applicable, with a reference to the RS used for determining UL TX spatial filter. The RS is determined based on an RS configured with *qcl-Type* set to 'typeD' in *QCL-Info* 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 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.

When the UE is configured *dl-OrJointTCI-StateList* or *TCI-UL-State* and is having two indicated TCI-States or TCI-UL-States, and if the UE is configured with [*followUnifiedTCI-StateSRS]* toa periodic, semi-persistent or aperiodic SRS resource set with higher layer parameter *usage* in *SRS-ResourceSet* set to ‘*codebook*’, ‘*nonCodebook*’ or ‘*antennaSwitching*’ or to an aperiodic SRS resource set with higher layer parameter *usage* in *SRS-ResourceSet* set to ‘*beamManagement*’

* The UE may be configured by higher layer parameter *applyIndicatedTCIState* to the SRS resource set to indicate whether the UE shall apply the first or the second indicated *TCI-State* or *TCI-UL-State* to the SRS resource set.
  + When a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the first and second indicated *TCI-States* or *TCI-UL-States* correspond to the indicated *TCI-States* or *TCI-UL-States* specific to *coresetPoolIndex* value 0 and value 1, respectively.
* When a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, and the aperiodic SRS resource set which is not configured with higher layer parameter *applyIndicatedTCIState* and the aperiodic SRS resource set is triggered by PDCCH on a CORESET associated with a *coresetPoolIndex* value, the UE shall apply the indicated *TCI-State* or *TCI-UL-State* specific to the *coresetPoolIndex* value to the aperiodic SRS resource set.
* When two SRS resource sets with higher layer parameter *usage* in *SRS-ResourceSet* set to 'codebook' or ‘nonCodebook’ are configured, the UE does not expectthat the first indicated *TCI-State* or *TCI-UL-State* is applied to the second SRS resource set and that the second indicated *TCI-State* or *TCI-UL-State* is applied to the first SRS resource set.

For aperiodic SRS at least one state of the DCI field is used to select at least one out of the configured SRS resource set(s).

The following SRS parameters are semi-statically configurable by higher layer parameter *SRS-Resource* or *SRS-PosResource*.

- *srs-ResourceId* or *SRS-PosResourceId* determines SRS resource configuration identity.

- Number of SRS ports, as defined by the higher layer parameter *nrofSRS-Ports* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, *nrofSRS-Ports* is 1.

*-* Time domain behaviour of SRS resource configuration as indicated by the higher layer parameter *resourceType*, which may be periodic, semi-persistent, aperiodic SRS transmission as defined in clause 6.4.1.4 of [4, TS 38.211].

- Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent. The UE is not expected to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* or *SRS-PosResourceSet* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset.* For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a list of up to four different available slot offset values from the reference slot *n* + *k* to the slot where the aperiodic SRS resource set is transmitted where *n* is the slot with triggering DCI and *k* is *slotOffset,* can be configured by the higher layer parameter *availableSlotOffsetList.* The parameter *availableSlotOffsetList* can be configured up to 4 different values*.* For an *SRS-PosResourceSet* configured with higher layer parameter r*esourceType* set to 'aperiodic', the slot level offset is defined by the higher layer parameter *slotOffset* for each SRS resource.

- Support of time division mapping subsets of ports of the SRS resource into *S* symbols (*S=2)*, as defined by the higher layer parameter [*tdm*], where the SRS ports are evenly distributed in two symbols.- Number of OFDM symbols in the SRS resource, starting OFDM symbol of the SRS resource within a slot including repetition factor R as defined by the higher layer parameter *resourceMapping* and described in clause 6.4.1.4 of [4, TS 38.211]. If *R* is not configured, then *R* is equal to the number of OFDM symbols in the SRS resource.

- SRS bandwidth and , as defined by the higher layer parameter *freqHopping* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, then= 0.

- Frequency hopping bandwidth , as defined by the higher layer parameter *freqHopping* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, then = 0.

- Defining partial frequency sounding factor and start RB index for partial frequency sounding as defined by the higher layer parameters *FreqScalingFactor* PF and *StartRBIndex k*F, respectively, and described in Clause 6.4.1.4 of [4, TS 38.211]. If not configured, then *P*F = 1 and *k*F,= 0.

- Defining start RB index hopping for partial frequency sounding in different SRS frequency hopping periods for aperiodic/periodic/semi-persistent SRS based on the hopping pattern *k*hop as described in clause 6.4.1.4.3 in [4, TS 38.211. If not configured, then start RB hopping is not enabled and *k*hop is fixed to be 0 for all SRS symbols.

- Defining frequency domain position and configurable shift, as defined by the higher layer parameters *freqDomainPosition* and *freqDomainShift*, respectively, and described in clause 6.4.1.4 of [4, TS 38.211]. If *freqDomainPosition* is not configured, *freqDomainPosition* is zero.

- Cyclic shift, as defined by the higher layer parameter *cyclicShift-n2*, *cyclicShift-n4, or cyclicShift-n8* for transmission comb value 2, 4 or 8, and described in clause 6.4.1.4 of [4, TS 38.211]. When cyclic shift hopping is configured by the higher layer parameter [*cyclicShiftHopping*] for an SRS resource in an SRS resource set with the usage configured as ‘*antennaSwitching’*, cyclic shift is updated at every symbol as described in [clause 6,4,1,4 of [4, TS 38.211]]. For the cyclic shift hopping, a UE can be configured with a subset of cyclic shifts by the higher layer parameter [*cyclicShiftHoppingSubset*], where the cyclic shift hopping is performed only across the cyclic shifts configured in the subset. The UE is not expecting that the cyclic shift hopping and the higher layer parameter [*tdm*] are configured simultaneously.

- Transmission comb value, as defined by the higher layer parameter *transmissionComb* described in clause 6.4.1.4 of [4, TS 38.211].

- Transmission comb offset, as defined by the higher layer parameter *combOffset-n2*, *combOffset-n4,* and *combOffset-n8* for transmission comb value 2, 4, or 8, and described in clause 6.4.1.4 of [4, TS 38.211]. When comb offset hopping is configured by the higher layer parameter [*combOffsetHopping*] for an SRS resource in an SRS resource set with the usage configured as ‘*antennaSwitching’*, transmission comb offset(s) are updated as described in [clause 6,4,1,4 of [4, TS 38.211]]. For the comb offset hopping, a UE can be configured with a subset of comb offsets by the higher layer parameter [c*ombOffsetHoppingSubset*], where the comb offset hopping is performed only across the comb offsets configured in the subset. The UE is not expecting that the comb offset hopping and the higher layer parameter [*tdm*] are configured simultaneously.

- SRS sequence ID, as defined by the higher layer parameter *sequenceId* in clause 6.4.1.4 of [4, TS 38.211].

- SRS cyclic shift and/or comb offset hopping ID, as defined by the higher layer parameter [*hoppingID*]

- The configuration of the spatial relation between a reference RS and the target SRS, where the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos*, if configured, contains the ID of the reference RS. The reference RS may be an SS/PBCH block, CSI-RS configured on serving cell indicated by higher layer parameter *servingCellId* if present, same serving cell as the target SRS otherwise, or an SRS configured on uplink BWP indicated by the higher layer parameter *uplinkBWP*, and serving cell indicated by the higher layer parameter *servingCellId* if present, same serving cell as the target SRS otherwise. When the target SRS is configured by the higher layer parameter *SRS-PosResourceSet*, the reference RS may also be a DL PRS configured on a serving cell or a non-serving cell indicated by the higher layer parameter *dl-PRS*, or an SS/PBCH block of a non-serving cell indicated by the higher layer parameter *ssb-Ncell*. If the UE is configured with *dl-OrJointTCI-StateList* or *ul-TCI-StateList*, the reference RS may additionally be an SS/PBCH block associated with a PCI different from the PCI of the serving cell.

The UE may be configured by the higher layer parameter *resourceMapping* in *SRS-Resource* with an SRS resource occupying  adjacent OFDM symbols within the last 6 symbols of the slot, or at any symbol location within the slot if *resourceMapping-r16* is provided subject to UE capability, where all antenna ports of the SRS resources are mapped to each symbol of the resource. When the SRS is configured with the higher layer parameter *SRS-PosResourceSet* the higher layer parameter *resourceMapping-r16* in *SRS-PosResource* indicates an SRS resource occupying adjacent symbols anywhere within the slot. When the SRS is configured with the higher layer parameter *SRS-ResourceSet,* the higher layer parameter *resourceMapping-r17* in *SRS-Resource* indicates an SRS resource occupying adjacent symbols anywhere within the slot.

If a PUSCH with a priority index 0 and SRS configured by *SRS-Resource* are transmitted in the same slot on a serving cell, the UE may only be configured to transmit SRS after the transmission of the PUSCH and the corresponding DM-RS.

If a PUSCH transmission with a priority index 1 or a PUCCH transmission with a priority index 1 would overlap in time with an SRS transmission on a serving cell, the UE does not transmit the SRS in the overlapping symbol(s).

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 'periodic':

- if the UE is configured with the higher layer parameter *spatialRelationInfo, spatialRelationInfo-PDC* or *spatialRelationInfoPos* containing the ID of a reference'ssb-Index', 'ssb-IndexServing', or 'ssb-IndexNcell', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference SS/PBCH block, if the higher layer parameter *spatialRelationInfo, spatialRelationInfo-PDC* or *spatialRelationInfoPos* contains the ID of a reference 'csi-RS-Index' or 'csi-RS-IndexServing', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference periodic CSI-RS or of the reference semi-persistent CSI-RS, if the higher layer parameter *spatialRelationInfo, spatialRelationInfo-PDC* or *spatialRelationInfoPos* containing the ID of a reference 'srs' or 'srs-spatialRelation', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the transmission of the reference periodic SRS. When the SRS is configured by the higher layer parameter *SRS-PosResource* and if the higher layer parameter *spatialRelationInfoPos* contains the ID of a reference 'dl-PRS', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference DL PRS. When the SRS is configured by the higher layer parameter *SRS-Resource* and if the higher layer parameter *spatialRelationInfo-PDC* contains the ID of a reference 'dl-PRS-PDC', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference DL PRS for RTT-based propagation delay compensation according to clause 9.

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 'semi-persistent':

- when a UE receives an activation command, as described in clause 6.1.3.17 or 6.1.3.36 of [10, TS 38.321], for an SRS resource, and when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command, the corresponding actions in [10, TS 38.321] and the UE assumptions on SRS transmission corresponding to the configured SRS resource set shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH. The activation command also contains spatial relation assumptions provided by a list of references to reference signal IDs, one per element of the activated SRS resource set. When the SRS is configured with the higher layer parameter *SRS-ResourceSet*, each ID in the list refers to a reference SS/PBCH block, NZP CSI-RS resource configured on serving cell indicated by *Resource Serving Cell ID* field in the activation command if present, same serving cell as the SRS resource set otherwise, or SRS resource configured on serving cell and uplink bandwidth part indicated by Resource *Serving Cell ID* field and *Resource BWP ID* field in the activation command if present, same serving cell and bandwidth part as the SRS resource set otherwise. When the SRS is configured with the higher layer parameter *SRS-PosResourceSet*, each ID in the list of reference signal IDs may refer to a reference SS/PBCH block on a serving or non-serving cell indicated by *PCI* field in the activation command, NZP CSI-RS resource configured on serving cell indicated by *Resource Serving Cell ID* field in the activation command if present, same serving cell as the SRS resource set otherwise, SRS resource configured on serving cell and uplink bandwidth part indicated by Resource *Serving Cell ID* field and *Resource BWP ID* field in the activation command if present, same serving cell and bandwidth part as the SRS resource set otherwise, or DL PRS resource of a serving or non-serving cell associated with a *dl-PRS-ID* indicated by *DL-PRS ID* field in the activation command.

- if an SRS resource in the activated resource set is configured with the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos*, the UE shall assume that the ID of the reference signal in the activation command overrides the one configured in *spatialRelationInfo* or *spatialRelationInfoPos.*

- when a UE receives a deactivation command [10, TS 38.321] for an activated SRS resource set, and when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the deactivation command, the corresponding actions in [10, TS 38.321] and UE assumption on cessation of SRS transmission corresponding to the deactivated SRS resource set shall apply starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH.

- if the UE is configured with the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* containing the ID of a reference 'ssb-Index', 'ssb-IndexServing', or 'ssb-IndexNcell' the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference SS/PBCH block, if the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* contains the ID of a reference 'csi-RS-Index' or 'csi-RS-IndexServing', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference periodic CSI-RS or of the reference semi-persistent CSI-RS, if the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* contains the ID of a reference 'srs' or 'srs-SpatialRelation', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the transmission of the reference periodic SRS or of the reference semi-persistent SRS. When the SRS is configured by the higher layer parameter *SRS-PosResourceSet* and if the higher layer parameter *spatialRelationInfoPos* contains the ID of a reference 'dl-PRS', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference DL PRS.

If the UE has an active semi-persistent SRS resource configuration and has not received a deactivation command, the semi-persistent SRS configuration is considered to be active in the UL BWP which is active, otherwise it is considered suspended.

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

*- k* is configured via higher layer parameter *slotOffset* for each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command, respectively;

*-*  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 SRS, as defined in [4, TS 38.211] clause 4.5.

- An available slot is a slot satisfying there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies UE capability on the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set. From the first symbol carrying the SRS request DCI to the last symbol of the triggered SRS resource set, UE does not expect to receive SFI indication, UL cancellation indication or dynamic scheduling of DL channel/signal(s) on flexible symbol(s) that may change the determination of available slot.

*- t* is configured via higher layer parameter *availableSlotOffsetList* with up to four different valuesof *AvailableSlotOffset* for each triggered SRS resources set and it is based on the subcarrier spacing of the triggered SRS transmission. When one or more SRS resource sets across all configured BWPs in a component carrier are configured, and at least one resource set is configured with *availableSlotOffsetList* parameter of more than one values, the indicated value of *t* is indicated by SOI field in DCI scheduling PUSCH/PDSCH and DCI 0\_1/0\_2 without data and without CSI request described in [5, TS 38.212]. The UE shall apply indicated value *t* specificallyfor those sets with configured *availableSlotOffsetList* parameter. When one or more SRS resource sets across all configured BWPs in a component carrier are configured and at least one resource set is configured with *availableSlotOffsetList* parameter, and the *availableSlotOffsetList* parameter for each SRS resource set has only one value, the UE shall apply the configured value specificallyfor those sets with configured *availableSlotOffsetList* parameter. For SRS resource set configured with *availableSlotOffsetList* parameter, each of resource set is configured with *K* values of *AvailableSlotOffset*. For SRS resource set configured without *availableSlotOffsetList* parameter, *t* = 0 is applied for the resource set.

- If the UE receives the DCI triggering aperiodic SRS in slot *n* and none of the resource sets is configured with parameter *availableSlotOffsetList* across all configured BWPs in a component carrier except when SRS is configured with the higher layer parameter *SRS-PosResource*

- if the UE is configured with *ca-SlotOffset* for at least one of the triggered and triggering cell, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot *,*

- otherwise, the UE transmits aperiodic SRS in each of the triggered resource set(s) in slot , where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where

*- k* is configured via higher layer parameter *slotOffset* for each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively;

*-* is the subcarrier spacing configuration for with a value of 0 for frequency range 1.

- 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 SRS, as defined in [4, TS 38.211] clause 4.5.

- If the UE receives the DCI triggering aperiodic SRS in slot *n* and when SRS is configured with the higher layer parameter *SRS-PosResource*, the UE transmits every aperiodic SRS resource in each of the triggered SRS resource set(s) in slot , if UE is configured with ca-SlotOffset for at least one of the triggered and triggering cell, , otherwise, where is a parameter configured by higher layer as specified in clause 4.2 of [6 TS 38.213], and where

*- k* is configured via higher layer parameter *slotOffset* for each aperiodic SRS resource in each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively;

*-*  is the subcarrier spacing configuration for with a value of 0 for frequency range 1.

- 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 SRS, as defined in [4, TS 38.211] clause 4.5.

- if the UE is configured with the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* containing the ID of a reference 'ssb-Index', 'ssb-IndexServing' or 'ssb-IndexNcell', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference SS/PBCH block, if the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* contains the ID of a reference 'csi-RS-Index' or 'csi-RS-IndexServing', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference periodic CSI-RS or of the reference semi-persistent CSI-RS, or of the latest reference aperiodic CSI-RS. If the higher layer parameter *spatialRelationInfo* or *spatialRelationInfoPos* contains the ID of a reference 'srs' or 'srs-SpatialRelation', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the transmission of the reference periodic SRS or of the reference semi-persistent SRS or of the reference aperiodic SRS. When the SRS is configured by the higher layer parameter *SRS-PosResourceSet* and if the higher layer parameter *spatialRelationInfoPos* contains the ID of a reference 'dl-PRS', the UE shall transmit the target SRS resource with the same spatial domain transmission filter used for the reception of the reference DL PRS.

- when a UE receives an spatial relation update command, as described in clause 6.1.3.26 of [10, TS 38.321], for an SRS resource configured with the higher layer parameter *SRS-Resource*, and when the HARQ-ACK corresponding to the PDSCH carrying the update command is transmitted in slot *n*, the corresponding actions in [10, TS 38.321] and the UE assumptions on updating spatial relation for the SRS resource shall be applied for SRS transmission starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH. The update command contains spatial relation assumptions provided by a list of references to reference signal IDs, one per element of the updated SRS resource set. Each ID in the list refers to a reference SS/PBCH block, NZP CSI-RS resource configured on serving cell indicated by *Resource Serving Cell ID* field in the update command if present, same serving cell as the SRS resource set otherwise, or SRS resource configured on serving cell and uplink bandwidth part indicated by *Resource* *Serving Cell ID* field and *Resource BWP ID* field in the update command if present, same serving cell and bandwidth part as the SRS resource set otherwise. When the UE is configured with the higher layer parameter *usage* in *SRS-ResourceSet* set to 'antennaSwitching', the UE shall not expect to be configured with different spatial relations for SRS resources in the same SRS resource set.

The UE is not expected to be configured with different time domain behavior for SRS resources in the same SRS resource set. The UE is also not expected to be configured with different time domain behavior between SRS resource and associated SRS resources set.

For operation in the same carrier, the UE is not expected to be configured on overlapping symbols with a SRS resource configured by the higher layer parameter *SRS-PosResource* and a SRS resource configured by the higher layer parameter *SRS-Resource* with *resourceType* of both SRS resources as 'periodic'.

For operation in the same carrier, the UE is not expected to be activated or triggered to transmit SRS on overlapping symbols with a SRS resource configured by the higher layer parameter *SRS-PosResource* and a SRS resource configured by the higher layer parameter *SRS-Resource* with *resourceType* of both SRS resources as 'semi-persistent' or 'aperiodic'.

For operations in the same carrier, the UE is not expected to be configured on overlapping symbols with more than one SRS resources configured by the higher layer parameter *SRS-PosResource* with *resourceType* of the SRS resources as 'periodic'.

For operations in the same carrier, the UE is not expected to be activated or triggered to transmit SRS on overlapping symbols with more than one SRS resources configured by the higher layer parameter *SRS-PosResource* with *resourceType* of the SRS resources as 'semi-persistent' or 'aperiodic'.

For intra-band and inter-band CA operations, a UE can simultaneously transmit more than one SRS resource configured by *SRS-PosResource* on different CCs, subject to UE's capability

For intra-band and inter-band CA operations, a UE can simultaneously transmit more than one SRS resource configured by *SRS-PosResource* and *SRS-Resource* on different CCs, subject to UE's capability.

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) 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'.

For PUCCH and SRS on the same carrier, a UE shall not transmit SRS when semi-persistent or periodic SRS is configured in the same symbol(s) with PUCCH carrying only CSI report(s), or only L1-RSRP report(s), or only L1-SINR report(s). A UE shall not transmit SRS when semi-persistent or periodic SRS is configured or aperiodic SRS is triggered to be transmitted in the same symbol(s) with PUCCH carrying HARQ-ACK, link recovery request (as defined in clause 9.2.4 of [6, 38.213]) and/or SR. In the case that SRS is not transmitted due to overlap with PUCCH, only the SRS symbol(s) that overlap with PUCCH symbol(s) are dropped. PUCCH shall not be transmitted when aperiodic SRS is triggered to be transmitted to overlap in the same symbol with PUCCH carrying semi-persistent/periodic CSI report(s) or semi-persistent/periodic L1-RSRP report(s) only, or only L1-SINR report(s).

In case of intra-band contiguous carrier aggregation, or in inter-band or intra-band non-contiguous CA band combination if simultaneous SRS and PUCCH/PUSCH transmissions are not supported by UE, the UE is not expected to be indicated with a SRS transmission from a carrier and to be configured or scheduled with a PUSCH/UL DM-RS/UL PT-RS/PUCCH transmission from a different carrier in the same symbol.

In case of intra-band contiguous carrier aggregation, or in inter-band CA band combination if simultaneous SRS and PRACH transmissions are not supported by UE, or in case of intra-band non-contiguous CA band combination if the UE is not configured with higher layer parameter *intraBandNC-PRACH-simulTx-r17,* the UE shall not transmit simultaneously SRS resource(s) from a carrier and PRACH from a different carrier.

In case of intra-band contiguous carrier aggregation, or in inter-band CA band combination if simultaneous SRS and MsgA transmissions are not supported by UE, the UE shall not transmit simultaneously SRS resource(s) from a carrier and MsgA from a different carrier.

In case a SRS resource with *resourceType* set as 'aperiodic' is triggered on the OFDM symbol(s) configured with periodic/semi-persistent SRS transmission, the UE shall transmit the aperiodic SRS resource and only the periodic/semi-persistent SRS symbol(s) overlapping within the symbol(s) are dropped, while the periodic/semi-persistent SRS symbol(s) that are not overlapped with the aperiodic SRS resource are transmitted. In case a SRS resource with *resourceType* set as 'semi-persistent' is triggered on the OFDM symbol(s) configured with periodic SRS transmission, the UE shall transmit the semi-persistent SRS resource and only the periodic SRS symbol(s) overlapping within the symbol(s) are dropped, while the periodic SRS symbol(s) that are not overlapped with the semi-persistent SRS resource are transmitted.

When the UE is configured with the higher layer parameter *usage* in *SRS-ResourceSet* set to 'antennaSwitching', and a guard period of Y symbols is configured according to Clause 6.2.1.2, the UE shall use the same priority rules as defined above during the guard period as if SRS was configured.

When a *spatialRelationInfo* is activated/updated for a semi-persistent or aperiodic SRS resource configured by the higher layer parameter *SRS-Resource* by a MAC CE for a set of CCs/BWPs, where the applicable list of CCs provided by higher layer parameter *simultaneousSpatial-UpdatedList1* or *simultaneousSpatial-UpdatedList2* is determined by the indicated CC in the MAC CE, the *spatialRelationInfo* is applied for the semi-persistent or aperiodic SRS resource(s) with the same SRS resource ID for all the BWPs in the determined CCs.

When the higher layer parameter *enableDefaultBeamPL-ForSRS* is set 'enabled', and if the higher layer parameter *spatialRelationInfo* for the SRS resource, except for the SRS resource with the higher layer parameter *usage* in SRS-ResourceSet set to 'beamManagement' or for the SRS resource with the higher layer parameter *usage* in SRS-ResourceSet set to 'nonCodebook' with configuration of *associatedCSI-RS* or for the SRS resource configured by the higher layer parameter *SRS-PosResourceSet*, is not configured in FR2 and if the UE is not configured with higher layer parameter(s) *pathlossReferenceRS*, and if the UE is not configured with different values of coresetPoolIndex in ControlResourceSets, and is not provided at least one TCI codepoint mapped with two TCI states, the UE shall transmit the target SRS resource in an active UL BWP of a CC,

- according to the spatial relation, if applicable, with a reference to the RS configured with *qcl-Type* set to 'typeD' corresponding to the QCL assumption of the CORESET with the lowest *controlResourceSetId* in the active DL BWP in the CC. If the CORESET is activated with two TCI states, *sfnSchemePdcch* is configured and the UE supports *sfn-DefaultUL-BeamSetup-r17*, UE shall use the first TCI state as the QCL assumption.

- according to the spatial relation, if applicable, with a reference to the RS configured with *qcl-Type* set to 'typeD' in the activated TCI state with the lowest ID applicable to PDSCH in the active DL BWP of the CC if the UE is not configured with any CORESET in the active DL BWP of the CC

<omitted text>

#### 6.2.1.2 UE sounding procedure for DL CSI acquisition

When the UE is configured with the higher layer parameter *usage* in *SRS-ResourceSet* set as 'antennaSwitching', the UE may be configured with only one of the following configurations depending on the indicated UE capability *supportedSRS-TxPortSwitch* ('t1r2' for 1T2R, 't1r1-t1r2' for 1T=1R/1T2R, 't2r4' for 2T4R, 't1r4' for 1T4R, 't8r8' for 8T8R, 't1r1-t1r2-t1r4' for 1T=1R/1T2R/1T4R, 't1r4-t2r4' for 1T4R/2T4R, 't1r1-t1r2-t2r2-t2r4' for 1T=1R/1T2R/2T=2R/2T4R, 't1r1-t1r2-t2r2-t1r4-t2r4' for 1T=1R/1T2R/2T=2R/1T4R/2T4R, 't1r1' for 1T=1R, 't2r2' for 2T=2R, 't1r1-t2r2' for 1T=1R/2T=2R, 't4r4' for 4T=4R, or 't1r1-t2r2-t4r4' for 1T=1R/2T=2R/4T=4R) or the UE may be configured with only one of the following configurations depending on the indicated UE capability *supportedSRS-TxPortSwitchBeyond4Rx* (‘t1r1’ for 1T=1R, ‘t2r2’ for 2T=2R, ‘t1r2’ for 1T2R, ‘t4r4’ for 4T=4R, ‘t2r4’ for 2T4R, ‘t1r4’ for 1T4R, ‘t2r6’ for 2T6R, ‘t1r6’ for 1T6R, ‘t4r8’ for 4T8R, ‘t2r8’ for 2T8R, ‘t1r8’ for 1T8R):

- For 1T2R, if the UE is indicating *srs-AntennaSwitching2SP-1Periodic* and/or *srs-ExtensionAperiodicSRS*:

- when the UE is indicating *srs-AntennaSwitching2SP-1Periodic* only, then up to two SRS resource sets with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' and up to one SRS resource set with *resourceType* in *SRS-ResourceSet* set to 'periodic' can be configured, or up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* can be configured, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time, each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the second resource in the set is associated with a different UE antenna port than the SRS port of the first resource in the same set.

- when the UE is indicating *srs-ExtensionAperiodicSRS* only, then up to two SRS resource sets with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' and up to one SRS resource set with *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' can be configured, or up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* can be configured. In the case of two resource sets with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', a total of two SRS resources are transmitted in different symbols of two different slots, the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port pair and the two sets are each configured with one SRS resource. In the case of the one resource set with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' is configured, a total of two SRS resources transmitted in different symbols of one slot and where the SRS port of the second resource in the given set is associated with a different UE antenna port than the SRS port of the first resource in the same set. Each SRS resource set with 'resourceType' in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the second resource in the set is associated with a different UE antenna port than the SRS port of the first resource in the same set.

- zero or one or two SRS resource sets configured with different value of *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with resourceType in SRS-ResourceSet set to 'semi-persistent' and up to one SRS resource set configured with resourceType in SRS-ResourceSet set to 'periodic' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. An SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the second resource in the set is associated with a different UE antenna port than the SRS port of the first resource in the same set, and

- zero or one SRS resource set with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is not indicating *srs-ExtensionAperiodicSRS*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is indicating *srs-ExtensionAperiodicSRS*, where in the case of one resource set, a total of two SRS resources transmitted in different symbols of one slot and where the SRS port of the second resource in the given set is associated with a different UE antenna port than the SRS port of the first resource in the same set. In the case of two resource sets, a total of two SRS resources are transmitted in different symbols of two different slots, the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port. The two sets are each configured with one SRS resource, or

- otherwise, for 1T2R, up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set, where each set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the second resource in the set is associated with a different UE antenna port than the SRS port of the first resource in the same set, or

- For 2T4R, if the UE is indicating *srs-AntennaSwitching2SP-1Periodic* and/or *srs-ExtensionAperiodicSRS*:

- when the UE is indicating *srs-AntennaSwitching2SP-1Periodic* only, then up to two SRS resource sets with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' and up to one SRS resource set with *resourceType* in *SRS-ResourceSet* set to 'periodic' can be configured, or up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* can be configured, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time, each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource.

- when the UE is indicating *srs-ExtensionAperiodicSRS* only, then up to two SRS resource sets with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' and up to one SRS resource set with *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' can be configured, or up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* can be configured. In the case of two resource sets with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', a total of two SRS resources are transmitted in different symbols of two different slots, the SRS port pair of each SRS resource in the given two sets is associated with a different UE antenna port pair and the two sets are each configured with one SRS resource. In the case of one resource set with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' is configured, a total of two SRS resources transmitted in different symbols in the same slot, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource. Each SRS resource set with 'resourceType' in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource.

- zero or one or two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' and up to one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource, and,

- zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is not indicating *srs-ExtensionAperiodicSRS*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is indicating *srs-ExtensionAperiodicSRS*, where in the case of one resource set, a total of two SRS resources transmitted in different symbols in the same slot, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource. In the case of two resource sets, a total of two SRS resources are transmitted in different symbols of two different slots, the SRS port pair of each SRS resource in the given two sets is associated with a different UE antenna port pair. The two sets are each configured with one SRS resource, or

- otherwise, up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet*, where each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource, or

- For 1T4R, if the UE is indicating *srs-AntennaSwitching2SP-1Periodic* and/or *srs-ExtensionAperiodicSRS* and/or *srs-OneAP-SRS*,

- zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to '*semi-persistent*' and up to one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to '*periodic*' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of each resource is associated with a different UE antenna port, and

- zero or two SRS resource sets each configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', if the UE is not indicating *srs-ExtensionAperiodicSRS* or *srs-OneAP-SRS*, or zero or one or two or four SRS resource sets each configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is indicating *srs-ExtensionAperiodicSRS* and *srs-OneAP-SRS*, or zero or two or four SRS resource sets each configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is indicating *srs-ExtensionAperiodicSRS* only, or zero or one or two SRS resource sets each configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic' if the UE is indicating *srs-OneAP-SRS* only. In the case of one resource set, a total of four SRS resources are transmitted in different symbols in the same slot, and the SRS port of each resource in the given set is associated with a different UE antenna port. In the case of two resource sets, a total of four SRS resources are transmitted in different symbols of two different slots, and the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port. The two sets are each configured with two SRS resources, or one set is configured with one SRS resource and the other set is configured with three SRS resources. In the case of four resource sets, if UE is capable if supporting four sets, a total of four SRS resources are transmitted in different symbols of four different slots, and the SRS port of each SRS resource in the given four sets is associated with a different UE antenna port. The four sets are each configured with one SRS resource. The UE shall expect that the value of the higher layer parameter *aperiodicSRS-ResourceTrigger* or the value of an entry in *AperiodicSRS-ResourceTriggerList* in each *SRS-ResourceSet* is the same, and the value of the higher layer parameter *slotOffset* in each *SRS-ResourceSet* is different when none of the SRS resource sets is configured with parameter availableSlotOffsetList across all configured BWPs in a component carrier. Or,

- otherwise, for 1T4R,

- zero or one SRS resource set configured with higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' with four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of each resource is associated with a different UE antenna port, and

- zero or two SRS resource sets each configured with higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic' and with a total of four SRS resources transmitted in different symbols of two different slots, and where the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port. The two sets are each configured with two SRS resources, or one set is configured with one SRS resource and the other set is configured with three SRS resources. The UE shall expect that the value of the higher layer parameter *aperiodicSRS-ResourceTrigger* or the value of an entry in *AperiodicSRS-ResourceTriggerList* in each *SRS-ResourceSet* is the same, and the value of the higher layer parameter *slotOffset* in each *SRS-ResourceSet* is different when none of the SRS resource sets is configured with parameter availableSlotOffsetList across all configured BWPs in a component carrier. Or,

- For 1T=1R, or 2T=2R, 4T=4R or 8T=8R, up to two SRS resource sets each with one SRS resource can be configured, where the number of SRS ports for each resource is equal to 1, 2, 4 or 8 if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*. Two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to '*semi-persistent*' and one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to '*periodic*' can be configured and the two SRS resource sets configured with '*semi-persistent*' are not activated at the same time, or up to two SRS resource sets can be configured, if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where each SRS resource set has one SRS resource, the number of SRS ports for each resource is equal to 1, 2, 4[, or 8] or

- For 1T6R, zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic', where in the case of one resource set has six SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the resource in the set is associated with a different UE antenna port, and

- For 1T6R, zero or one SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has six SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the resource in the set is associated with a different UE antenna port, and

- For 1T6R, zero or one or two or three SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', where in the case of one resource set a total of six SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of each resource in the set is associated with a different UE antenna port. In the case of two resource sets a total of six SRS resources are transmitted in different symbols of two different slots, and the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port. In the case of three resource sets, a total of six SRS resources are transmitted in different symbols of three different slots, and the SRS port of each SRS resource in the given three sets is associated with a different UE antenna port, or

- For 1T8R, zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic', where in the case of one resource set has eight SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the resource in the set is associated with a different UE antenna port, and

- For 1T8R, zero or one SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has eight SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the resource in the set is associated with a different UE antenna port, and

- For 1T8R, zero or two or three or four SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', where in the case of two resource sets a total of eight SRS resources transmitted in different symbols of two different slots, and where the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port. In the case of three resource sets a total of eight SRS resources are transmitted in different symbols of three different slots, and the SRS port of each SRS resource in the given three sets is associated with a different UE antenna port. In the case of four resource sets a total of eight SRS resources are transmitted in different symbols of four different slots, and the SRS port of each SRS resource in the given four sets is associated with a different UE antenna port, or

- For 2T6R, zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic', where in the case of one resource set has three SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair, and

- For 2T6R, zero or one SRS resource sets configured *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with 'semi-persistent' and up to one SRS resource set configured with 'periodic' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has three SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair, and

- For 2T6R, zero or one or two or three SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic, where in the case of one resource set has three SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair. In the case of two resource sets a total of three SRS resources are transmitted in different symbols of two different slots, and the SRS port pair of each SRS resource in the given two sets is associated with a different UE antenna port pair. One set is configured with two SRS resources and another set with one resource. In the case of three resource sets a total of three SRS resources are transmitted in different symbols of three different slots, and the SRS port pair of each SRS resource in the given three sets is associated with a different UE antenna port pair, or

- For 2T8R, zero or one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to 'periodic', where in the case of one resource set has four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair, and

- For 2T8R, zero or one SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with 'semi-persistent' and up to one SRS resource set configured with 'periodic' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair, and

- For 2T8R, zero or one or two or three or four SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', where in the case of one resource set has four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a two SRS ports, and the SRS port pair of the resource in the set is associated with a different UE antenna port pair. In the case of two resource sets a total of four SRS resources transmitted in different symbols of two different slots, and where the SRS port pair of each SRS resource in the given two sets is associated with a different UE antenna port pair. In the case of three resource sets a total of four SRS resources transmitted in different symbols of three different slots, and where the SRS port pair of each SRS resource in the given three sets is associated with a different UE antenna port pair. Two sets are configured with one SRS resource in each set and one resource set is configured with two resources. In the case of four resource sets a total of four SRS resources transmitted in different symbols of four different slots, and where the SRS port pair of each SRS resource in the given four sets is associated with a different UE antenna port pair. Four sets are configured with one SRS resource in each set, or

- For 4T8R, zero or one or two SRS resource set configured with a different value of *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' if the UE is not indicating *srs-AntennaSwitching2SP-1Periodic*, or up to two SRS resource sets configured with 'semi-persistent' and up to one SRS resource set configured with 'periodic' if the UE is indicating *srs-AntennaSwitching2SP-1Periodic*, where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a four SRS ports, and the SRS ports of the resource in the set are associated with a different UE antenna ports, or

- For 4T8R, zero or one or two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to 'aperiodic', where in the case of one resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a four SRS ports, and the SRS ports of the resource in the set are associated with a different UE antenna ports. In the case of two resource sets a total of two SRS resources are transmitted in different symbols of two different slots, and where the SRS ports of each SRS resource in the given two sets are associated with a different UE antenna ports.

The UE is configured with a guard period of *Y* symbols, in which the UE does not transmit any other signal, in the case the SRS resources of a set are transmitted in the same slot. The guard period is in-between the SRS resources of the set. For two SRS resource sets of an antenna switching located in two consecutive slots, if UE is capable of transmitting SRS in all symbols in one slot, a guard period of *Y* symbols exists between the last OFDM symbol occupied by the SRS resource set in the first slot and the first OFDM symbol occupied by the SRS resource set in the second slot.

For the inter-set guard period, the UE does not transmit any other signal on any symbols of the interval if the interval between SRS resource sets is *Y* symbols.

- When both the SRS resource on all of the corresponding symbols prior to the gap and the SRS resource on all of the corresponding symbols after the gap are dropped due to collision handling, the gap period is also dropped with same priority and can be used for UL transmission.

The UE shall expect to be configured with the same number of SRS ports for all SRS resources in the SRS resource set(s) with higher layer parameter *usage* set as 'antennaSwitching'.

In the case that more than one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to ‘aperiodic’, the UE shall expect that the more than one set are configured with the same values of the higher layer parameters *alpha*, *p0*, *pathlossReferenceRS*, and *srs-PowerControlAdjustmentStates* in *SRS-ResourceSet*.

For 1T2R, 1T4R, 2T4R, 1T6R, 1T8R, 2T6R, 2T8R, 4T8R, or 8T8R, the UE shall not expect to be configured or triggered with more than one SRS resource set with higher layer parameter *usage* set as 'antennaSwitching' in the same slot. For 1T=1R, 2T=2R 4T=4R, or 8T=8R, the UE shall not expect to be configured or triggered with more than one SRS resource set with higher layer parameter *usage* set as 'antennaSwitching' in the same symbol.

The value of *Y* is defined by Table 6.2.1.2-1.

Table 6.2.1.2-1: The minimum guard period between two SRS resources of an SRS resource set for antenna switching

|  |  |  |
| --- | --- | --- |
|  |  | *Y* [symbol] |
| 0 | 15 | 1 |
| 1 | 30 | 1 |
| 2 | 60 | 1 |
| 3 | 120 | 2 |
| 5 | 480 | 7 |
| 6 | 960 | 14 |

### 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*.

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 or DCI format 0\_1 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, or

4-7 or 12-15 for DM-RS configuration enhanced type 1 or

6-11 or 18-23 for DM-RS configuration enhanced type 2

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 MsgA PUSCH transmission, the UE is not expected to be configured with the higher layer parameters [*enhanced-dmrs-Type\_r18*] set to ‘enabled’.

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 and enhanced type 1 | DM-RS configuration type 2 and enhanced 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 or format 0\_1 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

When transform precoding is not enabled and if a UE is configured with the higher layer parameter *phaseTrackingRS* in *DMRS-UplinkConfig,*

- the higher layer parameters *timeDensity* and *frequencyDensity* in *PTRS-UplinkConfig* indicate the threshold values *ptrs-MCSi*, *i*=1,2,3 and *NRB,i* , *i*=0,1, as shown in Table 6.2.3.1-1 and Table 6.2.3.1-2, respectively.

- if either or both higher layer parameters *timeDensity* and/or *frequencyDensity* in *PTRS-UplinkConfig* are configured, the UE shall assume the PT-RS antenna ports' presence and pattern are a function of the corresponding scheduled MCS of the codeword associated with the PT-RS and scheduled bandwidth in a corresponding bandwidth part as shown in Table 6.2.3.1-1 and Table 6.2.3.1-2, respectively,

- if the higher layer parameter *timeDensity* is not configured, the UE shall assume *LPT-RS* = 1.

- if the higher layer parameter *frequencyDensity* is not configured, the UE shall assume *KPT-RS* = 2.

- if none of the higher layer parameters *timeDensity* and *frequencyDensity* in *PTRS-UplinkConfig* are configured, the UE shall assume *LPT-RS* = 1 and *KPT-RS* = 2.

Table 6.2.3.1-1: Time density of PT-RS as a function of scheduled MCS

|  |  |
| --- | --- |
| Scheduled MCS | Time density() |
| IMCS < ptrs-MCS1 | PT-RS is not present |
| ptrs-MCS1  IMCS < ptrs-MCS2 | 4 |
| ptrs-MCS2  IMCS < ptrs-MCS3 | 2 |
| ptrs-MCS3  IMCS < ptrs-MCS4 | 1 |

Table 6.2.3.1-2: Frequency density of PT-RS as a function of scheduled bandwidth

|  |  |
| --- | --- |
| Scheduled bandwidth | Frequency density () |
| NRB < NRB0 | PT-RS is not present |
| NRB0  NRB < NRB1 | 2 |
| NRB1  NRB | 4 |

The higher layer parameter *PTRS-UplinkConfig* provides the parameters *ptrs-MCSi*, *i*=1,2,3 andwith values in 0-29 when MCS Table 5.1.3.1-1 or Table 5.1.3.1-3 is used and 0-28 when MCS Table 5.1.3.1-2 is used, respectively. *ptrs-MCS4* is not explicitly configured by higher layers but assumed 29 when MCS Table 5.1.3.1-1 or Table 5.1.3.1-3 is used and 28 when MCS Table 5.1.3.1-2 is used. The higher layer parameter *PTRS-UplinkConfig* provides the parameters *NRBi**i*=0,1with values in range 1-276.

If the higher layer parameter *PTRS-UplinkConfig* indicates that the time density thresholds *ptrs-MCSi* = *ptrs-MCSi+1*, then the time density *LPTRS* of the associated row where both these thresholds appear in Table 6.2.3.1-1 is disabled. If the higher layer parameter *frequencyDensity* in *PTRS-UplinkConfig* indicates that the frequency density thresholds *NRB,i* = *NRB,i+1*, then the frequency density *KPTRS* of the associated row where both these thresholds appear in Table 6.2.3.1-2 is disabled.

If either or both of the parameters PT-RS time density (*LPT-RS*) and PT-RS frequency density (*KPT-RS*), shown in Table 6.2.3.1-1 and Table 6.2.3.1-2, indicates that are configured as 'PT-RS not present', the UE shall assume that PT-RS is not present.

When a UE is scheduled to transmit PUSCH with allocation duration of 2 symbols or less, and if *LPT-RS* is set to 2 or 4, the UE shall not transmit PT-RS. When a UE is scheduled to transmit PUSCH with allocation duration of 4 symbols or less, and if *LPT-RS* is set to 4, the UE shall not transmit PT-RS.

When a UE is scheduled to transmit PUSCH for retransmission, if the UE is scheduled with *IMCS* > *V*, where *V* = 28 for MCS Table 5.1.3.1-1 and MCS Table 5.1.3.1-3 and *V* = 27 for MCS Table 5.1.3.1-2, respectively, the MCS for PT-RS time-density determination is obtained from the DCI for the same transport block in the initial transmission, which is smaller than or equal to V.

The maximum number of configured PT-RS ports is given by the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig.* The UE is not expected to be configured with a larger number of UL PT-RS ports than it has reported need for.

If a UE has reported the capability of supporting full-coherent UL transmission, the UE shall expect the number of UL PT-RS ports to be configured as one if UL-PTRS is configured.

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 and DCI format 0\_2. 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 and DCI format 0\_2 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.

When the higher layer parameter *multipanelScheme* is set to ‘sdmscheme’ and 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'/’nonCodebook’ and higher layer parameter *maxNrofPortsforSDM* in *PTRS-UplinkConfig* set to n2, the actual number of UL PT-RS port(s) to transmit corresponding to SRS resource sets is *2*.

When the higher layer parameter *multipanelScheme* is set to ‘sdmscheme’ and 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'/’nonCodebook’ and the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* is set to *n1*, 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 and DCI format 0\_2 according to Table 7.3.1.1.2-25 described in Clause 7.3.1.1.2 [TS 38.212].

When the higher layer parameter *multipanelScheme* is set to ‘SFNscheme’ and 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'/’nonCodebook’ and the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* is set to *n2*, the actual number of UL PT-RS port(s) to transmit corresponding to each SRS resource set is determined based on 1st TPMI codepoint field for ‘codebook’ or 1st SRI(s) codepoint field for ‘nonCodebook’. When the number of UL PT-RS port(s) is one, 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 and DCI format 0\_2 according to Table 7.3.1.1.2-25 described in Clause 7.3.1.1.2 of [5, TS 38.212]. When the number of UL PT-RS port(s) is two, 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 and DCI format 0\_2 according to Table 7.3.1.1.2-26 described in Clause 7.3.1.1.2 of [5, TS 38.212].

When the higher layer parameter *multipanelScheme* is set to ‘SFNscheme’ and 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'/’nonCodebook’ and the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* is set to *n1*, 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 and DCI format 0\_2 according to Table 7.3.1.1.2-25 described in Clause 7.3.1.1.2 of [5, TS 38.212].

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 and DCI format 0\_2 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 and DCI format 0\_2 described in Clause 7.3.1 of [5, TS38.212].

If a UE is scheduled with two codewords:,

- if the UE is configured with the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* set to 'n1', the PT-RS port is associated with the one of DM-RS ports indicated by DCI field *PTRS-DMRS association* for the codeword with the higher MCS. If the MCS indices of the two codewords are the same, the PT-RS antenna port is associated with codeword 0. When a codeword is scheduled to transmit PUSCH for retransmission, the MCS for determining PT-RS association to codeword is obtained from the DCI for the same transport block in the initial transmission. - if the UE is configured with the higher layer parameter *maxNrofPorts* in *PTRS-UplinkConfig* set to 'n2', each PT-RS port is associated with the one of DM-RS pors indicated by DCI field PTRS-DMRS association. PUSCH antenna port 1000, 1001, 1004 and 1005 share PT-RS port 0, and PUSCH antenna port 1002, 1003, 1006 and 1007 share PT-RS port 1.

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

- If the UE is configured with higher layer parameter *ptrs-Power*, the PUSCH to PT-RS power ratio per layer per RE  is given by , where  is shown in the Table 6.2.3.1-3 and Table 6.2.3.1-3A according to the higher layer parameter *ptrs-Power*, the PT-RS scaling factor  specified in clause 6.4.1.2.2.1 of [4, TS 38.211] is given by and also on the '*Precoding Information and Number of Layers'* field in DCI.

- The UE shall assume *ptrs-Power* in *PTRS-UplinkConfig* is set to state "00" in Table 6.2.3.1-3 if not configured or in case of non-codebook based PUSCH.

- For partial coherent codebook for 8TX PUSCH transmission, *Lx* is the number of PUSCH layers in the antenna group with are precoded coherently with the PUSCH layer/DMRS port where PTRS port x is associated with, and *Qp*

Table 6.2.3.1-3: Factor related to PUSCH to PT-RS power ratio per layer per RE other than 8TX PUSCH transmission

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *UL-PTRS-power /* |  | The number of PUSCH layers ( ) | | | | | | |
| 1 | 2 | | 3 | | 4 | | |
| All cases | Full coherent | Partial and non- coherent and non-codebook based | Full coherent | Partial and non- coherent and non-codebook based | Full coherent | Partial coherent | Non-coherent and non-codebook based |
| 00 | 0 | 3 | 3*Qp*-3 | 4.77 | 3*Qp*-3 | 6 | 3*Qp* | 3*Qp*-3 |
| 01 | 0 | 3 | 3 | 4.77 | 4.77 | 6 | 6 | 6 |
| 10 | Reserved | | | | | | | |
| 11 | Reserved | | | | | | | |

Table 6.2.3.1-3A: Factor related to PUSCH to PT-RS power ratio per layer per RE for 8TX PUSCH transmission

|  |  |  |  |
| --- | --- | --- | --- |
| *UL-PTRS-power /* | The number of PUSCH layers () | | |
| 1-8 | | |
| Full coherent | Partial coherent | Non-coherent and non-codebook based |
| 00 |  | TBD |  |
| 01 |  |  |  |
| 10 | Reserved | | |
| 11 | Reserved | | |

<omitted text>