

3GPP TS 36.213 V15.10.0 (2020-06)

Technical Specification

3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (Release 15)



The present document has been developed within the 3rd Generation Partnership Project (3GPP™) and may be further elaborated for the purposes of 3GPP.
The present document has not been subject to any approval process by the 3GPP Organisational Partners and shall not be implemented.
This Specification is provided for future development work within 3GPP only. The Organisational Partners accept no liability for any use of this Specification.
Specifications and reports for implementation of the 3GPP™ system should be obtained via the 3GPP Organisational Partners' Publications Offices.

Keywords

E-UTRA, radio, layer 1

3GPP

Postal address

3GPP support office address

650 Route des Lucioles – Sophia Antipolis
Valbonne – France
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Internet

<http://www.3gpp.org>

Copyright Notification

No part may be reproduced except as authorized by written permission.
The copyright and the foregoing restriction extend to reproduction in all media.

© 2020, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).
All rights reserved.

UMTSTM is a Trade Mark of ETSI registered for the benefit of its members

3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners

LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners

GSM® and the GSM logo are registered and owned by the GSM Association

Contents

| | |
|--|-----|
| Foreword | 8 |
| 1 Scope..... | 9 |
| 2 References | 9 |
| 3 Symbols and abbreviations..... | 10 |
| 3.1 Symbols..... | 10 |
| 3.2 Abbreviations..... | 10 |
| 4 Synchronization procedures | 12 |
| 4.1 Cell search | 12 |
| 4.2 Timing synchronization..... | 12 |
| 4.2.1 Radio link monitoring | 12 |
| 4.2.2 Inter-cell synchronization..... | 12 |
| 4.2.3 Transmission timing adjustments | 12 |
| 4.3 Timing for Secondary Cell Activation / Deactivation | 14 |
| 5 Power control..... | 15 |
| 5.1 Uplink power control | 15 |
| 5.1.1 Physical uplink shared channel..... | 15 |
| 5.1.1.1 UE behaviour | 16 |
| 5.1.1.2 Power headroom..... | 30 |
| 5.1.2 Physical uplink control channel..... | 33 |
| 5.1.2.1 UE behaviour | 34 |
| 5.1.2.2 Sounding Reference Symbol (SRS) | 39 |
| 5.1.3.1 UE behaviour | 39 |
| 5.1.3.2 Power headroom for Type3 report..... | 41 |
| 5.1.4 Power allocation for EUTRA dual connectivity | 42 |
| 5.1.4.1 Dual connectivity power control Mode 1..... | 43 |
| 5.1.4.2 Dual connectivity power control Mode 2..... | 50 |
| 5.1.5 Power allocation for PUCCH-SCell | 54 |
| 5.2 Downlink power allocation..... | 55 |
| 5.2.1 eNodeB Relative Narrowband TX Power (RNTP) restrictions | 58 |
| 6 Random access procedure | 59 |
| 6.1 Physical non-synchronized random access procedure | 59 |
| 6.1.1 Timing | 60 |
| 6.2 Random Access Response Grant | 61 |
| 7 Physical downlink shared channel related procedures | 66 |
| 7.1 UE procedure for receiving the physical downlink shared channel | 67 |
| 7.1.1 Single-antenna port scheme..... | 86 |
| 7.1.2 Transmit diversity scheme | 86 |
| 7.1.3 Large delay CDD scheme | 86 |
| 7.1.4 Closed-loop spatial multiplexing scheme..... | 86 |
| 7.1.5 Multi-user MIMO scheme..... | 87 |
| 7.1.5A Dual layer scheme | 87 |
| 7.1.5B Up to 8 layer transmission scheme | 87 |
| 7.1.6 Resource allocation..... | 87 |
| 7.1.6.1 Resource allocation type 0 | 89 |
| 7.1.6.2 Resource allocation type 1 | 90 |
| 7.1.6.3 Resource allocation type 2 | 91 |
| 7.1.6.4 PDSCH starting position..... | 94 |
| 7.1.6.4A PDSCH starting position for BL/CE UEs | 96 |
| 7.1.6.5 Physical Resource Block (PRB) bundling | 96 |
| 7.1.7 Modulation order and transport block size determination | 98 |
| 7.1.7.1 Modulation order and redundancy version determination..... | 100 |
| 7.1.7.2 Transport block size determination | 106 |
| 7.1.7.2.1 Transport blocks not mapped to two or more layer spatial multiplexing..... | 111 |
| 7.1.7.2.2 Transport blocks mapped to two-layer spatial multiplexing..... | 119 |

| | | |
|-----------|---|-----|
| 7.1.7.2.3 | Transport blocks mapped for DCI Format 1C and DCI Format 6-2..... | 119 |
| 7.1.7.2.4 | Transport blocks mapped to three-layer spatial multiplexing | 120 |
| 7.1.7.2.5 | Transport blocks mapped to four-layer spatial multiplexing | 120 |
| 7.1.7.2.6 | Transport blocks mapped for BL/CE UEs configured with CEModeB and PDSCH bandwidth up to 1.4MHz..... | 121 |
| 7.1.7.2.7 | Transport blocks mapped for BL/CE UEs <i>SystemInformationBlockType1-BR</i> | 122 |
| 7.1.7.2.8 | Transport blocks mapped for UEs configured with <i>ce-pdsch-maxBandwidth-config</i> value of 5 MHz or with <i>pdsch-MaxBandwidth-SC-MTCH</i> value of 24 PRBs | 122 |
| 7.1.7.3 | Redundancy Version determination for Format 1C..... | 122 |
| 7.1.8 | Storing soft channel bits..... | 123 |
| 7.1.9 | PDSCH resource mapping parameters..... | 123 |
| 7.1.10 | Antenna ports quasi co-location for PDSCH..... | 125 |
| 7.1.11 | PDSCH subframe assignment for BL/CE UE | 126 |
| 7.2 | UE procedure for reporting Channel State Information (CSI) | 128 |
| 7.2.1 | Aperiodic CSI Reporting using PUSCH | 138 |
| 7.2.2 | Periodic CSI Reporting using PUCCH | 163 |
| 7.2.3 | Channel Quality Indicator (CQI) definition | 203 |
| 7.2.4 | Precoding Matrix Indicator (PMI) definition..... | 217 |
| 7.2.5 | Channel-State Information – Reference Signal (CSI-RS) definition | 245 |
| 7.2.6 | Channel-State Information – Interference Measurement (CSI-IM) Resource definition..... | 247 |
| 7.2.7 | Zero Power CSI-RS Resource definition | 247 |
| 7.2.8 | CSI-RS Activation / Deactivation..... | 247 |
| 7.3 | UE procedure for reporting HARQ-ACK..... | 248 |
| 7.3.1 | FDD HARQ-ACK reporting procedure | 250 |
| 7.3.2 | TDD HARQ-ACK reporting procedure | 255 |
| 7.3.2.1 | TDD HARQ-ACK reporting procedure for same UL/DL configuration | 256 |
| 7.3.2.2 | TDD HARQ-ACK reporting procedure for different UL/DL configurations | 271 |
| 7.3.3 | FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 1 | 278 |
| 7.3.4 | FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 2 | 280 |
| 8 | Physical uplink shared channel related procedures | 281 |
| 8.0 | UE procedure for transmitting the physical uplink shared channel | 281 |
| 8.0.1 | Single-antenna port scheme..... | 307 |
| 8.0.2 | Closed-loop spatial multiplexing scheme..... | 307 |
| 8.1 | Resource allocation for PDCCH/EPDCCCH/SPDCCCH with uplink DCI format..... | 308 |
| 8.1.1 | Uplink resource allocation type 0 | 308 |
| 8.1.2 | Uplink resource allocation type 1 | 309 |
| 8.1.3 | Uplink resource allocation type 2 | 309 |
| 8.1.4 | Uplink resource allocation type 3 | 310 |
| 8.1.5 | Uplink resource allocation type 4 | 311 |
| 8.1.5.1 | UL Resource Block Groups | 311 |
| 8.1.6 | Uplink resource allocation type 5 | 312 |
| 8.2 | UE sounding procedure | 314 |
| 8.3 | UE HARQ-ACK procedure | 325 |
| 8.3A | Autonomous uplink feedback procedure | 327 |
| 8.4 | UE PUSCH hopping procedure | 327 |
| 8.4.1 | Type 1 PUSCH hopping | 328 |
| 8.4.2 | Type 2 PUSCH hopping | 328 |
| 8.5 | UE Reference Symbol (RS) procedure | 329 |
| 8.6 | Modulation order, redundancy version and transport block size determination | 330 |
| 8.6.1 | Modulation order and redundancy version determination | 330 |
| 8.6.2 | Transport block size determination | 338 |
| 8.6.3 | Control information MCS offset determination | 344 |
| 8.7 | UE transmit antenna selection | 348 |
| 8.8 | Transmission timing adjustments..... | 348 |
| 9 | Physical downlink control channel procedures | 348 |
| 9.1 | UE procedure for determining physical downlink control channel assignment | 349 |
| 9.1.1 | PDCCH assignment procedure | 349 |
| 9.1.2 | PHICH assignment procedure | 353 |
| 9.1.3 | Control Format Indicator (CFI) assignment procedure | 356 |
| 9.1.4 | EPDCCCH assignment procedure..... | 357 |

| | | |
|------------|--|-----|
| 9.1.4.1 | EPDCCH starting position | 364 |
| 9.1.4.2 | Antenna ports quasi co-location for EPDCCH..... | 364 |
| 9.1.4.3 | Resource mapping parameters for EPDCCH | 365 |
| 9.1.4.4 | PRB-pair indication for EPDCCH..... | 365 |
| 9.1.5 | MPDCCH assignment procedure..... | 366 |
| 9.1.5.1 | MPDCCH starting position..... | 373 |
| 9.1.5.2 | Antenna ports quasi co-location for MPDCCH..... | 373 |
| 9.1.6 | SPDCCH assignment procedure..... | 373 |
| 9.1.6.1 | Resource mapping parameters for SPDCCH | 375 |
| 9.1.6.2 | PRB-pair indication for SPDCCH..... | 375 |
| 9.1.6.3 | Physical Resource Block (PRB) bundling for DMRS-based SPDCCH..... | 375 |
| 9.1.6.4 | Antenna ports quasi co-location for DMRS-based SPDCCH | 376 |
| 9.2 | PDCCH/EPDCCH/MPDCCH/SPDCCH validation for semi-persistent scheduling..... | 377 |
| 9.2A | PDCCH/EPDCCH validation for autonomous uplink transmissions | 379 |
| 9.3 | PDCCH/EPDCCH/MPDCCH/SPDCCH control information procedure | 380 |
| 10 | Physical uplink control channel procedures | 381 |
| 10.1 | UE procedure for determining physical uplink control channel assignment..... | 382 |
| 10.1.1 | PUCCH format information | 387 |
| 10.1.2 | FDD HARQ-ACK feedback procedures | 393 |
| 10.1.2.1 | FDD HARQ-ACK procedure for one configured serving cell | 393 |
| 10.1.2.2 | FDD HARQ-ACK procedures for more than one configured serving cell | 397 |
| 10.1.2.2.1 | PUCCH format 1b with channel selection HARQ-ACK procedure..... | 397 |
| 10.1.2.2.2 | PUCCH format 3 HARQ-ACK procedure | 401 |
| 10.1.2.2.3 | PUCCH format 4 HARQ-ACK procedure | 403 |
| 10.1.2.2.4 | PUCCH format 5 HARQ-ACK procedure | 406 |
| 10.1.3 | TDD HARQ-ACK feedback procedures..... | 407 |
| 10.1.3.1 | TDD HARQ-ACK procedure for one configured serving cell..... | 409 |
| 10.1.3.2 | TDD HARQ-ACK procedure for more than one configured serving cell..... | 423 |
| 10.1.3.2.1 | PUCCH format 1b with channel selection HARQ-ACK procedure..... | 423 |
| 10.1.3.2.2 | PUCCH format 3 HARQ-ACK procedure | 439 |
| 10.1.3.2.3 | PUCCH format 4 HARQ-ACK procedure | 446 |
| 10.1.3.2.4 | PUCCH format 5 HARQ-ACK procedure | 463 |
| 10.1.3A | FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 2 | 463 |
| 10.1.4 | HARQ-ACK Repetition procedure..... | 465 |
| 10.1.5 | Scheduling Request (SR) procedure | 466 |
| 10.2 | Uplink HARQ-ACK timing..... | 468 |
| 11 | Physical Multicast Channel (PMCH) related procedures..... | 473 |
| 11.1 | UE procedure for receiving the PMCH | 473 |
| 11.2 | UE procedure for receiving MCCH and system information change notification..... | 474 |
| 12 | Assumptions independent of physical channel..... | 474 |
| 13 | Uplink/Downlink configuration determination procedure for Frame Structure Type 2 | 474 |
| 13.1 | UE procedure for determining eIMTA-uplink/downlink configuration | 475 |
| 13A | Subframe configuration for Frame Structure Type 3 | 476 |
| 14 | UE procedures related to Sidelink | 479 |
| 14.1 | Physical Sidelink Shared Channel related procedures..... | 480 |
| 14.1.1 | UE procedure for transmitting the PSSCH..... | 480 |
| 14.1.1.1 | UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 1 | 482 |
| 14.1.1.1.1 | Determination of subframe indicator bitmap | 482 |
| 14.1.1.2 | UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 1 | 485 |
| 14.1.1.2.1 | PSSCH resource allocation for sidelink transmission mode 1 | 485 |
| 14.1.1.2.2 | PSSCH frequency hopping for sidelink transmission mode 1..... | 486 |
| 14.1.1.3 | UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 2 | 486 |
| 14.1.1.4 | UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 2 | 487 |

| | | |
|------------|---|-----|
| 14.1.1.4A | UE procedure for determining subframes and resource blocks for transmitting PSSCH for sidelink transmission mode 3 | 487 |
| 14.1.1.4B | UE procedure for determining subframes and resource blocks for transmitting PSSCH and reserving resources for sidelink transmission mode 4 | 488 |
| 14.1.1.4C | UE procedure for determining subframes and resource blocks for PSSCH transmission associated with an SCI format 1 | 488 |
| 14.1.1.5 | UE procedure for PSSCH power control | 490 |
| 14.1.1.6 | UE procedure for determining the subset of resources to be reported to higher layers in PSSCH resource selection in sidelink transmission mode 4 and in sensing measurement in sidelink transmission mode 3 | 491 |
| 14.1.1.7 | Conditions for selecting resources when the number of HARQ transmissions is two in sidelink transmission mode 4 | 494 |
| 14.1.2 | UE procedure for receiving the PSSCH | 495 |
| 14.1.3 | UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 2 | 495 |
| 14.1.5 | UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 3 and 4 | 496 |
| 14.2 | Physical Sidelink Control Channel related procedures | 497 |
| 14.2.1 | UE procedure for transmitting the PSCCH | 497 |
| 14.2.1.1 | UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 1 | 500 |
| 14.2.1.2 | UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 2 | 501 |
| 14.2.1.3 | UE procedure for PSCCH power control | 501 |
| 14.2.2 | UE procedure for receiving the PSCCH | 502 |
| 14.2.3 | UE procedure for determining resource block pool and subframe pool for PSCCH | 502 |
| 14.2.4 | UE procedure for determining resource block pool for PSCCH in sidelink transmission mode 3 and 4 | 503 |
| 15 | Void | 507 |
| 16 | UE Procedures related to narrowband IoT | 507 |
| 16.1 | Synchronization procedures | 507 |
| 16.1.1 | Cell search | 507 |
| 16.1.2 | Timing synchronization | 507 |
| 16.2 | Power control | 507 |
| 16.2.1 | Uplink power control | 507 |
| 16.2.1.1 | Narrowband physical uplink shared channel | 508 |
| 16.2.1.1.1 | UE behaviour | 508 |
| 16.2.1.2 | Power headroom | 508 |
| 16.2.1.2 | SR | 509 |
| 16.2.1.2.1 | UE behaviour | 509 |
| 16.2.2 | Downlink power allocation | 509 |
| 16.3 | Random access procedure | 510 |
| 16.3.1 | Physical non-synchronized random access procedure | 510 |
| 16.3.2 | Timing | 510 |
| 16.3.3 | Narrowband random access response grant | 511 |
| 16.4 | Narrowband physical downlink shared channel related procedures | 513 |
| 16.4.1 | UE procedure for receiving the narrowband physical downlink shared channel | 513 |
| 16.4.1.1 | Single-antenna port scheme | 516 |
| 16.4.1.2 | Transmit diversity scheme | 516 |
| 16.4.1.3 | Resource allocation | 516 |
| 16.4.1.4 | NPDSCH starting position | 519 |
| 16.4.1.5 | Modulation order and transport block size determination | 520 |
| 16.4.1.5.1 | Transport blocks not mapped for <i>SystemInformationBlockType1-NB</i> | 520 |
| 16.4.1.5.2 | Transport blocks mapped for <i>SystemInformationBlockType1-NB</i> | 521 |
| 16.4.2 | UE procedure for reporting ACK/NACK | 521 |
| 16.5 | Narrowband physical uplink shared channel related procedures | 522 |
| 16.5.1 | UE procedure for transmitting format 1 narrowband physical uplink shared channel | 523 |
| 16.5.1.1 | Resource allocation | 524 |
| 16.5.1.2 | Modulation order, redundancy version and transport block size determination | 525 |
| 16.5.2 | UE procedure for NPUSCH retransmission | 527 |

| | | |
|-------------------------------|---|------------|
| 16.5.3 | UE procedure for transmitting SR | 527 |
| 16.6 | Narrowband physical downlink control channel related procedures | 527 |
| 16.6.1 | NPDCCH starting position..... | 533 |
| 16.6.2 | NPDCCH control information procedure..... | 533 |
| 16.6.3 | NPDCCH validation for semi-persistent scheduling..... | 533 |
| 16.7 | Assumptions independent of physical channel related to narrowband IoT | 534 |
| 16.8 | UE procedure for acquiring cell-specific reference signal sequence and raster offset..... | 534 |
| 16.9 | UE procedure for receiving narrowband wake up signal..... | 534 |
| 17 | Wake-up signal related procedures for BL/CE UE..... | 535 |
| Annex A (informative): | Change history | 536 |

6 Random access procedure

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

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

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE is not expected to transmit any uplink physical channel or signal in the serving cell on subframes other than offset-UL subframes, where the offset-UL subframes are determined by applying an offset value given by *harq-Offset-r15* to the subframes denoted as uplink in the UL/DL configuration *subframeAssignment-r15*.

Prior to initiation of the non-synchronized physical random access procedure, Layer 1 shall receive the following information from the higher layers:

- Random access channel parameters (PRACH configuration and frequency position)
- Parameters for determining the root sequences and their cyclic shifts in the preamble sequence set for the primary cell (index to logical root sequence table, cyclic shift (N_{CS}), and set type (unrestricted or restricted set))

6.1 Physical non-synchronized random access procedure

From the physical layer perspective, the L1 random access procedure encompasses the transmission of random access preamble and random access response. The remaining messages are scheduled for transmission by the higher layer on the shared data channel and are not considered part of the L1 random access procedure. A random access channel occupies 6 resource blocks in a subframe or set of consecutive subframes reserved for random access preamble transmissions. The eNodeB is not prohibited from scheduling data in the resource blocks reserved for random access channel preamble transmission.

A UE is not expected to be configured with PRACH on a LAA SCell.

The following steps are required for the L1 random access procedure:

- Layer 1 procedure is triggered upon request of a preamble transmission by higher layers.
- A preamble index, a target preamble received power (PREAMBLE_RECEIVED_TARGET_POWER), a corresponding RA-RNTI and a PRACH resource are indicated by higher layers as part of the request.
- For a BL/CE UE, a number of PRACH repetitions for preamble transmission attempt is also indicated by higher layers as part of the request. For a non-BL/CE UE or for a BL/CE UE with the PRACH coverage enhancement level 0/1/2, a preamble transmission power P_{PRACH} is determined as

$$P_{PRACH} = \min\{ P_{CMAX,c}(i), PREAMBLE_RECEIVED_TARGET_POWER + PL_c \} \text{ [dBm]},$$
 where
 $P_{CMAX,c}(i)$ is the configured UE transmit power defined in [6] for subframe i of serving cell c and PL_c is the downlink path loss estimate calculated in the UE for serving cell c . For a BL/CE UE, P_{PRACH} is set to $P_{CMAX,c}(i)$ for the highest PRACH coverage enhancement level 3.
- A preamble sequence is selected from the preamble sequence set using the preamble index.
- A single preamble is transmitted using the selected preamble sequence with transmission power P_{PRACH} on the indicated PRACH resource. For a BL/CE UE, the single preamble is transmitted for the number of PRACH repetitions for the associated PRACH coverage enhancement level as indicated by higher layers.
- For non-BL/CE UEs, detection of a PDCCH with the indicated RA-RNTI is attempted during a window controlled by higher layers (see [8], Subclause 5.1.4). If detected, the corresponding DL-SCH transport block is

passed to higher layers. The higher layers parse the transport block and indicate the 20-bit uplink grant to the physical layer, which is processed according to Subclause 6.2.

- For BL/CE UEs, detection of a MPDCCH with DCI scrambled by RA-RNTI is attempted during a window controlled by higher layers (see [8], Subclause 5.1.4). If detected, the corresponding DL-SCH transport block is passed to higher layers. The higher layers parse the transport block and indicate the Nr-bit uplink grant to the physical layer, which is processed according to Subclause 6.2.

6.1.1 Timing

For the L1 random access procedure, a non-BL/CE UE's uplink transmission timing after a random access preamble transmission is as follows.

- a) If a PDCCH with associated RA-RNTI is detected in subframe n , and the corresponding DL-SCH transport block contains a response to the transmitted preamble sequence, the UE shall, according to the information in the response, transmit an UL-SCH transport block in the first subframe $n+k_1$. If the UE supports reduced control plane latency and *reducedControlPlaneLatency* is enabled, $k_1 \geq 5$, otherwise, $k_1 \geq 6$. If the UL delay field in Subclause 6.2 is set to zero, $n+k_1$ is the first available UL subframe for PUSCH transmission, where for TDD serving cell, the first UL subframe for PUSCH transmission is determined based on the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers. The UE shall postpone the PUSCH transmission to the next available UL subframe after $n+k_1$ if the field is set to 1.
- b) If a random access response is received in subframe n , and the corresponding DL-SCH transport block does not contain a response to the transmitted preamble sequence, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+5$.
- c) If no random access response is received in subframe n , where subframe n is the last subframe of the random access response window, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+4$, except if the transmitted preamble sequence is on a TDD serving cell not configured for PUSCH/PUCCH transmission.

For the L1 random access procedure, a BL/CE UE's uplink transmission after a random access preamble transmission is as follows.

- a) If a MPDCCH with associated RA-RNTI is detected and the corresponding DL-SCH transport block reception ending in subframe n contains a response to the transmitted preamble sequence, the UE shall, according to the information in the response, transmit an UL-SCH transport block in the first subframe $n+k_1$, $k_1 \geq 6$, if the UL delay field in Subclause 6.2 is set to zero where the subframe $n+k_1$ is the first available UL subframe for PUSCH transmission, where for TDD serving cell, the first UL subframe for PUSCH transmission is determined based on the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers.

When the number of Msg3 PUSCH repetitions, Δ , as indicated in the random access response, is greater than 1, the subframe $n+k_1$ is the first available UL subframe in the set of BL/CE UL subframes. The UE shall postpone the PUSCH transmission to the next available UL subframe after $n+k_1 + \Delta$, if the UL delay field is set to 1.

When the number of Msg3 PUSCH repetitions, Δ , as indicated in the random access response, is equal to 1, the subframe $n+k_1$ is the first available UL subframe for PUSCH transmission determined by $k_1 = 6$ for FDD and the parameter *subframeAssignment* for TDD. The UE shall postpone the PUSCH transmission to the next available UL subframe after $n+k_1 + \Delta$, if the UL delay field is set to 1.

- b) If a random access response is received and its reception ends in subframe n , and the corresponding DL-SCH transport block does not contain a response to the transmitted preamble sequence, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+5$.
- c) If the most recent PRACH coverage enhancement level for the UE is 0 or 1,
 - if no random access response is received in subframe n , where subframe n is the last subframe of the random access response window, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+4$.

If the most recent PRACH coverage enhancement level for the UE is 2 or 3,

- if no MPDCCH scheduling random access response is received in subframe n , where subframe n is the last subframe of the random access response window, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+4$;
- if an MPDCCH with associated RA-RNTI is detected and the corresponding DL-SCH transport block reception ending in subframe n cannot be successfully decoded, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than in subframe $n+4$.

In case a random access procedure is initiated by a "PDCCH order" in subframe n for non-BL/CE UEs, or "PDCCH order" reception ending in subframe n for BL/CE UEs, the UE shall, if requested by higher layers, transmit random access preamble in the first subframe $n+k_2$, $k_2 \geq 6$, where a PRACH resource is available.

If a UE is configured with multiple TAGs, and if the UE is configured with the carrier indicator field for a given serving cell, the UE shall use the carrier indicator field value from the detected "PDCCH order" to determine the serving cell for the corresponding random access preamble transmission.

6.2 Random Access Response Grant

The higher layers indicate the Nr-bit UL Grant to the physical layer, as defined in 3GPP TS 36.321 [8]. This is referred to the Random Access Response Grant in the physical layer.

If BL/CE UE then

- If the most recent PRACH coverage enhancement level for the UE is 0 or 1, the contents of the Random Access Response Grant are interpreted according to CemodeA.
- If the most recent PRACH coverage enhancement level for the UE is 2 or 3, the contents of the Random Access Response Grant are interpreted according to CemodeB.
- The content of these Nr bits starting with the MSB and ending with the LSB are given in Table 6-2 for CemodeA and CemodeB if the higher layers do not indicate EDT to the physical layer as defined in [8], and in Table 6.2-F if the higher layers indicate EDT.:.
- where $N_{\text{NB}} = \lfloor N_{\text{RB}}^{\text{UL}} / 6 \rfloor$ and $N_{\text{NB}}^{\text{index}} = \lceil \log_2(N_{\text{NB}}) \rceil$

Table 6-2: Random Access Response Grant Content field size

| DCI contents | CemodeA | CemodeB |
|--------------------------------------|------------------------------------|---------|
| Msg3 PUSCH narrowband index | $N_{\text{NB}}^{\text{index}}$ | 2 |
| Msg3 PUSCH Resource allocation | 4 | 3 |
| Number of Repetitions for Msg3 PUSCH | 2 | 3 |
| MCS | 3 | 0 |
| TBS | 0 | 2 |
| TPC | 3 | 0 |
| CSI request | 1 | 0 |
| UL delay | 1 | 0 |
| Msg3/4 MPDCCH narrowband index | 2 | 2 |
| Zero padding | $4 - N_{\text{NB}}^{\text{index}}$ | 0 |
| Total Nr-bits | 20 | 12 |

Table 6.2-F: Random Access Response Grant Content field size for EDT

| DCI contents | CEmodeA | CEmodeB |
|--------------------------------------|------------------------------|---------|
| Msg3 PUSCH narrowband index | N_{NB}^{index} | 3 |
| Msg3 PUSCH Resource allocation | 5 | 3 |
| Number of Repetitions for Msg3 PUSCH | 2 | 3 |
| TPC | 3 | 0 |
| CSI request | 1 | 0 |
| UL delay | 1 | 0 |
| Msg3/4 MPDCCH narrowband index | N_{NB}^{index} | 3 |
| Zero padding | $8 - 2 \cdot N_{NB}^{index}$ | 0 |
| Total Nr-bits | 20 | 12 |

- For CEmodeB, the Msg3 PUSCH narrowband index indicates the narrowband to be used for first subframe of Msg3 PUSCH transmission as given in Table 6.2-A if the higher layers do not indicate EDT to the physical layer as defined in [8], Table 6.2-G otherwise.
- NB_{RAR} given in Table 6.2-A, Table 6.2-B and Table 6.2-G is the narrow band used for first subframe of MPDCCH for Random Access Response and is determined by higher layer parameter *mpdcch-NarrowbandsToMonitor-r13* if only one narrowband is configured, otherwise, it is determined by Table 6-2-E.

Table 6.2-A: Msg3 PUSCH Narrowband Value for CEmodeB.

| Value of 'Msg3 narrowband index' | Msg3 PUSCH Narrowband |
|----------------------------------|-------------------------------|
| '00' | $NB_{RAR} \bmod N_{NB}$ |
| '01' | $(NB_{RAR} + 1) \bmod N_{NB}$ |
| '10' | $(NB_{RAR} + 2) \bmod N_{NB}$ |
| '11' | $(NB_{RAR} + 3) \bmod N_{NB}$ |

Table 6.2-G: Msg3 PUSCH Narrowband Value for CEmodeB and EDT.

| Value of 'Msg3 narrowband index' | Msg3 PUSCH Narrowband |
|----------------------------------|-------------------------------|
| '000' | $NB_{RAR} \bmod N_{NB}$ |
| '001' | $(NB_{RAR} + 1) \bmod N_{NB}$ |
| '010' | $(NB_{RAR} + 2) \bmod N_{NB}$ |
| '011' | $(NB_{RAR} + 3) \bmod N_{NB}$ |
| '100' | $(NB_{RAR} + 4) \bmod N_{NB}$ |
| '101' | $(NB_{RAR} + 5) \bmod N_{NB}$ |
| '110' | $(NB_{RAR} + 6) \bmod N_{NB}$ |
| '111' | $(NB_{RAR} + 7) \bmod N_{NB}$ |

- The Msg3/4 MPDCCH narrowband index indicates the narrowband used for first subframe of MPDCCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure as given in Table 6.2-B if the higher layers do not indicate EDT to the physical layer as defined in [8], value of N_{NB}^{index} for CEmodeA and Table 6.2-H for CEmodeB otherwise. The number of downlink narrowbands is given by $N_{NB2} = \lfloor N_{RB}^{\text{DL}} / 6 \rfloor$.

Table 6.2-B: Msg3/4 MPDCCH Narrowband Value for CEmodeA and CEmodeB.

| Value of 'Msg3/4 MPDCCH narrowband index' | Msg3/4 MPDCCH Narrowband |
|---|--------------------------------|
| '00' | $NB_{RAR} \bmod N_{NB2}$ |
| '01' | $(NB_{RAR} + 1) \bmod N_{NB2}$ |
| '10' | $(NB_{RAR} + 2) \bmod N_{NB2}$ |
| '11' | $(NB_{RAR} + 3) \bmod N_{NB2}$ |

Table 6.2-H: Msg3/4 MPDCCH Narrowband Value for CEmodeB and EDT.

| Value of 'Msg3/4 MPDCCH narrowband index' | Msg3/4 MPDCCH Narrowband |
|---|--------------------------------|
| '000' | $NB_{RAR} \bmod N_{NB2}$ |
| '001' | $(NB_{RAR} + 1) \bmod N_{NB2}$ |
| '010' | $(NB_{RAR} + 2) \bmod N_{NB2}$ |
| '011' | $(NB_{RAR} + 3) \bmod N_{NB2}$ |
| '100' | $(NB_{RAR} + 4) \bmod N_{NB2}$ |
| '101' | $(NB_{RAR} + 5) \bmod N_{NB2}$ |
| '110' | $(NB_{RAR} + 6) \bmod N_{NB2}$ |
| '111' | $(NB_{RAR} + 7) \bmod N_{NB2}$ |

- The repetition number field in the random access response grant configured by higher layers indicates the repetition level (N_{Msg3}) for the initial transmission of Msg3 PUSCH as given in Table 6.2-C for CEmodeA and Table 6.2-D for CEmodeB, where
 - Y_A is determined by higher layer parameter *pusch-maxNumRepetitionCEmodeA-r13* if it is signaled, otherwise $Y_A = 8$,
 - Y_B is determined by higher layer parameter *pusch-maxNumRepetitionCEmodeB-r13* if it is signaled, otherwise $Y_B = 512$.

If the higher layers indicate EDT to the physical layer as defined in [8] and if the UE is configured with higher layer parameter *edt-SmallTBS-Enabled-r15*, the repetition number for the initial transmission of Msg3 PUSCH is the smallest integer multiple of M that is equal to or larger than $TBS_{Msg3}/TBS_{Msg3,max} \cdot N_{Msg3}$ where TBS_{Msg3} is the TBS of Msg3 PUSCH as determined in subclause 8.6.2, and $TBS_{Msg3,max}$ is the value of the higher layer parameter *edt-TBS-r15*. $M=4$ if $N_{Msg3} > 4$, $M = 1$ otherwise.

Table 6.2-C: Msg3 PUSCH Repetition Level Value for CEmodeA.

| Value of 'Repetition number' | Msg3 PUSCH Repetition level |
|------------------------------|-----------------------------|
| '00' | $Y_A / 8$ |
| '01' | $Y_A / 4$ |
| '10' | $Y_A / 2$ |
| '11' | Y_A |

Table 6.2-D: Msg3 PUSCH Repetition Level Value for CEmodeB.

| Value of 'Repetition number' | Msg3 PUSCH Repetition level |
|------------------------------|-----------------------------|
| '000' | $\lfloor Y_B / 128 \rfloor$ |
| '001' | $Y_B / 64$ |
| '010' | $Y_B / 32$ |
| '011' | $Y_B / 16$ |
| '100' | $Y_B / 8$ |
| '101' | $Y_B / 4$ |
| '110' | $Y_B / 2$ |
| '111' | Y_B |

Table 6.2-E: Narrowband (NB_{RAR}) for MPDCCH RAR.

| Mapped Preamble Index | NB_{RAR} |
|--|---|
| $\text{mod}(\text{Preamble Index}, 2) = 0$ | First narrowband configured by high layer parameter <i>mpdcch-NarrowbandsToMonitor-r13</i> |
| $\text{mod}(\text{Preamble Index}, 2) = 1$ | Second narrowband configured by high layer parameter <i>mpdcch-NarrowbandsToMonitor-r13</i> |

- The resource allocation field is interpreted as follows:
 - For CEmodeA,
 - if the higher layers indicate EDT to the physical layer as defined in [8], then
 - interpret the resource allocation using UL resource allocation type 0 within the indicated narrowband
 - else,
 - insert one most significant bit with value set to '0', and interpret the expanded resource allocation using UL resource allocation type 0 within the indicated narrowband.
 - For CEmodeB, interpret the resource allocation using UL resource allocation type 2 within the indicated narrowband.
- The truncated modulation and coding scheme field is interpreted such that the modulation and coding scheme corresponding to the Random Access Response grant is determined from MCS indices 0 through 7 for CEmodeA in Table 8.6.1-1

The truncated TBS field is interpreted such that the TBS value corresponding to the Random Access Response grant is determined from TBS indices 0 through 3 for CEmodeB in Table 7.1.7.2.1-1

else,

- Nr=20, and the content of these 20 bits starting with the MSB and ending with the LSB are as follows:
 - Hopping flag – 1 bit
 - Fixed size resource block assignment – 10 bits
 - Truncated modulation and coding scheme – 4 bits

If a UE is performing non-contention based random access procedure and is configured with higher layer parameter *pusch-EnhancementsConfig*, then

- Repetition number of Msg3 – 3 bits

else

- TPC command for scheduled PUSCH – 3 bits
- UL delay – 1 bit
- CSI request – 1 bit
- The UE shall use the single-antenna port uplink transmission scheme for the PUSCH transmission corresponding to the Random Access Response Grant and the PUSCH retransmission for the same transport block.
- The UE shall perform PUSCH frequency hopping if the single bit frequency hopping (FH) field in a corresponding Random Access Response Grant is set as 1 and the uplink resource block assignment is type 0, otherwise no PUSCH frequency hopping is performed. When the hopping flag is set, the UE shall perform PUSCH hopping as indicated via the fixed size resource block assignment detailed below.
- The fixed size resource block assignment field is interpreted as follows:
 - if $N_{\text{RB}}^{\text{UL}} \leq 44$
 - Truncate the fixed size resource block assignment to its b least significant bits, where $b = \lceil \log_2(N_{\text{RB}}^{\text{UL}} \cdot (N_{\text{RB}}^{\text{UL}} + 1)/2) \rceil$, and interpret the truncated resource block assignment according to the rules for a regular DCI format 0
 - else
 - Insert b most significant bits with value set to '0' after the $N_{\text{UL_hop}}$ hopping bits in the fixed size resource block assignment, where the number of hopping bits $N_{\text{UL_hop}}$ is zero when the hopping flag bit is not set to 1, and is defined in Table 8.4-1 when the hopping flag bit is set to 1, and $b = (\lceil \log_2(N_{\text{RB}}^{\text{UL}} \cdot (N_{\text{RB}}^{\text{UL}} + 1)/2) \rceil - 10)$, and interpret the expanded resource block assignment according to the rules for a regular DCI format 0
- end if
- The truncated modulation and coding scheme field is interpreted such that the modulation and coding scheme corresponding to the Random Access Response grant is determined from MCS indices 0 through 15 in Table 8.6.1-1.
- The TPC command δ_{msg2} shall be used for setting the power of the PUSCH, and is interpreted according to Table 6.2-1.

end if

Table 6.2-1: TPC Command δ_{msg2} for Scheduled PUSCH

| TPC Command | Value (in dB) |
|-------------|---------------|
| 0 | -6 |
| 1 | -4 |
| 2 | -2 |
| 3 | 0 |
| 4 | 2 |
| 5 | 4 |
| 6 | 6 |
| 7 | 8 |

In non-contention based random access procedure, the CSI request field is interpreted to determine whether an aperiodic CQI, PMI, RI, and CRI report is included in the corresponding PUSCH transmission according to Subclause 7.2.1. In contention based random access procedure, the CSI request field is reserved.

The UL delay applies for TDD, FDD and FDD-TDD and this field can be set to 0 or 1 to indicate whether the delay of PUSCH is introduced as shown in Subclause 6.1.1. A BL/CE UE interpreting the contents of the random access response according to CEModeB shall follow the description of UL delay field set to 0.

7 Physical downlink shared channel related procedures

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

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

If a UE is configured with *dl-TTI-Length*, and PDSCH is received in a slot, the term 'slot/subslot' refers to a slot in this clause.

If the UE is configured with *dl-TTI-Length*, and PDSCH is received in a subslot, the term 'slot/subslot' refers to a subslot in this clause.

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

For FDD,

- if the UE supports *ce-pdsch-tenProcesses* and is configured with CEModeA and higher layer parameter *ce-pdsch-tenProcesses-config* set to 'On' there shall be a maximum of 10 downlink HARQ processes per serving cell;
- 16 downlink HARQ processes per serving cell configured with higher layer parameter *dl-TTI-Length*
- otherwise, there shall be a maximum of 8 downlink HARQ processes per serving cell.

For FDD-TDD and primary cell frame structure type 1, there shall be a maximum of

- 16 downlink HARQ processes per serving cell configured with higher layer parameter *dl-TTI-Length*
- 8 downlink HARQ processes per serving cell, otherwise.

For TDD and a UE not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell,, if the UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, the maximum number of downlink HARQ processes per serving cell configured with higher layer parameter *dl-TTI-Length* shall be 16, otherwise determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in Table 7-1.

For TDD, if a UE is configured with more than one serving cell and if the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and primary cell frame structure type 2 and serving cell frame structure type 2, the maximum number of downlink HARQ processes for a serving cell configured with higher layer parameter *dl-TTI-Length* shall be 16, otherwise determined as indicated in Table 7-1, wherein the "TDD UL/DL configuration" in Table 7-1 refers to the DL-reference UL/DL configuration for the serving cell (as defined in Subclause 10.2).

For FDD-TDD and primary cell frame structure type 2 and serving cell frame structure type 1, the maximum number of downlink HARQ processes for the serving cell configured with higher layer parameter *dl-TTI-Length* shall be 16, otherwise determined by the DL-reference UL/DL configuration for the serving cell (as defined in Subclause 10.2), as indicated in Table 7-2.

A BL/CE UE configured with CEModeB is not expected to support more than 2 downlink HARQ processes.

For TDD and a BL/CE configured with CEModeA, the maximum number of downlink HARQ processes for a serving cell shall be determined as indicated in Table 7-3.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the maximum number of downlink HARQ processes for the serving cell

shall be determined by DL-reference UL/DL configuration given by *subframeAssignment-r15* for the serving cell, as indicated in Table 7-2.

For a UE configured with EN-DC/NE-DC and more than one serving cells with primary cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the primary cell, the maximum number of downlink HARQ processes for each secondary cell is equal to the maximum number of downlink HARQ processes for the primary cell.

The dedicated broadcast HARQ process defined in [8] is not counted as part of the maximum number of HARQ processes for FDD, TDD and FDD-TDD.

Table 7-1: Maximum number of DL HARQ processes for TDD

| TDD UL/DL configuration | Maximum number of HARQ processes |
|-------------------------|----------------------------------|
| 0 | 4 |
| 1 | 7 |
| 2 | 10 |
| 3 | 9 |
| 4 | 12 |
| 5 | 15 |
| 6 | 6 |

Table 7-2: Maximum number of DL HARQ processes for FDD-TDD, primary cell frame structure type 2, and serving cell frame structure type 1

| DL-reference UL/DL Configuration | Maximum number of HARQ processes |
|----------------------------------|----------------------------------|
| 0 | 10 |
| 1 | 11 |
| 2 | 12 |
| 3 | 15 |
| 4 | 16 |
| 5 | 16 |
| 6 | 12 |

Table 7-3: Maximum number of DL HARQ processes for TDD (UE configured with CEModeA)

| TDD UL/DL configuration | Maximum number of HARQ processes |
|-------------------------|----------------------------------|
| 0 | 6 |
| 1 | 9 |
| 2 | 12 |
| 3 | 11 |
| 4 | 14 |
| 5 | 16 |
| 6 | 8 |

7.1 UE procedure for receiving the physical downlink shared channel

Except the subframes indicated by the higher layer parameter *mbsfn-SubframeConfigList* or by *mbsfn-SubframeConfigList-v1250* or by *mbsfn-SubframeConfigList-v14xy* or by *laa-SCellSubframeConfig* of serving cell *c*, a UE shall

- upon detection of a PDCCH of the serving cell with DCI format 1, 1A, 1B, 1C, 1D, 2, 2A, 2B, 2C, or 2D intended for the UE in a subframe, or
- upon detection of an EPDCCH of the serving cell with DCI format 1, 1A, 1B, 1D, 2, 2A, 2B, 2C, or 2D intended for the UE in a subframe, or
- upon detection of a PDCCH of the serving cell with DCI format 7-1A, 7-1B, 7-1C, 7-1D, 7-1E, 7-1F, 7-1G intended for the UE in the first slot/subslot of a subframe

- upon detection of a SPDCCH of the serving cell with DCI format 7-1A, 7-1B, 7-1C, 7-1D, 7-1E, 7-1F, 7-1G intended for the UE in a slot/subslot

decode the corresponding PDSCH in the same subframe/slot/subslot with the restriction of the number of transport blocks defined in the higher layers, unless specified otherwise.

For a given serving cell, if the UE is configured with higher layer parameter *blindSubframePDSCH-Repetitions*, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 1A with CRC scrambled by C-RNTI in UE-specific search space of subframe n , intended for the UE, decode, starting from subframe n , the corresponding PDSCH transmission in k consecutive DL subframe(s) according to the PDCCH information, where the value of k is determined by the repetition number field in the corresponding DCI. For $k > 1$,

- if the UE is configured with transmission mode 1, 2, 3, 4, 5, 6, 7 or 8 for the serving cell, the k consecutive DL subframes do not include MBSFN subframe(s).
- the UE shall assume the truncated modulation and coding scheme field is interpreted such that the modulation and coding scheme corresponding to DCI format 1A is determined from MCS indices 0 through 15 if the higher layer parameter *MCS-restrictionSubframePDSCH-Repetitions* is set to '1'.
- The UE shall assume all the k PDSCH data transmissions are received in the same resource blocks.
- For TDD cell, the k consecutive DL subframes include the k DL subframes or special subframes according to the UL/DL configuration indicated by higher layer parameter *subframeAssignment* for the serving cell.
 - If the UE is configured with higher layer parameter *EIMTA-MainConfigServCell-r12*, the UE shall discard any PDCCH/EPDCCH for PDSCH data transmission with $k > 1$ in a subframe which has been indicated as an UL subframe or a special subframe by higher layer parameter *subframeAssignment* but indicated as a DL subframe by a PDCCH with CRC scrambled by eIMTA-RNTI containing an UL/DL configuration for the serving cell.

For a given serving cell, if the UE is configured with higher layer parameter *blindSlotSubslotPDSCH-Repetitions*, the UE shall upon detection of a PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI in slot/sublot n , intended for the UE, decode, starting from slot/subslot n , the corresponding PDSCH transmission in k consecutive DL slot(s)/subslot(s) according to the PDCCH/SPDCCH information, where the value of k is determined by the repetition number field in the corresponding DCI. For $k > 1$,

- the UE is not expected to receive the PDSCH data transmissions with more than two transmission layers.
- if the k consecutive DL slots/subslots cross two consecutive subframes with different downlink transmission modes, the UE is not expected to receive the PDSCH data transmissions after the former subframe.
- for DCI format 7-1F/7-1G, the UE shall assume the value of the DMRS position indicator field (defined in 3GPP TS 36.212 [4]) is set to '0'.
- the UE shall assume the modulation and coding scheme corresponding to DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is determined from MCS indices 0 through 15 if the higher layer parameter *MCS-restrictionSlotSubslotPDSCH-Repetitions* is set to '1'.
- the UE shall assume the "PDSCH RE Mapping and Quasi-Co-Location Indicator" field is applied to all the k PDSCH data transmissions signaled via PDCCH/SPDCCH with DCI format 7-1G.
- the UE shall assume the "precoding information" field is applied to all the k PDSCH data transmissions signaled via PDCCH/SPDCCH with DCI format 7-1C.
- the UE shall assume the "TPMI information for precoding" field is applied to all the k PDSCH data transmissions signaled via PDCCH/SPDCCH with DCI format 7-1D.
- the UE shall assume all the k PDSCH data transmissions are received in the same resource blocks.
- For FDD cell,
 - the UE may assume that the same precoder applies to all scheduled k PDSCH transmissions.
 - subslot 0 of a subframe is not counted as a DL subslot for k PDSCH transmissions if the CFI value is 2 or 3.
- For TDD cell,

- the UE may assume that the same precoder applies to those of the k scheduled PDSCH transmissions occur between guard periods of two adjacent special subframes.
- the k consecutive DL slots include the k DL slots of DL subframe or DwPTS according to the UL/DL configuration indicated by higher layer parameter *subframeAssignment* for the serving cell.

For BL/CE UEs, the higher layers indicate the set of BL/CE DL subframes according to *fdd-DownlinkOrTddSubframeBitmapBR* [11].

A BL/CE UE shall upon detection of a MPDCCH with DCI format 6-1A, 6-1B, 6-2 intended for the UE, decode the corresponding PDSCH in one more BL/CE DL subframes as described in Subclause 7.1.11, with the restriction of the number of transport blocks defined in the higher layers.

For the purpose of decoding PDSCH containing *SystemInformationBlockType2*, a BL/CE UE shall assume that subframes in which *SystemInformationBlockType2* is scheduled are non-MBSFN subframes.

If a UE is configured with more than one serving cell and if the frame structure type of any two configured serving cells is different, then the UE is considered to be configured for FDD-TDD carrier aggregation.

Except for MBMS reception, the UE is not required to monitor PDCCH with CRC scrambled by the SI-RNTI on the PSCell.

A UE may assume that positioning reference signals are not present in resource blocks in which it shall decode PDSCH according to a detected PDCCH with CRC scrambled by the SI-RNTI or P-RNTI with DCI format 1A or 1C intended for the UE.

A UE configured with the carrier indicator field for a given serving cell shall assume that the carrier indicator field is not present in any PDCCH of the serving cell in the common search space that is described in Subclause 9.1. Otherwise, the configured UE shall assume that for the given serving cell the carrier indicator field is present in PDCCH/EPDCCH located in the UE specific search space described in Subclause 9.1 when the PDCCH/EPDCCH CRC is scrambled by C-RNTI or SPS C-RNTI.

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the SI-RNTI, the UE shall decode the PDCCH and the corresponding PDSCH according to any of the combinations defined in Table 7.1-1. The scrambling initialization of PDSCH corresponding to these PDCCHs is by SI-RNTI.

A UE operating in an MBMS-dedicated carrier may be configured with two SI-RNTI values, in which case the UE shall apply the procedure described in this clause for each of the SI-RNTIs.

Table 7.1-1: PDCCH and PDSCH configured by SI-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|---------------|--------------|--|
| DCI format 1C | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2). |
| DCI format 1A | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2). |

For BL/CE UE, for PDSCH carrying *SystemInformationBlockType1-BR* and SI-messages, the UE shall decode PDSCH according to Table 7.1-1A. The scrambling initialization of PDSCH is by SI-RNTI.

Table 7.1-1A: PDSCH configured by SI-RNTI

| Transmission scheme of PDSCH |
|--|
| If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2). |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the P-RNTI, the UE shall decode the PDCCH and the corresponding PDSCH according to any of the combinations defined in Table 7.1-2. The scrambling initialization of PDSCH corresponding to these PDCCHs is by P-RNTI.

If a UE is configured by higher layers to decode MPDCCH with CRC scrambled by the P-RNTI, the UE shall decode the MPDCCH and any corresponding PDSCH according to any of the combinations defined in Table 7.1-2A. The scrambling initialization of PDSCH corresponding to these MPDCCHs is by P-RNTI.

The UE is not required to monitor PDCCH with CRC scrambled by the P-RNTI on the PSCell.

Table 7.1-2: PDCCH and PDSCH configured by P-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|---------------|--------------|---|
| DCI format 1C | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| DCI format 1A | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

Table 7.1-2A: MPDCCH and PDSCH configured by P-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|------------|--------------|---|
| 6-2 | Type1-common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the RA-RNTI, the UE shall decode the PDCCH and the corresponding PDSCH according to any of the combinations defined in Table 7.1-3. The scrambling initialization of PDSCH corresponding to these PDCCHs is by RA-RNTI.

If a UE is configured by higher layers to decode MPDCCH with CRC scrambled by the RA-RNTI, the UE shall decode the MPDCCH and the corresponding PDSCH according to any of the combinations defined in Table 7.1-3A. The scrambling initialization of PDSCH corresponding to these MPDCCHs is by RA-RNTI.

When RA-RNTI and either C-RNTI or SPS C-RNTI are assigned in the same subframe, the UE is not required to decode a PDSCH on the primary cell indicated by a PDCCH/EPDCCH/SPDCCH with a CRC scrambled by C-RNTI or SPS C-RNTI.

Table 7.1-3: PDCCH and PDSCH configured by RA-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|---------------|--------------|---|
| DCI format 1C | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| DCI format 1A | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

Table 7.1-3A: MPDCCH and PDSCH configured by RA-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|--------------|--------------|---|
| 6-1A or 6-1B | Type2-common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the G-RNTI or SC-RNTI, the UE shall decode the PDCCH and the corresponding PDSCH according to any of the combinations defined in Table 7.1-4. The scrambling initialization of PDSCH corresponding to these PDCCHs is by G-RNTI or SC-RNTI.

Table 7.1-4: PDCCH and PDSCH configured by G-RNTI or SC-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|---------------|--------------|--|
| DCI format 1C | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2). |
| DCI format 1A | Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2). |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the SC-N-RNTI, the UE shall decode the PDCCH according to the combination defined in table 7.1-4A.

Table 7.1-4A: PDCCH configured by SC-N-RNTI

| DCI format | Search Space |
|---------------|--------------|
| DCI format 1C | Common |

If a UE is configured by higher layers to decode MPDCCH with CRC scrambled by the SC-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 7.1-4B.

Table 7.1-4B: MPDCCH and PDSCH configured by SC-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|------------|---------------|---|
| 6-2 | Type1A-common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

If a UE is configured by higher layers to decode MPDCCH with CRC scrambled by the G-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 7.1-4C.

Table 7.1-4C: MPDCCH and PDSCH configured by G-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|--------------|---------------|---|
| 6-1A or 6-1B | Type2A-common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

The UE is semi-statically configured via higher layer signalling to receive PDSCH data transmissions signalled via PDCCH/EPDCCH with DCI formats other than 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G according to one of the transmission modes, denoted mode 1 to mode 10. If the UE is configured with higher layer parameter *dl-TTI-Length*, the UE is semi-statically configured via higher layer signalling to receive PDSCH transmissions signalled via PDCCH/SPDCCH with DCI formats 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G according to

- one of the transmission modes, denoted mode 1, 2, 3, 4, 6, 9, 10 for frame structure type 1, and mode 1,2,3,4,6,8,9,10 for frame structure type 2 in non-MBSFN subframes.
- one of the transmission modes, denoted mode 9, 10 for frame structure type 1 and frame structure type 2 in MBSFN subframes

For a BL/CE UE, the UE is semi-statically configured via higher layer signalling to receive PDSCH data transmissions signalled via MPDCCH according to one of the transmission modes: mode 1, mode 2, mode 6, and mode 9.

For LAA Scells, the UE is not expected to receive PDSCH data transmissions signalled via PDCCH/EPDCCH according to transmission modes 5, 6, 7.

For a serving cell, if the UE is configured with higher layer parameter *shortTTI*, and if the UE does not support *pdsch-SlotSubslotPDSCH-Decoding* (3GPP TS 36.331 [11]), the UE is not expected to receive PDSCH data transmissions signalled via PDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI Formats other than DCI Format 7-1

A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in a subframe, if also PDSCHs assigned by PDCCH/SPDCCH associated with DCI Format 7-1 A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is received in the same subframe of the same serving cell. Additionally, the UE shall transmit HARQ-ACK associated with both the subframe-PDSCH and slot/subslot-PDSCH, regardless of the support of *pdsch-SlotSubslotPDSCH-Decoding*.

For a UE configured with higher layer parameter *shortTTI*, the UE may skip decoding any transport block(s) received in PDSCH transmissions signalled via PDCCH/EPDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI Formats other than DCI Format 7-1 A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in the last W_{DL} subframes if the UE has detected PDCCH/SPDCCH associated with DCI Format 7-1 A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, and if $W_{DL} > 0$ is indicated by *skipSubframeProcessing* capability [12]. If the UE skips decoding, the physical layer indicates to higher layer that the transport block(s) are not successfully decoded.

For a UE configured with higher layer parameter *shortTTI*, and for PDSCH data transmissions in subslot n signalled via PDCCH/SPDCCH of a serving cell

- with DCI format 7-1F/7-1G, the UE is not expected to receive UE-specific reference signals corresponding to a transport block mapped to more than two-layer spatial multiplexing in subslot n of subframe N ,
 - if the UE has received UE-specific reference signals corresponding to a transport block mapped to more than two-layer spatial multiplexing in subslot $n-1$ of subframe N or
 - if $n=0$ and if the UE has received UE-specific reference signals corresponding to a transport block mapped to more than two-layer spatial multiplexing in subslot 5 of subframe $N-1$, and if the UE does not support *dmrs-RepetitionSubslotPDSCH* (3GPP TS 36.331 [11])
- with DCI format 7-1F/7-1G, the UE may assume that UE-specific reference signals were present in those PRGs of subslot $n-1$, where PDSCH is mapped to

if the DCI associated with the subslot-PDSCH indicates the absence of the UE-specific reference signal in subslot n (See DMRS position indicator field in 3GPP TS 36.212 [4]).

For a serving cell, if the UE is configured with higher layer parameter *shortTTI*, the UE is not expected to receive

- PDSCH data transmissions signalled via PDCCH/SPDCCH of the serving cell with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G for a transport block corresponding to a HARQ process with NDI not toggled if the previous PDSCH transmission of the transport block was signalled via PDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI with DCI format other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G when the number of codewords for the previous PDSCH transmissions is two or the transport block size is more than the maximum transport block size supported for slot/subslot-PDSCH transmission.
- PDSCH data transmissions signalled via PDCCH/SPDCCH of the serving cell with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI format 7-1F/7-1G in subslot n , if the PDCCH/SPDCCH indicates the absence of the UE-specific reference signal in subslot n and
 - if $n=0$ and if the UE does not support *dmrs-SharingSubslotPDSCH* (3GPP TS 36.331 [11]) or
 - if the UE has not received a PDCCH/SPDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI format 7-1F/7-1G in one subslot before subslot n or
 - if the UE has received a PDCCH/SPDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI DCI format 7-1F/7-1G in one subslot before subslot n indicating
 - the absence of the UE-specific reference signal in one subslot before subslot n or
 - the presence of the UE-specific reference signal in one subslot before subslot n
 - if the PDSCH PRGs of one subslot before subslot n do not include all the PDSCH PRGs of subslot n or
 - if the number of antenna ports associated with the PDSCH of one subslot before subslot n is less than the number of antenna ports associated with the PDSCH of subslot n or

- if the number of antenna ports associated with the PDSCH of both subslot n and one subslot before subslot n is 1 but different antenna port is indicated between subslot n and one subslot before the subslot n

The UE shall provide the HARQ-ACK response associated with the PDCCH/SPDCCH received in subslot n if the UE has not received a PDCCH/SPDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI and DCI format 7-1F/7-1G in one subslot before the subslot n .

For a UE configured with higher layer parameter *shortProcessingTime*,

- the UE is not expected to receive PDCCH in common search space for which HARQ-ACK response shall be provided in a subframe n , and PDCCH in UE specific search space for which HARQ-ACK response shall be provided in the same subframe n .
- the UE is not expected to receive PDCCH in common search space in subframe n , and PDCCH in UE specific search space in the same subframe n .

For frame structure type 1,

- the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5 in any subframe in which the number of OFDM symbols for PDCCH with normal CP is equal to four;
- a non-BL/CE UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5, 7, 8, 9, 10, 11, 12, 13 or 14 in the two PRBs to which a pair of VRBs is mapped if either one of the two PRBs overlaps in frequency with a transmission of either PBCH or primary or secondary synchronization signals in the same subframe;
- the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 7 for which distributed VRB resource allocation is assigned.
- The UE may skip decoding the transport block(s) if it does not receive all assigned PDSCH resource blocks except if it is capable of receiving the non-colliding PDSCH resource blocks in an assignment which partly collides in frequency with a transmission of PBCH or primary synchronization signal or secondary synchronization signal in the same subframes and that capability is indicated by *pdsch-CollisionHandling* [12]. If the UE skips decoding, the physical layer indicates to higher layer that the transport block(s) are not successfully decoded.

For frame structure type 2,

- the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5 in any subframe in which the number of OFDM symbols for PDCCH with normal CP is equal to four;
- the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5 in the two PRBs to which a pair of VRBs is mapped if either one of the two PRBs overlaps in frequency with a transmission of PBCH in the same subframe;
- a non-BL/CE UE is not expected to receive PDSCH resource blocks transmitted on antenna port 7, 8, 9, 10, 11, 12, 13 or 14 in the two PRBs to which a pair of VRBs is mapped if either one of the two PRBs overlaps in frequency with a transmission of primary or secondary synchronization signals in the same subframe;
- with normal CP configuration, the UE is not expected to receive PDSCH on antenna port 5 for which distributed VRB resource allocation is assigned in the special subframe with configuration #1 or #6;
- the UE is not expected to receive PDSCH on antenna port 7 for which distributed VRB resource allocation is assigned;
- with normal cyclic prefix, the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5 in DwPTS when the UE is configured with special subframe configuration 9 or 10.
- The UE may skip decoding the transport block(s) if it does not receive all assigned PDSCH resource blocks except if it is capable of receiving the non-colliding PDSCH resource blocks in an assignment which partly collides in frequency with a transmission of PBCH or primary synchronization signal or secondary synchronization signal in the same subframe and that capability is indicated by *pdsch-CollisionHandling* [12]. If the UE skips decoding, the physical layer indicates to higher layer that the transport block(s) are not successfully decoded.

- If the UE is not configured for PUSCH/PUCCH transmission for at least one TDD serving cell, the UE is not expected to receive PDSCH on serving cell c_1 if the PDSCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on TDD serving cell c_2 not configured for PUSCH/PUCCH transmission, and if the UE is not capable of simultaneous reception and transmission on serving cell c_1 and serving cell c_2 .
- if a UE is configured with higher layer parameter *shortTTI* for a serving cell, the UE is not expected to
 - receive PDSCH data transmissions signalled via PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in
 - DwPTS when the UE is configured with special subframe configuration 0 and 5;
 - the second slot of DwPTS when the UE is configured with special subframe configuration 1, 2, 6 and 7.
 - be configured with *EIMTA-MainConfigServCell-r12* for the serving cell.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE is not expected to receive PDSCH data transmissions signalled via PDCCH in common search space for which HARQ-ACK response shall be provided in a subframe n , and PDSCH data transmissions signalled via PDCCH/EPDCCH in UE specific search space for which HARQ-ACK response shall be provided in the same subframe n .

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the C-RNTI, the UE shall decode the PDCCH and any corresponding PDSCH according to the respective combinations defined in Table 7.1-5. The scrambling initialization of PDSCH corresponding to these PDCCHs is by C-RNTI. The UE shall decode the PDCCH DCI Format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G only if the UE is configured with higher layer parameter *shortTTI*.

If a UE is configured by higher layers to decode EPDCCH with CRC scrambled by the C-RNTI, the UE shall decode the EPDCCH and any corresponding PDSCH according to the respective combinations defined in Table 7.1-5A. The scrambling initialization of PDSCH corresponding to these EPDCCHs is by C-RNTI.

If a BL/CE UE is configured by higher layers to decode MPDCCH with CRC scrambled by the C-RNTI except for random access procedure, the UE shall decode the MPDCCH and any corresponding PDSCH according to the respective combinations defined in Table 7.1-5B. The scrambling initialization of PDSCH corresponding to these MPDCCHs is by C-RNTI.

If a UE is configured with CEModeA, the UE shall decode MPDCCH DCI Format 6-1A. If the UE is configured with CEModeB, the UE shall decode MPDCCH DCI Format 6-1B.

If a UE is configured with higher layer parameter *shortTTI* and the UE is configured by higher layers to decode SPDCCH with CRC scrambled by the C-RNTI, the UE shall decode the SPDCCH and any corresponding PDSCH according to the respective combinations defined in Table 7.1-5C. The scrambling initialization of PDSCH corresponding to these SPDCCHs is by C-RNTI.

If the UE is configured with the carrier indicator field for a given serving cell and, if the UE is configured by higher layers to decode PDCCH/EPDCCH with CRC scrambled by the C-RNTI, then the UE shall decode PDSCH of the serving cell indicated by the carrier indicator field value in the decoded PDCCH/EPDCCH.

When a UE configured in transmission mode 3, 4, 8, 9 or 10 receives a DCI Format 1A assignment, it shall assume that the PDSCH transmission is associated with transport block 1 and that transport block 2 is disabled.

When a UE is configured in transmission mode 7, scrambling initialization of UE-specific reference signals corresponding to these PDCCHs/EPDCCHs is by C-RNTI.

The UE does not support transmission mode 8 if extended cyclic prefix is used in the downlink.

When a UE is configured in transmission mode 9 or 10, in the downlink subframes indicated by the higher layer parameter *mbsfn-SubframeConfigList* or by *mbsfn-SubframeConfigList-v1250* or by *mbsfn-SubframeConfigList-v14xy* or by *laa-SCellSubframeConfig* of serving cell c except in subframes for the serving cell

- indicated by higher layers to decode PMCH or,

- configured by higher layers to be part of a positioning reference signal occasion and the positioning reference signal occasion is only configured within MBSFN subframes and the cyclic prefix length used in subframe #0 is normal cyclic prefix,

the UE shall upon detection of a PDCCH with CRC scrambled by the C-RNTI with DCI format 1A/2C/2D intended for the UE or, upon detection of an EPDCCH with CRC scrambled by the C-RNTI with DCI format 1A/2C/2D intended for the UE, decode the corresponding PDSCH in the same subframe.

A UE configured in transmission mode 10 can be configured with scrambling identities, $n_{\text{ID}}^{\text{DMRS},i}$, $i = 0,1$ by higher layers for UE-specific reference signal generation as defined in Subclause 6.10.3.1 of [3] to decode PDSCH according to a detected PDCCH/EPDCCH with CRC scrambled by the C-RNTI with DCI format 2D intended for the UE.

Table 7.1-5: PDCCH and PDSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|-------------------|------------------------|----------------------------------|---|
| Mode 1 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| | DCI format 1 and 7-1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 and 7-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2A and 7-1B | UE specific by C-RNTI | Large delay CDD (see Subclause 7.1.3) or Transmit diversity (see Subclause 7.1.2) |
| Mode 4 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2 and 7-1C | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) or Transmit diversity (see Subclause 7.1.2) |
| Mode 5 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1D | UE specific by C-RNTI | Multi-user MIMO (see Subclause 7.1.5) |
| Mode 6 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1B | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) using a single transmission layer |
| | DCI format 7-1D | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) using a single transmission layer or transmit diversity (see Subclause 7.1.2) |
| Mode 7 | DCI format 1A | Common and UE specific by C-RNTI | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| Mode 8 | DCI format 1A | Common and UE specific by C-RNTI | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2B | UE specific by C-RNTI | Dual layer transmission, port 7 and 8 (see Subclause 7.1.5A) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| | DCI format 7-1E | UE specific by C-RNTI | Dual layer transmission, port 7 and 8 (see Subclause 7.1.5A) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or Transmit Diversity, port 7 and 8 (see Subclause 7.1.2) |
| Mode 9 | DCI format 1A | Common and UE specific by C-RNTI | <ul style="list-style-type: none"> Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) MBSFN subframe: Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2C | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) or dual layer transmission port 7-8 (see Subclause 7.1.5A), if UE is configured with higher layer parameter <i>semiOpenLoop</i> , up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise |

| | | | |
|----------------|-----------------|----------------------------------|---|
| | DCI format 7-1F | UE specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2), if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i></p> <p>Up to 2 layer transmission, ports 7-8 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8, (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8, (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7 or 8 (see Subclause 7.1.1).</p> |
| Mode 10 | DCI format 1A | Common and UE specific by C-RNTI | <ul style="list-style-type: none"> Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) MBSFN subframe: Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2D | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) or dual layer transmission port 7-8 (see Subclause 7.1.5A), if UE is configured with higher layer parameter <i>semiOpenLoop</i> , up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmsr-tableAlt</i> , single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise |
| | DCI format 7-1G | US specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2), if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i>.</p> <p>Up to 2 layer transmission, ports 7-8 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8, (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8 (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TxDiv-4layer-TM9/10</i> (3GPP TS 36.331</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) otherwise, or single-antenna port, port 7 or 8 (see Subclause 7.1.1)</p> |

Table 7.1-5A: EPDCCH and PDSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to EPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2A | UE specific by C-RNTI | Large delay CDD (see Subclause 7.1.3) or Transmit diversity (see Subclause 7.1.2) |
| Mode 4 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2 | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) or Transmit diversity (see Subclause 7.1.2) |
| Mode 5 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1D | UE specific by C-RNTI | Multi-user MIMO (see Subclause 7.1.5) |
| Mode 6 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1B | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) using a single transmission layer |
| Mode 7 | DCI format 1A | UE specific by C-RNTI | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| Mode 8 | DCI format 1A | UE specific by C-RNTI | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2B | UE specific by C-RNTI | Dual layer transmission, port 7 and 8 (see Subclause 7.1.5A) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| Mode 9 | DCI format 1A | UE specific by C-RNTI | <ul style="list-style-type: none"> Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) MBSFN subframe: Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2C | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) or dual layer transmission port 7-8 (see Subclause 7.1.5A), if UE is configured with higher layer parameter <i>semiOpenLoop</i> , up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise |
| Mode 10 | DCI format 1A | UE specific by C-RNTI | <ul style="list-style-type: none"> Non-MBSFN subframe: If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) MBSFN subframe: Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2D | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) or dual layer transmission port 7-8 (see Subclause 7.1.5A), if UE is configured with higher layer parameter <i>semiOpenLoop</i> , up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise |

Table 7.1-5B: MPDCCH and PDSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | 6-1A | Type0-Common | Single-antenna port, port 0 (see Subclause 7.1.1) |
| | 6-1A or 6-1B | UE specific by C-RNTI | |
| Mode 2 | 6-1A | Type0-Common | Transmit diversity (see Subclause 7.1.2) |
| | 6-1A or 6-1B | UE specific by C-RNTI | |
| Mode 6 | 6-1A | Type0-Common | Transmit diversity (see Subclause 7.1.2) |
| | 6-1A | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) using a single transmission layer |
| Mode 9 | 6-1A | Type0-Common | If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| | 6-1A | UE specific by C-RNTI | Single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| | 6-1B | UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |

Table 7.1-5C: SPDCCH and PDSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to SPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | DCI format 7-1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 7-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 7-1B | UE specific by C-RNTI | Large delay CDD (see Subclause 7.1.3) |
| Mode 4 | DCI format 7-1C | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) or Transmit diversity (see Subclause 7.1.2) |
| Mode 6 | DCI format 7-1D | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 7.1.4) using a single transmission layer or Transmit diversity (see Subclause 7.1.2) |
| Mode 8 | DCI format 7-1E | UE specific by C-RNTI | Dual layer transmission, port 7 and 8 (see Subclause 7.1.5A) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or Transmit Diversity, port 7 and port 8 (see Subclause 7.1.2) |
| Mode 9 | DCI format 7-1F | UE specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2), if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i>.</p> <p>Up to 2 layer transmission, ports 7-8 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8, (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8 (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7 or 8 (see Subclause 7.1.1).</p> |
| Mode 10 | DCI format 7-1G | UE specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2), if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i>.</p> <p>Up to 2 layer transmission, port 7-8 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (see Subclause 7.1.1) or transmit diversity, port 7-8 (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) or single-antenna port, port 7 or 8 (See Subclause 7.1.1) or transmit diversity, port 7-8 (see Subclause 7.1.2) if the UE is configured with <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Up to 4 layer transmission, ports 7-10 (see Subclause 7.1.5B) otherwise; or single-antenna port, port 7 or 8 (see Subclause 7.1.1).</p> |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the SPS C-RNTI, the UE shall decode the PDCCH on the primary cell and any corresponding PDSCH on the primary cell according to the respective combinations defined in Table 7.1-6 unless the UE is configured with higher layer parameter *shortProcessingTime* and for DCI formats 1/1A/2/2A/2B/2C/2D mapped onto the UE-specific search space. The same PDSCH related configuration applies in the case that a PDSCH is transmitted without a corresponding PDCCH. The scrambling initialization of PDSCH corresponding to these PDCCHs and PDSCH without a corresponding PDCCH is by SPS C-RNTI.

If a UE is configured by higher layers to decode EPDCCH with CRC scrambled by the SPS C-RNTI, the UE shall decode the EPDCCH on the primary cell and any corresponding PDSCH on the primary cell according to the respective combinations defined in Table 7.1-6A. The same PDSCH related configuration applies in the case that a PDSCH is transmitted without a corresponding EPDCCH. The scrambling initialization of PDSCH corresponding to these EPDCCHs and PDSCH without a corresponding EPDCCH is by SPS C-RNTI.

If a UE configured with CEModeA is configured by higher layers to decode MPDCCH with CRC scrambled by the SPS C-RNTI, the UE shall decode the MPDCCH on the primary cell and any corresponding PDSCH on the primary cell according to the respective combinations defined in Table 7.1-6B. The same PDSCH related configuration applies in the case that a PDSCH is transmitted without a corresponding MPDCCH. The scrambling initialization of PDSCH corresponding to these MPDCCHs and PDSCH without a corresponding MPDCCH is by SPS C-RNTI.

When a UE is configured in transmission mode 7, scrambling initialization of UE-specific reference signals for PDSCH corresponding to these PDCCHs/EPDCCHs and for PDSCH without a corresponding PDCCH/EPDCCH is by SPS C-RNTI.

When a UE is configured in transmission mode 9 or 10, in the downlink subframes indicated by the higher layer parameter *mbsfn-SubframeConfigList* or by *mbsfn-SubframeConfigList-v1250* or by *mbsfn-SubframeConfigList-v14xy* of serving cell *c* except in subframes for the serving cell

- indicated by higher layers to decode PMCH or,
- configured by higher layers to be part of a positioning reference signal occasion and the positioning reference signal occasion is only configured within MBSFN subframes and the cyclic prefix length used in subframe #0 is normal cyclic prefix,

the UE shall upon detection of a PDCCH with CRC scrambled by the SPS C-RNTI with DCI format 1A/2C/2D/7-1F/7-1G except when the UE is configured with higher layer parameter *shortProcessingTime* and with DCI format 1A/2C/2D mapped onto the UE-specific search space, or upon detection of a EPDCCH with CRC scrambled by the SPS C-RNTI with DCI format 1A/2C/2D, or upon detection of a SPDCCH with CRC scrambled by the SPS C-RNTI with DCI format 7-1F/7-1G, or for a configured PDSCH without PDCCH intended for the UE, decode the corresponding PDSCH in the same subframe/slot/subslot.

A UE configured in transmission mode 10 can be configured with scrambling identities, $n_{ID}^{DMRS,i}$, $i = 0,1$ by higher layers for UE-specific reference signal generation as defined in Subclause 6.10.3.1 of [3] to decode PDSCH according to a detected

- PDCCH/EPDCCH with CRC scrambled by the SPS C-RNTI with DCI format 2D
- PDCCH/SPDCCH with CRC scrambled by the SPS C-RNTI with DCI format 7-1G

intended for the UE.

For PDSCH without a corresponding PDCCH/EPDCCH, the UE shall use the value of n_{SCID} and the scrambling identity of $n_{ID}^{(n_{SCID})}$ (as defined in Subclause 6.10.3.1 of [3]) derived from the DCI format 2D/7-1G corresponding to the associated SPS activation for UE-specific reference signal generation.

Table 7.1-6: PDCCH and PDSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|--------------------------|------------------------|----------------------------------|---|
| Mode 1 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| | DCI format 1 and 7-1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 and 7-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2A and 7-1B | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 4 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2 and 7-1C | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 5 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 6 | DCI format 1A | Common and UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 7-1D | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 7 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| Mode 8 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2B and 7-1E | UE specific by C-RNTI | Single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| Mode 9 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2C | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoop</i> , or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise |
| | DCI format 7-1F | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i> , Transmit diversity, port 7-8, (see Subclause 7.1.2) or single antenna port, port 7 or 8, (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> or <i>subSlotslotPDSCH</i> TS 36.331 [11]. Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise. |
| Mode 10 | DCI format 1A | Common and UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2D | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoop</i> , or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise |
| | DCI format 7-1G | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoop</i> , Transmit diversity, port 7,8 (see Subclause 7.1.2) or single antenna port, port 7 or 8, (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> or <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331[11]). Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise. |

Table 7.1-6A: EPDCCH and PDSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to EPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 1 | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 4 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| | DCI format 2 | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 5 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 6 | DCI format 1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 7 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| | DCI format 1 | UE specific by C-RNTI | Single-antenna port, port 5 (see Subclause 7.1.1) |
| Mode 8 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2B | UE specific by C-RNTI | Single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| Mode 9 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2C | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoop</i> , or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise |
| Mode 10 | DCI format 1A | UE specific by C-RNTI | Single-antenna port, port 7 (see Subclause 7.1.1) |
| | DCI format 2D | UE specific by C-RNTI | Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoop</i> , or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>dmrs-tableAlt</i> , Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise |

Table 7.1-6B: MPDCCH and PDSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | 6-1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | 6-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 6 | 6-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 9 | 6-1A | UE specific by C-RNTI | Single-antenna port, port 7 or 8 (see Subclause 7.1.1) |

NOTE: For BL/CE UEs configured with transmission mode 6, and for DCI 6-1A mapped onto the UE specific search space and with CRC scrambled by the SPS C-RNTI, the bits corresponding to TPMI information for precoding and PMI information for precoding are set to zero.

Table 7.1-6C: SPDCCH and PDSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PDSCH corresponding to SPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | DCI format 7-1A | UE specific by C-RNTI | Single-antenna port, port 0 (see Subclause 7.1.1) |
| Mode 2 | DCI format 7-1A | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 3 | DCI format 7-1B | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 4 | DCI format 7-1C | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 6 | DCI format 7-1D | UE specific by C-RNTI | Transmit diversity (see Subclause 7.1.2) |
| Mode 8 | DCI format 7-1E | UE specific by C-RNTI | Single-antenna port, port 7 or 8 (see Subclause 7.1.1) |
| Mode 9 | DCI format 7-1F | UE specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i>.</p> <p>Transmit diversity, port 7-8, (see Subclause 7.1.2) or single antenna port, port 7 or 8, (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> or <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise.</p> |
| Mode 10 | DCI format 7-1G | UE specific by C-RNTI | <p>Transmit diversity, port 7-8, (see Subclause 7.1.2) if UE is configured with higher layer parameter <i>semiOpenLoopSTTI</i>.</p> <p>Transmit diversity, port 7-8, (see Subclause 7.1.2) or single antenna port, port 7 or 8, (see Subclause 7.1.1) if UE is configured with higher layer parameter <i>slotSubslotPDSCH-TXDiv-2layer-TM9/10</i> or <i>slotSubslotPDSCH-TXDiv-4layer-TM9/10</i> (3GPP TS 36.331 [11]).</p> <p>Single-antenna port, port 7 or 8, (see Subclause 7.1.1) otherwise.</p> |

If a UE is configured by higher layers to decode PDCCH with CRC scrambled by the Temporary C-RNTI and is not configured to decode PDCCH with CRC scrambled by the C-RNTI, the UE shall decode the PDCCH and the corresponding PDSCH according to the combination defined in Table 7.1-7. The scrambling initialization of PDSCH corresponding to these PDCCHs is by Temporary C-RNTI.

If a UE is configured by higher layers to decode MPDCCH with CRC scrambled by the Temporary C-RNTI and is not configured to decode MPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH and the corresponding PDSCH according to the combination defined in Table 7.1-8. The scrambling initialization of PDSCH corresponding to these MPDCCHs is by Temporary C-RNTI.

If a UE is also configured by higher layers to decode MPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH and the corresponding PDSCH according to the combination defined in Table 7.1-8. The scrambling initialization of PDSCH corresponding to these MPDCCHs is by C-RNTI.

Table 7.1-7: PDCCH and PDSCH configured by Temporary C-RNTI

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to PDCCH |
|-------------------|--|--|
| DCI format 1A | Common and UE specific by Temporary C-RNTI | If the number of PBCH antenna port is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| DCI format 1 | UE specific by Temporary C-RNTI | If the number of PBCH antenna port is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

Table 7.1-8: MPDCCH and PDSCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure

| DCI format | Search Space | Transmission scheme of PDSCH corresponding to MPDCCH |
|-----------------|--------------|--|
| DCI format 6-1A | Type2-Common | If the number of PBCH antenna port is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |
| DCI format 6-1B | Type2-Common | If the number of PBCH antenna port is one, Single-antenna port, port 0 is used (see Subclause 7.1.1), otherwise Transmit diversity (see Subclause 7.1.2) |

If the UE is configured with higher layer parameter *must-Config-r14*, and if the PDCCH/EPDCCH DCI of the corresponding PDSCH transmission indicates MUST interference is present [4],

- the UE may assume that the starting OFDM symbol of MUST interference is same as the starting OFDM symbol of the corresponding PDSCH transmission,
- for transmission modes 8-10, the UE may assume n_{SCID} , $n_{\text{ID}}^{(n_{\text{SCID}})}$ of MUST interference are same as that of the corresponding PDSCH transmission.

A UE is not required to receive PDSCH assigned by MPDCCH with DCI CRC scrambled by SC-RNTI or G-RNTI if the set of subframes carrying the PDSCH includes any subframes in which the UE monitors Type1-MPDCCH common search space or PDSCH assigned by MPDCCH sent in Type1-MPDCCH common search space.

A UE is not required to receive PDSCH assigned by MPDCCH with DCI CRC scrambled by G-RNTI if the set of subframes carrying the PDSCH includes any subframes in which the UE monitors Type1A-MPDCCH common search space, or includes any subframes in which the UE receives PDSCH assigned by MPDCCH with DCI CRC scrambled by SC-RNTI.

The transmission schemes of the PDSCH are described in the following sub-Subclauses.

7.1.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 0/5/7/8/11/13) of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed according to Subclause 6.3.4.1 of [3].

If the UE is not configured with higher layer parameter *dmrs-tableAlt* and in case an antenna port $p \in \{7,8\}$ is used, or if the higher layer parameter *dmrs-tableAlt* is set to 1 and in case an antenna port $p \in \{7,8\}$ corresponding to one codeword values 0-3 in Table 5.3.3.1.5C-2 [4] is used, the UE cannot assume that the other antenna port in the set $\{7,8\}$ is not associated with transmission of PDSCH to another UE.

If the UE is configured with higher layer parameter *dmrs-tableAlt*, and in case of single layer transmission scheme on antenna port $p \in \{7,8,11,13\}$ corresponding to one codeword values 4-11 in Table 5.3.3.1.5C-2 [4] is used, the UE cannot assume that the other antenna ports in the set $\{7,8,11,13\}$ is not associated with transmission of PDSCH to another UE.

7.1.2 Transmit diversity scheme

For the transmit diversity transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed according to Subclause 6.3.4.3 of [3].

7.1.3 Large delay CDD scheme

For the large delay CDD transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed according to large delay CDD as defined in Subclause 6.3.4.2.2 of [3].

7.1.4 Closed-loop spatial multiplexing scheme

For the closed-loop spatial multiplexing transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed according to the applicable number of transmission layers as defined in Subclause 6.3.4.2.1 of [3].

7.1.5 Multi-user MIMO scheme

For the multi-user MIMO transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed on one layer and according to Subclause 6.3.4.2.1 of [3]. The $\delta_{\text{power-offset}}$ dB value signalled on PDCCH/EPDCCH with DCI format 1D using the downlink power offset field is given in Table 7.1.5-1.

Table 7.1.5-1: Mapping of downlink power offset field in DCI format 1D to the $\delta_{\text{power-offset}}$ value.

| Downlink power offset field | $\delta_{\text{power-offset}}$ [dB] |
|-----------------------------|-------------------------------------|
| 0 | $-10\log_{10}(2)$ |
| 1 | 0 |

7.1.5A Dual layer scheme

For the dual layer transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed with two transmission layers on antenna ports 7 and 8 as defined in Subclause 6.3.4.4 of [3].

7.1.5B Up to 8 layer transmission scheme

For the up to 8 layer transmission scheme of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed with up to 8 transmission layers on antenna ports 7 - 14 as defined in Subclause 6.3.4.4 of [3].

If the UE is configured with higher layer parameter *dmrs-tableAlt*, and in case of dual layer transmission scheme on antenna ports {7,8} or {11,13} corresponding to two codewords values 2-5 in Table 5.3.3.1.5C-2 [4] is used, the UE cannot assume that the other antenna ports in the set {7,8,11,13} is not associated with transmission of PDSCH to another UE.

7.1.6 Resource allocation

The UE shall interpret the resource allocation field depending on the PDCCH/EPDCCH DCI format detected. A resource allocation field in each PDCCH/EPDCCH includes two parts, a resource allocation header field and information consisting of the actual resource block assignment.

PDCCH DCI formats 1, 2, 2A, 2B, 2C and 2D with type 0 and PDCCH DCI formats 1, 2, 2A, 2B, 2C and 2D with type 1 resource allocation have the same format and are distinguished from each other via the single bit resource allocation header field which exists depending on the downlink system bandwidth (Subclause 5.3.3.1 of [4]), where type 0 is indicated by 0 value and type 1 is indicated otherwise. PDCCH with DCI format 1A, 1B, 1C and 1D have a type 2 resource allocation while PDCCH with DCI format 1, 2, 2A, 2B, 2C and 2D have type 0 or type 1 resource allocation. PDCCH DCI formats with a type 2 resource allocation do not have a resource allocation header field.

EPDCCH DCI formats 1, 2, 2A, 2B, 2C and 2D with type 0 and EPDCCH DCI formats 1, 2, 2A, 2B, 2C and 2D with type 1 resource allocation have the same format and are distinguished from each other via the single bit resource allocation header field which exists depending on the downlink system bandwidth (Subclause 5.3.3.1 of [4]), where type 0 is indicated by 0 value and type 1 is indicated otherwise. EPDCCH with DCI format 1A, 1B, and 1D have a type 2 resource allocation while EPDCCH with DCI format 1, 2, 2A, 2B, 2C and 2D have type 0 or type 1 resource allocation. EPDCCH DCI formats with a type 2 resource allocation do not have a resource allocation header field.

If the UE is configured with higher layer parameter *shortTTI*, PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G utilizes a higher layer configured resource allocation type 0 or resource allocation type 2.

If the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and the resource block assignment flag is set to 0

- MPDCCH with DCI format 6-1A utilizes a type 0 resource allocation.

else if the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and the resource block assignment flag is set to 1, or the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 5 MHz, or *mpdcch-PDSCH-MaxBandwidth-SC-MTCH* is set to 24 PRBs,

For system bandwidth larger than 1.4 MHz,

MPDCCH with DCI format 6-1A utilizes same type 2 resource allocation within each allocated narrowband.

otherwise,

MPDCCH with DCI format 6-1A utilizes a type 2 resource allocation.

otherwise

- MPDCCH with DCI format 6-1A utilizes a type 2 resource allocation.

Resource allocation for MPDCCH with DCI format 6-1B is given by the Resource block assignment field as described in [4]. For a UE configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and CEModeB, the allocated widebands (WBs) are based on the wideband combination index according to Table 7.1.6-2.

MPDCCH with DCI format 6-2 assigns a set of six contiguously allocated localized virtual resource blocks within a narrowband. Localized virtual resource blocks are always used in case of MPDCCH with DCI format 6-1A, 6-1B, or 6-2.

A UE may assume, for any PDSCH transmission scheduled by a cell with physical cell identity given in *NAICS-AssistanceInfo-r12* and the PDSCH transmission mode belonging to *transmissionModeList-r12* associated with the cell except spatial multiplexing using up to 8 transmission layers in transmission mode 10, that the resource allocation granularity and precoding granularity in terms of PRB pairs in the frequency domain are both given by *N*, where *N* is given by the higher layer parameter *resAllocGranularity-r12* associated with the cell. The first set of *N* consecutive PRB pairs of the resource allocation starts from the lowest frequency of the system bandwidth and the UE may assume the same precoding applies to all PRB pairs within a set.

For a BL/CE UE, the resource allocation for PDSCH carrying *SystemInformationBlockType1-BR* and SI messages is a set of six contiguously allocated localized virtual resource blocks within a narrowband. The number of repetitions for the PDSCH carrying *SystemInformationBlockType1-BR* is determined based on the parameter *schedulingInfoSIB1-BR* configured by higher-layers and according to Table 7.1.6-1. If the value of the parameter *schedulingInfoSIB1-BR* configured by higher-layers is set to 0, UE assumes that *SystemInformationBlockType1-BR* is not transmitted.

Table 7.1.6-1: Number of repetitions for PDSCH carrying *SystemInformationBlockType1-BR* for BL/CE UE.

| Value of <i>schedulingInfoSIB1-BR</i> | Number of PDSCH repetitions |
|--|-----------------------------------|
| 0 | N/A |
| 1 | 4 |
| 2 | 8 |
| 3 | 16 |
| 4 | 4 |
| 5 | 8 |
| 6 | 16 |
| 7 | 4 |
| 8 | 8 |
| 9 | 16 |
| 10 | 4 |
| 11 | 8 |
| 12 | 16 |
| 13 | 4 |
| 14 | 8 |
| 15 | 16 |
| 16 | 4 |
| 17 | 8 |
| 18 | 16 |
| 19-31 | Reserved |

Table 7.1.6-2: Wideband combination index for a UE configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and CEModeB

| Wideband combination index | Indices of allocated WBs | | |
|----------------------------|--------------------------|--------------------|---------------------|
| | $N_{RB}^{DL} = 50$ | $N_{RB}^{DL} = 75$ | $N_{RB}^{DL} = 100$ |
| 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 1 |
| 2 | 0,1 | 2 | 2 |
| 3 | Reserved | 0,1 | 3 |
| 4 | NA | 1,2 | 0,1 |
| 5 | NA | 0,2 | 2,3 |
| 6 | NA | 0,1,2 | 0,1,2 |
| 7 | NA | Reserved | 0,1,2,3 |

7.1.6.1 Resource allocation type 0

In resource allocations of type 0, resource block assignment information includes a bitmap indicating the Resource Block Groups (RBGs) that are allocated to the scheduled UE where a RBG is a set of consecutive virtual resource blocks (VRBs) of localized type as defined in Subclause 6.2.3.1 of [3].

For a UE configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and the resource block assignment flag is set to 0

- Resource block group size (P) is given by the value S described in sub clause 5.3.3.1.12 of [4].
- $N_{RB}^{DL} = 6 \cdot \left\lfloor \frac{N_{RB}^{DL}}{6} \right\rfloor$ and N_{RB}^{DL} is used in place of N_{RB}^{DL} for the rest of this sub-clause, unless explicitly mentioned.

otherwise

- Resource block group size (P) is a function of the system bandwidth as shown in Table 7.1.6.1-1A if a UE is configured with higher layer parameter *shortTTI* and for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, Table 7.1.6.1-1 otherwise.

For DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the total number of RBGs (N_{RBG}) for downlink system bandwidth of N_{RB}^{DL} is given by $N_{RBG} = \lceil N_{RB}^{DL} / P \rceil$ where $\lceil N_{RB}^{DL} / P \rceil$ of the RBGs are of size P and if $N_{RB}^{DL} \bmod P > 0$ then one of the RBGs is of size $N_{RB}^{DL} - P \cdot \lfloor N_{RB}^{DL} / P \rfloor$. If a UE is configured with higher layer parameter *shortTTI* and for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the total number of RBGs (N_{RBG}) for downlink system bandwidth of N_{RB}^{DL} is given by $N_{RBG} = \lfloor N_{RB}^{DL} / P \rfloor$ where $N_{RBG} - \lceil (N_{RB}^{DL} \bmod P) / P \rceil$ of the RBGs are of size P and if $N_{RB}^{DL} \bmod P > 0$ then the last RBGs is of size $P + N_{RB}^{DL} \bmod P$. The bitmap is of size N_{RBG} bits with one bitmap bit per RBG such that each RBG is addressable.

For a UE configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 20MHz and the resource block assignment flag is set to 0

- The RBGs shall be indexed according to RBG indexing described in Subclause 8.1.5.1 by replacing N_{RBG}^{UL} with N_{RBG} , 'uplink' with 'downlink', and N_{RB}^{UL} with N_{RB}^{DL} (but not N_{RB}^{DL}).

otherwise

- For DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the RBGs shall be indexed in the order of increasing frequency and non-increasing RBG sizes starting at the lowest frequency.
- For DCI formats 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the RBGs shall be indexed in the order of increasing frequency and non-decreasing RBG sizes starting at the lowest frequency.

The order of RBG to bitmap bit mapping is such that RBG 0 to RBG $N_{\text{RBG}} - 1$ are mapped to MSB to LSB of the bitmap. The RBG is allocated to the UE if the corresponding bit value in the bitmap is 1, the RBG is not allocated to the UE otherwise.

Table 7.1.6.1-1: Type 0 resource allocation RBG size vs. Downlink System Bandwidth

| System Bandwidth $N_{\text{RB}}^{\text{DL}}$ | RBG Size (P) |
|---|-----------------|
| ≤ 10 | 1 |
| 11 – 26 | 2 |
| 27 – 63 | 3 |
| 64 – 110 | 4 |

Table 7.1.6.1-1A: Type 0 resource allocation RBG size vs. Downlink System Bandwidth for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G

| System Bandwidth $N_{\text{RB}}^{\text{DL}}$ | RBG Size (P) |
|---|-----------------|
| ≤ 10 | 1 |
| 11 – 24 | 2 |
| 25 – 63 | 6 |
| 64 – 110 | 12 |

7.1.6.2 Resource allocation type 1

In resource allocations of type 1, a resource block assignment information of size N_{RBG} indicates to a scheduled UE the VRBs from the set of VRBs from one of P RBG subsets. The virtual resource blocks used are of localized type as defined in Subclause 6.2.3.1 of [3]. Also P is the RBG size associated with the system bandwidth as shown in Table 7.1.6.1-1. A RBG subset p , where $0 \leq p < P$, consists of every P th RBG starting from RBG p . The resource block assignment information consists of three fields [4].

The first field with $\lceil \log_2(P) \rceil$ bits is used to indicate the selected RBG subset among P RBG subsets.

The second field with one bit is used to indicate a shift of the resource allocation span within a subset. A bit value of 1 indicates shift is triggered. Shift is not triggered otherwise.

The third field includes a bitmap, where each bit of the bitmap addresses a single VRB in the selected RBG subset in such a way that MSB to LSB of the bitmap are mapped to the VRBs in the increasing frequency order. The VRB is allocated to the UE if the corresponding bit value in the bit field is 1, the VRB is not allocated to the UE otherwise. The portion of the bitmap used to address VRBs in a selected RBG subset has size $N_{\text{RB}}^{\text{TYPE1}}$ and is defined as

$$N_{\text{RB}}^{\text{TYPE1}} = \lceil N_{\text{RB}}^{\text{DL}} / P \rceil - \lceil \log_2(P) \rceil - 1$$

The addressable VRB numbers of a selected RBG subset start from an offset, $\Delta_{\text{shift}}(p)$ to the smallest VRB number within the selected RBG subset, which is mapped to the MSB of the bitmap. The offset is in terms of the number of VRBs and is done within the selected RBG subset. If the value of the bit in the second field for shift of the resource allocation span is set to 0, the offset for RBG subset p is given by $\Delta_{\text{shift}}(p) = 0$. Otherwise, the offset for RBG subset p is given by $\Delta_{\text{shift}}(p) = N_{\text{RB}}^{\text{RBG subset}}(p) - N_{\text{RB}}^{\text{TYPE1}}$, where the LSB of the bitmap is justified with the highest VRB number within the selected RBG subset. $N_{\text{RB}}^{\text{RBG subset}}(p)$ is the number of VRBs in RBG subset p and can be calculated by the following equation,

$$N_{\text{RB}}^{\text{RBG subset}}(p) = \begin{cases} \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P^2} \right\rfloor \cdot P + P & , p < \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P} \right\rfloor \text{mod } P \\ \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P^2} \right\rfloor \cdot P + (N_{\text{RB}}^{\text{DL}} - 1) \text{mod } P + 1 & , p = \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P} \right\rfloor \text{mod } P \\ \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P^2} \right\rfloor \cdot P & , p > \left\lfloor \frac{N_{\text{RB}}^{\text{DL}} - 1}{P} \right\rfloor \text{mod } P \end{cases}$$

Consequently, when RBG subset p is indicated, bit i for $i = 0, 1, \dots, N_{\text{RB}}^{\text{TYPE1}} - 1$ in the bitmap field indicates VRB number,

$$n_{\text{VRB}}^{\text{RBG subset}}(p) = \left\lfloor \frac{i + \Delta_{\text{shift}}(p)}{P} \right\rfloor P^2 + p \cdot P + (i + \Delta_{\text{shift}}(p)) \text{mod } P.$$

7.1.6.3 Resource allocation type 2

For BL/CE UEs with resource allocation type 2 resource assignment, $N_{\text{RB}}^{\text{DL}} = 6$ and $N_{\text{VRB}}^{\text{DL}} = 6$ is used in the rest of this Subclause.

In resource allocations of type 2, the resource block assignment information indicates to a scheduled UE a set of contiguously allocated localized virtual resource blocks or distributed virtual resource blocks. In case of resource allocation signalled with PDCCH DCI format 1A, 1B or 1D, or for resource allocation signalled with EPDCCH DCI format 1A, 1B, or 1D, one bit flag indicates whether localized virtual resource blocks or distributed virtual resource blocks are assigned (value 0 indicates Localized and value 1 indicates Distributed VRB assignment) while distributed virtual resource blocks are always assigned in case of resource allocation signalled with PDCCH DCI format 1C and localized virtual resource blocks are always assigned in case of resource allocation signalled with PDCCH/SPDCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G. Localized VRB allocations for a UE vary from a single VRB up to a maximum number of VRBs spanning the system bandwidth. For DCI format 1A the distributed VRB allocations for a UE vary from a single VRB up to $N_{\text{VRB}}^{\text{DL}}$ VRBs, where $N_{\text{VRB}}^{\text{DL}}$ is defined in [3], if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI. With PDCCH DCI format 1B, 1D with a CRC scrambled by C-RNTI, or with DCI format 1A with a CRC scrambled with C-RNTI, SPS C-RNTI or Temporary C-RNTI distributed VRB allocations for a UE vary from a single VRB up to $N_{\text{VRB}}^{\text{DL}}$ VRBs if $N_{\text{RB}}^{\text{DL}}$ is 6-49 and vary from a single VRB up to 16 if $N_{\text{RB}}^{\text{DL}}$ is 50-110. With EPDCCH DCI format 1B, 1D with a CRC scrambled by C-RNTI, or with DCI format 1A with a CRC scrambled with C-RNTI, SPS C-RNTI distributed VRB allocations for a UE vary from a single VRB up to $N_{\text{VRB}}^{\text{DL}}$ VRBs if $N_{\text{RB}}^{\text{DL}}$ is 6-49 and vary from a single VRB up to 16 if $N_{\text{RB}}^{\text{DL}}$ is 50-110. With PDCCH DCI format 1C and 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, VRB allocations for a UE vary from $N_{\text{RB}}^{\text{step}}$ VRB(s) up to $\left\lfloor N_{\text{VRB}}^{\text{DL}} / N_{\text{RB}}^{\text{step}} \right\rfloor \cdot N_{\text{RB}}^{\text{step}}$ VRBs with an increment step of $N_{\text{RB}}^{\text{step}}$, where $N_{\text{RB}}^{\text{step}}$ value is determined depending on the downlink system bandwidth as shown in Table 7.1.6.3-1 for DCI format 1C and Table 7.1.6.3-1A for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G.

Table 7.1.6.3-1: $N_{\text{RB}}^{\text{step}}$ values vs. Downlink System Bandwidth

| System BW ($N_{\text{RB}}^{\text{DL}}$) | $N_{\text{RB}}^{\text{step}}$ |
|---|-------------------------------|
| | DCI format 1C |
| 6-49 | 2 |
| 50-110 | 4 |

Table 7.1.6.3-1A: $N_{\text{RB}}^{\text{step}}$ values vs. Downlink System Bandwidth

| System BW ($N_{\text{RB}}^{\text{DL}}$) | $N_{\text{RB}}^{\text{step}}$ |
|---|---|
| | DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G |
| 20 – 26 | 4 |
| 27 – 63 | 6 |
| 64 – 110 | 4 |

For PDCCH DCI format 1A, 1B, or 1D or for PDCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and $N_{\text{RB}}^{\text{DL}} < 20$, or for EPDCCH DCI format 1A, 1B, or 1D, or for MPDCCH DCI format 6-1A, or for SPDCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and $N_{\text{RB}}^{\text{DL}} < 20$, a type 2 resource allocation field consists of a resource indication value (*RIV*) corresponding to a starting resource block (RB_{start}) and a length in terms of virtually contiguously allocated resource blocks L_{CRBs} .

The resource indication value is defined by

if $(L_{\text{CRBs}} - 1) \leq \lfloor N_{\text{RB}}^{\text{DL}} / 2 \rfloor$ then

$$RIV = N_{\text{RB}}^{\text{DL}}(L_{\text{CRBs}} - 1) + RB_{\text{start}}$$

else

$$RIV = N_{\text{RB}}^{\text{DL}}(N_{\text{RB}}^{\text{DL}} - L_{\text{CRBs}} + 1) + (N_{\text{RB}}^{\text{DL}} - 1 - RB_{\text{start}})$$

where $L_{\text{CRBs}} \geq 1$ and shall not exceed $N_{\text{VRB}}^{\text{DL}} - RB_{\text{start}}$.

For a BL/CE UE configured with CEModeA, and configured with higher layer parameter *ce-PDSCH-FlexibleStartPRB-AllocConfig-r15*, and $0 \leq RIV - N_{\text{RB}}^{\text{DL}}(N_{\text{RB}}^{\text{DL}} + 1) / 2 < 10$, the RB_{start} and L_{CRBs} is determined according to Table 7.1.6.3-2 where,

- $n_{\text{NB},0}, n_{\text{NB},5}$ is the smallest and the largest physical resource-block number, respectively, of the allocated narrowband as defined in Subclause 6.2.7 of [3]
- $\bar{N}_{\text{RB}}^{\text{DL}}$ is the value of the downlink system bandwidth
- P is the RBG size associated with the downlink system bandwidth, $\bar{N}_{\text{RB}}^{\text{DL}}$, according to Table 7.1.6.1-1
- $n_{\text{RB}} = \min\left(P \left\lfloor \frac{n_{\text{NB},5}}{P} \right\rfloor + P, \bar{N}_{\text{RB}}^{\text{DL}}\right) - n_{\text{NB},0} - 1$
- Physical resource-blocks with indices $RB_{\text{start}} + l < 0$ or $RB_{\text{start}} + l \geq N_{\text{RB}}^{\text{DL}}, l = 0, 1, \dots, L_{\text{CRBs}} - 1$ correspond to physical resource-blocks outside the allocated narrowband relative to physical resource-block $n_{\text{NB},0}$
- L_{CRBs} shall not exceed $(\bar{N}_{\text{RB}}^{\text{DL}} - n_{\text{NB},0} - RB_{\text{start}})$

Table 7.1.6.3-2: RB_{start} and L_{CRBs} for $0 \leq RIV - N_{RB}^{DL}(N_{RB}^{DL} + 1)/2 < 10$ and **CEModeA**

| $RIV - N_{RB}^{DL}(N_{RB}^{DL} + 1)/2$ | RB_{start} | L_{CRBs} |
|--|--|------------|
| 0 | $P \left\lfloor \frac{n_{NB,0}}{P} \right\rfloor - n_{NB,0}$ | 2 |
| 1 | | 3 |
| 2 | | 4 |
| 3 | | 5 |
| 4 | | 6 |
| 5 | n_{RB} | 6 |
| 6 | $n_{RB} + 1$ | 5 |
| 7 | $n_{RB} + 2$ | 4 |
| 8 | $n_{RB} + 3$ | 3 |
| 9 | $n_{RB} + 4$ | 2 |

For PDCCH DCI format 1C or for PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and $N_{RB}^{DL} \geq 20$, a type 2 resource block assignment field consists of a resource indication value (RIV) corresponding to a virtual starting resource block ($RB_{start} = 0$, N_{RB}^{step} , $2N_{RB}^{step}$, ..., $(\lfloor N_{VRB}^{DL} / N_{RB}^{step} \rfloor - 1)N_{RB}^{step}$) and a length in terms of virtually contiguously allocated resource blocks ($L_{CRBs} = N_{RB}^{step}$, $2N_{RB}^{step}$, ..., $\lfloor N_{VRB}^{DL} / N_{RB}^{step} \rfloor \cdot N_{RB}^{step}$).

The resource indication value is defined by:

if $(L'_{CRBs} - 1) \leq \lfloor N'_{VRB}^{DL} / 2 \rfloor$ then

$$RIV = N'_{VRB}^{DL}(L'_{CRBs} - 1) + RB'_{start}$$

else

$$RIV = N'_{VRB}^{DL}(N'_{VRB}^{DL} - L'_{CRBs} + 1) + (N'_{VRB}^{DL} - 1 - RB'_{start})$$

where $L'_{CRBs} = L_{CRBs} / N_{RB}^{step}$, $RB'_{start} = RB_{start} / N_{RB}^{step}$ and $N'_{VRB}^{DL} = \lfloor N_{VRB}^{DL} / N_{RB}^{step} \rfloor$, and where

$$L'_{CRBs} \geq 1 \text{ and shall not exceed } N'_{VRB}^{DL} - RB'_{start}.$$

For PDCCH DCI format 1C or for PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and $N_{RB}^{DL} \geq 26$, the starting resource block index is the same as the virtual starting resource block index (RB_{start}). For PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and $20 \leq N_{RB}^{DL} \leq 26$, the LSB of RIV indicates whether the starting resource block index is RB_{start} or $RB_{start} + 2$ (value 0 indicates RB_{start} and value 1 indicates $RB_{start} + 2$). In case of resource allocation signalled with

- PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D, and $20 \leq N_{RB}^{DL} \leq 26$, if the resource allocation indicates the corresponding PDSCH is mapped to RB index 23, the UE shall assume the PDSCH is also mapped to RB index 24.
- PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, and $27 \leq N_{RB}^{DL} \leq 63$, if the resource allocation indicates the corresponding PDSCH is mapped to RB index 47, the UE shall assume the PDSCH is also mapped to RB index 48 and 49.
- PDCCH/SPDCCCH DCI format 7-1A/7-1B/7-1C/7-1D, and $64 \leq N_{RB}^{DL} \leq 75$, if the resource allocation indicates the corresponding PDSCH is mapped to RB index 71, the UE shall assume the PDSCH is also mapped to RB index 72, 73 and 74.

- PDCCH/SPDCCH DCI format 7-1E/7-1F/7-1G, and $64 \leq N_{\text{RB}}^{\text{DL}} \leq 75$, if the resource allocation indicates the corresponding PDSCH is mapped to RB index 71, the UE shall assume the PDSCH is also mapped to RB index 72, and 73.

7.1.6.4 PDSCH starting position

This Subclause describes PDSCH starting position for UEs that are not BL/CE UEs.

PDSCH starting position for BL/CE UEs is described in Subclause 7.1.6.4A.

The starting OFDM symbol for the PDSCH of each activated serving cell is given by index $l_{\text{DataStart}}$.

For a UE configured in transmission mode 1-9, for a given activated serving cell

- if the PDSCH is assigned by EPDCCH received in the same serving cell, or if the UE is configured to monitor EPDCCH in the subframe and the PDSCH is not assigned by a PDCCH/EPDCCH, and if the UE is configured with the higher layer parameter *epdcch-StartSymbol-r11*
 - $l_{\text{DataStart}}$ is given by the higher-layer parameter *epdcch-StartSymbol-r11*.
- else if PDSCH and the corresponding PDCCH/EPDCCH are received on different serving cells
 - $l_{\text{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received,
- Otherwise
 - $l_{\text{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{DataStart}}$ is given by the CFI value + 1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$.

For a UE configured in transmission mode 10, for a given activated serving cell

- if the PDSCH is assigned by a PDCCH with DCI format 1C or by a PDCCH with DCI format 1A and with CRC scrambled with P-RNTI/RA-RNTI/SI-RNTI/Temporary C-RNTI
 - $l_{\text{DataStart}}$ is given by the span of the DCI given by the CFI value in the subframe of the given serving cell according to Subclause 5.3.4 of [4].
- if the PDSCH is assigned by a PDCCH/EPDCCH with DCI format 1A and with CRC scrambled with C-RNTI and if the PDSCH transmission is on antenna ports 0 - 3
 - if the PDSCH is assigned by EPDCCH received in the same serving cell
 - $l_{\text{DataStart}}$ is given by $l_{\text{EPDCCHStart}}$ for the EPDCCH-PRB-set where EPDCCH with the DCI format 1A was received ($l_{\text{EPDCCHStart}}$ as defined in Subclause 9.1.4.1),
 - else if PDSCH and the corresponding PDCCH/EPDCCH are received on different serving cells
 - $l_{\text{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received.
 - otherwise
 - $l_{\text{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{DataStart}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$.
- if the PDSCH is assigned by or semi-statically scheduled by a PDCCH/EPDCCH with DCI format 1A and if the PDSCH transmission is on antenna port 7

- if the value of the higher layer parameter *pdsch-Start-r11* determined from parameter set 1 in table 7.1.9-1 for the serving cell on which PDSCH is received belongs to {1,2,3,4},
 - $l_{\text{DataStart}}$ is given by the higher layer parameter *pdsch-Start-r11* determined from parameter set 1 in table 7.1.9-1 for the serving cell on which PDSCH is received.
- else,
 - if PDSCH and the corresponding PDCCH/EPDCCH are received on different serving cells,
 - $l_{\text{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received
 - otherwise
 - $l_{\text{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and
 $l_{\text{DataStart}}$ is given by the CFI value + 1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$.
- if the subframe on which PDSCH is received is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* determined from parameter set 1 in table 7.1.9-1 for the serving cell on which PDSCH is received, or if the PDSCH is received on subframe 1 or 6 for the frame structure type 2,
 - $l_{\text{DataStart}} = \min(2, l_{\text{DataStart}})$,
 - otherwise
 - $l_{\text{DataStart}} = l_{\text{DataStart}}$.
- if the PDSCH is assigned by or semi-persistently scheduled by a PDCCH/EPDCCH with DCI format 2D,
 - if the value of the higher layer parameter *pdsch-Start-r11* determined from the DCI (according to Subclause 7.1.9) for the serving cell on which PDSCH is received belongs to {1,2,3,4},
 - $l_{\text{DataStart}}$ is given by parameter *pdsch-Start-r11* determined from the DCI (according to Subclause 7.1.9) for the serving cell on which PDSCH is received except if UE is configured with Type C quasi co-location and when two codewords are transmitted then $l_{\text{DataStart}}$ is given by the maximum of the *pdsch-Start-r11* and *pdsch-Start2-r15* parameters,
 - else,
 - if PDSCH and the corresponding PDCCH/EPDCCH are received on different serving cells,
 - $l_{\text{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received
 - Otherwise
 - $l_{\text{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and
 $l_{\text{DataStart}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$.
 - if the subframe on which PDSCH is received is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* determined from the DCI (according to Subclause 7.1.9) for the serving cell on which PDSCH is received, or if the PDSCH is received on subframe 1 or 6 for frame structure type 2,
 - $l_{\text{DataStart}} = \min(2, l_{\text{DataStart}})$,
 - otherwise
 - $l_{\text{DataStart}} = l_{\text{DataStart}}$.

7.1.6.4A PDSCH starting position for BL/CE UEs

The starting OFDM symbol for PDSCH is given by index $l_{\text{DataStart}}$ in the first slot in a subframe k and is determined as follows

- for reception of SIB1-BR
 - $l_{\text{DataStart}} = 3$ if $N_{\text{RB}}^{\text{DL}} > 10$ for the cell on which PDSCH is received
 - $l_{\text{DataStart}} = 4$ if $N_{\text{RB}}^{\text{DL}} \leq 10$ for the cell on which PDSCH is received
- else
 - $l_{\text{DataStart}}$ is given by the higher layer parameter *startSymbolBR*
 - if subframe k is a special subframe or configured as an MBSFN subframe, and if the BL/CE UE is configured in CEModeA
 - $l_{\text{DataStart}} = \min(2, l_{\text{DataStart}})$
 - else
 - $l_{\text{DataStart}} = l_{\text{DataStart}}$.

7.1.6.5 Physical Resource Block (PRB) bundling

A UE configured for transmission mode 9 for a given serving cell c may assume that precoding granularity is multiple resource blocks in the frequency domain when PMI/RI reporting is configured.

For a given serving cell c , if a UE is configured for transmission mode 10

- if PMI/RI reporting is configured for all configured CSI processes for the serving cell c , the UE may assume that precoding granularity is multiple resource blocks in the frequency domain,
- otherwise, the UE shall assume the precoding granularity is one resource block in the frequency domain.

If the UE is non-BL/CE UE, fixed system bandwidth dependent Precoding Resource block Groups (PRGs) of size P' partition the system bandwidth and each PRG consists of consecutive PRBs. The PRG size a UE may assume for a given system bandwidth is given by Table 7.1.6.5-1. If $N_{\text{RB}}^{\text{DL}} \bmod P' > 0$ then one of the PRGs is of size $N_{\text{RB}}^{\text{DL}} - P' \lfloor N_{\text{RB}}^{\text{DL}} / P' \rfloor$. The PRG size is non-increasing starting at the lowest frequency. The UE may assume that the same precoder applies on all scheduled PRBs within a PRG.

If the UE is a BL/CE UE not configured with higher layer parameter *ce-PDSCH-FlexibleStartPRB-AllocConfig-r15*, PRGs of size $P' = 3$ partition a narrowband with RB indices 0-2 in the narrowband in one PRG and RB indices 3-5 in the narrowband in another PRG.

If the UE is a BL/CE UE configured with CEModeA and configured with higher layer parameter *ce-PDSCH-FlexibleStartPRB-AllocConfig-r15*,

- if $0 \leq RIV - N_{\text{RB}}^{\text{DL}}(N_{\text{RB}}^{\text{DL}} + 1)/2 < 5$ in Table 7.1.6.3-2, then the set of two PRGs is starting from RB_{start} ;
- if $5 \leq RIV - N_{\text{RB}}^{\text{DL}}(N_{\text{RB}}^{\text{DL}} + 1)/2 < 10$, then the set of two PRGs is ending ending at $(RB_{\text{start}} + L_{\text{CRBS}} - 1)$.

If the UE is a BL/CE UE configured with CEModeB and configured with higher layer parameter *ce-PDSCH-FlexibleStartPRB-AllocConfig-r15*, the set of PRGs is starting from the lowest RB of the narrowband n_{NB} shifted by $n_{\text{NB}}^{\text{shift}}$, according to Table 6.2.7-1 [3].

Table 7.1.6.5-1

| System Bandwidth ($N_{\text{RB}}^{\text{DL}}$) | PRG Size (P') (PRBs) |
|--|--|
| ≤10 | 1 |
| 11 – 26 | 2 |
| 27 – 63 | 3 |
| 64 – 110 | 2 |

For a UE configured for transmission mode 9, 10 using frame structure type 1 or transmission modes 8, 9, 10 using frame structure type 2, for a given serving cell c and for slot/subslot-PDSCH transmissions, precoding granularity is 2 resource blocks in frequency domain. Precoding Resource block Groups (PRGs) of size 2 partition the system bandwidth and each PRG consists of consecutive PRBs. The UE is expected to receive UE-specific reference signal corresponding to a PDSCH over both resource blocks of a PRG. If $N_{\text{RB}}^{\text{DL}} \bmod 2 > 0$ then, PDSCH is not mapped to the last resource block. The UE may assume that the same precoder applies on the two PRBs within a PRG.

7.1.7 Modulation order and transport block size determination

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

- if the UE is a BL/CE UE
 - if PDSCH is assigned by MPDCCH DCI format 6-1A
 - if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the DCI is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1
 - read the 5-bit extended "modulation and coding scheme (I_{MCS}^1)" field in the DCI
 - otherwise
 - read the 4-bit "modulation and coding scheme (I_{MCS}^1)" field in the DCI
 - The UE is not expected to receive a DCI format 6-1A indicating $I_{\text{MCS}}^1 > 15$
 - else if PDSCH is assigned by MPDCCH DCI format 6-2
 - read the 3-bit "modulation and coding scheme (I_{MCS}^1)" field in the DCI
 - The UE is not expected to receive a DCI format 6-2 indicating $I_{\text{MCS}}^1 > 7$
 - else if PDSCH is assigned by MPDCCH DCI format 6-1B
 - read the 4-bit "modulation and coding scheme (I_{MCS}^1)" field in the DCI and set $I_{\text{TBS}}^1 = I_{\text{MCS}}^1$.
 - else if PDSCH carriers *SystemInformationBlockType1-BR*
 - set I_{TBS} to the value of the parameter *schedulingInfoSIB1-BR* configured by higher-layers
- otherwise
 - read the 5 or 6-bit "modulation and coding scheme" field (I_{MCS}) in the DCI

and second if the PDCCH DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI then

- for DCI format 1A:
 - set the Table 7.1.7.2.1-1 column indicator N_{PRB} to $N_{\text{PRB}}^{1\text{A}}$ from Subclause 5.3.3.1.3 in [4]
- for DCI format 1C:
 - use Table 7.1.7.2.3-1 for determining its transport block size.

else

- if the UE is a BL/CE UE
 - if MPDCCH DCI CRC is scrambled by RA-RNTI for DCI format 6-1A
 - set the Table 7.1.7.2.1-1 column indicator N_{PRB} to $N_{\text{PRB}}^{1\text{A}}$ from Subclause 5.3.3.1.12 in [4]
 - else if PDSCH is assigned by MPDCCH DCI format 6-2
 - use Table 7.1.7.2.3-1 for determining its transport block size.
 - else if PDSCH carriers *SystemInformationBlockType1-BR*

- use Subclause 7.1.7.2.7 for determining its transport block size.
- else if PDSCH is assigned by MPDCCH DCI format 6-1B
 - use Subclause 7.1.7.2.6 for determining its transport block size if the UE is not configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value $\geq 5\text{MHz}$ and not configured with higher layer parameter *mpdch-PDSCH-MaxBandwidth-SC-MTCH* with value 24 PRBs.
- otherwise,
 - set N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Subclause 7.1.6.
 - if PDSCH is assigned by MPDCCH DCI format 6-1A, the repetition number field in the DCI indicates PDSCH repetition level 1, and the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, then
 - for special subframe configuration 9 with normal cyclic prefix:

$$N_{\text{PRB}} = \max \left\{ \left\lfloor N'_{\text{PRB}} \times 0.375 \right\rfloor, 1 \right\}$$
 - set the Table 7.1.7.2.1-1 column indicator
 - for other special subframe configurations:
 - set the Table 7.1.7.2.1-1 column indicator $N_{\text{PRB}} = \max \left\{ \left\lfloor N'_{\text{PRB}} \times 0.75 \right\rfloor, 1 \right\}$,
 - else set the Table 7.1.7.2.1-1 column indicator $N_{\text{PRB}} = N'_{\text{PRB}}$.
- otherwise
 - set N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Subclause 7.1.6.
 - if the higher layer parameter *altMCS-Table* is not configured, or for PDSCH assigned by DCI other than DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI; if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, or is transmitted in the subframes with the same duration as the DwPTS duration of a special subframe configuration in frame structure type 3, then
 - for special subframe configuration 9 and 10 with normal cyclic prefix or special subframe configuration 7 with extended cyclic prefix:

$$N_{\text{PRB}} = \max \left\{ \left\lfloor N'_{\text{PRB}} \times 0.375 \right\rfloor, 1 \right\}$$
 - set the Table 7.1.7.2.1-1 column indicator
 - for other special subframe configurations:
 - set the Table 7.1.7.2.1-1 column indicator $N_{\text{PRB}} = \max \left\{ \left\lfloor N'_{\text{PRB}} \times 0.75 \right\rfloor, 1 \right\}$,
 - else if the higher layer parameter *altMCS-Table* is configured, and for PDSCH assigned by DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI; if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, or is transmitted in the subframes with the same duration as the DwPTS duration of a special subframe configuration in frame structure type 3, then
 - if $44 \leq I_{\text{MCS}} \leq 58$, set α to higher layer parameter *altMCS-Table-scaling*, otherwise $\alpha = 1$
 - for special subframe configuration 9 and 10 with normal cyclic prefix or special subframe configuration 7 with extended cyclic prefix:
 - set the Table 7.1.7.2.1-1 column indicator $N_{\text{PRB}} = \max \{ [N'_{\text{PRB}} \times 0.375 \times \alpha], 1 \}$
 - for other special subframe configurations:
 - set the Table 7.1.7.2.1-1 column indicator $N_{\text{PRB}} = \max \{ [N'_{\text{PRB}} \times 0.75 \times \alpha], 1 \}$

- else if the higher layer parameter *altMCS-Table* is configured, and for PDSCH assigned by DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI; then
 - if $44 \leq I_{MCS} \leq 58$, set α to higher layer parameter *altMCS-Table-scaling*, otherwise $\alpha = 1$
 - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\{[N'_{PRB} \times \alpha], 1\}$
 - else, set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.
- for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the derived transport block size (after TBS translation as described in sections 7.1.7.2.2, 7.1.7.2.4, 7.1.7.2.5 when the transport block is mapped to more than one spatial layer) is scaled by α ($\alpha = 0.5$ for slot-PDSCH, and $\alpha = \frac{1}{6}$ for subslot-PDSCH), then rounded to the closest (NOTE 1) valid transport block size in
 - Table 7.1.7.2.1-1 when the transport block is mapped to one spatial layer,
 - The union of Table 7.1.7.2.1-1 and Table 7.1.7.2.2-1 when the transport block is mapped to two spatial layers,
 - The union of Table 7.1.7.2.1-1 and Table 7.1.7.2.4-1 when the transport block is mapped to three spatial layers,
 - The union of Table 7.1.7.2.1-1 and Table 7.1.7.2.5-1 when the transport block is mapped to four spatial layers.

If the scaled TBS is closest to two valid transport block sizes, it is rounded to the larger transport block size.

NOTE 1: In the rounding procedure, and for a given serving cell:

- For UEs configured with neither *altCQI-Table1024QAM-STTI* nor *altCQI-TableSTTI*, the UE shall only include in the rounding procedure the TBS entries present in Table 7.1.7.2.1-1 with $I_{TBS} \leq 26A$, and the entries in 7.1.7.2.2-1, 7.1.7.2.4-1, 7.1.7.2.5-1 for which the TBS_L1 is present in Table 7.1.7.2.1-1 with $I_{TBS} \leq 26A$.
- For UEs configured with *altCQI-TableSTTI*, the UE shall only include in the rounding procedure the TBS entries present in Table 7.1.7.2.1-1 with $I_{TBS} \leq 33B$, and the entries in 7.1.7.2.2-1, 7.1.7.2.4-1, 7.1.7.2.5-1 for which the TBS_L1 is present in Table 7.1.7.2.1-1 with $I_{TBS} \leq 33B$.

The UE may skip decoding a transport block in an initial transmission if the effective channel code rate is higher than 0.932, where the effective channel code rate is defined as the number of downlink information bits (including CRC bits) divided by the number of physical channel bits on PDSCH. If the UE skips decoding, the physical layer indicates to higher layer that the transport block is not successfully decoded. For the special subframe configurations 0 and 5 with normal downlink CP or configurations 0 and 4 with extended downlink CP in frame structure type 2, or for subframes with the same duration as the DwPTS duration of the special subframe configuration 0 and 5 in frame structure type 3, with the special subframe configurations shown in Table 4.2-1 of [3], or for the special subframe configuration 10 configured by the higher layer signalling *ssp10-CRS-LessDwPTS*, a non-BL/CE UE shall assume there is no PDSCH transmission in DwPTS of the special subframe.

For frame structure type 2, a BL/CE UE shall assume PDSCH is dropped in a special subframe considered as BL/CE DL subframe according to Subclause 6.8B.1 of [3] in the following cases

- for PDSCH scheduled from UE-specific search space, Type0-MPDCCH common search space, Type1-MPDCCH common search space or Type2-MPDCCH common search space, if an MPDCCH belonging to the corresponding search space is dropped in the special subframe according to clause 9.1.5.
- if PDSCH carries SI messages.

7.1.7.1 Modulation order and redundancy version determination

For BL/CE UEs configured with CEModeA, I_{MCS}^1 is used in place of I_{MCS} in the rest of this Subclause.

The UE shall use $Q_m = 2$ if the DCI CRC is scrambled by P-RNTI, RA-RNTI, SI-RNTI, or SC-RNTI, or if PDSCH is assigned by MPDCCH DCI Format 6-1B, or if PDSCH carries *SystemInformationBlockType1-BR*, or if PDSCH carries BL/CE SI messages, or if the UE is configured with CEModeA and higher layer parameter *ce-pdsch-puschEnhancement-config* with value 'On' and repetition number field in the corresponding DCI indicates a value greater than 1, otherwise,

- if the higher layer parameter *altMCS-Table* is configured, and if the PDSCH is assigned by a PDCCH/EPDCCH with DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI,
- if the assigned PDSCH is transmitted only in the second slot of a subframe, the UE shall use I_{MCS} and Table 7.1.7.1-1C to determine the modulation order (Q_m^+). The modulation order (Q_m) used in the physical downlink shared channel is set to $Q_m = Q_m^+$;
- otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1C to determine the modulation order (Q_m) used in the physical downlink shared channel.
- else if the higher layer parameter *altCQI-Table-1024QAM-r15* is configured, and if the PDSCH is assigned by a PDCCH/EPDCCH with DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI,
- if the assigned PDSCH is transmitted only in the second slot of a subframe, the UE shall use I_{MCS} and Table 7.1.7.1-1B to determine the modulation order (Q_m^+). The modulation order (Q_m) used in the physical downlink shared channel is set to $Q_m = Q_m^+$;
- otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1B to determine the modulation order (Q_m) used in the physical downlink shared channel.
- else if the higher layer parameter *altCQI-Table-1024QAM-STTI_r15* is configured, and if the PDSCH is assigned by a PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI or SPS-C-RNTI,
- the UE shall use I_{MCS} and Table 7.1.7.1-1B to determine the modulation order (Q_m) used in the physical downlink shared channel.
- else if the higher layer parameter *altCQI-Table-r12* is configured, and if the PDSCH is assigned by a PDCCH/EPDCCH with DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI,
- if the assigned PDSCH is transmitted only in the second slot of a subframe, the UE shall use I_{MCS} and Table 7.1.7.1-1A to determine the modulation order (Q_m^+). The modulation order (Q_m) used in the physical downlink shared channel is set to $Q_m = Q_m^+$;
- otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1A to determine the modulation order (Q_m) used in the physical downlink shared channel.
- else
 - if the higher layer parameter *altCQI-Table-STTI-r15* is configured, and if the PDSCH is assigned by a PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI,
 - the UE shall use I_{MCS} and Table 7.1.7.1-1A to determine the modulation order (Q_m) used in the physical downlink shared channel.
 - if the assigned PDSCH is transmitted only in the second slot of a subframe, the UE shall use I_{MCS} and Table 7.1.7.1-1 to determine the modulation order (Q_m^+). The modulation order (Q_m) used in the physical downlink shared channel is set to $Q_m = Q_m^+$;
 - otherwise, the UE shall use I_{MCS} and Table 7.1.7.1-1 to determine the modulation order (Q_m) used in the physical downlink shared channel.

Table 7.1.7.1-1: Modulation and TBS index table for PDSCH

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|--------------------------------------|--|---|--------------------------------------|
| 0 | 2 | 2 | 0 |
| 1 | 2 | 2 | 1 |
| 2 | 2 | 2 | 2 |
| 3 | 2 | 2 | 3 |
| 4 | 2 | 2 | 4 |
| 5 | 2 | 4 | 5 |
| 6 | 2 | 4 | 6 |
| 7 | 2 | 4 | 7 |
| 8 | 2 | 4 | 8 |
| 9 | 2 | 4 | 9 |
| 10 | 4 | 6 | 9 |
| 11 | 4 | 6 | 10 |
| 12 | 4 | 6 | 11 |
| 13 | 4 | 6 | 12 |
| 14 | 4 | 6 | 13 |
| 15 | 4 | 6 | 14 |
| 16 | 4 | 6 | 15 |
| 17 | 6 | 6 | 15 |
| 18 | 6 | 6 | 16 |
| 19 | 6 | 6 | 17 |
| 20 | 6 | 6 | 18 |
| 21 | 6 | 6 | 19 |
| 22 | 6 | 6 | 20 |
| 23 | 6 | 6 | 21 |
| 24 | 6 | 6 | 22 |
| 25 | 6 | 6 | 23 |
| 26 | 6 | 6 | 24 |
| 27 | 6 | 6 | 25 |
| 28 | 6 | 6 | 26/26A |
| 29 | 2 | 2 | reserved |
| 30 | 4 | 4 | |
| 31 | 6 | 6 | |

Table 7.1.7.1-1A. Modulation and TBS index table 2 for PDSCH

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|--------------------------------------|--|---|--------------------------------------|
| 0 | 2 | 2 | 0 |
| 1 | 2 | 2 | 2 |
| 2 | 2 | 2 | 4 |
| 3 | 2 | 4 | 6 |
| 4 | 2 | 4 | 8 |
| 5 | 4 | 6 | 10 |
| 6 | 4 | 6 | 11 |
| 7 | 4 | 6 | 12 |
| 8 | 4 | 6 | 13 |
| 9 | 4 | 6 | 14 |
| 10 | 4 | 8 | 15 |
| 11 | 6 | 8 | 16 |
| 12 | 6 | 8 | 17 |
| 13 | 6 | 8 | 18 |
| 14 | 6 | 8 | 19 |

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|-------------------------------|-------------------------------------|--------------------------------------|-------------------------------|
| 15 | 6 | 8 | 20 |
| 16 | 6 | 8 | 21 |
| 17 | 6 | 8 | 22 |
| 18 | 6 | 8 | 23 |
| 19 | 6 | 8 | 24 |
| 20 | 8 | 8 | 25 |
| 21 | 8 | 8 | 27 |
| 22 | 8 | 8 | 28 |
| 23 | 8 | 8 | 29 |
| 24 | 8 | 8 | 30 |
| 25 | 8 | 8 | 31 |
| 26 | 8 | 8 | 32 |
| 27 | 8 | 8 | 33/33A/33B |
| 28 | 2 | 2 | reserved |
| 29 | 4 | 4 | |
| 30 | 6 | 6 | |
| 31 | 8 | 8 | |

Table 7.1.7.1-1B. Modulation and TBS index table 3 for PDSCH

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|-------------------------------|-------------------------------------|--------------------------------------|-------------------------------|
| 0 | 2 | 2 | 0 |
| 1 | 2 | 2 | 2 |
| 2 | 2 | 2 | 4 |
| 3 | 2 | 4 | 6 |
| 4 | 2 | 4 | 8 |
| 5 | 4 | 6 | 11 |
| 6 | 4 | 6 | 13 |
| 7 | 4 | 8 | 15 |
| 8 | 6 | 8 | 16 |
| 9 | 6 | 8 | 18 |
| 10 | 6 | 8 | 20 |
| 11 | 6 | 8 | 21 |
| 12 | 6 | 8 | 22 |
| 13 | 6 | 8 | 23 |
| 14 | 6 | 8 | 24 |
| 15 | 8 | 8 | 25 |
| 16 | 8 | 8 | 27 |
| 17 | 8 | 8 | 28 |
| 18 | 8 | 8 | 29 |
| 19 | 8 | 8 | 30 |
| 20 | 8 | 8 | 31 |

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|-------------------------------|-------------------------------------|--------------------------------------|-------------------------------|
| 21 | 8 | 8 | 32 |
| 22 | 8 | 8 | 33/33A/33B |
| 23 | 10 | 10 | 34A |
| 24 | 10 | 10 | 35 |
| 25 | 10 | 10 | 36 |
| 26 | 10 | 10 | 37A/37 |
| 27 | 2 | 2 | reserved |
| 28 | 4 | 4 | |
| 29 | 6 | 6 | |
| 30 | 8 | 8 | |
| 31 | 10 | 10 | |

Table 7.1.7.1-1C. Modulation and TBS index table 4 for PDSCH

| MCS Index I_{MCS} | Modulation Order \mathcal{Q}_m | Modulation Order \mathcal{Q}'_m | TBS Index I_{TBS} |
|-------------------------------|-------------------------------------|--------------------------------------|-------------------------------|
| 0 | 2 | 2 | 0 |
| 1 | 2 | 2 | 1 |
| 2 | 2 | 2 | 2 |
| 3 | 2 | 2 | 3 |
| 4 | 2 | 2 | 4 |
| 5 | 2 | 4 | 5 |
| 6 | 2 | 4 | 6 |
| 7 | 2 | 4 | 7 |
| 8 | 2 | 4 | 8 |
| 9 | 2 | 4 | 9 |
| 10 | 4 | 6 | 9 |
| 11 | 4 | 6 | 10 |
| 12 | 4 | 6 | 11 |
| 13 | 4 | 6 | 12 |
| 14 | 4 | 6 | 13 |
| 15 | 4 | 6 | 14 |
| 16 | 4 | 6 | 15 |
| 17 | 6 | 6 | 15 |
| 18 | 6 | 6 | 16 |
| 19 | 6 | 6 | 17 |
| 20 | 6 | 6 | 18 |
| 21 | 6 | 6 | 19 |
| 22 | 6 | 6 | 20 |
| 23 | 6 | 6 | 21 |
| 24 | 6 | 6 | 22 |
| 25 | 6 | 6 | 23 |
| 26 | 6 | 6 | 24 |
| 27 | 6 | 6 | 25 |

| MCS Index I_{MCS} | Modulation Order Q_m | Modulation Order Q'_m | TBS Index I_{TBS} |
|-------------------------------|---------------------------|----------------------------|-------------------------------|
| 28 | 6 | 6 | 27 |
| 29 | 6 | 6 | 28 |
| 30 | 8 | 8 | 25 |
| 31 | 8 | 8 | 27 |
| 32 | 8 | 8 | 28 |
| 33 | 8 | 8 | 29 |
| 34 | 8 | 8 | 30 |
| 35 | 8 | 8 | 31 |
| 36 | 8 | 8 | 32 |
| 37 | 8 | 8 | 33A |
| 38 | 8 | 8 | 33/33B |
| 39 | 10 | 10 | 34A |
| 40 | 10 | 10 | 35 |
| 41 | 10 | 10 | 36 |
| 42 | 10 | 10 | 37A |
| 43 | 10 | 10 | 37 |
| 44 | 2 | 2 | 0 |
| 45 | 2 | 2 | 2 |
| 46 | 4 | 6 | 9 |
| 47 | 4 | 6 | 11 |
| 48 | 4 | 6 | 13 |
| 49 | 6 | 6 | 15 |
| 50 | 6 | 6 | 17 |
| 51 | 6 | 6 | 19 |
| 52 | 6 | 6 | 21 |
| 53 | 8 | 8 | 25 |
| 54 | 8 | 8 | 28 |
| 55 | 8 | 8 | 30 |
| 56 | 8 | 8 | 32 |
| 57 | 10 | 10 | 34A |
| 58 | 10 | 10 | 36 |
| 59 | 2 | 2 | Reserved |
| 60 | 4 | 4 | |
| 61 | 6 | 6 | |
| 62 | 8 | 8 | |
| 63 | 10 | 10 | |

For a given serving cell, if the UE is configured with higher layer parameter *blindSubframePDSCH-Repetitions*, for PDSCH transmitted in a given block of k subframes corresponding to DCI format 1A with CRC scrambled by C-RNTI in UE-specific search space, the redundancy version (rv_{idx}) for the j^{th} subframe is determined according to

- Table 7.1.7.1-2 using $rv = (j + rv_{DCI}) \bmod 4$, where $j = 0, 1, \dots, k - 1$ if the configured higher layer parameter *RV-cyclingSequenceSubframePDSCH-Repetitions* parameter is set to '{0,2,3,1}';
- Otherwise, $rv = 0$ for all of the k PDSCH transmissions.

where the value of rv_{DCI} and k are determined by the 'Redundancy version' and 'Repetition number' fields in the corresponding DCI, respectively.

For a given serving cell, if the UE is configured with higher layer parameter *blindSlotSubslotPDSCH-Repetitions*, for PDSCH transmitted in a given block of k slots/subslots corresponding to DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the redundancy version (rv_{idx}) for the j^{th} slot/subslot is determined according to

- Table 7.1.7.1-2 using $rv = (j + rv_{DCI}) \bmod 4$, where $j = 0, 1, \dots, k - 1$ if the configured higher layer parameter *RV-cyclingSequenceSlotsublotPDSCH-Repetitions* parameter is set to '{0,2,3,1}';
- Otherwise, $rv = 0$ for all of the k PDSCH transmissions.

where the value of rv_{DCI} and k are determined by the 'Redundancy version' and 'Repetition number' fields in the corresponding DCI, respectively.

For a UE configured with *altMCS-Table*, the UE is not expected to receive a PDSCH with a modulation order of 1024QAM unless configured with *altCQI-Table-1024QAM-r15*, and the UE is not expected to receive a PDSCH with a modulation order of 256QAM unless configured with *altCQI-Table-r12* or *altCQI-Table-1024QAM-r15*.

For BL/CE UEs, the same redundancy version is applied to PDSCH transmitted in a given block of N_{acc} consecutive subframes, if the PDSCH is not carrying *SystemInformationBlockType1-BR* or SI message. The subframe number of the first subframe in each block of N_{acc} consecutive subframes, denoted as $n_{\text{abs},1}$, satisfies $(n_{\text{abs},1} - \delta) \bmod N_{\text{acc}} = 0$, where $\delta = 0$ for FDD and $\delta = 2$ for TDD. Denote i_0 as the subframe number of the first downlink subframe intended for PDSCH, given by $n+x$ as defined in Subclause 7.1.11. The PDSCH transmission spans $N_{\text{abs}}^{\text{PDSCH}}$ consecutive subframes including subframes that are not BL/CE DL subframes where the PDSCH transmission is postponed. For the j^{th} block of N_{acc} consecutive subframes within the set of $N_{\text{abs}}^{\text{PDSCH}}$ subframes, the redundancy version (rv_{idx}) is determined according to Table 7.1.7.1-2 using $rv = (j + rv_{DCI}) \bmod 4$, where

$$j = 0, 1, \dots, J^{\text{PDSCH}} - 1, \text{ and } J^{\text{PDSCH}} = \left\lceil \frac{N_{\text{abs}}^{\text{PDSCH}} + ((i_0 - \delta) \bmod N_{\text{acc}})}{N_{\text{acc}}} \right\rceil. \text{ The } J^{\text{PDSCH}} \text{ blocks of subframes are}$$

sequential in time, starting with $j = 0$ to which subframe i_0 belongs. For a BL/CE UE configured in CEModeA, $N_{\text{acc}} = 1$ and rv_{DCI} is determined by the 'Redundancy version' field in DCI format 6-1A. For a BL/CE UE configured with CEModeB, or a BL/CE UE receiving PDSCH associated with P-RNTI, $N_{\text{acc}} = 4$ for FDD and $N_{\text{acc}} = 10$ for TDD, and $rv_{DCI} = 0$.

Table 7.1.7.1-2: Redundancy version

| Redundancy version Index <i>rv</i> | <i>rv_{idx}</i> |
|---------------------------------------|-------------------------|
| 0 | 0 |
| 1 | 2 |
| 2 | 3 |
| 3 | 1 |

7.1.7.2 Transport block size determination

For BL/CE UEs configured with CEModeA, I_{MCS}^1 is used in place of I_{MCS} in the rest of this Subclause

If the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI then

- for DCI format 1A or DCI format 6-1A:

- the UE shall set the TBS index (I_{TBS}) equal to I_{MCS} and determine its TBS by the procedure in Subclause 7.1.7.2.1 for $0 \leq I_{TBS} \leq 26$.
- for DCI format 1C and DCI format 6-2:
 - the UE shall set the TBS index (I_{TBS}) equal to I_{MCS} and determine its TBS from Table 7.1.7.2.3-1.

else if the DCI CRC is scrambled by SC-RNTI then

- the UE shall set the TBS index (I_{TBS}) equal to I_{MCS} and determine its TBS from Table 7.1.7.2.3-1.

else if the higher layer parameter *altMCS-Table* is configured, and for DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI

- for $0 \leq I_{MCS} \leq 58$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1C except if the transport block is disabled in DCI formats 2, 2A, 2B, 2C and 2D as specified below. When $I_{MCS} = 38$, if the UE is scheduled by DCI formats 1/1B/2/2A and is configured with b33 in *tbsIndexAlt2*, I_{TBS} is 33B; otherwise I_{TBS} is 33. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2. For a transport block that is mapped to three-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.4. For a transport block that is mapped to four-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.5.
- for $59 \leq I_{MCS} \leq 63$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{MCS} \leq 58$.
- In DCI formats 2, 2A, 2B, 2C and 2D a transport block is disabled if $I_{MCS} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.

else if the higher layer parameter *altCQI-Table-r12* is configured, then

- for DCI format 1A with CRC scrambled by C-RNTI and for DCI format 1/1A/2/2A/2B/2C/2D with CRC scrambled by SPS C-RNTI:
 - for $0 \leq I_{MCS} \leq 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1 except if the transport block is disabled in DCI formats 2, 2A, 2B, 2C and 2D as specified below. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1.
 - for $29 \leq I_{MCS} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{TBS} \leq 33$. If there is no PDCCH/EPDCCH for the same transport block using $0 \leq I_{TBS} \leq 26$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/EPDCCH.
 - In DCI formats 2, 2A, 2B, 2C and 2D a transport block is disabled if $I_{MCS} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.
- for DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI
 - for $0 \leq I_{MCS} \leq 27$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1A except if the transport block is disabled in DCI formats 2, 2A, 2B, 2C and 2D as specified below. When $I_{MCS} = 27$, if the UE is scheduled by DCI formats 2C/2D and is configured with a33 in *tbsIndexAlt*, I_{TBS} is 33A, or if the UE is scheduled by DCI formats 1/1B/2/2A and is configured with b33 in *tbsIndexAlt2*, I_{TBS} is 33B; otherwise I_{TBS} is 33. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2. For a transport

block that is mapped to three-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.4. For a transport block that is mapped to four-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.5.

- for $28 \leq I_{\text{MCS}} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{\text{TBS}} \leq 27$.
- In DCI formats 2, 2A, 2B, 2C and 2D a transport block is disabled if $I_{\text{MCS}} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.

else if the higher layer parameter *altCQI-Table-STTI-r15* is configured, then

- for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by SPS C-RNTI:
 - for $0 \leq I_{\text{MCS}} \leq 28$, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} by the procedure in Subclause 7.1.7.
 - for $29 \leq I_{\text{MCS}} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/SPDCCH for the same transport block using $0 \leq I_{\text{TBS}} \leq 33$. If there is no PDCCH/SPDCCH for the same transport block using $0 \leq I_{\text{TBS}} \leq 26$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/SPDCCH.
- for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI
 - for $0 \leq I_{\text{MCS}} \leq 27$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1A. When $I_{\text{MCS}} = 27$, if the UE is scheduled by DCI formats 7-1F/7-1G and is configured with a33 in *tbsIndexAlt-STTI*, I_{TBS} is 33A, or if the UE is scheduled by DCI formats 7-1D/7-1C/7-1B and is configured with b33 in *tbsIndexAlt2-STTI*, I_{TBS} is 33B; otherwise I_{TBS} is 33. When $I_{\text{MCS}} = 27$, I_{TBS} is 33. The TBS is determined by the procedure in Subclause 7.1.7.
 - for $28 \leq I_{\text{MCS}} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/SPDCCH for the same transport block using $0 \leq I_{\text{MCS}} \leq 27$.

else if the higher layer parameter *altCQI-Table-1024QAM-r15* is configured, then

- for DCI format 1A with CRC scrambled by C-RNTI and for DCI format 1/1A/2/2A/2B/2C/2D with CRC scrambled by SPS C-RNTI:
 - for $0 \leq I_{\text{MCS}} \leq 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1. For a transport block, the TBS is determined by the procedure in Subclause 7.1.7.2.1.
 - for $29 \leq I_{\text{MCS}} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{\text{TBS}} \leq 37$. If there is no PDCCH/EPDCCH for the same transport block using $0 \leq I_{\text{TBS}} \leq 26$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/EPDCCH.
- for DCI format 1/1B/1D/2/2A/2B/2C/2D with CRC scrambled by C-RNTI;
 - for $0 \leq I_{\text{MCS}} \leq 26$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1B except if the transport block is disabled in DCI formats 2, 2A, 2B, 2C and 2D as specified below. When $I_{\text{MCS}} = 22$, if the UE is scheduled by DCI formats 2C/2D and is configured with a33 in *tbsIndexAlt*, I_{TBS} is 33A, or if

the UE is scheduled by DCI formats 1/1B/2/2A and is configured with b33 in *tbsIndexAlt2*, I_{TBS} is 33B; otherwise I_{TBS} is 33. When $I_{MCS} = 26$, if the UE is configured with a37 in *tbsIndexAlt3*, I_{TBS} is 37A, otherwise I_{TBS} is 37. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2. For a transport block that is mapped to three-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.4. For a transport block that is mapped to four-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.5.

- for $27 \leq I_{MCS} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{TBS} \leq 37$. If there is no PDCCH/EPDCCH for the same transport block using $0 \leq I_{TBS} \leq 37$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/EPDCCH.
- In DCI formats 2, 2A, 2B, 2C and 2D a transport block is disabled if $I_{MCS} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.

else if the higher layer parameter *altCQI-Table-1024QAM-STTI_r15* is configured, then

- for DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI or SPS C-RNTI;
 - for $0 \leq I_{MCS} \leq 26$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1B. When $I_{MCS} = 22$, if the UE is scheduled by DCI formats 7-1F/7-1G and is configured with a33 in *tbsIndexAlt-STTI*, I_{TBS} is 33A, or if the UE is scheduled by DCI formats 7-1B/7-1C/7-1D and is configured with b33 in *tbsIndexAlt2-STTI*, I_{TBS} is 33B; otherwise I_{TBS} is 33. When $I_{MCS} = 26$, if the UE is scheduled by DCI formats 7-1F/7-1G and is configured with a37 in *tbsIndexAlt3-STTI*, I_{TBS} is 37A, otherwise I_{TBS} is 37. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7 and 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7 and 7.1.7.2.2. For a transport block that is mapped to three-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7 and 7.1.7.2.4. For a transport block that is mapped to four-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7 and 7.1.7.2.5.
 - for $27 \leq I_{MCS} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/SPDCCH for the same transport block using $0 \leq I_{TBS} \leq 37$. If there is no PDCCH/SPDCCH for the same transport block using $0 \leq I_{TBS} \leq 37$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/SPDCCH.

else if the UE supports *ce-pdsch-pusich-maxBandwidth* with value $\geq 5\text{MHz}$, or if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,

- for $29 \leq I_{MCS} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest MPDCCH for the same transport block using $0 \leq I_{MCS} \leq 28$. If there is no MPDCCH for the same transport block using $0 \leq I_{MCS} \leq 28$, and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment MPDCCH.
- for $0 \leq I_{MCS} \leq 28$ the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1
 - if the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value 5MHz or if the UE is configured with higher layer parameter *pdsch-MaxBandwidth-SC-MTCH* with value 24 PRBs

- For CEModeA,
 - if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,
 - set TBS' to the TBS determined by the procedure in Subclause 7.1.7.2.1,
 - $TBS = \min\{TBS', 4008\}$
 - otherwise, TBS is determined by the procedure in Subclause 7.1.7.2.8 for $0 \leq I_{TBS} \leq 14$
- For CEModeB, TBS is determined by the procedure in Subclause 7.1.7.2.8 for $0 \leq I_{TBS} \leq 9$
- if the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value $> 5\text{MHz}$
 - For CEModeA,
 - if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,
 - set TBS' to the TBS determined by the procedure in Subclause 7.1.7.2.1,
 - $TBS = \min\{TBS', 27376\}$
 - otherwise, TBS is determined by the procedure in Subclause 7.1.7.2.1 for $0 \leq I_{TBS} \leq 14$
 - For CEModeB, TBS is determined by the procedure in Subclause 7.1.7.2.1 for $0 \leq I_{TBS} \leq 9$
- otherwise,
 - if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the MPDCCH DCI format 6-1A is mapped onto the UE specific search space and the repetition number field in the DCI indicates PDSCH repetition level 1,
 - set TBS' to the TBS determined by the procedure in Subclause 7.1.7.2.1,
 - $TBS = \min\{TBS', 1000\}$
 - otherwise
 - TBS is determined by the procedure in Subclause 7.1.7.2.1

else

- for $0 \leq I_{MCS} \leq 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 7.1.7.1-1 except if the transport block is disabled in DCI formats 2, 2A, 2B, 2C and 2D as specified below. When $I_{MCS} = 28$, if the UE is scheduled by DCI formats 2C/2D and is configured with a26 in *tbsIndexAlt*, I_{TBS} is 26A; otherwise I_{TBS} is 26. For a transport block that is not mapped to more than single-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2. For a transport block that is mapped to three-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.4. For a transport block that is mapped to four-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.5.
- for $29 \leq I_{MCS} \leq 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \leq I_{MCS} \leq 28$. If there is no PDCCH/EPDCCH for the same transport block using $0 \leq I_{MCS} \leq 28$, and if the initial PDSCH for the same transport block is semi-

persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH/EPDCCH.

- In DCI formats 2, 2A, 2B, 2C and 2D a transport block is disabled if $I_{\text{MCS}} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.

The NDI and HARQ process ID, as signalled on PDCCH/EPDCCH/MPDCCH/SPDCCH, and the TBS, as determined above, shall be delivered to higher layers.

7.1.7.2.1 Transport blocks not mapped to two or more layer spatial multiplexing

For $1 \leq N_{\text{PRB}} \leq 110$, the TBS is given by the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1.

Table 7.1.7.2.1-1: Transport block size table (dimension 44x110)

| I_{TBS} | N_{PRB} | | | | | | | | | |
|------------------|------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 0 | 16 | 32 | 56 | 88 | 120 | 152 | 176 | 208 | 224 | 256 |
| 1 | 24 | 56 | 88 | 144 | 176 | 208 | 224 | 256 | 328 | 344 |
| 2 | 32 | 72 | 144 | 176 | 208 | 256 | 296 | 328 | 376 | 424 |
| 3 | 40 | 104 | 176 | 208 | 256 | 328 | 392 | 440 | 504 | 568 |
| 4 | 56 | 120 | 208 | 256 | 328 | 408 | 488 | 552 | 632 | 696 |
| 5 | 72 | 144 | 224 | 328 | 424 | 504 | 600 | 680 | 776 | 872 |
| 6 | 328 | 176 | 256 | 392 | 504 | 600 | 712 | 808 | 936 | 1032 |
| 7 | 104 | 224 | 328 | 472 | 584 | 712 | 840 | 968 | 1096 | 1224 |
| 8 | 120 | 256 | 392 | 536 | 680 | 808 | 968 | 1096 | 1256 | 1384 |
| 9 | 136 | 296 | 456 | 616 | 776 | 936 | 1096 | 1256 | 1416 | 1544 |
| 10 | 144 | 328 | 504 | 680 | 872 | 1032 | 1224 | 1384 | 1544 | 1736 |
| 11 | 176 | 376 | 584 | 776 | 1000 | 1192 | 1384 | 1608 | 1800 | 2024 |
| 12 | 208 | 440 | 680 | 904 | 1128 | 1352 | 1608 | 1800 | 2024 | 2280 |
| 13 | 224 | 488 | 744 | 1000 | 1256 | 1544 | 1800 | 2024 | 2280 | 2536 |
| 14 | 256 | 552 | 840 | 1128 | 1416 | 1736 | 1992 | 2280 | 2600 | 2856 |
| 15 | 280 | 600 | 904 | 1224 | 1544 | 1800 | 2152 | 2472 | 2728 | 3112 |
| 16 | 328 | 632 | 968 | 1288 | 1608 | 1928 | 2280 | 2600 | 2984 | 3240 |
| 17 | 336 | 696 | 1064 | 1416 | 1800 | 2152 | 2536 | 2856 | 3240 | 3624 |
| 18 | 376 | 776 | 1160 | 1544 | 1992 | 2344 | 2792 | 3112 | 3624 | 4008 |
| 19 | 408 | 840 | 1288 | 1736 | 2152 | 2600 | 2984 | 3496 | 3880 | 4264 |
| 20 | 440 | 904 | 1384 | 1864 | 2344 | 2792 | 3240 | 3752 | 4136 | 4584 |
| 21 | 488 | 1000 | 1480 | 1992 | 2472 | 2984 | 3496 | 4008 | 4584 | 4968 |
| 22 | 520 | 1064 | 1608 | 2152 | 2664 | 3240 | 3752 | 4264 | 4776 | 5352 |
| 23 | 552 | 1128 | 1736 | 2280 | 2856 | 3496 | 4008 | 4584 | 5160 | 5736 |
| 24 | 584 | 1192 | 1800 | 2408 | 2984 | 3624 | 4264 | 4968 | 5544 | 5992 |
| 25 | 616 | 1256 | 1864 | 2536 | 3112 | 3752 | 4392 | 5160 | 5736 | 6200 |
| 26 | 712 | 1480 | 2216 | 2984 | 3752 | 4392 | 5160 | 5992 | 6712 | 7480 |
| 26A | 632 | 1288 | 1928 | 2600 | 3240 | 3880 | 4584 | 5160 | 5992 | 6456 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 0 | 288 | 328 | 344 | 376 | 392 | 424 | 456 | 488 | 504 | 536 |
| 1 | 376 | 424 | 456 | 488 | 520 | 568 | 600 | 632 | 680 | 712 |
| 2 | 472 | 520 | 568 | 616 | 648 | 696 | 744 | 776 | 840 | 872 |
| 3 | 616 | 680 | 744 | 808 | 872 | 904 | 968 | 1032 | 1096 | 1160 |
| 4 | 776 | 840 | 904 | 1000 | 1064 | 1128 | 1192 | 1288 | 1352 | 1416 |
| 5 | 968 | 1032 | 1128 | 1224 | 1320 | 1384 | 1480 | 1544 | 1672 | 1736 |
| 6 | 1128 | 1224 | 1352 | 1480 | 1544 | 1672 | 1736 | 1864 | 1992 | 2088 |
| 7 | 1320 | 1480 | 1608 | 1672 | 1800 | 1928 | 2088 | 2216 | 2344 | 2472 |
| 8 | 1544 | 1672 | 1800 | 1928 | 2088 | 2216 | 2344 | 2536 | 2664 | 2792 |
| 9 | 1736 | 1864 | 2024 | 2216 | 2344 | 2536 | 2664 | 2856 | 2984 | 3112 |
| 10 | 1928 | 2088 | 2280 | 2472 | 2664 | 2792 | 2984 | 3112 | 3368 | 3496 |
| 11 | 2216 | 2408 | 2600 | 2792 | 2984 | 3240 | 3496 | 3624 | 3880 | 4008 |
| 12 | 2472 | 2728 | 2984 | 3240 | 3368 | 3624 | 3880 | 4136 | 4392 | 4584 |
| 13 | 2856 | 3112 | 3368 | 3624 | 3880 | 4136 | 4392 | 4584 | 4968 | 5160 |
| 14 | 3112 | 3496 | 3752 | 4008 | 4264 | 4584 | 4968 | 5160 | 5544 | 5736 |
| 15 | 3368 | 3624 | 4008 | 4264 | 4584 | 4968 | 5160 | 5544 | 5736 | 6200 |
| 16 | 3624 | 3880 | 4264 | 4584 | 4968 | 5160 | 5544 | 5992 | 6200 | 6456 |
| 17 | 4008 | 4392 | 4776 | 5160 | 5352 | 5736 | 6200 | 6456 | 6712 | 7224 |
| 18 | 4392 | 4776 | 5160 | 5544 | 5992 | 6200 | 6712 | 7224 | 7480 | 7992 |
| 19 | 4776 | 5160 | 5544 | 5992 | 6456 | 6968 | 7224 | 7736 | 8248 | 8504 |

| | | | | | | | | | | |
|-----|------|------|------|-------|-------|-------|-------|-------|-------|-------|
| 20 | 5160 | 5544 | 5992 | 6456 | 6968 | 7480 | 7992 | 8248 | 8760 | 9144 |
| 21 | 5544 | 5992 | 6456 | 6968 | 7480 | 7992 | 8504 | 9144 | 9528 | 9912 |
| 22 | 5992 | 6456 | 6968 | 7480 | 7992 | 8504 | 9144 | 9528 | 10296 | 10680 |
| 23 | 6200 | 6968 | 7480 | 7992 | 8504 | 9144 | 9912 | 10296 | 11064 | 11448 |
| 24 | 6712 | 7224 | 7992 | 8504 | 9144 | 9912 | 10296 | 11064 | 11448 | 12216 |
| 25 | 6968 | 7480 | 8248 | 8760 | 9528 | 10296 | 10680 | 11448 | 12216 | 12576 |
| 26 | 8248 | 8760 | 9528 | 10296 | 11064 | 11832 | 12576 | 13536 | 14112 | 14688 |
| 26A | 7224 | 7736 | 8504 | 9144 | 9912 | 10296 | 11064 | 11832 | 12576 | 12960 |

| I_{TBS} | N_{PRB} | | | | | | | | | |
|------------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 0 | 568 | 600 | 616 | 648 | 680 | 712 | 744 | 776 | 776 | 808 |
| 1 | 744 | 776 | 808 | 872 | 904 | 936 | 968 | 1000 | 1032 | 1064 |
| 2 | 936 | 968 | 1000 | 1064 | 1096 | 1160 | 1192 | 1256 | 1288 | 1320 |
| 3 | 1224 | 1256 | 1320 | 1384 | 1416 | 1480 | 1544 | 1608 | 1672 | 1736 |
| 4 | 1480 | 1544 | 1608 | 1736 | 1800 | 1864 | 1928 | 1992 | 2088 | 2152 |
| 5 | 1864 | 1928 | 2024 | 2088 | 2216 | 2280 | 2344 | 2472 | 2536 | 2664 |
| 6 | 2216 | 2280 | 2408 | 2472 | 2600 | 2728 | 2792 | 2984 | 2984 | 3112 |
| 7 | 2536 | 2664 | 2792 | 2984 | 3112 | 3240 | 3368 | 3368 | 3496 | 3624 |
| 8 | 2984 | 3112 | 3240 | 3368 | 3496 | 3624 | 3752 | 3880 | 4008 | 4264 |
| 9 | 3368 | 3496 | 3624 | 3752 | 4008 | 4136 | 4264 | 4392 | 4584 | 4776 |
| 10 | 3752 | 3880 | 4008 | 4264 | 4392 | 4584 | 4776 | 4968 | 5160 | 5352 |
| 11 | 4264 | 4392 | 4584 | 4776 | 4968 | 5352 | 5544 | 5736 | 5992 | 5992 |
| 12 | 4776 | 4968 | 5352 | 5544 | 5736 | 5992 | 6200 | 6456 | 6712 | 6712 |
| 13 | 5352 | 5736 | 5992 | 6200 | 6456 | 6712 | 6968 | 7224 | 7480 | 7736 |
| 14 | 5992 | 6200 | 6456 | 6968 | 7224 | 7480 | 7736 | 7992 | 8248 | 8504 |
| 15 | 6456 | 6712 | 6968 | 7224 | 7736 | 7992 | 8248 | 8504 | 8760 | 9144 |
| 16 | 6712 | 7224 | 7480 | 7736 | 7992 | 8504 | 8760 | 9144 | 9528 | 9912 |
| 17 | 7480 | 7992 | 8248 | 8760 | 9144 | 9528 | 9912 | 10296 | 10296 | 10680 |
| 18 | 8248 | 8760 | 9144 | 9528 | 9912 | 10296 | 10680 | 11064 | 11448 | 11832 |
| 19 | 9144 | 9528 | 9912 | 10296 | 10680 | 11064 | 11448 | 12216 | 12576 | 12960 |
| 20 | 9912 | 10296 | 10680 | 11064 | 11448 | 12216 | 12576 | 12960 | 13536 | 14112 |
| 21 | 10680 | 11064 | 11448 | 12216 | 12576 | 12960 | 13536 | 14112 | 14688 | 15264 |
| 22 | 11448 | 11832 | 12576 | 12960 | 13536 | 14112 | 14688 | 15264 | 15840 | 16416 |
| 23 | 12216 | 12576 | 12960 | 13536 | 14112 | 14688 | 15264 | 15840 | 16416 | 16992 |
| 24 | 12960 | 13536 | 14112 | 14688 | 15264 | 15840 | 16416 | 16992 | 17568 | 18336 |
| 25 | 13536 | 14112 | 14688 | 15264 | 15840 | 16416 | 16992 | 17568 | 18336 | 19080 |
| 26 | 15264 | 16416 | 16992 | 17568 | 18336 | 19080 | 19848 | 20616 | 21384 | 22152 |
| 26A | 13536 | 14112 | 15264 | 15840 | 16416 | 16992 | 17568 | 18336 | 19080 | 19848 |

| I_{TBS} | N_{PRB} | | | | | | | | | |
|------------------|------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 0 | 840 | 872 | 904 | 936 | 968 | 1000 | 1032 | 1032 | 1064 | 1096 |
| 1 | 1128 | 1160 | 1192 | 1224 | 1256 | 1288 | 1352 | 1384 | 1416 | 1416 |
| 2 | 1384 | 1416 | 1480 | 1544 | 1544 | 1608 | 1672 | 1672 | 1736 | 1800 |
| 3 | 1800 | 1864 | 1928 | 1992 | 2024 | 2088 | 2152 | 2216 | 2280 | 2344 |
| 4 | 2216 | 2280 | 2344 | 2408 | 2472 | 2600 | 2664 | 2728 | 2792 | 2856 |
| 5 | 2728 | 2792 | 2856 | 2984 | 3112 | 3112 | 3240 | 3368 | 3496 | 3496 |
| 6 | 3240 | 3368 | 3496 | 3496 | 3624 | 3752 | 3880 | 4008 | 4136 | 4136 |
| 7 | 3752 | 3880 | 4008 | 4136 | 4264 | 4392 | 4584 | 4776 | 4776 | 4968 |
| 8 | 4392 | 4584 | 4584 | 4776 | 4968 | 4968 | 5160 | 5352 | 5544 | 5544 |
| 9 | 4968 | 5160 | 5160 | 5352 | 5544 | 5736 | 5736 | 5992 | 6200 | 6200 |
| 10 | 5544 | 5736 | 5736 | 5992 | 6200 | 6200 | 6456 | 6712 | 6712 | 6968 |
| 11 | 6200 | 6456 | 6712 | 6968 | 6968 | 7224 | 7480 | 7736 | 7736 | 7992 |
| 12 | 6968 | 7224 | 7480 | 7736 | 7992 | 8248 | 8504 | 8760 | 8760 | 9144 |
| 13 | 7992 | 8248 | 8504 | 8760 | 9144 | 9144 | 9528 | 9912 | 9912 | 10296 |
| 14 | 8760 | 9144 | 9528 | 9912 | 9912 | 10296 | 10680 | 11064 | 11064 | 11448 |
| 15 | 9528 | 9912 | 10296 | 10296 | 10680 | 11064 | 11448 | 11832 | 11832 | 12216 |
| 16 | 9912 | 10296 | 10680 | 11064 | 11448 | 11832 | 12216 | 12216 | 12576 | 12960 |
| 17 | 11064 | 11448 | 11832 | 12216 | 12576 | 12960 | 13536 | 13536 | 14112 | 14688 |
| 18 | 12216 | 12576 | 12960 | 13536 | 14112 | 14112 | 14688 | 15264 | 15264 | 15840 |
| 19 | 13536 | 13536 | 14112 | 14688 | 15264 | 15264 | 15840 | 16416 | 16992 | 16992 |
| 20 | 14688 | 14688 | 15264 | 15840 | 16416 | 16992 | 16992 | 17568 | 18336 | 18336 |
| 21 | 15840 | 15840 | 16416 | 16992 | 17568 | 18336 | 18336 | 19080 | 19848 | 19848 |
| 22 | 16992 | 16992 | 17568 | 18336 | 19080 | 19080 | 19848 | 20616 | 21384 | 21384 |
| 23 | 17568 | 18336 | 19080 | 19848 | 19848 | 20616 | 21384 | 22152 | 22152 | 22920 |
| 24 | 19080 | 19848 | 19848 | 20616 | 21384 | 22152 | 22152 | 22920 | 23688 | 24496 |
| 25 | 19848 | 20616 | 20616 | 21384 | 22152 | 22920 | 23688 | 24496 | 24496 | 25456 |
| 26 | 22920 | 23688 | 24496 | 25456 | 25456 | 26416 | 27376 | 28336 | 29296 | 29296 |
| 26A | 20616 | 20616 | 21384 | 22152 | 22920 | 23688 | 24496 | 24496 | 25456 | 26416 |

| I_{TBS} | N_{PRB} | | | | | | | | | |
|-----------|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 0 | 1128 | 1160 | 1192 | 1224 | 1256 | 1256 | 1288 | 1320 | 1352 | 1384 |
| 1 | 1480 | 1544 | 1544 | 1608 | 1608 | 1672 | 1736 | 1736 | 1800 | 1800 |
| 2 | 1800 | 1864 | 1928 | 1992 | 2024 | 2088 | 2088 | 2152 | 2216 | 2216 |
| 3 | 2408 | 2472 | 2536 | 2536 | 2600 | 2664 | 2728 | 2792 | 2856 | 2856 |
| 4 | 2984 | 2984 | 3112 | 3112 | 3240 | 3240 | 3368 | 3496 | 3496 | 3624 |
| 5 | 3624 | 3752 | 3752 | 3880 | 4008 | 4008 | 4136 | 4264 | 4392 | 4392 |
| 6 | 4264 | 4392 | 4584 | 4584 | 4776 | 4776 | 4968 | 4968 | 5160 | 5160 |
| 7 | 4968 | 5160 | 5352 | 5352 | 5544 | 5736 | 5736 | 5992 | 5992 | 6200 |
| 8 | 5736 | 5992 | 5992 | 6200 | 6200 | 6456 | 6456 | 6712 | 6968 | 6968 |
| 9 | 6456 | 6712 | 6712 | 6968 | 6968 | 7224 | 7480 | 7480 | 7736 | 7992 |
| 10 | 7224 | 7480 | 7480 | 7736 | 7992 | 7992 | 8248 | 8504 | 8504 | 8760 |
| 11 | 8248 | 8504 | 8760 | 8760 | 9144 | 9144 | 9528 | 9528 | 9912 | 9912 |
| 12 | 9528 | 9528 | 9912 | 9912 | 10296 | 10680 | 10680 | 11064 | 11064 | 11448 |
| 13 | 10680 | 10680 | 11064 | 11448 | 11448 | 11832 | 12216 | 12216 | 12576 | 12960 |
| 14 | 11832 | 12216 | 12216 | 12576 | 12960 | 12960 | 13536 | 13536 | 14112 | 14112 |
| 15 | 12576 | 12960 | 12960 | 13536 | 13536 | 14112 | 14688 | 14688 | 15264 | 15264 |
| 16 | 13536 | 13536 | 14112 | 14112 | 14688 | 14688 | 15264 | 15840 | 15840 | 16416 |
| 17 | 14688 | 15264 | 15264 | 15840 | 16416 | 16416 | 16992 | 17568 | 17568 | 18336 |
| 18 | 16416 | 16416 | 16992 | 17568 | 17568 | 18336 | 19080 | 19080 | 19848 | |
| 19 | 17568 | 18336 | 18336 | 19080 | 19080 | 19848 | 20616 | 20616 | 21384 | 21384 |
| 20 | 19080 | 19848 | 19848 | 20616 | 20616 | 21384 | 22152 | 22152 | 22920 | 22920 |
| 21 | 20616 | 21384 | 21384 | 22152 | 22920 | 22920 | 23688 | 24496 | 24496 | 25456 |
| 22 | 22152 | 22920 | 22920 | 23688 | 24496 | 24496 | 25456 | 25456 | 26416 | 27376 |
| 23 | 23688 | 24496 | 24496 | 25456 | 25456 | 26416 | 27376 | 27376 | 28336 | 28336 |
| 24 | 25456 | 25456 | 26416 | 26416 | 27376 | 28336 | 28336 | 29296 | 29296 | 30576 |
| 25 | 26416 | 26416 | 27376 | 28336 | 28336 | 29296 | 29296 | 30576 | 31704 | 31704 |
| 26 | 30576 | 30576 | 31704 | 32856 | 32856 | 34008 | 35160 | 35160 | 36696 | 36696 |
| 26A | 26416 | 27376 | 27376 | 29296 | 29296 | 29296 | 30576 | 30576 | 31704 | 32856 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 0 | 1416 | 1416 | 1480 | 1480 | 1544 | 1544 | 1608 | 1608 | 1608 | 1672 |
| 1 | 1864 | 1864 | 1928 | 1992 | 1992 | 2024 | 2088 | 2088 | 2152 | 2152 |
| 2 | 2280 | 2344 | 2344 | 2408 | 2472 | 2536 | 2600 | 2664 | 2664 | |
| 3 | 2984 | 2984 | 3112 | 3112 | 3240 | 3240 | 3368 | 3496 | 3496 | |
| 4 | 3624 | 3752 | 3752 | 3880 | 4008 | 4008 | 4136 | 4136 | 4264 | |
| 5 | 4584 | 4584 | 4776 | 4776 | 4776 | 4968 | 4968 | 5160 | 5160 | |
| 6 | 5352 | 5352 | 5544 | 5736 | 5736 | 5992 | 5992 | 5992 | 6200 | |
| 7 | 6200 | 6456 | 6456 | 6712 | 6712 | 6712 | 6968 | 6968 | 7224 | |
| 8 | 7224 | 7224 | 7480 | 7480 | 7736 | 7736 | 7992 | 7992 | 8248 | |
| 9 | 7992 | 8248 | 8248 | 8504 | 8760 | 8760 | 9144 | 9144 | 9528 | |
| 10 | 9144 | 9144 | 9144 | 9528 | 9528 | 9912 | 9912 | 10296 | 10296 | |
| 11 | 10296 | 10680 | 10680 | 11064 | 11064 | 11448 | 11448 | 11832 | 11832 | |
| 12 | 11832 | 11832 | 12216 | 12216 | 12576 | 12576 | 12960 | 12960 | 13536 | |
| 13 | 12960 | 13536 | 13536 | 14112 | 14112 | 14688 | 14688 | 14688 | 15264 | |
| 14 | 14688 | 14688 | 15264 | 15264 | 15840 | 15840 | 16416 | 16416 | 16992 | |
| 15 | 15840 | 15840 | 16416 | 16416 | 16992 | 16992 | 17568 | 17568 | 18336 | |
| 16 | 16416 | 16992 | 16992 | 17568 | 17568 | 18336 | 19080 | 19080 | 19848 | |
| 17 | 18336 | 19080 | 19080 | 19848 | 19848 | 20616 | 20616 | 20616 | 21384 | |
| 18 | 19848 | 20616 | 21384 | 21384 | 22152 | 22152 | 22920 | 22920 | 23688 | |
| 19 | 22152 | 22920 | 22920 | 23688 | 24496 | 24496 | 25456 | 25456 | 25456 | |
| 20 | 23688 | 24496 | 24496 | 25456 | 25456 | 26416 | 26416 | 27376 | 27376 | |
| 21 | 25456 | 26416 | 26416 | 27376 | 27376 | 28336 | 28336 | 29296 | 29296 | |
| 22 | 27376 | 28336 | 28336 | 29296 | 29296 | 30576 | 30576 | 31704 | 31704 | |
| 23 | 29296 | 29296 | 30576 | 30576 | 31704 | 31704 | 32856 | 32856 | 34008 | |
| 24 | 31704 | 31704 | 32856 | 32856 | 34008 | 34008 | 35160 | 35160 | 36696 | |
| 25 | 32856 | 32856 | 34008 | 34008 | 35160 | 35160 | 36696 | 36696 | 37888 | |
| 26 | 37888 | 37888 | 39232 | 40576 | 40576 | 40576 | 42368 | 42368 | 43816 | |
| 26A | 32856 | 34008 | 34008 | 35160 | 36696 | 36696 | 37888 | 37888 | 39232 | |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 0 | 1672 | 1736 | 1736 | 1800 | 1800 | 1800 | 1864 | 1864 | 1928 | 1928 |
| 1 | 2216 | 2280 | 2280 | 2344 | 2344 | 2408 | 2472 | 2472 | 2536 | 2536 |
| 2 | 2728 | 2792 | 2856 | 2856 | 2856 | 2984 | 2984 | 3112 | 3112 | |
| 3 | 3624 | 3624 | 3624 | 3752 | 3752 | 3880 | 3880 | 4008 | 4008 | |
| 4 | 4392 | 4392 | 4584 | 4584 | 4584 | 4776 | 4776 | 4968 | 4968 | |
| 5 | 5352 | 5544 | 5544 | 5736 | 5736 | 5736 | 5992 | 5992 | 5992 | |
| 6 | 6456 | 6456 | 6456 | 6712 | 6712 | 6968 | 6968 | 7224 | 7224 | |

| | | | | | | | | | | |
|------------------|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 7 | 7480 | 7480 | 7736 | 7736 | 7992 | 7992 | 8248 | 8248 | 8504 | 8504 |
| 8 | 8504 | 8760 | 8760 | 9144 | 9144 | 9144 | 9528 | 9528 | 9528 | 9912 |
| 9 | 9528 | 9912 | 9912 | 10296 | 10296 | 10296 | 10680 | 10680 | 11064 | 11064 |
| 10 | 10680 | 11064 | 11064 | 11448 | 11448 | 11448 | 11832 | 11832 | 12216 | 12216 |
| 11 | 12216 | 12576 | 12576 | 12960 | 12960 | 13536 | 13536 | 13536 | 14112 | 14112 |
| 12 | 14112 | 14112 | 14112 | 14688 | 14688 | 15264 | 15264 | 15264 | 15840 | 15840 |
| 13 | 15840 | 15840 | 16416 | 16416 | 16992 | 16992 | 16992 | 17568 | 17568 | 18336 |
| 14 | 17568 | 17568 | 18336 | 18336 | 18336 | 19080 | 19080 | 19848 | 19848 | 19848 |
| 15 | 18336 | 19080 | 19080 | 19848 | 19848 | 20616 | 20616 | 20616 | 21384 | 21384 |
| 16 | 19848 | 19848 | 20616 | 20616 | 21384 | 21384 | 22152 | 22152 | 22920 | 22920 |
| 17 | 22152 | 22152 | 22920 | 22920 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 |
| 18 | 24496 | 24496 | 24496 | 25456 | 25456 | 26416 | 26416 | 27376 | 27376 | 27376 |
| 19 | 26416 | 26416 | 27376 | 27376 | 28336 | 28336 | 29296 | 29296 | 30576 | 30576 |
| 20 | 28336 | 29296 | 29296 | 30576 | 30576 | 31704 | 31704 | 31704 | 32856 | 32856 |
| 21 | 30576 | 31704 | 31704 | 32856 | 32856 | 34008 | 34008 | 35160 | 35160 | 35160 |
| 22 | 32856 | 34008 | 34008 | 35160 | 35160 | 36696 | 36696 | 36696 | 37888 | 37888 |
| 23 | 35160 | 35160 | 36696 | 36696 | 37888 | 37888 | 37888 | 39232 | 39232 | 40576 |
| 24 | 36696 | 37888 | 37888 | 39232 | 39232 | 40576 | 40576 | 42368 | 42368 | 42368 |
| 25 | 39232 | 39232 | 40576 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 43816 |
| 26 | 45352 | 45352 | 46888 | 46888 | 48936 | 48936 | 48936 | 51024 | 51024 | 52752 |
| 26A | 40576 | 40576 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 45352 | 45352 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 0 | 1992 | 1992 | 2024 | 2088 | 2088 | 2088 | 2152 | 2152 | 2216 | 2216 |
| 1 | 2600 | 2600 | 2664 | 2728 | 2728 | 2792 | 2792 | 2856 | 2856 | 2856 |
| 2 | 3240 | 3240 | 3240 | 3368 | 3368 | 3368 | 3496 | 3496 | 3496 | 3624 |
| 3 | 4136 | 4264 | 4264 | 4392 | 4392 | 4392 | 4584 | 4584 | 4584 | 4776 |
| 4 | 5160 | 5160 | 5160 | 5352 | 5352 | 5544 | 5544 | 5544 | 5736 | 5736 |
| 5 | 6200 | 6200 | 6456 | 6456 | 6712 | 6712 | 6712 | 6968 | 6968 | 6968 |
| 6 | 7480 | 7480 | 7736 | 7736 | 7736 | 7992 | 7992 | 8248 | 8248 | 8248 |
| 7 | 8760 | 8760 | 8760 | 9144 | 9144 | 9144 | 9528 | 9528 | 9528 | 9912 |
| 8 | 9912 | 9912 | 10296 | 10296 | 10680 | 10680 | 10680 | 11064 | 11064 | 11064 |
| 9 | 11064 | 11448 | 11448 | 11832 | 11832 | 12216 | 12216 | 12576 | 12576 | 12576 |
| 10 | 12576 | 12576 | 12960 | 12960 | 13536 | 13536 | 13536 | 14112 | 14112 | 14112 |
| 11 | 14112 | 14688 | 14688 | 15264 | 15264 | 15840 | 15840 | 15840 | 16416 | 16416 |
| 12 | 16416 | 16416 | 16416 | 16992 | 16992 | 17568 | 17568 | 18336 | 18336 | 18336 |
| 13 | 18336 | 18336 | 19080 | 19080 | 19080 | 19848 | 19848 | 20616 | 20616 | 20616 |
| 14 | 20616 | 20616 | 20616 | 21384 | 21384 | 22152 | 22152 | 22920 | 22920 | 22920 |
| 15 | 22152 | 22152 | 22920 | 22920 | 23688 | 23688 | 23688 | 24496 | 24496 | 26416 |
| 16 | 22920 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 | 25456 | 25456 | 26416 |
| 17 | 25456 | 26416 | 26416 | 26416 | 27376 | 27376 | 27376 | 28336 | 28336 | 29296 |
| 18 | 28336 | 28336 | 29296 | 29296 | 30576 | 30576 | 30576 | 31704 | 31704 | 31704 |
| 19 | 30576 | 31704 | 31704 | 32856 | 32856 | 32856 | 34008 | 34008 | 34008 | 34008 |
| 20 | 32856 | 34008 | 34008 | 35160 | 35160 | 35160 | 36696 | 36696 | 36696 | 36696 |
| 21 | 35160 | 36696 | 36696 | 37888 | 37888 | 39232 | 39232 | 39232 | 40576 | 40576 |
| 22 | 37888 | 39232 | 39232 | 40576 | 40576 | 42368 | 42368 | 42368 | 43816 | 43816 |
| 23 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 43816 | 45352 | 45352 | 45352 |
| 24 | 43816 | 43816 | 45352 | 45352 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 |
| 25 | 45352 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 | 51024 |
| 26 | 52752 | 52752 | 55056 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 | 59256 |
| 26A | 45352 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 | 51024 | 52752 | 52752 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 0 | 2280 | 2280 | 2280 | 2344 | 2344 | 2408 | 2408 | 2472 | 2472 | 2536 |
| 1 | 2984 | 2984 | 2984 | 3112 | 3112 | 3112 | 3240 | 3240 | 3240 | 3240 |
| 2 | 3624 | 3624 | 3752 | 3752 | 3880 | 3880 | 3880 | 4008 | 4008 | 4008 |
| 3 | 4776 | 4776 | 4776 | 4968 | 4968 | 4968 | 5160 | 5160 | 5160 | 5352 |
| 4 | 5736 | 5992 | 5992 | 5992 | 5992 | 6200 | 6200 | 6200 | 6456 | 6456 |
| 5 | 7224 | 7224 | 7224 | 7480 | 7480 | 7480 | 7736 | 7736 | 7736 | 7992 |
| 6 | 8504 | 8504 | 8760 | 8760 | 8760 | 9144 | 9144 | 9144 | 9144 | 9528 |
| 7 | 9912 | 9912 | 10296 | 10296 | 10296 | 10680 | 10680 | 10680 | 11064 | 11064 |
| 8 | 11448 | 11448 | 11448 | 11832 | 11832 | 12216 | 12216 | 12216 | 12576 | 12576 |
| 9 | 12960 | 12960 | 12960 | 13536 | 13536 | 13536 | 13536 | 14112 | 14112 | 14112 |
| 10 | 14112 | 14688 | 14688 | 14688 | 14688 | 15264 | 15264 | 15264 | 15840 | 15840 |
| 11 | 16416 | 16416 | 16992 | 16992 | 16992 | 17568 | 17568 | 17568 | 18336 | 18336 |
| 12 | 18336 | 19080 | 19080 | 19080 | 19080 | 19848 | 19848 | 19848 | 20616 | 20616 |
| 13 | 20616 | 21384 | 21384 | 21384 | 22152 | 22152 | 22152 | 22920 | 22920 | 22920 |
| 14 | 22920 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 | 25456 | 25456 | 25456 |
| 15 | 24496 | 25456 | 25456 | 25456 | 26416 | 26416 | 26416 | 27376 | 27376 | 27376 |
| 16 | 26416 | 26416 | 27376 | 27376 | 27376 | 28336 | 28336 | 29296 | 29296 | 29296 |
| 17 | 29296 | 29296 | 30576 | 30576 | 30576 | 30576 | 31704 | 31704 | 32856 | 32856 |

| | | | | | | | | | | |
|------------------|------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 18 | 31704 | 32856 | 32856 | 32856 | 34008 | 34008 | 34008 | 35160 | 35160 | 35160 |
| 19 | 35160 | 35160 | 35160 | 36696 | 36696 | 36696 | 37888 | 37888 | 37888 | 39232 |
| 20 | 37888 | 37888 | 39232 | 39232 | 39232 | 40576 | 40576 | 40576 | 42368 | 42368 |
| 21 | 40576 | 40576 | 42368 | 42368 | 42368 | 43816 | 43816 | 43816 | 45352 | 45352 |
| 22 | 43816 | 43816 | 45352 | 45352 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 |
| 23 | 46888 | 46888 | 46888 | 48936 | 48936 | 48936 | 51024 | 51024 | 51024 | 51024 |
| 24 | 48936 | 51024 | 51024 | 51024 | 52752 | 52752 | 52752 | 52752 | 55056 | 55056 |
| 25 | 51024 | 52752 | 52752 | 52752 | 55056 | 55056 | 55056 | 55056 | 57336 | 57336 |
| 26 | 59256 | 59256 | 61664 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 |
| 26A | 52752 | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 | 59256 | |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 0 | 2536 | 2536 | 2600 | 2600 | 2664 | 2664 | 2728 | 2728 | 2728 | 2792 |
| 1 | 3368 | 3368 | 3368 | 3496 | 3496 | 3496 | 3496 | 3624 | 3624 | 3624 |
| 2 | 4136 | 4136 | 4136 | 4264 | 4264 | 4264 | 4392 | 4392 | 4392 | 4584 |
| 3 | 5352 | 5352 | 5352 | 5544 | 5544 | 5544 | 5736 | 5736 | 5736 | 5736 |
| 4 | 6456 | 6456 | 6712 | 6712 | 6712 | 6968 | 6968 | 6968 | 6968 | 7224 |
| 5 | 7992 | 7992 | 8248 | 8248 | 8248 | 8504 | 8504 | 8760 | 8760 | 8760 |
| 6 | 9528 | 9528 | 9528 | 9912 | 9912 | 9912 | 10296 | 10296 | 10296 | 10296 |
| 7 | 11064 | 11448 | 11448 | 11448 | 11448 | 11832 | 11832 | 11832 | 12216 | 12216 |
| 8 | 12576 | 12960 | 12960 | 12960 | 13536 | 13536 | 13536 | 13536 | 14112 | 14112 |
| 9 | 14112 | 14688 | 14688 | 14688 | 15264 | 15264 | 15264 | 15264 | 15840 | 15840 |
| 10 | 15840 | 16416 | 16416 | 16416 | 16992 | 16992 | 16992 | 16992 | 17568 | 17568 |
| 11 | 18336 | 18336 | 19080 | 19080 | 19080 | 19080 | 19848 | 19848 | 19848 | 19848 |
| 12 | 20616 | 21384 | 21384 | 21384 | 21384 | 22152 | 22152 | 22152 | 22920 | 22920 |
| 13 | 23688 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 | 25456 | 25456 | 25456 |
| 14 | 26416 | 26416 | 26416 | 27376 | 27376 | 27376 | 28336 | 28336 | 28336 | 28336 |
| 15 | 28336 | 28336 | 28336 | 29296 | 29296 | 29296 | 29296 | 30576 | 30576 | 30576 |
| 16 | 29296 | 30576 | 30576 | 30576 | 30576 | 31704 | 31704 | 31704 | 32856 | 32856 |
| 17 | 32856 | 32856 | 34008 | 34008 | 34008 | 35160 | 35160 | 35160 | 36696 | 36696 |
| 18 | 36696 | 36696 | 36696 | 37888 | 37888 | 37888 | 37888 | 39232 | 39232 | 39232 |
| 19 | 39232 | 39232 | 40576 | 40576 | 40576 | 40576 | 42368 | 42368 | 42368 | 43816 |
| 20 | 42368 | 42368 | 43816 | 43816 | 43816 | 45352 | 45352 | 46888 | 46888 | |
| 21 | 45352 | 46888 | 46888 | 46888 | 46888 | 48936 | 48936 | 48936 | 51024 | |
| 22 | 48936 | 48936 | 51024 | 51024 | 51024 | 51024 | 52752 | 52752 | 52752 | 55056 |
| 23 | 52752 | 52752 | 52752 | 55056 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 |
| 24 | 55056 | 57336 | 57336 | 57336 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 |
| 25 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 | 61664 | 61664 | 63776 | 63776 |
| 26 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 | 75376 |
| 26A | 59256 | 59256 | 59256 | 61664 | 61664 | 61664 | 63776 | 63776 | 66592 | |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| 0 | 2792 | 2856 | 2856 | 2856 | 2984 | 2984 | 2984 | 2984 | 2984 | 3112 |
| 1 | 3752 | 3752 | 3752 | 3752 | 3880 | 3880 | 3880 | 4008 | 4008 | 4008 |
| 2 | 4584 | 4584 | 4584 | 4584 | 4776 | 4776 | 4776 | 4776 | 4968 | 4968 |
| 3 | 5992 | 5992 | 5992 | 5992 | 6200 | 6200 | 6200 | 6200 | 6456 | 6456 |
| 4 | 7224 | 7224 | 7480 | 7480 | 7480 | 7480 | 7736 | 7736 | 7992 | 7992 |
| 5 | 8760 | 9144 | 9144 | 9144 | 9144 | 9144 | 9528 | 9528 | 9528 | 9528 |
| 6 | 10680 | 10680 | 10680 | 10680 | 11064 | 11064 | 11064 | 11448 | 11448 | 11448 |
| 7 | 12216 | 12576 | 12576 | 12576 | 12960 | 12960 | 12960 | 12960 | 13536 | 13536 |
| 8 | 14112 | 14112 | 14688 | 14688 | 14688 | 14688 | 15264 | 15264 | 15264 | 15264 |
| 9 | 15840 | 16416 | 16416 | 16416 | 16416 | 16992 | 16992 | 16992 | 17568 | 17568 |
| 10 | 17568 | 18336 | 18336 | 18336 | 18336 | 18336 | 19080 | 19080 | 19080 | 19080 |
| 11 | 20616 | 20616 | 20616 | 21384 | 21384 | 21384 | 21384 | 22152 | 22152 | 22152 |
| 12 | 22920 | 23688 | 23688 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 | 25456 |
| 13 | 26416 | 26416 | 26416 | 26416 | 27376 | 27376 | 27376 | 27376 | 28336 | 28336 |
| 14 | 29296 | 29296 | 29296 | 29296 | 30576 | 30576 | 30576 | 30576 | 31704 | 31704 |
| 15 | 30576 | 31704 | 31704 | 31704 | 31704 | 32856 | 32856 | 32856 | 34008 | 34008 |
| 16 | 32856 | 32856 | 34008 | 34008 | 34008 | 34008 | 35160 | 35160 | 35160 | 35160 |
| 17 | 36696 | 36696 | 36696 | 37888 | 37888 | 37888 | 39232 | 39232 | 39232 | 39232 |
| 18 | 40576 | 40576 | 40576 | 40576 | 42368 | 42368 | 42368 | 42368 | 43816 | 43816 |
| 19 | 43816 | 43816 | 43816 | 45352 | 45352 | 45352 | 46888 | 46888 | 46888 | 46888 |
| 20 | 46888 | 46888 | 48936 | 48936 | 48936 | 48936 | 48936 | 51024 | 51024 | 51024 |
| 21 | 51024 | 51024 | 51024 | 52752 | 52752 | 52752 | 52752 | 55056 | 55056 | 55056 |
| 22 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 | 57336 | 59256 | 59256 | 59256 |
| 23 | 57336 | 59256 | 59256 | 59256 | 59256 | 61664 | 61664 | 61664 | 61664 | 63776 |
| 24 | 61664 | 61664 | 63776 | 63776 | 63776 | 63776 | 66592 | 66592 | 66592 | 66592 |
| 25 | 63776 | 63776 | 66592 | 66592 | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 |
| 26 | 75376 | 75376 | 75376 | 75376 | 75376 | 75376 | 75376 | 75376 | 75376 | |
| 26A | 66592 | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 71112 |

| I_{TBS} | N_{PRB} | | | | | | | | | |
|-----------|-----------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 27 | 648 | 1320 | 1992 | 2664 | 3368 | 4008 | 4584 | 5352 | 5992 | 6712 |
| 28 | 680 | 1384 | 2088 | 2792 | 3496 | 4264 | 4968 | 5544 | 6200 | 6968 |
| 29 | 712 | 1480 | 2216 | 2984 | 3752 | 4392 | 5160 | 5992 | 6712 | 7480 |
| 30 | 776 | 1544 | 2344 | 3112 | 3880 | 4776 | 5544 | 6200 | 6968 | 7736 |
| 31 | 808 | 1608 | 2472 | 3240 | 4136 | 4968 | 5736 | 6456 | 7480 | 8248 |
| 32 | 840 | 1672 | 2536 | 3368 | 4264 | 5160 | 5992 | 6712 | 7736 | 8504 |
| 32A | 904 | 1864 | 2792 | 3752 | 4584 | 5544 | 6456 | 7480 | 8248 | 9144 |
| 33 | 968 | 1992 | 2984 | 4008 | 4968 | 5992 | 6968 | 7992 | 8760 | 9912 |
| 33A | 840 | 1736 | 2600 | 3496 | 4392 | 5160 | 5992 | 6968 | 7736 | 8760 |
| 33B | 968 | 1992 | 2984 | 4008 | 4968 | 5992 | 6968 | 7992 | 8760 | 9912 |
| 34 | 1032 | 2088 | 3112 | 4264 | 5160 | 6200 | 7224 | 8504 | 9528 | 10296 |
| 34A | 1064 | 2088 | 3112 | 4264 | 5352 | 6456 | 7480 | 8504 | 9528 | 10680 |
| 35 | 1096 | 2216 | 3240 | 4392 | 5544 | 6712 | 7736 | 8760 | 9912 | 11064 |
| 36 | 1160 | 2280 | 3496 | 4584 | 5736 | 6968 | 7992 | 9144 | 10296 | 11448 |
| 37A | 1192 | 2408 | 3624 | 4776 | 5992 | 7224 | 8504 | 9528 | 10680 | 11832 |
| 37 | 1224 | 2472 | 3752 | 4968 | 6200 | 7480 | 8760 | 9912 | 11064 | 12384 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 27 | 7224 | 7992 | 8504 | 9144 | 9912 | 10680 | 11448 | 11832 | 12576 | 12960 |
| 28 | 7736 | 8504 | 9144 | 9912 | 10680 | 11064 | 11832 | 12576 | 13536 | 14112 |
| 29 | 8248 | 8760 | 9528 | 10296 | 11064 | 11832 | 12576 | 13536 | 14112 | 14688 |
| 30 | 8504 | 9528 | 10296 | 11064 | 11832 | 12576 | 13536 | 14112 | 14688 | 15840 |
| 31 | 9144 | 9912 | 10680 | 11448 | 12216 | 12960 | 14112 | 14688 | 15840 | 16416 |
| 32 | 9528 | 10296 | 11064 | 11832 | 12960 | 13536 | 14688 | 15264 | 16416 | 16992 |
| 32A | 10296 | 11064 | 12216 | 12960 | 14112 | 14688 | 15840 | 16416 | 17568 | 18336 |
| 33 | 10680 | 11832 | 12960 | 13536 | 14688 | 15840 | 16992 | 17568 | 19080 | 19848 |
| 33A | 9528 | 10296 | 11448 | 12216 | 12960 | 14112 | 14688 | 15840 | 16416 | 17568 |
| 33B | 10680 | 11832 | 12960 | 13536 | 14688 | 15840 | 16992 | 17568 | 19080 | 19848 |
| 34 | 11448 | 12576 | 13536 | 14688 | 15840 | 16992 | 17568 | 19080 | 19848 | 20616 |
| 34A | 11448 | 12576 | 13536 | 14688 | 15840 | 16992 | 17568 | 19080 | 19848 | 21384 |
| 35 | 12216 | 12960 | 14112 | 15264 | 16416 | 17568 | 18336 | 19848 | 20616 | 22152 |
| 36 | 12576 | 13536 | 14688 | 15840 | 16992 | 18336 | 19848 | 20616 | 22152 | 22920 |
| 37A | 12960 | 14112 | 15840 | 16992 | 18336 | 19080 | 20616 | 21384 | 22920 | 23688 |
| 37 | 13536 | 14688 | 15840 | 17568 | 18336 | 19848 | 21384 | 22152 | 23688 | 24496 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 27 | 14112 | 14688 | 15264 | 15840 | 16416 | 16992 | 17568 | 18336 | 19080 | 19848 |
| 28 | 14688 | 15264 | 16416 | 16992 | 17568 | 18336 | 19080 | 19848 | 20616 | 21384 |
| 29 | 15840 | 16416 | 16992 | 17568 | 18336 | 19080 | 19848 | 20616 | 21384 | 22152 |
| 30 | 16416 | 16992 | 18336 | 19080 | 19848 | 20616 | 21384 | 22152 | 22920 | 23688 |
| 31 | 17568 | 18336 | 19080 | 19848 | 20616 | 21384 | 22152 | 22920 | 23688 | 24496 |
| 32 | 17568 | 19080 | 19848 | 20616 | 21384 | 22152 | 22920 | 23688 | 24496 | 25456 |
| 32A | 19848 | 20616 | 21384 | 22152 | 22920 | 24496 | 25456 | 26416 | 27376 | 27376 |
| 33 | 20616 | 21384 | 22920 | 23688 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 |
| 33A | 18336 | 19080 | 19848 | 20616 | 22152 | 22920 | 23688 | 24496 | 25456 | 26416 |
| 33B | 20616 | 21384 | 22920 | 23688 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 |
| 34 | 22152 | 22920 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 | 30576 | 31704 |
| 34A | 22152 | 22920 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 | 30576 | 31704 |
| 35 | 22920 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 | 30576 | 31704 | 32856 |
| 36 | 24496 | 25456 | 26416 | 27376 | 28336 | 29296 | 30576 | 31704 | 32856 | 34008 |
| 37A | 25456 | 26416 | 27376 | 28336 | 30576 | 31704 | 32856 | 34008 | 35160 | 36696 |
| 37 | 26416 | 27376 | 28336 | 29296 | 30576 | 31704 | 32856 | 35160 | 35160 | 36696 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 27 | 20616 | 21384 | 22152 | 22920 | 22920 | 23688 | 24496 | 25456 | 25456 | 26416 |
| 28 | 22152 | 22152 | 22920 | 23688 | 24496 | 25456 | 26416 | 26416 | 27376 | 28336 |
| 29 | 22920 | 23688 | 24496 | 25456 | 26416 | 26416 | 27376 | 28336 | 29296 | 29296 |
| 30 | 24496 | 25456 | 25456 | 26416 | 27376 | 28336 | 29296 | 29296 | 30576 | 31704 |
| 31 | 25456 | 26416 | 27376 | 28336 | 29296 | 29296 | 30576 | 31704 | 31704 | 32856 |
| 32 | 26416 | 27376 | 28336 | 29296 | 29296 | 30576 | 31704 | 32856 | 32856 | 34008 |
| 32A | 28336 | 29296 | 30576 | 31704 | 32856 | 32856 | 34008 | 35160 | 36696 | 36696 |
| 33 | 30576 | 31704 | 32856 | 34008 | 35160 | 35160 | 36696 | 37888 | 39232 | 39232 |
| 33A | 27376 | 27376 | 29296 | 29296 | 30576 | 30576 | 31704 | 32856 | 34008 | 35160 |
| 33B | 30576 | 31704 | 32856 | 34008 | 35160 | 35160 | 36696 | 37888 | 39232 | 39232 |
| 34 | 32856 | 34008 | 35160 | 35160 | 36696 | 37888 | 39232 | 39232 | 40576 | 42368 |

| | | | | | | | | | | |
|------------------|------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| 34A | 32856 | 34008 | 35160 | 35160 | 36696 | 37888 | 39232 | 40576 | 40576 | 42368 |
| 35 | 34008 | 35160 | 36696 | 37888 | 37888 | 39232 | 40576 | 42368 | 42368 | 43816 |
| 36 | 35160 | 36696 | 37888 | 39232 | 40576 | 40576 | 42368 | 43816 | 45352 | 45352 |
| 37A | 36696 | 37888 | 39232 | 40576 | 42368 | 43816 | 43816 | 45352 | 46888 | 48936 |
| 37 | 37888 | 39232 | 40576 | 42368 | 43816 | 43816 | 45352 | 46888 | 48936 | 48936 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 27 | 27376 | 27376 | 28336 | 29296 | 29296 | 30576 | 31704 | 31704 | 32856 | 32856 |
| 28 | 29296 | 29296 | 30576 | 30576 | 31704 | 32856 | 32856 | 34008 | 34008 | 35160 |
| 29 | 30576 | 31704 | 31704 | 32856 | 34008 | 34008 | 35160 | 35160 | 36696 | 36696 |
| 30 | 31704 | 32856 | 34008 | 34008 | 35160 | 36696 | 36696 | 37888 | 37888 | 39232 |
| 31 | 34008 | 35160 | 35160 | 36696 | 36696 | 37888 | 39232 | 39232 | 40576 | 40576 |
| 32 | 35160 | 35160 | 36696 | 37888 | 37888 | 39232 | 40576 | 40576 | 42368 | 42368 |
| 32A | 37888 | 39232 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 45352 | 46888 |
| 33 | 40576 | 40576 | 42368 | 43816 | 43816 | 45352 | 46888 | 46888 | 48936 | 48936 |
| 33A | 35160 | 36696 | 36696 | 37888 | 39232 | 40576 | 40576 | 40576 | 42368 | 43816 |
| 33B | 40576 | 40576 | 42368 | 43816 | 43816 | 45352 | 46888 | 46888 | 48936 | 48936 |
| 34 | 42368 | 43816 | 45352 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 | 52752 |
| 34A | 43816 | 43816 | 45352 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 | 52752 |
| 35 | 45352 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 | 52752 | 52752 | 55056 |
| 36 | 46888 | 48936 | 48936 | 51024 | 51024 | 52752 | 55056 | 55056 | 57336 | 57336 |
| 37A | 48936 | 51024 | 51024 | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 |
| 37 | 51024 | 52752 | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 61664 | 61664 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 27 | 34008 | 34008 | 35160 | 35160 | 36696 | 36696 | 37888 | 37888 | 39232 | 39232 |
| 28 | 35160 | 36696 | 36696 | 37888 | 39232 | 39232 | 40576 | 40576 | 42368 | 42368 |
| 29 | 37888 | 39232 | 39232 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 45352 |
| 30 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 45352 | 45352 | 46888 | 46888 |
| 31 | 42368 | 42368 | 43816 | 45352 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 |
| 32 | 43816 | 43816 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 | 51024 | 51024 |
| 32A | 46888 | 48936 | 48936 | 51024 | 51024 | 52752 | 52752 | 52752 | 55056 | 55056 |
| 33 | 51024 | 51024 | 52752 | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 |
| 33A | 43816 | 45352 | 45352 | 46888 | 48936 | 48936 | 48936 | 51024 | 51024 | 52752 |
| 33B | 51024 | 51024 | 52752 | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 |
| 34 | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 | 61664 | 61664 | 63776 |
| 34A | 52752 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 | 61664 | 61664 | 63776 |
| 35 | 55056 | 57336 | 57336 | 59256 | 59256 | 61664 | 61664 | 63776 | 63776 | 66592 |
| 36 | 59256 | 59256 | 61664 | 61664 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 |
| 37A | 61664 | 61664 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 | 71112 | 71112 |
| 37 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 | 71112 | 71112 | 73712 | 75376 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 27 | 40576 | 40576 | 42368 | 42368 | 43816 | 43816 | 43816 | 45352 | 45352 | 46888 |
| 28 | 42368 | 43816 | 43816 | 45352 | 45352 | 46888 | 46888 | 46888 | 48936 | 48936 |
| 29 | 45352 | 45352 | 46888 | 46888 | 48936 | 48936 | 48936 | 51024 | 51024 | 52752 |
| 30 | 46888 | 48936 | 48936 | 51024 | 51024 | 51024 | 52752 | 52752 | 55056 | 55056 |
| 31 | 51024 | 51024 | 52752 | 52752 | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 |
| 32 | 52752 | 52752 | 52752 | 55056 | 55056 | 57336 | 57336 | 57336 | 59256 | 59256 |
| 32A | 57336 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 | 63776 | 63776 | 63776 |
| 33 | 59256 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 |
| 33A | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 | 59256 | 61664 | 61664 |
| 33B | 59256 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 |
| 34 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 | 71112 | 71112 | 73712 | 73712 |
| 34A | 63776 | 66592 | 66592 | 68808 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 |
| 35 | 66592 | 68808 | 68808 | 71112 | 71112 | 73712 | 73712 | 75376 | 76208 | 76208 |
| 36 | 71112 | 71112 | 73712 | 73712 | 75376 | 76208 | 76208 | 78704 | 78704 | 81176 |
| 37A | 73712 | 73712 | 75376 | 76208 | 78704 | 78704 | 81176 | 81176 | 84760 | 84760 |
| 37 | 76208 | 76208 | 78704 | 78704 | 81176 | 81176 | 81176 | 84760 | 84760 | 87936 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 27 | 46888 | 46888 | 48936 | 48936 | 48936 | 51024 | 51024 | 51024 | 52752 | 52752 |
| 28 | 48936 | 51024 | 51024 | 52752 | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 |
| 29 | 52752 | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 | 59256 | 59256 | 59256 |
| 30 | 55056 | 57336 | 57336 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 | 63776 |
| 31 | 59256 | 59256 | 59256 | 61664 | 61664 | 63776 | 63776 | 66592 | 66592 | 66592 |
| 32 | 61664 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 | 68808 | 68808 |

| | | | | | | | | | | |
|-----------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| 32A | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 73712 | 73712 | 73712 |
| 33 | 71112 | 71112 | 71112 | 73712 | 75376 | 76208 | 76208 | 76208 | 78704 | 78704 |
| 33A | 61664 | 61664 | 63776 | 63776 | 66592 | 66592 | 66592 | 68808 | 68808 | 68808 |
| 33B | 71112 | 71112 | 71112 | 73712 | 75376 | 76208 | 76208 | 76208 | 78704 | 78704 |
| 34 | 75376 | 76208 | 76208 | 78704 | 78704 | 78704 | 81176 | 81176 | 84760 | 84760 |
| 34A | 75376 | 76208 | 76208 | 78704 | 78704 | 81176 | 81176 | 84760 | 84760 | 84760 |
| 35 | 78704 | 78704 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 87936 | 87936 |
| 36 | 81176 | 81176 | 84760 | 84760 | 84760 | 87936 | 87936 | 90816 | 90816 | 90816 |
| 37A | 84760 | 84760 | 87936 | 87936 | 90816 | 90816 | 90816 | 93800 | 93800 | 97896 |
| 37 | 87936 | 87936 | 90816 | 90816 | 93800 | 93800 | 93800 | 97896 | 97896 | 97896 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 27 | 52752 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 | 59256 | 59256 | 59256 |
| 28 | 57336 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 | 61664 | 63776 | 63776 |
| 29 | 59256 | 61664 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 | 66592 |
| 30 | 63776 | 63776 | 63776 | 66592 | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 |
| 31 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 | 73712 |
| 32 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 | 73712 | 75376 | 76208 | 76208 |
| 32A | 75376 | 76208 | 76208 | 78704 | 78704 | 78704 | 81176 | 81176 | 84760 | 84760 |
| 33 | 81176 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 87936 | 87936 | 87936 |
| 33A | 71112 | 71112 | 71112 | 73712 | 75376 | 75376 | 76208 | 76208 | 78704 | 78704 |
| 33B | 81176 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 87936 | 87936 | 87936 |
| 34 | 84760 | 84760 | 87936 | 87936 | 87936 | 90816 | 90816 | 93800 | 93800 | 93800 |
| 34A | 84760 | 87936 | 87936 | 87936 | 90816 | 90816 | 90816 | 93800 | 93800 | 93800 |
| 35 | 87936 | 90816 | 90816 | 93800 | 93800 | 93800 | 93800 | 97896 | 97896 | 97896 |
| 36 | 93800 | 93800 | 93800 | 97896 | 97896 | 97896 | 101840 | 101840 | 101840 | 101840 |
| 37A | 97896 | 97896 | 97896 | 101840 | 101840 | 101840 | 105528 | 105528 | 105528 | 107832 |
| 37 | 101840 | 101840 | 101840 | 105528 | 105528 | 107832 | 107832 | 110136 | 110136 | 112608 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 27 | 59256 | 61664 | 61664 | 61664 | 63776 | 63776 | 63776 | 66592 | 66592 | 66592 |
| 28 | 63776 | 63776 | 66592 | 66592 | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 |
| 29 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 | 73712 |
| 30 | 71112 | 71112 | 73712 | 73712 | 75376 | 75376 | 76208 | 76208 | 78704 | 78704 |
| 31 | 75376 | 76208 | 76208 | 78704 | 78704 | 78704 | 81176 | 81176 | 81176 | 81176 |
| 32 | 78704 | 78704 | 78704 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 84760 |
| 32A | 84760 | 84760 | 87936 | 87936 | 87936 | 87936 | 90816 | 90816 | 90816 | 93800 |
| 33 | 90816 | 90816 | 90816 | 93800 | 93800 | 93800 | 93800 | 97896 | 97896 | 97896 |
| 33A | 78704 | 81176 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 87936 | 87936 |
| 33B | 90816 | 90816 | 90816 | 93800 | 93800 | 93800 | 93800 | 97896 | 97896 | 100752 |
| 34 | 93800 | 97896 | 97896 | 97896 | 101840 | 101840 | 101840 | 105528 | 105528 | 105528 |
| 34A | 93800 | 97896 | 97896 | 97896 | 101840 | 101840 | 101840 | 105528 | 105528 | 105528 |
| 35 | 97896 | 101840 | 101840 | 101840 | 105528 | 105528 | 105528 | 107832 | 110136 | 110136 |
| 36 | 105528 | 105528 | 107832 | 107832 | 110136 | 110136 | 112608 | 112608 | 115040 | 115040 |
| 37A | 110136 | 110136 | 112608 | 112608 | 115040 | 115040 | 117256 | 117256 | 119816 | 119816 |
| 37 | 112608 | 115040 | 115040 | 115040 | 117256 | 119816 | 119816 | 124464 | 125808 | 125808 |
| I_{TBS} | N_{PRB} | | | | | | | | | |
| | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109 | 110 |
| 27 | 66592 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 71112 | 73712 |
| 28 | 71112 | 71112 | 73712 | 73712 | 73712 | 75376 | 75376 | 76208 | 76208 | 76208 |
| 29 | 75376 | 76208 | 76208 | 76208 | 78704 | 78704 | 78704 | 81176 | 81176 | 81176 |
| 30 | 78704 | 81176 | 81176 | 81176 | 84760 | 84760 | 84760 | 84760 | 84760 | 87936 |
| 31 | 84760 | 84760 | 84760 | 87936 | 87936 | 90816 | 90816 | 97896 | 101840 | 101840 |
| 32 | 87936 | 87936 | 87936 | 87936 | 90816 | 90816 | 90816 | 93800 | 93800 | 93800 |
| 32A | 93800 | 93800 | 93800 | 97896 | 97896 | 97896 | 97896 | 101840 | 101840 | 101840 |
| 33 | 97896 | 97896 | 97896 | 97896 | 97896 | 97896 | 97896 | 97896 | 97896 | 97896 |
| 33A | 87936 | 87936 | 87936 | 90816 | 90816 | 90816 | 93800 | 93800 | 93800 | 97896 |
| 33B | 100752 | 100752 | 100752 | 100752 | 100752 | 100752 | 100752 | 100752 | 100752 | 100752 |
| 34 | 105528 | 105528 | 105528 | 105528 | 105528 | 105528 | 105528 | 105528 | 105528 | 105528 |
| 34A | 105528 | 107832 | 107832 | 110136 | 110136 | 112608 | 112608 | 115040 | 115040 | 115040 |
| 35 | 110136 | 110136 | 112608 | 112608 | 115040 | 115040 | 117256 | 119816 | 119816 | 119816 |
| 36 | 117256 | 117256 | 117256 | 119816 | 119816 | 119816 | 124464 | 124464 | 125808 | 125808 |
| 37A | 119816 | 124464 | 124464 | 124464 | 125808 | 125808 | 128496 | 128496 | 130392 | 130392 |
| 37 | 125808 | 125808 | 128496 | 128496 | 128496 | 133208 | 133208 | 133208 | 133208 | 137792 |

7.1.7.2.2 Transport blocks mapped to two-layer spatial multiplexing

For $1 \leq N_{\text{PRB}} \leq 55$, the TBS is given by the $(I_{\text{TBS}}, 2 \cdot N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1.

For $56 \leq N_{\text{PRB}} \leq 110$, a baseline TBS_L1 is taken from the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1, which is then translated into TBS_L2 using the mapping rule shown in Table 7.1.7.2.2-1. The TBS is given by TBS_L2.

Table 7.1.7.2.2-1: One-layer to two-layer TBS translation table

| TBS_L1 | TBS_L2 | TBS_L1 | TBS_L2 | TBS_L1 | TBS_L2 | TBS_L1 | TBS_L2 |
|--------|--------|--------|--------|--------|--------|--------|--------|
| 1544 | 3112 | 3752 | 7480 | 10296 | 20616 | 28336 | 57336 |
| 1608 | 3240 | 3880 | 7736 | 10680 | 21384 | 29296 | 59256 |
| 1672 | 3368 | 4008 | 7992 | 11064 | 22152 | 30576 | 61664 |
| 1736 | 3496 | 4136 | 8248 | 11448 | 22920 | 31704 | 63776 |
| 1800 | 3624 | 4264 | 8504 | 11832 | 23688 | 32856 | 66592 |
| 1864 | 3752 | 4392 | 8760 | 12216 | 24496 | 34008 | 68808 |
| 1928 | 3880 | 4584 | 9144 | 12576 | 25456 | 35160 | 71112 |
| 1992 | 4008 | 4776 | 9528 | 12960 | 25456 | 36696 | 73712 |
| 2024 | 4008 | 4968 | 9912 | 13536 | 27376 | 37888 | 76208 |
| 2088 | 4136 | 5160 | 10296 | 14112 | 28336 | 39232 | 78704 |
| 2152 | 4264 | 5352 | 10680 | 14688 | 29296 | 40576 | 81176 |
| 2216 | 4392 | 5544 | 11064 | 15264 | 30576 | 42368 | 84760 |
| 2280 | 4584 | 5736 | 11448 | 15840 | 31704 | 43816 | 87936 |
| 2344 | 4776 | 5992 | 11832 | 16416 | 32856 | 45352 | 90816 |
| 2408 | 4776 | 6200 | 12576 | 16992 | 34008 | 46888 | 93800 |
| 2472 | 4968 | 6456 | 12960 | 17568 | 35160 | 48936 | 97896 |
| 2536 | 5160 | 6712 | 13536 | 18336 | 36696 | 51024 | 101840 |
| 2600 | 5160 | 6968 | 14112 | 19080 | 37888 | 52752 | 105528 |
| 2664 | 5352 | 7224 | 14688 | 19848 | 39232 | 55056 | 110136 |
| 2728 | 5544 | 7480 | 14688 | 20616 | 40576 | 57336 | 115040 |
| 2792 | 5544 | 7736 | 15264 | 21384 | 42368 | 59256 | 119816 |
| 2856 | 5736 | 7992 | 15840 | 22152 | 43816 | 61664 | 124464 |
| 2984 | 5992 | 8248 | 16416 | 22920 | 45352 | 63776 | 128496 |
| 3112 | 6200 | 8504 | 16992 | 23688 | 46888 | 66592 | 133208 |
| 3240 | 6456 | 8760 | 17568 | 24496 | 48936 | 68808 | 137792 |
| 3368 | 6712 | 9144 | 18336 | 25456 | 51024 | 71112 | 142248 |
| 3496 | 6968 | 9528 | 19080 | 26416 | 52752 | 73712 | 146856 |
| 3624 | 7224 | 9912 | 19848 | 27376 | 55056 | 75376 | 149776 |
| 76208 | 152976 | 81176 | 161760 | 87936 | 175600 | 93800 | 187712 |
| 78704 | 157432 | 84760 | 169544 | 90816 | 181656 | 97896 | 195816 |
| 100752 | 201936 | 101840 | 203704 | 105528 | 211936 | | |
| 107832 | 214176 | 110136 | 220296 | 112608 | 226416 | 115040 | 230104 |
| 117256 | 236160 | 119816 | 239656 | 124464 | 248272 | 125808 | 251640 |

7.1.7.2.3 Transport blocks mapped for DCI Format 1C and DCI Format 6-2

The TBS is given by the I_{TBS} entry of Table 7.1.7.2.3-1. For DCI Format 6-2, $0 \leq I_{\text{TBS}} \leq 7$.

Table 7.1.7.2.3-1: Transport Block Size (TBS) table for DCI format 1C and DCI Format 6-2

| | | | | | | | | | | | | | | | | |
|------------------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
| I_{TBS} | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| TBS | 40 | 56 | 72 | 120 | 136 | 144 | 176 | 208 | 224 | 256 | 280 | 296 | 328 | 336 | 392 | 488 |
| I_{TBS} | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| TBS | 552 | 600 | 632 | 696 | 776 | 840 | 904 | 1000 | 1064 | 1128 | 1224 | 1288 | 1384 | 1480 | 1608 | 1736 |

7.1.7.2.4 Transport blocks mapped to three-layer spatial multiplexing

For $1 \leq N_{\text{PRB}} \leq 36$, the TBS is given by the $(I_{\text{TBS}}, 3 \cdot N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1.

For $37 \leq N_{\text{PRB}} \leq 110$, a baseline TBS_L1 is taken from the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1, which is then translated into TBS_L3 using the mapping rule shown in Table 7.1.7.2.4-1. The TBS is given by TBS_L3.

Table 7.1.7.2.4-1: One-layer to three-layer TBS translation table

| TBS_L1 | TBS_L3 | TBS_L1 | TBS_L3 | TBS_L1 | TBS_L3 | TBS_L1 | TBS_L3 |
|--------|--------|--------|--------|--------|--------|--------|--------|
| 1032 | 3112 | 2664 | 7992 | 8248 | 24496 | 26416 | 78704 |
| 1064 | 3240 | 2728 | 8248 | 8504 | 25456 | 27376 | 81176 |
| 1096 | 3240 | 2792 | 8248 | 8760 | 26416 | 28336 | 84760 |
| 1128 | 3368 | 2856 | 8504 | 9144 | 27376 | 29296 | 87936 |
| 1160 | 3496 | 2984 | 8760 | 9528 | 28336 | 30576 | 90816 |
| 1192 | 3624 | 3112 | 9144 | 9912 | 29296 | 31704 | 93800 |
| 1224 | 3624 | 3240 | 9528 | 10296 | 30576 | 32856 | 97896 |
| 1256 | 3752 | 3368 | 9912 | 10680 | 31704 | 34008 | 101840 |
| 1288 | 3880 | 3496 | 10296 | 11064 | 32856 | 35160 | 105528 |
| 1320 | 4008 | 3624 | 10680 | 11448 | 34008 | 36696 | 110136 |
| 1352 | 4008 | 3752 | 11064 | 11832 | 35160 | 37888 | 115040 |
| 1384 | 4136 | 3880 | 11448 | 12216 | 36696 | 39232 | 119816 |
| 1416 | 4264 | 4008 | 11832 | 12576 | 37888 | 40576 | 119816 |
| 1480 | 4392 | 4136 | 12576 | 12960 | 39232 | 42368 | 128496 |
| 1544 | 4584 | 4264 | 12960 | 13536 | 40576 | 43816 | 133208 |
| 1608 | 4776 | 4392 | 12960 | 14112 | 42368 | 45352 | 137792 |
| 1672 | 4968 | 4584 | 13536 | 14688 | 43816 | 46888 | 142248 |
| 1736 | 5160 | 4776 | 14112 | 15264 | 45352 | 48936 | 146856 |
| 1800 | 5352 | 4968 | 14688 | 15840 | 46888 | 51024 | 152976 |
| 1864 | 5544 | 5160 | 15264 | 16416 | 48936 | 52752 | 157432 |
| 1928 | 5736 | 5352 | 15840 | 16992 | 51024 | 55056 | 165216 |
| 1992 | 5992 | 5544 | 16416 | 17568 | 52752 | 57336 | 171888 |
| 2024 | 5992 | 5736 | 16992 | 18336 | 55056 | 59256 | 177816 |
| 2088 | 6200 | 5992 | 18336 | 19080 | 57336 | 61664 | 185728 |
| 2152 | 6456 | 6200 | 18336 | 19848 | 59256 | 63776 | 191720 |
| 2216 | 6712 | 6456 | 19080 | 20616 | 61664 | 66592 | 199824 |
| 2280 | 6712 | 6712 | 19848 | 21384 | 63776 | 68808 | 205880 |
| 2344 | 6968 | 6968 | 20616 | 22152 | 66592 | 71112 | 214176 |
| 2408 | 7224 | 7224 | 21384 | 22920 | 68808 | 73712 | 221680 |
| 2472 | 7480 | 7480 | 22152 | 23688 | 71112 | 75376 | 226416 |
| 2536 | 7480 | 7736 | 22920 | 24496 | 73712 | | |
| 2600 | 7736 | 7992 | 23688 | 25456 | 76208 | | |
| 76208 | 230104 | 81176 | 245648 | 87936 | 266440 | 93800 | 284608 |
| 78704 | 236160 | 84760 | 254328 | 90816 | 275376 | 97896 | 293736 |
| 105528 | 314888 | 107832 | 324336 | 110136 | 324336 | 112608 | 336576 |
| 115040 | 339112 | 117256 | 351224 | 119816 | 363336 | 124464 | 373296 |
| 125808 | 375448 | | | | | | |

7.1.7.2.5 Transport blocks mapped to four-layer spatial multiplexing

For $1 \leq N_{\text{PRB}} \leq 27$, the TBS is given by the $(I_{\text{TBS}}, 4 \cdot N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1.

For $28 \leq N_{\text{PRB}} \leq 110$, a baseline TBS_L1 is taken from the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1, which is then translated into TBS_L4 using the mapping rule shown in Table 7.1.7.2.5-1. The TBS is given by TBS_L4.

Table 7.1.7.2.5-1: One-layer to four-layer TBS translation table

| TBS_L1 | TBS_L4 | TBS_L1 | TBS_L4 | TBS_L1 | TBS_L4 | TBS_L1 | TBS_L4 |
|--------|--------|--------|--------|--------|--------|--------|--------|
| 776 | 3112 | 2280 | 9144 | 7224 | 29296 | 24496 | 97896 |
| 808 | 3240 | 2344 | 9528 | 7480 | 29296 | 25456 | 101840 |
| 840 | 3368 | 2408 | 9528 | 7736 | 30576 | 26416 | 105528 |
| 872 | 3496 | 2472 | 9912 | 7992 | 31704 | 27376 | 110136 |
| 904 | 3624 | 2536 | 10296 | 8248 | 32856 | 28336 | 115040 |
| 936 | 3752 | 2600 | 10296 | 8504 | 34008 | 29296 | 115040 |
| 968 | 3880 | 2664 | 10680 | 8760 | 35160 | 30576 | 124464 |
| 1000 | 4008 | 2728 | 11064 | 9144 | 36696 | 31704 | 128496 |
| 1032 | 4136 | 2792 | 11064 | 9528 | 37888 | 32856 | 133208 |
| 1064 | 4264 | 2856 | 11448 | 9912 | 39232 | 34008 | 137792 |
| 1096 | 4392 | 2984 | 11832 | 10296 | 40576 | 35160 | 142248 |
| 1128 | 4584 | 3112 | 12576 | 10680 | 42368 | 36696 | 146856 |
| 1160 | 4584 | 3240 | 12960 | 11064 | 43816 | 37888 | 151376 |
| 1192 | 4776 | 3368 | 13536 | 11448 | 45352 | 39232 | 157432 |
| 1224 | 4968 | 3496 | 14112 | 11832 | 46888 | 40576 | 161760 |
| 1256 | 4968 | 3624 | 14688 | 12216 | 48936 | 42368 | 169544 |
| 1288 | 5160 | 3752 | 15264 | 12576 | 51024 | 43816 | 175600 |
| 1320 | 5352 | 3880 | 15264 | 12960 | 51024 | 45352 | 181656 |
| 1352 | 5352 | 4008 | 15840 | 13536 | 55056 | 46888 | 187712 |
| 1384 | 5544 | 4136 | 16416 | 14112 | 57336 | 48936 | 195816 |
| 1416 | 5736 | 4264 | 16992 | 14688 | 59256 | 51024 | 203704 |
| 1480 | 5992 | 4392 | 17568 | 15264 | 61664 | 52752 | 211936 |
| 1544 | 6200 | 4584 | 18336 | 15840 | 63776 | 55056 | 220296 |
| 1608 | 6456 | 4776 | 19080 | 16416 | 66592 | 57336 | 230104 |
| 1672 | 6712 | 4968 | 19848 | 16992 | 68808 | 59256 | 236160 |
| 1736 | 6968 | 5160 | 20616 | 17568 | 71112 | 61664 | 245648 |
| 1800 | 7224 | 5352 | 21384 | 18336 | 73712 | 63776 | 254328 |
| 1864 | 7480 | 5544 | 22152 | 19080 | 76208 | 66592 | 266440 |
| 1928 | 7736 | 5736 | 22920 | 19848 | 78704 | 68808 | 275376 |
| 1992 | 7992 | 5992 | 23688 | 20616 | 81176 | 71112 | 284608 |
| 2024 | 7992 | 6200 | 24496 | 21384 | 84760 | 73712 | 293736 |
| 2088 | 8248 | 6456 | 25456 | 22152 | 87936 | 75376 | 299856 |
| 2152 | 8504 | 6712 | 26416 | 22920 | 90816 | | |
| 2216 | 8760 | 6968 | 28336 | 23688 | 93800 | | |
| 76208 | 305976 | 81176 | 324336 | 87936 | 351224 | 93800 | 375448 |
| 78704 | 314888 | 84760 | 339112 | 90816 | 363336 | 97896 | 391656 |
| 105528 | 422232 | 107832 | 422232 | 110136 | 440616 | 112608 | 452832 |
| 115040 | 460232 | 117256 | 471192 | 119816 | 478400 | 124464 | 501792 |
| 125808 | 502624 | | | | | | |

7.1.7.2.6 Transport blocks mapped for BL/CE UEs configured with CEModeB and PDSCH bandwidth up to 1.4MHz

BL/CE UEs configured with CEModeB and not configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value $\geq 5\text{MHz}$ and not configured with higher layer parameter *mpdcch-PDSCH-MaxBandwidth-SC-MTCH* with

value 24 PRBs shall set $I_{\text{TBS}} = I_{\text{TBS}}^1$ and determine its TBS by the procedure in Subclause 7.1.7.2.1 for $0 \leq I_{\text{TBS}} \leq 9$, and $N_{\text{PRB}} = 4$ or $N_{\text{PRB}} = 6$.

7.1.7.2.7 Transport blocks mapped for BL/CE UEs *SystemInformationBlockType1-BR*

The TBS is given by the I_{TBS} entry of Table 7.1.7.2.7-1.

Table 7.1.7.2.7-1: Transport block size (TBS) table for PDSCH carrying *SystemInformationBlockType1-BR*

| I_{TBS} | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----------|
| TBS | N/A | 208 | 208 | 208 | 256 | 256 | 256 | 328 | 328 | 328 | 504 | 504 | 504 | 712 | 712 | 712 |
| I_{TBS} | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| TBS | 936 | 936 | 936 | | | | | | | | | | | | | Reserved |

7.1.7.2.8 Transport blocks mapped for UEs configured with *ce-pdsch-maxBandwidth-config* value of 5 MHz or with *pdsch-MaxBandwidth-SC-MTCH* value of 24 PRBs

For $1 \leq N_{\text{PRB}} \leq 14$, and $0 \leq I_{\text{TBS}} \leq 14$ the TBS is given by the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.1-1.

For $15 \leq N_{\text{PRB}} \leq 24$, and $0 \leq I_{\text{TBS}} \leq 14$ the TBS is given by the $(I_{\text{TBS}}, N_{\text{PRB}})$ entry of Table 7.1.7.2.8-1.

Table 7.1.7.2.8-1: Transport block size (TBS) table for UEs configured with *ce-pdsch-maxBandwidth-config* value of 5 MHz or with *pdsch-MaxBandwidth-SC-MTCH* value of 24 PRBs

| I_{TBS} | N_{PRB} | | | | | | | | | |
|------------------|------------------|------|------|------|------|------|------|------|------|------|
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| 0 | 392 | 424 | 456 | 488 | 504 | 536 | 568 | 600 | 616 | 648 |
| 1 | 520 | 568 | 600 | 632 | 680 | 712 | 744 | 776 | 808 | 872 |
| 2 | 648 | 696 | 744 | 776 | 840 | 872 | 936 | 968 | 1000 | 1064 |
| 3 | 872 | 904 | 968 | 1032 | 1096 | 1160 | 1224 | 1256 | 1320 | 1384 |
| 4 | 1064 | 1128 | 1192 | 1288 | 1352 | 1416 | 1480 | 1544 | 1608 | 1736 |
| 5 | 1320 | 1384 | 1480 | 1544 | 1672 | 1736 | 1864 | 1928 | 2024 | 2088 |
| 6 | 1544 | 1672 | 1736 | 1864 | 1992 | 2088 | 2216 | 2280 | 2408 | 2472 |
| 7 | 1800 | 1928 | 2088 | 2216 | 2344 | 2472 | 2536 | 2664 | 2792 | 2984 |
| 8 | 2088 | 2216 | 2344 | 2536 | 2664 | 2792 | 2984 | 3112 | 3240 | 3368 |
| 9 | 2344 | 2536 | 2664 | 2856 | 2984 | 3112 | 3368 | 3496 | 3624 | 3752 |
| 10 | 2664 | 2792 | 2984 | 3112 | 3368 | 3496 | 3752 | 3880 | 4008 | 4008 |
| 11 | 2984 | 3240 | 3496 | 3624 | 3880 | 4008 | 4008 | | | |
| 12 | 3368 | 3624 | 3880 | 4008 | 4008 | | | | | |
| 13 | 3880 | 4008 | 4008 | | | | | | | |
| 14 | 4008 | | | | | | | | | |

7.1.7.3 Redundancy Version determination for Format 1C

If the DCI Format 1C CRC is scrambled by P-RNTI or RA-RNTI, then

- the UE shall set the Redundancy Version to 0

Else if the DCI Format 1C CRC is scrambled by SI-RNTI, then

- the UE shall set the Redundancy Version as defined in [8].

7.1.8 Storing soft channel bits

For FDD, TDD and FDD-TDD, if the UE is configured with more than one serving cell or if the UE is configured with a SCG, then for each serving cell, for at least $K_{\text{MIMO}} \cdot \min(M_{\text{DL_HARQ}}, M_{\text{limit}})$ transport blocks, upon decoding failure of a code block of a transport block, the UE shall store received soft channel bits corresponding to a range of at least W_k

$W_{k+1}, \dots, W_{\text{mod}(k+n_{SB}-1, N_{cb})}$, where:

$$n_{SB} = \min\left(N_{cb}, \left\lfloor \frac{N'_{soft}}{C \cdot N_{cells}^{DL} \cdot K_{\text{MIMO}} \cdot \min(M_{\text{DL_HARQ}}, M_{\text{limit}})} \right\rfloor\right),$$

W_k , C , N_{cb} , K_{MIMO} , and M_{limit} are defined in Subclause 5.1.4.1.2 of [4].

$M_{\text{DL_HARQ}}$ is the maximum number of DL HARQ processes.

If the UE is configured with a SCG

- N_{cells}^{DL} is the number of configured serving cells across both MCG and SCG.

else

- N_{cells}^{DL} is the number of configured serving cells.

N'_{soft} is the maximum "Total number of soft channel bits" [12] among all the indicated UE categories [11] of this UE.

In determining k , the UE should give priority to storing soft channel bits corresponding to lower values of k . W_k shall correspond to a received soft channel bit. The range $W_k, W_{k+1}, \dots, W_{\text{mod}(k+n_{SB}-1, N_{cb})}$ may include subsets not containing received soft channel bits.

7.1.9 PDSCH resource mapping parameters

A UE configured in transmission mode 10 for a given serving cell can be configured with up to 8 parameter sets by higher layer signaling to decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 2D intended for the UE and the given serving cell. The UE shall use the parameter set according to the value of the 'PDSCH RE Mapping and Quasi-Co-Location indicator' field (mapping defined in Table 7.1.9-1 for Type B and defined in Table 7.9.1-1A for Type C quasi co-location) in the detected PDCCH/EPDCCH with DCI format 2D for determining the RE mapping (defined in Subclause 6.4 of [3]), and for determining antenna port quasi co-location (defined in Subclause 7.1.10) for PDSCH if the UE is configured with Type B quasi co-location type (defined in Subclause 7.1.10) or for each PDSCH codeword if the UE is configured with Type C quasi co-location (defined in Subclause 7.1.10). If the UE is configured with Type C quasi co-location and not configured with parameter set for codeword 1, the UE shall assume the parameter set for codeword 1 is the same as the parameter set for codeword 0.

For PDSCH without a corresponding PDCCH/EPDCCH, the UE shall use the parameter set indicated in the PDCCH/EPDCCH with DCI format 2D corresponding to the associated SPS activation for determining the RE mapping (defined in Subclause 6.4 of [3]) and antenna port quasi co-location (defined in Subclause 7.1.10) for PDSCH if the UE is configured with Type B quasi co-location and for each PDSCH codeword if the UE is configured with Type C quasi co-location.

Table 7.1.9-1: PDSCH RE Mapping and Quasi-Co-Location Indicator field in DCI format 2D for Type B quasi co-location

| Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field | Description |
|---|---|
| '00' | Parameter set 1 configured by higher layers |
| '01' | Parameter set 2 configured by higher layers |
| '10' | Parameter set 3 configured by higher layers |
| '11' | Parameter set 4 configured by higher layers |

Table 7.1.9-1A: PDSCH RE Mapping and Quasi-Co-Location Indicator field in DCI format 2D for Type C quasi co-location

| Value of 'PDSCH RE Mapping and Quasi-Co-Location Indicator' field | Description |
|---|--|
| '00' | Parameter set 1 configured by higher layers for codeword 0 and Parameter set 2 configured by higher layers for codeword 1 (if any) |
| '01' | Parameter set 3 configured by higher layers for codeword 0 and Parameter set 4 configured by higher layers for codeword 1 (if any) |
| '10' | Parameter set 5 configured by higher layers for codeword 0 and Parameter set 6 configured by higher layers for codeword 1 (if any) |
| '11' | Parameter set 7 configured by higher layers for codeword 0 and Parameter set 8 configured by higher layers for codeword 1 (if any) |

The following parameters for determining PDSCH RE mapping and PDSCH antenna port quasi co-location are configured via higher layer signaling for each parameter set for Type B quasi co-location and parameter set 1,3,5,7 for Type C quasi co-location:

- *crs-PortsCount-r11.*
- *crs-FreqShift-r11.*
- *mbsfn-SubframeConfigList-r11.*
- *csi-RS-ConfigZPId-r11.*
- *pdsch-Start-r11.*
- *qcl-CSI-RS-ConfigNZPId-r11.*

The following parameters for determining PDSCH RE mapping and PDSCH antenna port quasi co-location are configured via higher layer signaling for parameter set 2,4,6,8 for Type C quasi co-location

- *crs-PortsCount-v15xy.*
- *crs-FreqShift-v15xy.*
- *mbsfn-SubframeConfigList-v15xy.*
- *csi-RS-ConfigZPId-v15xy.*
- *pdsch-Start-v15xy.*
- *qcl-CSI-RS-ConfigNZPId-v15xy.*

To decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 1A with CRC scrambled with C-RNTI intended for the UE and the given serving cell and for PDSCH transmission on antenna port 7, a UE configured in transmission mode 10 for a given serving cell shall use the parameter set 1 in table 7.1.9-1 or table 7.1.9-1A for determining the PDSCH RE mapping (defined in Subclause 6.4 of [3]), and for determining PDSCH antenna port quasi co-location (defined in Subclause 7.1.10) if the UE is configured with Type B or Type C quasi co-location type (defined in Subclause 7.1.10).

To decode PDSCH corresponding to detected PDCCH/EPDCCH with DCI format 1A with CRC scrambled with SPS C-RNTI and PDSCH without a corresponding PDCCH/EPDCCH associated with SPS activation indicated in PDCCH/EPDCCH with DCI format 1A, a UE configured in transmission mode 10 for a given serving cell shall use the parameter set 1 in table 7.1.9-1 or table 7.1.9-1A for determining the PDSCH RE mapping (defined in Subclause 6.4 of [3]), and for determining PDSCH antenna port quasi co-location (defined in Subclause 7.1.10) if the UE is configured with Type B or Type C quasi co-location type (defined in Subclause 7.1.10).

If the UE is configured in transmission mode 10 and configured with Type B or Type C quasi co-location and configured with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot' for a CSI process, the UE is not expected to receive a 'PDSCH RE Mapping and Quasi-Co-Location indicator' selecting a parameter set with CSI-RS resource configuration for the CSI process identified by the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* corresponding to a deactivated CSI-RS resource (defined in Subclause 7.2.8) or an activated CSI-RS resource (defined in Subclause 7.2.8) with no CSI-RS transmission since the activation of the CSI-RS resource.

If the UE is configured in transmission mode 10 and configured with Type B or Type C quasi co-location and configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and configured with higher layer parameter *csi-RS-NZP-mode* set to 'aperiodic' for a CSI process, the UE is not expected to receive a 'PDSCH RE Mapping and Quasi-Co-Location indicator' selecting a parameter set with CSI-RS resource configuration for the CSI process identified by the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11*.

To decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 1A intended for the UE on a given serving cell and for PDSCH transmission on antenna port 0 – 3, a UE configured in transmission mode 10 for the given serving cell shall determine the PDSCH RE mapping (as described in Subclause 6.4 of [3]) using the lowest indexed zero-power CSI-RS resource.

To decode PDSCH according to a detected SPDCCH with DCI format 7-1 A, 7-1B, 7-1C, 7-1D, 7-1E, 7-1F, 7-1G with CRC scrambled with C-RNTI or retransmission of PDSCH according to a detected SPDCCH with DCI format 7-1 A, 7-1B, 7-1C, 7-1D, 7-1E, 7-1F, 7-1G with CRC scrambled with SPS C-RNTI intended for the UE and the given serving cell, a UE shall use the value of the higher layer parameter *rateMatchingMode* (for each SPDCCH-PRB set), and the 'Used/Unused SPDCCH resource indication' field (if present) in the SPDCCH for determining the PDSCH RE mapping (defined in Subclause 6.4 of [3]).

A UE configured with higher layer parameter *csi-RS-ConfigZP-ApList* for a given serving cell is configured with 4 aperiodic zero-power CSI-RS resources by higher layer signaling to decode PDSCH according to a detected PDCCH/EPDCCH with DCI format 1/1B/1D//2/2A/2B/2C/2D intended for the UE and the given serving cell. The UE shall use the aperiodic zero-power CSI-RS resource according to the value of the 'Aperiodic zero-power CSI-RS resource indicator for PDSCH RE Mapping' field (mapping defined in Table 7.1.9-2) in the detected PDCCH/EPDCCH with DCI format 1/1B/1D/2/2A/2B/2C/2D for determining the PDSCH RE mapping (defined in Subclause 6.4 of [3]).

Table 7.1.9-2: Aperiodic zero-power CSI-RS resource indicator for PDSCH RE Mapping field in DCI format 1/1B/1D/2/2A/2B/2C/2D

| Value of Aperiodic zero-power CSI-RS resource indicator for PDSCH RE Mapping ' field | Description |
|--|---|
| '00' | Aperiodic zero-power CSI-RS resources 1 configured by higher layers |
| '01' | Aperiodic zero-power CSI-RS resources 2 configured by higher layers |
| '10' | Aperiodic zero-power CSI-RS resources 3 configured by higher layers |
| '11' | Aperiodic zero-power CSI-RS resources 4 configured by higher layers |

7.1.10 Antenna ports quasi co-location for PDSCH

A UE configured in transmission mode 8-10 for a serving cell may assume the antenna ports 7 – 14 of the serving cell are quasi co-located (as defined in [3]) for a given subframe with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

A UE configured in transmission mode 1-9 for a serving cell may assume the antenna ports 0 – 3, 5, 7 – 46 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

A UE configured in transmission mode 10 for a serving cell is configured with one of three quasi co-location types for the serving cell by higher layer parameter *qcl-Operation* to decode PDSCH according to transmission scheme associated with antenna ports 7-14:

- Type A: The UE may assume the antenna ports 0 – 3, 7 – 46 of a serving cell are quasi co-located (as defined in [3]) with respect to delay spread, Doppler spread, Doppler shift, and average delay.
- Type B: The UE may assume the antenna ports 15 – 46 corresponding to the CSI-RS resource configuration identified by the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* (defined in Subclause 7.1.9) and the antenna ports 7 – 14 associated with the PDSCH are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.
- Type C: The UE may assume the antenna ports 15 – 46 corresponding to the CSI-RS resource configuration identified by the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* or *qcl-CSI-RS-ConfigNZPId2-r15* (defined in Subclause 7.1.9) and the antenna ports 7 – 14 associated with each PDSCH codeword are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

For a LAA Scell, the UE is not expected to be configured with quasi co-location type B or type C.

7.1.11 PDSCH subframe assignment for BL/CE UE

A BL/CE UE shall upon detection of a MPDCCH with DCI format 6-1A/6-1B/6-2 intended for the UE, decode the corresponding PDSCH in subframe(s) $n+k_i$ with $i = 0, 1, \dots, N-1$ according to the MPDCCH, where

- subframe n is the last subframe in which the MPDCCH is transmitted and is determined from the starting subframe of MPDCCH transmission and the DCI subframe repetition number field in the corresponding DCI; and
- subframe(s) $n+k_i$ with $i=0,1,\dots,N-1$ are N consecutive BL/CE DL subframe(s) where, $x=k_0 < k_1 < \dots, k_{N-1}$ and the value of $N \in \{n1, n2, \dots, n_{\max}\}$ is determined by the repetition number field in the corresponding DCI, where $n1, n2, \dots, n_{\max}$ are given in Table 7.1.11-1, Table 7.1.11-2 and Table 7.1.11-3, respectively and subframe $n+x$ is the second BL/CE DL subframe after subframe n .

For BL/CE UEs, and for a PDSCH transmission starting in subframe $n+k_0$ without a corresponding MPDCCH, the UE shall decode the PDSCH transmission in subframe(s) $n+k_i$ with $i = 0, 1, \dots, N-1$, where

- subframe(s) $n+k_i$ with $i=0,1,\dots,N-1$ are N consecutive BL/CE DL subframe(s), where $0 \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of $N \in \{n1, n2, \dots, n_{\max}\}$ is determined by the repetition number field in the activation DCI, where $n1, n2, \dots, n_{\max}$ are given in Table 7.1.11-1, Table 7.1.11-2 and Table 7.1.11-3, respectively.

If PDSCH carrying *SystemInformationBlockType1-BR* is transmitted in one narrowband in subframe $n+k_i$, a BL/CE UE shall assume any other PDSCH in the same narrowband in the subframe $n+k_i$ is dropped. If PDSCH carrying SI message is transmitted in one narrowband in subframe $n+k_i$, a BL/CE UE shall assume any other PDSCH not carrying *SystemInformationBlockType1-BR* in the same narrowband in the subframe $n+k_i$ is dropped.

For single antenna port (port 0), transmit diversity and closed-loop spatial multiplexing transmission schemes, if a PDSCH is transmitted in BL/CE DL subframe $n+k_i$ and BL/CE DL subframe $n+k_i$ is configured as an MBSFN subframe, a BL/CE UE shall assume that the PDSCH in subframe $n+k_i$ is dropped.

For PDSCH assigned by MPDCCH with DCI CRC scrambled by G-RNTI and DCI Format 6-1A, the UE shall use the higher layer parameter *pdsch-maxNumRepetitionCEmodeA-SC-MTCH* instead of *pdsch-maxNumRepetitionCEmodeA* in Table 7.1.11-1.

For PDSCH assigned by MPDCCH with DCI CRC scrambled by G-RNTI and DCI Format 6-1B, the UE shall use the higher layer parameter *pdsch-maxNumRepetitionCEmodeB-SC-MTCH* instead of *pdsch-maxNumRepetitionCEmodeB* in Table 7.1.11-2.

For a BL/CE UE in half-duplex FDD operation, if the UE is configured with CEModeA, and configured with higher layer parameter *ce-HARQ-AckBundling*, and 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, the UE shall assume $N = n1 = 1$.

Table 7.1.11-1: PDSCH repetition levels (DCI Format 6-1A)

| Higher layer parameter ' <i>pdsch-</i> <i>maxNumRepetitionCEmodeA'</i> ' | $\{n1, n2, n3, n4\}$ |
|--|----------------------|
| Not configured | $\{1, 2, 4, 8\}$ |
| 16 | $\{1, 4, 8, 16\}$ |
| 32 | $\{1, 4, 16, 32\}$ |

Table 7.1.11-2: PDSCH repetition levels (DCI Format 6-1B)

| Higher layer parameter 'pdsch-maxNumRepetitionCEmodeB' | $\{n1, n2, \dots, n8\}$ |
|---|--|
| Not configured | $\{4, 8, 16, 32, 64, 128, 256, 512\}$ |
| 192 | $\{1, 4, 8, 16, 32, 64, 128, 192\}$ |
| 256 | $\{4, 8, 16, 32, 64, 128, 192, 256\}$ |
| 384 | $\{4, 16, 32, 64, 128, 192, 256, 384\}$ |
| 512 | $\{4, 16, 64, 128, 192, 256, 384, 512\}$ |
| 768 | $\{8, 32, 128, 192, 256, 384, 512, 768\}$ |
| 1024 | $\{4, 8, 16, 64, 128, 256, 512, 1024\}$ |
| 1536 | $\{4, 16, 64, 256, 512, 768, 1024, 1536\}$ |
| 2048 | $\{4, 16, 64, 128, 256, 512, 1024, 2048\}$ |

Table 7.1.11-3: PDSCH repetition levels (DCI Format 6-2)

| 2-bit "DCI subframe repetition number" field in DCI Format 6-2 | $\{n1, n2, \dots, n8\}$ |
|---|---|
| 00 | $\{1, 2, 4, 8, 16, 32, 64, 128\}$ |
| 01 | $\{4, 8, 16, 32, 64, 128, 192, 256\}$ |
| 10 | $\{32, 64, 128, 192, 256, 384, 512, 768\}$ |
| 11 | $\{192, 256, 384, 512, 768, 1024, 1536, 2048\}$ |

7.2 UE procedure for reporting Channel State Information (CSI)

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

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', and 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell or serving cells belonging to the primary PUCCH group respectively unless stated otherwise.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell' and 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively unless stated otherwise. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

If a UE is configured with a LAA SCell for UL transmissions, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA SCell unless stated otherwise.

The time and frequency resources that can be used by the UE to report CSI which consists of Channel Quality Indicator (CQI), precoding matrix indicator (PMI), precoding type indicator (PTI), CSI-RS resource indicator (CRI), and/or rank indication (RI) are controlled by the eNB. For spatial multiplexing, as given in [3], the UE shall determine a RI corresponding to the number of useful transmission layers. For transmit diversity as given in [3], RI is equal to one.

A non-BL/CE UE in transmission mode 8 or 9 is configured with or without PMI/RI reporting by the higher layer parameter *pmi-RI-Report*.

A UE in transmission mode 10 can be configured with one or more CSI processes per serving cell by higher layers.

For a UE in transmission mode 10,

- If a UE is not configured with higher layer parameter *eMIMO-Type*, each CSI process is associated with a CSI-RS resource (defined in Subclause 7.2.5) and a CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6). A UE can be configured with up to two CSI-IM resources for a CSI process if the UE is configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubFramePatternConfig-r12* for the CSI process.
- If the UE is configured with higher layer parameter *eMIMO-Type* and not configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', each CSI process is associated with a CSI-RS resource (defined in Subclause 7.2.5) and a CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6). A UE can be configured with up to two CSI-IM resources for a CSI process if the UE is configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubFramePatternConfig-r12* for the CSI process.
- If the UE is configured with higher layer parameter *eMIMO-Type* and not configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B', each CSI process is associated with one or more CSI-RS resource (defined in Subclause 7.2.5) and one or more CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6). Each CSI-RS resource is associated with a CSI-IM resource by higher layers. For a CSI process with one CSI-RS resource, a UE can be configured with CSI-IM resource for each CSI subframe sets if the UE is configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubFramePatternConfig-r12* for the CSI process. If a UE is configured with higher layer parameter *FeCoMPCSIEnabled* for a CSI process, the CSI process is associated with two CSI-RS resource and one CSI-IM resource.
- If the UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B', each CSI process is associated with a CSI-RS resource (defined in Subclause 7.2.5) and a CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6) for *eMIMO-Type*, and one CSI-RS resource (defined in Subclause 7.2.5) and one CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6) for *eMIMO-Type2*. A UE can be configured with up to two CSI-IM resources for each *eMIMO-Type* and *eMIMO-Type2* of a CSI process if the UE is configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubFramePatternConfig-r12* for the CSI process.
- If the UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B', and *eMIMO-Type2* is set to 'CLASS B', each CSI process is associated with more than one CSI-RS

resource (defined in Subclause 7.2.5) and more than one CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6) with association of each CSI-RS resource with a CSI-IM resource by higher layers for *eMIMO-Type*, and one CSI-RS resource (defined in Subclause 7.2.5) and one CSI-interference measurement (CSI-IM) resource (defined in Subclause 7.2.6) for *eMIMO-Type2*.

For a UE in transmission mode 10, a CSI reported by the UE corresponds to a CSI process configured by higher layers. Each CSI process can be configured with or without PMI/RI reporting by higher layer signalling.

If a UE is configured with a serving cell with frame structure 3, the UE is not required to update measurements for more than 5 CSI processes in a subframe, in case the total number of serving cells is no more than 5. If a UE is configured with more than 5 serving cells, the UE is not required to update measurements for more than N_y CSI processes in a subframe, where the value of N_y is given by

- *maxNumberUpdatedCSI-Proc-r13* if the UE is configured with a serving cell with frame structure 3
- *maxNumberUpdatedCSI-Proc-SPT-r15* if the UE is configured with higher layer parameter *shortProcessingTime*

If a UE is configured with the higher layer parameter *shortTTI*, the UE is not required to update measurements for more than N_y CSI processes in a DL

- slot, where the value of N_y is given by *maxNumberUpdatedCSI-Proc-STTI-Comb77-r15* if the higher layer parameter *dl-TTI-Length* is set to 'slot' and if the higher layer parameter *ul-TTI-Length* is set to 'slot'.
- subslot, where the value of N_y is given by *maxNumberUpdatedCSI-Proc-STTI-Comb27-r15* if the higher layer parameter *dl-TTI-Length* is set to 'subslot' and if the higher layer parameter *ul-TTI-Length* is set to 'slot'.
- subslot, where the value of N_y is given by *maxNumberUpdatedCSI-Proc-STTI-Comb22-Set1-r15* if the higher layer parameter *dl-TTI-Length* is set to 'subslot' and if the higher layer parameter *ul-TTI-Length* is set to 'subslot' and if *proc-Timeline-r15* is set to 'nplus4set1' or 'nplus6set1'.
- subslot, where the value of N_y is given by *maxNumberUpdatedCSI-Proc-STTI-Comb22-Set2-r15* if the higher layer parameter *dl-TTI-Length* is set to 'subslot' and if the higher layer parameter *ul-TTI-Length* is set to 'subslot' and if *proc-Timeline-r15* is set to 'nplus6set2' or 'nplus8set2'.

For UE in transmission mode 9 and the UE configured with higher layer parameter *eMIMO-Type*, the term 'CSI process' in this Subclause refers to the CSI configured for the UE.

For a UE in transmission mode 9, and if the UE is configured with higher layer parameter *eMIMO-Type*, and,

- UE is not configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS A', each CSI process is associated with a CSI-RS resource (defined in Subclause 7.2.5).
- UE is not configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS B', each CSI process is associated with one or more CSI-RS resource (defined in Subclause 7.2.5).
- UE is configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS A' and *eMIMO-Type2* is set to 'CLASS B', each CSI process is associated with a CSI-RS resource (defined in Subclause 7.2.5) for *eMIMO-Type*, and a CSI-RS resource (defined in Subclause 7.2.5) for *eMIMO-Type2*.
- UE is configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS B' and *eMIMO-Type2* is set to 'CLASS B', each CSI process is associated with more than one CSI-RS resource (defined in Subclause 7.2.5) for *eMIMO-Type*, and a CSI-RS resource (defined in Subclause 7.2.5) for *eMIMO-Type2*.

For a CSI process, and if a UE is configured in transmission mode 9 or 10, and UE is not configured with higher layer parameter *pmi-RI-Report*, and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of CSI-RS antenna ports in at least one of the one or more configured CSI-RS resource is more than one, the UE is considered to be configured without PMI reporting.

For a UE configured in transmission mode 9 or 10, UE is not expected to be configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and more than one CSI-RS resource configured, and the number

of CSI-RS resource configured with one antenna port is not equal to total number number of CSI-RS resources associated with the CSI process.

A UE is configured with resource-restricted CSI measurements if the subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers. A UE can also be configured with resource restricted CSI measurements for dormant serving cells with subframe sets $C_{CSI,0\text{-dormant}}$ and $C_{CSI,1\text{-dormant}}$. If the UE is configured with resource restricted CSI measurements for dormant serving cells, $C_{CSI,0}$ and $C_{CSI,1}$ in this clause refer to $C_{CSI,0}$ and $C_{CSI,1}$ for activated serving cells, and to $C_{CSI,0\text{-dormant}}$ and $C_{CSI,1\text{-dormant}}$ for dormant serving cells.

For a serving cell with frame structure type 1, a UE is not expected to be configured with *csi-SubframePatternConfig-r12*.

CSI reporting is periodic or aperiodic.

A BL/CE UE configured with CEModeB is not expected to be configured with either aperiodic CSI or periodic CSI reporting.

If the UE is configured with more than one serving cell, it transmits aperiodic CSI for activated serving cell(s) only, and periodic CSI for activated and/or dormant serving cell(s) only.

If a UE is not configured for simultaneous PUSCH and PUCCH transmission, it shall transmit periodic CSI reporting on PUCCH as defined hereafter in subframes with no PUSCH allocation.

If a UE is not configured for simultaneous PUSCH and PUCCH transmission, it shall transmit periodic CSI reporting on PUSCH of the serving cell with smallest *ServCellIndex* as defined hereafter in subframes with a PUSCH allocation, where the UE shall use the same PUCCH-based periodic CSI reporting format on PUSCH.

A UE shall transmit aperiodic CSI reporting on PUSCH if the conditions specified hereafter are met. For aperiodic CQI/PMI reporting, RI reporting is transmitted only if the configured CSI feedback type supports RI reporting.

Table 7.2-1: Void

In case both periodic and aperiodic CSI reporting would occur in the same subframe, the UE shall only transmit the aperiodic CSI report in that subframe. If the aperiodic CSI reporting occurs on an LAA SCell, the UE shall assume that the UL channel access procedure, as described in subclause 4.2 of [13], is successful to determine whether periodic and aperiodic CSI reporting would occur in the same subframe.

If the higher layer parameter *altCQI-TableSTTI-r15* is configured and is set to *allSubframes* and aperiodic CSI is triggered through DCI format 7-0A or 7-0B,

- the UE shall report CQI according to Table 7.2.3-2.

Else if the higher layer parameter *altCQI-Table1024QAM-STTI-r15* is configured and is set to *allSubframes* and aperiodic CSI is triggered through DCI format 7-0A or 7-0B,

- the UE shall report CQI according to Table 7.2.3-4.

Else if the higher layer parameter *altCQI-TableSTTI-r15* is configured and is set to *csi-SubframeSet1* or *csi-SubframeSet2* and aperiodic CSI is triggered through DCI format 7-0A or 7-0B,

- the UE shall report CQI according to Table 7.2.3-2 for the corresponding CSI subframe set configured by *altCQI-TableSTTI-r15*
- the UE shall report CQI for the other CSI subframe set according to Table 7.2.3-1.

Else if the higher layer parameter *altCQI-Table1024QAM-STTI-r15* is configured and is set to *csi-SubframeSet1* or *csi-SubframeSet2* and aperiodic CSI is triggered through DCI format 7-0A or 7-0B,

- the UE shall report CQI according to Table 7.2.3-4 for the corresponding CSI subframe set configured by *altCQI-Table1024QAM-STTI-r15*
- the UE shall report CQI for the other CSI subframe set according to Table 7.2.3-1.

Else if aperiodic CSI is triggered through DCI format 7-0A or 7-0B,

- the UE shall report CQI according to Table 7.2.3-1.

Else if the higher layer parameter *altCQI-Table-r12* is configured and is set to *allSubframes*,

- the UE shall report CQI according to Table 7.2.3-2.

Else if the higher layer parameter *altCQI-Table-1024QAM-r15* is configured and is set to *allSubframes*

- the UE shall report CQI according to Table 7.2.3-4.

Else if the higher layer parameter *altCQI-Table-r12* is configured and is set to *csi-SubframeSet1* or *csi-SubframeSet2*,

- the UE shall report CQI according to Table 7.2.3-2 for the corresponding CSI subframe set configured by *altCQI-Table-r12*
- the UE shall report CQI for the other CSI subframe set according to Table 7.2.3-1.

Else if the higher layer parameter *altCQI-Table-1024QAM-r15* is configured and is set to *csi-SubframeSet1* or *csi-SubframeSet2*,

- the UE shall report CQI according to Table 7.2.3-4 for the corresponding CSI subframe set configured by *altCQI-Table-1024QAM-r15*
- the UE shall report CQI for the other CSI subframe set according to Table 7.2.3-1.

Else

- the UE shall report CQI according to Table 7.2.3-1.

For a BL/CE UE, if the UE is configured with higher layer parameter *ce-PDSCH-64QAM-Config-r15* and the higher layer parameter *csi-NumRepetitionCE-r13* indicates more than one subframe, or if the UE is configured with higher layer parameter *ce-CQI-AlternativeTableConfig-r15*,

- the UE shall report CQI according to Table 7.2.3-6.
- if the UE is not capable of supporting 64QAM in PDSCH, or the UE is configured with higher layer parameter *mpdcch-pdsch-HoppingConfig-r13* set to 'on' and the UE is calculating CQI for a wideband CSI report, the reported CQI < 13.

Else if the higher layer parameter *ce-PDSCH-64QAM-Config-r15* is configured,

- the UE shall report CQI according to Table 7.2.3-5.
- if the UE is configured with higher layer parameter *mpdcch-pdsch-HoppingConfig-r13* set to 'on' and the UE is calculating CQI for a wideband CSI report, the reported CQI < 11.

Else

- the UE shall report CQI according to Table 7.2.3-3 with CQI index between 1 and 10.

For a non-BL/CE UE, when reporting RI the UE reports a single instance of the number of useful transmission layers. For each RI reporting interval when the UE is configured in transmission modes 4 or when the UE is configured in transmission mode 8, 9 or 10 with PMI/RI reporting, a UE shall determine a RI from the supported set of RI values as defined in Subclause 5.2.2.6 of [4] and report the number in each RI report. For each RI reporting interval when the UE is configured in transmission mode 3, a UE shall determine RI as defined in Subclause 5.2.2.6 of [4] in each reporting interval and report the detected number in each RI report to support selection between transmit diversity and large delay CDD.

For a UE configured in transmission mode 9 or 10, when reporting CRI the UE reports a single instance of one or more selected CSI-RS resource(s). For each CRI reporting interval, when a UE is configured in transmission mode 10 with higher layer parameter *FeCoMPCSIEnabled* and determines CRI=2 from the supported set of CRI values as defined in Subclause 5.2.2.6 of [4], the UE reports the CRI=2 in each CRI report, where CRI value 2 corresponds to the configured two CSI-RS resources and one CSI-IM resource. Otherwise, when a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for a CSI process, the UE shall determine a CRI from the supported set of CRI values as defined in Subclause 5.2.2.6 of [4] and report the number in each CRI report, where

CRI value 0 corresponds to the configured *csi-RS-ConfigNZPId*, first entry of *csi-IM-ConfigIdList*, first entry of *p-C-AndCBSR-PerResourceConfigList*, and *alternativeCodebookEnabledFor4TXProc*, and CRI value k ($k > 0$) corresponds to the configured k -th entry of *csi-RS-ConfigNZPIdListExt*, $(k+1)$ -th entry of *csi-IM-ConfigIdList*, $(k+1)$ -th entry of *p-C-AndCBSR-PerResourceConfigList*, and k -th entry of *ace-For4Tx-PerResourceConfigList*.

For a UE configured in transmission mode 9 or 10, when reporting CRI the UE reports a single instance of one or more selected CSI-RS resource(s). For each CRI reporting interval, when a UE is configured in transmission mode 10 with higher layer parameter *FeCoMPCSIEnabled* and determines CRI=2 from the supported set of CRI values as defined in Subclause 5.2.2.6 of [4], the UE reports the CRI=2 in each CRI report, where CRI value 2 corresponds to the configured two CSI-RS resources and one CSI-IM resource. Otherwise, when a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and high layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one for a CSI process, the UE shall determine a CRI from the supported set of CRI values as defined in subclause 5.2.2.6 of [4] and report the number in each CRI report, where, if *csi-RS-ConfigNZPId* is activated, CRI value 0 corresponds to the activated *csi-RS-ConfigNZPId*, first entry of *csi-IM-ConfigIdList*, *p-C-AndCBSR-PerResourceConfigList*, and *alternativeCodebookEnabledFor4TXProc*, and CRI value k ($k > 0$) corresponds to the $(k+1)$ -th activated CSI-RS resource, which is associated with l -th entry of *csi-RS-ConfigNZPIdListExt*, $(l+1)$ -th entry of *csi-IM-ConfigIdList*, $(l+1)$ -th entry of *p-C-AndCBSR-PerResourceConfigList*, and l -th entry of *ace-For4Tx-PerResourceConfigList*; If *csi-RS-ConfigNZPId* is not activated, CRI value k corresponds to the $(k+1)$ -th activated CSI-RS resource, which is associated with l -th entry of *csi-RS-ConfigNZPIdListExt*, $(l+1)$ -th entry of *csi-IM-ConfigIdList*, $(l+1)$ -th entry of *p-C-AndCBSR-PerResourceConfigList*, and l -th entry of *ace-For4Tx-PerResourceConfigList*.

For a non-BL/CE UE, when reporting PMI the UE reports either a single or a multiple PMI report. The number of RBs represented by a single UE PMI report can be $N_{\text{RB}}^{\text{DL}}$ or a smaller subset of RBs. The number of RBs represented by a single PMI report is semi-statically configured by higher layer signalling. A UE is restricted to report PMI, RI and PTI on a subframe-PUCCH/PUSCH within a precoder codebook subset specified by one or more bitmap parameter(s) *codebookSubsetRestriction*, *codebookSubsetRestriction-1*, *codebookSubsetRestriction-2*, *codebookSubsetRestriction-3*, *codebookSubsetRestriction-4* configured by higher layer signalling. If a UE is configured by higher-layer parameter *shortTTI*, the UE is restricted to report PMI, RI and PTI on subslot/slot-based PUSCH within a precoder codebook subset specified by a bitmap parameter *codebookSubsetRestriction*, configured by higher layer signalling for the subslot/slot-based transmission.

For a UE configured in transmission mode 10 and the UE not configured with higher layer parameter *eMIMO-Type* for a CSI process, or for a UE configured in transmission mode 9 or 10 and the UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured for a CSI process, the bitmap parameter *codebookSubsetRestriction* is configured for each CSI process and each subframe sets (if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10 and for a CSI process and the UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured for *eMIMO-Type2* of the CSI process, the bitmap parameter *codebookSubsetRestriction* is configured for *eMIMO-Type2* of each CSI process and each subframe sets (if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10, and for a CSI process and UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', except when the UE is configured with higher layer parameter *advancedCodebookEnabled* and *advancedCodebookEnabled* is set to 'TRUE', the bitmap parameters *codebookSubsetRestriction-1*, *codebookSubsetRestriction-2* is configured for the CSI process and each subframe sets (if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10, and for a CSI process and UE configured with higher layer parameter *advancedCodebookEnabled* and *advancedCodebookEnabled* is set to 'TRUE', and the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', and the UE is configured with 8, 12, 16, 20, 24, 28, and 32 antenna ports, the UE is either configured with bitmap parameter *codebookSubsetRestriction-1*, or, the UE is configured with bitmap parameter *codebookSubsetRestriction-4* for the CSI process and each subframe sets (if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10, and for a CSI process and UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*, the bitmap parameter *codebookSubsetRestriction-3* is

configured for the CSI process and each subframe sets (if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10, and for a CSI process and the UE configured with higher layer parameter $eMIMO-Type2$, and $eMIMO-Type2$ is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter $alternativeCodebookEnabledCLASSB_K1=TRUE$ for $eMIMO-Type2$ of the CSI process, the bitmap parameter $codebookSubsetRestriction-3$ is configured for $eMIMO-Type2$ of the CSI process and each subframe sets (if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers) by higher layer signaling.

For a UE configured in transmission mode 9 or 10, and for a CSI process and UE configured with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS B', and more than one CSI-RS resource configured, the bitmap parameter $codebookSubsetRestriction$ is configured for each CSI-RS resource of the CSI process and each subframe sets (if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers) by higher layer signaling.

For a specific precoder codebook and associated transmission mode, the bitmap can specify all possible precoder codebook subsets from which the UE can assume the eNB may be using when the UE is configured in the relevant transmission mode. Codebook subset restriction is supported for transmission modes 3, 4, 5, 6 and for transmission modes 8, 9 and 10 with PMI/RI reporting, and transmission mode 9 and 10 without PMI reporting. The resulting number of bits for each transmission mode are given in Table 7.2-1b, Table 7.2-1d, Table 7.2-1e, and Table 7.2-1f. The bitmap parameter $codebookSubsetRestriction$, $codebookSubsetRestriction-1$ or $codebookSubsetRestriction-3$ forms the bit sequence $a_{A_c-1}, \dots, a_3, a_2, a_1, a_0$ where a_0 is the LSB and a_{A_c-1} is the MSB and where a bit value of zero indicates that the PMI and RI reporting is not allowed to correspond to precoder(s) associated with the bit. The bitmap parameter $codebookSubsetRestriction-2$ forms the bit sequence $b_{B_c-1}, \dots, b_3, b_2, b_1, b_0$ where b_0 is the LSB and b_{B_c-1} is the MSB and where a bit value of zero indicates that the PMI and RI reporting is not allowed to correspond to precoder(s) associated with the bit. The association of bits to precoders for the relevant transmission modes are given as follows:

1. Transmission mode 3

- a. 2 antenna ports: bit $a_{v-1}, v=2$ is associated with the precoder in Table 6.3.4.2.3-1 of [3] corresponding to v layers and codebook index 0 while bit a_0 is associated with the precoder for 2 antenna ports in Subclause 6.3.4.3 of [3].
- b. 4 antenna ports: bit $a_{v-1}, v=2,3,4$ is associated with the precoders in Table 6.3.4.2.3-2 of [3] corresponding to v layers and codebook indices 12, 13, 14, and 15 while bit a_0 is associated with the precoder for 4 antenna ports in Subclause 6.3.4.3 of [3].

2. Transmission mode 4

- a. 2 antenna ports: see Table 7.2-1c

- b. 4 antenna ports: bit $a_{16(v-1)+i_c}$ is associated with the precoder for v layers and with codebook index i_c in Table 6.3.4.2.3-2 of [3].

3. Transmission modes 5 and 6

- a. 2 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer with codebook index i_c in Table 6.3.4.2.3-1 of [3].
- b. 4 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer with codebook index i_c in Table 6.3.4.2.3-2 of [3].

4. Transmission mode 8

- a. 2 antenna ports: see Table 7.2-1c

- b. 4 antenna ports except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured: bit $a_{16(v-1)+i_c}$ is associated with the precoder for v layers and with codebook index i_c in Table 6.3.4.2.3-2 of [3], $v=1,2$.
 - c. 4 antenna ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured: bit $a_{16(v-1)+i_1}$ is associated with the precoder for v layers ($v \in \{1,2\}$) and codebook index i_1 and bit $a_{32+16(v-1)+i_2}$ is associated with the precoder for v layers ($v \in \{1,2\}$) and codebook index i_2 . Codebook indices i_1 and i_2 are given in Table 7.2.4-0A or 7.2.4-0B, for $v=1$ or 2 respectively.
5. Transmission modes 9 and 10
- a. 2 antenna ports except when a UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for a CSI process, or when a UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for *eMIMO-Type2* of a CSI process: see Table 7.2-1c
 - b. 4 antenna ports except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured or for a CSI process the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* or for a CSI process the UE is configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for *eMIMO-Type2* of a CSI process: bit $a_{16(v-1)+i_c}$ is associated with the precoder for v layers and with codebook index i_c in Table 6.3.4.2.3-2 of [3].
 - c. 4 antenna ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured except when a UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for a CSI process, or when a UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for *eMIMO-Type2* of a CSI process: bit $a_{16(v-1)+i_1}$ is associated with the precoder for v layers ($v \in \{1,2\}$) and codebook index i_1 and bit $a_{32+16(v-1)+i_2}$ is associated with the precoder for v layers ($v \in \{1,2,3,4\}$) and codebook index i_2 . Codebook indices i_1 and i_2 are given in Table 7.2.4-0A, 7.2.4-0B, 7.2.4-0C or 7.2.4-0D, for $v=1,2,3$ or 4 respectively.
 - d. 8 antenna ports except when a UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', or for when a UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for a CSI process, or for when a UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for *eMIMO-Type2* of a CSI process: bit $a_{f1(v-1)+i_1}$ is associated with the precoder for v layers ($v \in \{1,2,3,4,5,6,7,8\}$) and codebook index i_1 where $f1(\cdot) = \{0,16,32,36,40,44,48,52\}$ and bit $a_{53+g1(v-1)+i_2}$ is associated with the precoder for v layers ($v \in \{1,2,3,4\}$) and codebook index i_2 where $g1(\cdot) = \{0,16,32,48\}$. Codebook indices i_1 and i_2 are given in Table 7.2.4-1, 7.2.4-2, 7.2.4-3, 7.2.4-4, 7.2.4-5, 7.2.4-6, 7.2.4-7, or 7.2.4-8, for $v=1,2,3,4,5,6,7$, or 8 respectively.
 - e. 8, 12, 16, 20, 24, 28, and 32 antenna ports and for a CSI process the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A': bit $a_{N_2O_2l+m}$ is associated with the precoder based on the quantity $v_{l,m} l=0,1,...,N_1O_1-1, m=0,1,...,N_2O_2-1$ and bit $a_{N_1O_1N_2O_2+v-1}$ is associated with the precoder for v layers ($v \in \{1,2,3,4,5,6,7,8\}$). The quantity $v_{l,m}$ is defined in Subclause 7.2.4. Bit $b_{g(v-1)+i_2}$ is associated with the precoder for v layers ($v \in \{1,2,3,4\}$) and codebook index i_2 where $g(\cdot)$ is given in

Table 7.2-1g. Codebook index i_2 is given in Table 7.2.4-10, 7.2.4-11, 7.2.4-12, 7.2.4-13, 7.2.4-14, 7.2.4-15, 7.2.4-16, or 7.2.4-17, for $v=1,2,3,4,5,6,7$, or 8 respectively.

- f. 2, 4, or 8 antenna ports and for a CSI process the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*, or the UE is configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* for *eMIMO-Type2* of the CSI process: bit $a_{f(v-1)+i_c}$ is associated with the precoder for v layers and codebook index i_c where $v \in \{1,2\}$ and $f(\cdot) = \{0,4\}$ for 2 antenna ports, $v \in \{1,2,3,4\}$ and $f(\cdot) = \{0,8,16,20\}$ for 4 antenna ports, and $v \in \{1,2,3,4,5,6,7,8\}$ and $f(\cdot) = \{0,16,32,48,56,57,58,59\}$ for 8 antenna ports. Codebook index i_c is given in Table 7.2.4-18, 7.2.4-19, or 7.2.4-20, for 2, 4, or 8 antenna ports respectively.
- g. 8, 12, 16, 20, 24, 28, and 32 antenna ports and for a CSI process the UE is configured with higher layer parameter *advancedCodebookEnabled* and *advancedCodebookEnabled* is set to 'TRUE', and the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', and the UE is configured with bitmap parameter *codebookSubsetRestriction-1*: bit $a_{N_2O_2l+m}$ is associated with the precoder based on the quantity $v_{l,m} l=0,1,\dots,N_1O_1-1, m=0,1,\dots,N_2O_2-1$ and bit $a_{N_1O_1N_2O_2+v-1}$ is associated with the precoder for v layers ($v \in \{1,2,3,4,5,6,7,8\}$). The quantity $v_{l,m}$ is defined in Subclause 7.2.4.
- h. 8, 12, 16, 20, 24, 28, and 32 antenna ports and for a CSI process the UE is configured with higher layer parameter *advancedCodebookEnabled* and *advancedCodebookEnabled* is set to 'TRUE', and the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', and the UE is configured with bitmap parameter *codebookSubsetRestriction-4*: The bitmap parameter *codebookSubsetRestriction-4* forms the bit sequence $a_{2N_1N_2+8-1}, \dots, a_3, a_2, a_1, a_0$, consisting of $2N_1N_2 + 8$ bits, where a_0 is the LSB and $a_{2N_1N_2+8-1}$ is the MSB. The bit pair $\{a_{2(N_2n_1+n_2)}, a_{2(N_2n_1+n_2)+1}\}$ is associated with the group of quantities $G(n_1, n_2) = \{v_{O_1n_1+q_1, O_2n_2+q_2} : q_1 = 0,1,2,3; q_2 = 0,1,2,3\}$ for $n_1 = 0, \dots, N_1 - 1, n_2 = 0, \dots, N_2 - 1$ if $N_2 > 1$ and $G(n_1, n_2) = \{v_{O_1n_1+q_1, 0} : q_1 = 0,1,2,3\}$ for $n_1 = 0, \dots, N_1 - 1, n_2 = 0$ if $N_2 = 1$ and the bit $a_{2N_1N_2+v-1}$ is associated with the precoder for v layers ($v \in \{1,2,3,4,5,6,7,8\}$). The quantity $v_{l,m}$ is defined in Subclause 7.2.4.
 - i. For $v=1,2$ layer reporting, PMI reporting is not allowed to correspond to a precoder where any quantity $v_{l,m}$ from the group of quantities $G(n_1, n_2)$ is selected by the codebook indices $\{i_{1,1}, i_{1,2}\}$, unless the corresponding bit pair $\{a_{2(N_2n_1+n_2)}, a_{2(N_2n_1+n_2)+1}\} = '11'$
 - ii. For $v=1,2$ layer reporting, PMI reporting is not allowed to correspond to a precoder where any quantity $v_{l,m}$ from the group of quantities $G(n_1, n_2)$ is selected by the codebook index $i_{1,3}$, if the relative power indicator (RPI), I_p , is larger than the maximum allowed value according to Table 7.2-1h.
 - iii. For $v=3,4,5,6,7,8$ layer reporting, PMI reporting is not allowed to correspond to a precoder where any quantity $v_{l,m}$ from the group of quantities $G(n_1, n_2)$ is associated with the precoder, unless the corresponding bit pair $\{a_{2(N_2n_1+n_2)}, a_{2(N_2n_1+n_2)+1}\} = '11'.$

For a BL/CE UE, when reporting PMI the UE reports a single PMI report. A UE is restricted to report PMI within a precoder codebook subset specified by a bitmap parameter *codebookSubsetRestriction* configured by higher layer signalling. For a specific precoder codebook and associated transmission mode, the bitmap can specify all possible precoder codebook subsets from which the UE can assume the eNB may be using when the UE is configured in the relevant transmission mode. Codebook subset restriction is supported for transmission modes 6 and 9. The resulting number of bits for each transmission mode is given in Table 7.2-1b. The bitmap forms the bit sequence

$a_{A_c-1}, \dots, a_3, a_2, a_1, a_0$ where a_0 is the LSB and a_{A_c-1} is the MSB and where a bit value of zero indicates that the PMI reporting is not allowed to correspond to precoder(s) associated with the bit. The association of bits to precoders for the relevant transmission modes are given as follows:

- Transmission mode 6
 - 2 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer with codebook index i_c in Table 6.3.4.2.3-1 of [3].
 - 4 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer with codebook index i_c in Table 6.3.4.2.3-2 of [3].
- Transmission mode 9
 - 2 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer with codebook index i_c in Table 6.3.4.2.3-1 of [3].
 - 4 antenna ports: bit a_{i_c} is associated with the precoder for $v=1$ layer and with codebook index i_c in Table 6.3.4.2.3-2 of [3].

Table 7.2-1b: Number of bits in codebook subset restriction *codebookSubsetRestriction* bitmap for applicable transmission modes

| | Number of bits A_c | | |
|-----------------------------|----------------------|--|-----------------|
| | 2 antenna ports | 4 antenna ports | 8 antenna ports |
| Transmission mode 3 | 2 | 4 | |
| Transmission mode 4 | 6 | 64 | |
| Transmission mode 5 | 4 | 16 | |
| Transmission mode 6 | 4 | 16 | |
| Transmission mode 8 | 6 | 64 with <i>alternativeCodeBookEnabledFor4TX-r12=TRUE</i> configured, otherwise 32 | |
| Transmission modes 9 and 10 | 6 | 96 with <i>alternativeCodeBookEnabledFor4TX-r12=TRUE</i> configured, otherwise 64 | 109 |

Table 7.2-1c: Association of bits in *codebookSubSetRestriction* bitmap to precoders in the 2 antenna port codebook of Table 6.3.4.2.3-1 in [3]

| Codebook index i_c | Number of layers v | |
|----------------------|----------------------|-------|
| | 1 | 2 |
| 0 | a_0 | - |
| 1 | a_1 | a_4 |
| 2 | a_2 | a_5 |
| 3 | a_3 | - |

Table 7.2-1d: Number of bits in codebook subset restriction $codebookSubsetRestriction1$ bitmap for applicable transmission modes

| | | Number of bits A_c |
|-----------------------------|--|-----------------------|
| Transmission modes 9 and 10 | | $N_1 O_1 N_2 O_2 + 8$ |

Table 7.2-1e: Number of bits in codebook subset restriction $codebookSubsetRestriction2$ bitmap for applicable transmission modes

| | | Value of codebookConfig | Number of bits A_c |
|-----------------------------|---|-------------------------|----------------------|
| Transmission modes 9 and 10 | 1 | 12 | |
| | 2 | 56 | |
| | 3 | 56 | |
| | 4 | 56 | |

Table 7.2-1f: Number of bits in codebook subset restriction $codebookSubsetRestriction3$ bitmap for applicable transmission modes

| | Number of bits A_c | | |
|-----------------------------|----------------------|-----------------|-----------------|
| | 2 antenna ports | 4 antenna ports | 8 antenna ports |
| Transmission modes 9 and 10 | 6 | 22 | 60 |

Table 7.2-1g: $g(\cdot)$ for a CSI process with eMIMO-Type set to 'CLASS A'

| Value of codebookConfig | $g(\cdot)$ |
|-------------------------|--------------|
| 1 | {0,4,8,10} |
| 2 | {0,16,32,48} |
| 3 | {0,16,32,48} |
| 4 | {0,16,32,48} |

Table 7.2-1h: Maximum value of relative power indicator for restricted $v_{l,m}$ quantities

| Value of bit pair $\{a_{2(N_2n_l+n_2)}, a_{2(N_2n_l+n_2)+1}\}$ | Maximum value of Relative Power Indicator I_p |
|---|---|
| '00' | 0 |
| '01' | 1 |
| '10' | 2 |
| '11' | 3 |

For a non-BL/CE UE, the set of subbands (S) a UE shall evaluate for CQI reporting spans the entire downlink system bandwidth. A subband is a set of k contiguous PRBs where k is a function of system bandwidth. Note the last subband in set S may have fewer than k contiguous PRBs depending on N_{RB}^{DL} . The number of subbands for system bandwidth

given by $N_{\text{RB}}^{\text{DL}}$ is defined by $N = \lceil N_{\text{RB}}^{\text{DL}} / k \rceil$. The subbands shall be indexed in the order of increasing frequency and non-increasing sizes starting at the lowest frequency.

- For transmission modes 1, 2, 3 and 5, as well as transmission modes 8, 9 and 10 without PMI/RI reporting, transmission mode 4 with RI=1, transmission modes 8, 9 and 10 with PMI/RI reporting and RI=1, and transmission modes 9 and 10 without PMI reporting and RI=1, a single 4-bit wideband CQI is reported.
- For transmission modes 3 and 4, as well as transmission modes 8, 9 and 10 with PMI/RI reporting, and transmission modes 9 and 10 without PMI reporting, CQI is calculated assuming transmission of
 - one codeword for slot/subslot-PUSCH based triggered reporting,
 - one codeword for RI=1 and two codewords for RI > 1.
- For RI > 1 with transmission mode 4, as well as transmission modes 8, 9 and 10 with PMI/RI reporting, and transmission modes 9 and 10 without PMI reporting, PUSCH based triggered reporting includes reporting a wideband CQI which comprises:
 - A 4-bit wideband CQI for codeword 0
 - A 4-bit wideband CQI for codeword 1 for subframe-PUSCH based triggered reporting
- For RI > 1 with transmission mode 4, as well as transmission modes 8, 9 and 10 with PMI/RI reporting, and transmission modes 9 and 10 without PMI reporting, PUCCH based reporting includes reporting a 4-bit wideband CQI for codeword 0 and a wideband spatial differential CQI. The wideband spatial differential CQI value comprises:
 - A 3-bit wideband spatial differential CQI value for codeword 1 offset level
 - Codeword 1 offset level = wideband CQI index for codeword 0 – wideband CQI index for codeword 1.
 - The mapping from the 3-bit wideband spatial differential CQI value to the offset level is shown in Table 7.2-2.

Table 7.2-2 Mapping spatial differential CQI value to offset level

| Spatial differential CQI value | Offset level |
|--------------------------------|--------------|
| 0 | 0 |
| 1 | 1 |
| 2 | 2 |
| 3 | ≥ 3 |
| 4 | ≤ -4 |
| 5 | -3 |
| 6 | -2 |
| 7 | -1 |

7.2.1 Aperiodic CSI Reporting using PUSCH

The term "UL/DL configuration" in this Subclause refers to the higher layer parameter *subframeAssignment* unless specified otherwise.

A non-BL/CE UE shall perform aperiodic CSI reporting using the PUSCH in subframe/slot/subslot $n+k$ on serving cell c , upon decoding in subframe/slot/subslot n either:

- an uplink DCI format [4], or
- a Random Access Response Grant,

for serving cell c if the respective CSI request field is set to trigger a report and is not reserved. If the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, the reported CSI shall be according to the transmission mode configured by higher layers for the subframe where the trigger was received. The UE is not expected to receive a CSI request field set to trigger a report in a DCI indicating a PUSCH transmission in UpPTS.

For a serving cell c that is a LAA SCell, aperiodic CSI reporting using the PUSCH in subframe $n+k$ is conditioned on if the UE is allowed to transmit in the subframe according to the channel access procedures described in subclause 4.2.1 of [13].

For a serving cell c that is a LAA SCell, a UE configured with Partial PUSCH mode 1 is not expected to receive an aperiodic CSI report request triggering a CSI report without UL-SCH.

A BL/CE UE shall perform aperiodic CSI reporting using the PUSCH upon decoding either:

- an uplink DCI format [4], or
- a Random Access Response Grant,

for serving cell c if the respective CSI request field is set to trigger a report and is not reserved. The subframe(s) in which the PUSCH carrying the corresponding aperiodic CSI reporting triggered by an UL DCI format is transmitted is determined according to Subclause 8.0.

If the CSI request field is 1 bit and the UE is configured in transmission mode 1-9 and the UE is not configured with *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered for serving cell c , if the CSI request field is set to '1'. If the UE is configured with higher layer parameter *eMIMO-Type2* for the aperiodic CSI on the serving cell c , the report is for a higher layer configured eMIMO type of the aperiodic CSI configured for the UE on the serving cell c . If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for the serving cell c , the report is for the activated CSI-RS resource for the serving cell c .

If the CSI request field is 1 bit and the UE is configured in transmission mode 10 and the UE is not configured with *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered for a set of CSI process(es) for serving cell c corresponding to the higher layer configured set of CSI process(es) associated with the value of CSI request field of '01' in Table 7.2.1-1B, if the CSI request field is set to '1'. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field of '01' for the CSI process. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a CSI process of the triggered set of CSI process(es), the report is for the activated CSI-RS resource for the CSI process.

If the CSI request field size is 2 bits and the UE is configured in transmission mode 1-9 for all serving cells and the UE is not configured with *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered according to the value in Table 7.2.1-1A corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for the aperiodic CSI on a serving cell of the triggered set of serving cells, the report is for a higher layer configured eMIMO type associated with the value of CSI request field of the aperiodic CSI configured for the UE on the serving cell. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a serving cell of the triggered set of serving cells, the report is for the activated CSI-RS resource for the serving cell.

If the CSI request field size is 2 bits and the UE is configured in transmission mode 10 for at least one serving cell and the UE is not configured with *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered according to the value in Table 7.2.1-1B corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a serving cell of the triggered set of serving cells, the report is for the activated CSI-RS resource for the serving cell.

If the CSI request field is 1 bit and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, a report is triggered for a set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) for serving cell c corresponding to the higher layer configured set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) associated with the value of CSI request field of '01' in Table 7.2.1-1C, if the CSI request field is set to '1'. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es) for serving cell c , the report is for a higher layer configured eMIMO type associated with the value of CSI request field of '01' for the CSI process for serving cell c . If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter

numberActivatedAperiodicCSI-RS-Resources is set to '1' for a CSI process of the triggered set of CSI process(es), the report is for the activated CSI-RS resource for the CSI process for the serving cell c .

If the CSI request field size is 2 bits and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, a report is triggered according to the value in Table 7.2.1-1C corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a CSI process of the triggered set of CSI process(es), the report is for the activated CSI-RS resource for the CSI process.

If the CSI request field size is 3 bits and the UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12* for any serving cell, and UE is not configured with higher layer parameter *csi-RS-ConfigNZP-ApList* or UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for each CSI process, a report is triggered according to the value in Table 7.2.1-1D corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a CSI process of the triggered set of CSI process(es), the report is for the activated CSI-RS resource for the CSI process.

If the CSI request field size is 3 bits and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, and UE is not configured with higher layer parameter *csi-RS-ConfigNZP-ApList* or UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for each CSI process, a report is triggered according to the value in Table 7.2.1-1E corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process. If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to '1' for a CSI process of the triggered set of CSI process(es), the report is for the activated CSI-RS resource for the CSI process.

If the CSI request field size is 3 bits and the UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12* for any serving cell, and UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to more than '1' for at least one CSI process, a report is triggered for serving cell c according to the value in Table 7.2.1-1F corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process for serving cell c .

If the CSI request field size is 3 bits and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, and UE is configured with *csi-RS-ConfigNZP-ApList* and the number of activated CSI-RS resources given by the higher layer parameter *numberActivatedAperiodicCSI-RS-Resources* is set to more than '1' for at least one CSI process, a report is triggered for serving cell c according to the value in Table 7.2.1-1G corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process for serving cell c .

If the CSI request field size is 4 bits and the UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered according to the value in Table 7.2.1-1H corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process.

If the CSI request field size is 4 bits and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, a report is triggered according to the value in Table 7.2.1-1I corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI

process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process.

If the CSI request field size is 5 bits and the UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12* for any serving cell, a report is triggered according to the value in Table 7.2.1-1J corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process.

If the CSI request field size is 5 bits and the UE is configured with the higher layer parameter *csi-SubframePatternConfig-r12* for at least one serving cell, a report is triggered according to the value in Table 7.2.1-1K corresponding to aperiodic CSI reporting. If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process of the triggered set of CSI process(es), the report is for a higher layer configured eMIMO type associated with the value of CSI request field for the CSI process.

If the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList* for a CSI process of the triggered set of CSI process(es), the UE shall assume the CSI-RS resource associated with the value of CSI request field for the CSI process is present in subframe *n*.

For a given serving cell, if the UE is configured in transmission modes 1-9, the "CSI process" in Table 7.2.1-1B, Table 7.2.1-1C, Table 7.2.1-1D, and Table 7.2.1-1E refers to the aperiodic CSI configured for the UE on the given serving cell. A UE is not expected to be configured by higher layers with more than 5 CSI processes in each of the 1st and 2nd set of CSI process(es) in Table 7.2.1-1B. A UE is not expected to be configured by higher layers with more than 5 CSI processes and/or {CSI process, CSI subframe set}-pair(s) in each of the 1st and 2nd set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) in Table 7.2.1-1C. A UE is not expected to be configured by higher layers with more than one instance of the same CSI process in each of the higher layer configured sets associated with the value of CSI request field of '01', '10', and '11' in Table 7.2.1-1B and Table 7.2.1-1C respectively. A UE is not expected to be configured by higher layers with more than 32 CSI processes in each of the 1st to 6th set of CSI process(es) in Table 7.2.1-1D. A UE is not expected to be configured by higher layers with more than 32 CSI processes and/or {CSI process, CSI subframe set}-pair(s) in each of the 1st to 6th set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) in Table 7.2.1-1E. A UE is not expected to be configured by higher layers with more than one instance of the same CSI process in each of the higher layer configured sets associated with the value of CSI request field of '001', '010', '011', '100', '101', '110' and '111' in Table 7.2.1-1D, Table 7.2.1-1E, Table 7.2.1-1F, and Table 7.2.1-1G respectively. A UE is not expected to be configured by higher layers with more than 32 of {CSI process, CSI-RS resource} in each of the 1st to 7th set of {CSI process, CSI-RS resource} in Table 7.2.1-1F. A UE is not expected to be configured by higher layers with more than 32 {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in each of the 1st to 7th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in Table 7.2.1-1G. A UE is not expected to be configured by higher layers with more than 32 of {CSI process, CSI-RS resource} in each of the 1st to 14th set of {CSI process, CSI-RS resource} in Table 7.2.1-1H. A UE is not expected to be configured by higher layers with more than 32 {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in each of the 1st to 14th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in Table 7.2.1-1I. A UE is not expected to be configured by higher layers with more than one instance of the same CSI process in each of the higher layer configured sets associated with the value of CSI request field of '0001', '0010', '0011', '0100', '0101', '0110', '0111', '1000', '1001', '1001', '1010', '1011', '1100', '1101', '1110', '1111' in Table 7.2.1-1H, and Table 7.2.1-1I respectively. A UE is not expected to be configured by higher layers with more than 32 of {CSI process, CSI-RS resource} in each of the 1st to 30th set of {CSI process, CSI-RS resource} in Table 7.2.1-1J. A UE is not expected to be configured by higher layers with more than 32 {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in each of the 1st to 30th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} in Table 7.2.1-1K. A UE is not expected to be configured by higher layers with more than one instance of the same CSI process in each of the higher layer configured sets associated with the value of CSI request field of '00001', '00010', '00011', '00100', '00101', '00110', '00111', '01000', '01001', '01010', '01011', '01100', '01101', '01110', '01111', '10000', '10001', '10010', '10011', '10100', '10101', '10110', '10111', '11000', '11001', '11010', '11011', '11100', '11101', '11110', '11111' in Table 7.2.1-1J, and Table 7.2.1-1K respectively.

A UE is not expected to receive more than one aperiodic CSI report request for a given subframe triggered by uplink DCI formats other than 7-0A/7-0B.

A UE is not expected to update CSI corresponding to the CSI reference resource (defined in Subclause 7.2.3) for all CSI report requests triggered by uplink DCI format 7-0A/7-0B except $\max(N_y - N_u, 0)$ CSI report requests when the

UE has N_u unreported aperiodic CSI requests, where a CSI request shall only be counted as unreported in a

slot/subslot before the slot/subslot where the PUSCH carrying the corresponding CSI is transmitted, and N_y is the maximum number of CSI requests triggered by uplink DCI format 7-0A/7-0B supported by the UE.

If a UE is configured with higher layer parameter *eMIMO-Type* for a CSI process, the UE is not expected to receive an aperiodic CSI report request for a given slot/subslot triggering a CSI report for the CSI process.

If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2* for a CSI process, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, the UE on reception of an aperiodic CSI report request triggering a CSI report for *eMIMO-Type2* of the CSI process is not expected to update CSI for *eMIMO-Type2* ($n_{CQI_ref} - 1$) (defined in Subclause 7.2.3) subframes before or ($n_{CQI_ref} - 1$) subframes after the subframe comprising the non-zero power CSI-RS (defined in [3]) within the CSI-RS resource associated with *eMIMO-Type* of the CSI process.

If a UE is configured with more than one CSI process for a serving cell, the UE on reception of an aperiodic CSI report request triggering a CSI report according to Table 7.2.1-1B is not expected to update CSI corresponding to the CSI reference resource (defined in Subclause 7.2.3) for all CSI processes except the $\max(N_x - N_u, 0)$ lowest-indexed CSI processes for the serving cell associated with the request when the UE has N_u unreported CSI processes associated with other aperiodic CSI requests for the serving cell, where a CSI process associated with a CSI request shall only be counted as unreported in a subframe/slot/subslot before the subframe/slot/subslot where the PUSCH carrying the corresponding CSI is transmitted, and N_{CSI-P} is the maximum number of CSI processes supported by the UE for the serving cell corresponding to subframe/slot/subslot-PUSCH, and:

- for FDD serving cell $N_x = N_{CSI-P}$;
- for TDD serving cell
 - if the UE is configured with four CSI processes for the serving cell, $N_x = N_{CSI-P}$
 - if the UE is configured with two or three CSI processes for the serving cell, $N_x = 3$.

If more than one value of N_{CSI-P} is included in the *UE-EUTRA-Capability*, the UE assumes a value of N_{CSI-P} that is consistent with its CSI process configuration. If more than one consistent value of N_{CSI-P} exists, the UE may assume any one of the consistent values.

If a UE is configured with multiple cell groups, and if the UE receives multiple aperiodic CSI report requests in a subframe for different cell groups triggering more than one CSI report, the UE is not required to update CSI for more than 5 CSI processes from the CSI processes corresponding to all the triggered CSI reports.

If a UE is configured with a PUCCH-SCell, and if the UE receives multiple aperiodic CSI report requests in a subframe for both the primary PUCCH group and the secondary PUCCH group triggering more than one CSI report, the UE is not required to update CSI for more than 5 CSI processes from the CSI processes corresponding to all the triggered CSI reports, in case the total number of serving cells in the primary and secondary PUCCH group is no more than 5. If a UE is configured with more than 5 serving cells, and if the UE receives aperiodic CSI report request in a subframe triggering more than N_y CSI reports, the UE is not required to update CSI for more than N_y CSI processes from the CSI processes corresponding to all the triggered CSI reports, where the value of N_y is given by *nMaxProc-r14* if *csi-RS-ConfigNZP-ApList* is configured for at least one CSI process for which aperiodic CSI report is requested, otherwise, by *maxNumberUpdatedCSI-Proc-r13*.

Table 7.2.1-1A: CSI Request field for PDCCH/EPDCCH/SPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|--|
| '00' | No aperiodic CSI report is triggered |
| '01' | Aperiodic CSI report is triggered for serving cell c |
| '10' | Aperiodic CSI report is triggered for a 1 st set of serving cells configured by higher layers |
| '11' | Aperiodic CSI report is triggered for a 2 nd set of serving cells configured by higher layers |

Table 7.2.1-1B: CSI Request field for PDCCH/EPDCCH/SPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|---|
| '00' | No aperiodic CSI report is triggered |
| '01' | Aperiodic CSI report is triggered for a set of CSI process(es) configured by higher layers for serving cell c |
| '10' | Aperiodic CSI report is triggered for a 1 st set of CSI process(es) configured by higher layers |
| '11' | Aperiodic CSI report is triggered for a 2 nd set of CSI process(es) configured by higher layers |

Table 7.2.1-1C: CSI Request field for PDCCH/EPDCCH/MPDCCH/SPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|--|
| '00' | No aperiodic CSI report is triggered |
| '01' | Aperiodic CSI report is triggered for a set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers for serving cell c |
| '10' | Aperiodic CSI report is triggered for a 1 st set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '11' | Aperiodic CSI report is triggered for a 2 nd set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |

Table 7.2.1-1D: CSI Request field for PDCCH/EPDCCH/SPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|---|
| '000' | No aperiodic CSI report is triggered |
| '001' | Aperiodic CSI report is triggered for a set of CSI process(es) configured by higher layers for serving cell c |
| '010' | Aperiodic CSI report is triggered for a 1 st set of CSI process(es) configured by higher layers |
| '011' | Aperiodic CSI report is triggered for a 2 nd set of CSI process(es) configured by higher layers |
| '100' | Aperiodic CSI report is triggered for a 3 rd set of CSI process(es) configured by higher layers |
| '101' | Aperiodic CSI report is triggered for a 4 th set of CSI process(es) configured by higher layers |
| '110' | Aperiodic CSI report is triggered for a 5 th set of CSI process(es) configured by higher layers |
| '111' | Aperiodic CSI report is triggered for a 6 th set of CSI process(es) configured by higher layers |

Table 7.2.1-1E: CSI Request field for PDCCH/EPDCCH/SPDCCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|-----------------------------------|--|
| '000' | No aperiodic CSI report is triggered |
| '001' | Aperiodic CSI report is triggered for a set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers for serving cell c |
| '010' | Aperiodic CSI report is triggered for a 1 st set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '011' | Aperiodic CSI report is triggered for a 2 nd set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '100' | Aperiodic CSI report is triggered for a 3 rd set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '101' | Aperiodic CSI report is triggered for a 4 th set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '110' | Aperiodic CSI report is triggered for a 5 th set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |
| '111' | Aperiodic CSI report is triggered for a 6 th set of CSI process(es) and/or {CSI process, CSI subframe set}-pair(s) configured by higher layers |

Table 7.2.1-1F: CSI Request field for PDCCH/EPDCCH/SPDCCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|-----------------------------------|--|
| '000' | No aperiodic CSI report is triggered |
| '001' | Aperiodic CSI report is triggered for a 1 st set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '010' | Aperiodic CSI report is triggered for a 2 nd set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '011' | Aperiodic CSI report is triggered for a 3 rd set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '100' | Aperiodic CSI report is triggered for a 4 th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '101' | Aperiodic CSI report is triggered for a 5 th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '110' | Aperiodic CSI report is triggered for a 6 th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '111' | Aperiodic CSI report is triggered for a 7 th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |

Table 7.2.1-1G: CSI Request field for PDCCH/EPDCCH/SPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|---|
| '000' | No aperiodic CSI report is triggered |
| '001' | Aperiodic CSI report is triggered for a 1 st set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '010' | Aperiodic CSI report is triggered for a 2 nd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '011' | Aperiodic CSI report is triggered for a 3 rd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '100' | Aperiodic CSI report is triggered for a 4 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '101' | Aperiodic CSI report is triggered for a 5 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '110' | Aperiodic CSI report is triggered for a 6 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |
| '111' | Aperiodic CSI report is triggered for a 7 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell _c |

Table 7.2.1-1H: CSI Request field for PDCCH/EPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|---|
| '0000' | No aperiodic CSI report is triggered |
| '0001' | Aperiodic CSI report is triggered for a set of {CSI process, CSI-RS resource} configured by higher layers for serving cell _c |
| '0010' | Aperiodic CSI report is triggered for a 1 st set of {CSI process, CSI-RS resource} configured by higher layers |
| '0011' | Aperiodic CSI report is triggered for a 2 nd set of {CSI process, CSI-RS resource} configured by higher layers |
| '0100' | Aperiodic CSI report is triggered for a 3 rd set of {CSI process, CSI-RS resource} configured by higher layers |
| '0101' | Aperiodic CSI report is triggered for a 4 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '0110' | Aperiodic CSI report is triggered for a 5 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '0111' | Aperiodic CSI report is triggered for a 6 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1000' | Aperiodic CSI report is triggered for a 7 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1001' | Aperiodic CSI report is triggered for a 8 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1010' | Aperiodic CSI report is triggered for a 9 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1011' | Aperiodic CSI report is triggered for a 10 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1100' | Aperiodic CSI report is triggered for a 11 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1101' | Aperiodic CSI report is triggered for a 12 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1110' | Aperiodic CSI report is triggered for a 13 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '1111' | Aperiodic CSI report is triggered for a 14 th set of {CSI process, CSI-RS resource} configured by higher layers |

Table 7.2.1-1I: CSI Request field for PDCCH/EPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|----------------------------|--|
| '0000' | No aperiodic CSI report is triggered |
| '0001' | Aperiodic CSI report is triggered for a set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell c |
| '0010' | Aperiodic CSI report is triggered for a 1 st set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '0011' | Aperiodic CSI report is triggered for a 2 nd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '0100' | Aperiodic CSI report is triggered for a 3 rd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '0101' | Aperiodic CSI report is triggered for a 4 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '0110' | Aperiodic CSI report is triggered for a 5 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '0111' | Aperiodic CSI report is triggered for a 6 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1000' | Aperiodic CSI report is triggered for a 7 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1001' | Aperiodic CSI report is triggered for a 8 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1010' | Aperiodic CSI report is triggered for a 9 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1011' | Aperiodic CSI report is triggered for a 10 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1100' | Aperiodic CSI report is triggered for a 11 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1101' | Aperiodic CSI report is triggered for a 12 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1110' | Aperiodic CSI report is triggered for a 13 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
| '1111' | Aperiodic CSI report is triggered for a 14 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |

Table 7.2.1-1J: CSI Request field for PDCCH/EPDCCH with uplink DCI format in UE specific search space

| Value of CSI request field | Description |
|-------------------------------------|--|
| '00000' | No aperiodic CSI report is triggered |
| '00001' | Aperiodic CSI report is triggered for a set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c |
| '00010' | Aperiodic CSI report is triggered for a 1 st set of {CSI process, CSI-RS resource} configured by higher layers |
| '00011' | Aperiodic CSI report is triggered for a 2 nd set of {CSI process, CSI-RS resource} configured by higher layers |
| '00100' | Aperiodic CSI report is triggered for a 3 rd set of {CSI process, CSI-RS resource} configured by higher layers |
| '00101' | Aperiodic CSI report is triggered for a 4 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '00110' | Aperiodic CSI report is triggered for a 5 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '00111' | Aperiodic CSI report is triggered for a 6 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01000' | Aperiodic CSI report is triggered for a 7 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01001' | Aperiodic CSI report is triggered for a 8 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01010' | Aperiodic CSI report is triggered for a 9 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01011' | Aperiodic CSI report is triggered for a 10 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01100' | Aperiodic CSI report is triggered for a 11 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01101' | Aperiodic CSI report is triggered for a 12 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01110' | Aperiodic CSI report is triggered for a 13 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '01111' | Aperiodic CSI report is triggered for a 14 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10000' | Aperiodic CSI report is triggered for a 15 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10001' | Aperiodic CSI report is triggered for a 16 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10010' | Aperiodic CSI report is triggered for a 17 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10011' | Aperiodic CSI report is triggered for a 18 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10100' | Aperiodic CSI report is triggered for a 19 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10101' | Aperiodic CSI report is triggered for a 20 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '10110' | Aperiodic CSI report is triggered for a 21 st set of {CSI process, CSI-RS resource} configured by higher layers |
| '10111' | Aperiodic CSI report is triggered for a 22 nd set of {CSI process, CSI-RS resource} configured by higher layers |
| '11000' | Aperiodic CSI report is triggered for a 23 rd set of {CSI process, CSI-RS resource} configured by higher layers |
| '11001' | Aperiodic CSI report is triggered for a 24 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11010' | Aperiodic CSI report is triggered for a 25 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11011' | Aperiodic CSI report is triggered for a 26 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11100' | Aperiodic CSI report is triggered for a 27 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11101' | Aperiodic CSI report is triggered for a 28 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11110' | Aperiodic CSI report is triggered for a 29 th set of {CSI process, CSI-RS resource} configured by higher layers |
| '11111' | Aperiodic CSI report is triggered for a 30 th set of {CSI process, CSI-RS resource} configured by higher layers |

Table 7.2.1-1K: CSI Request field for PDCCH/EPDCCH with uplink DCI format in UE specific search space

| | |
|---------|--|
| '11111' | Aperiodic CSI report is triggered for a 30 th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers |
|---------|--|

NOTE: PDCCH/EPDCCH/MPDCCH/SPDCCH with DCI formats used to grant PUSCH transmissions as given by DCI format 0, DCI format 4, DCI format 6-0A and DCI format 7-0A/7-0B are herein referred to as uplink DCI format when common behaviour is addressed.

For a serving cell c that is not a LAA SCell, and a non-BL/CE UE, when the CSI request field from an uplink DCI format other than 7-0A/7-0B is set to trigger a report,

- for FDD $k=3$ if the UE is configured with higher layer parameter *shortProcessingTime*, and the corresponding DCI format is mapped onto the UE-specific search space and $k=4$ otherwise,
- for TDD UL/DL configuration 1-6, k is given in Table 8-2,
- for TDD UL/DL configuration 0,
 - if the MSB of the UL index is set to 1 and LSB of the UL index is set to 0, k is given in Table 8-2i if the UE is configured with higher layer parameter *shortProcessingTime*, and the corresponding DCI format is mapped onto the UE-specific search space, in Table 8-2 otherwise; or
 - if MSB of the UL index is set to 0 and LSB of the UL index is set to 1, k is equal to 6 if the UE is configured with higher layer parameter *shortProcessingTime*, and the corresponding DCI format is mapped onto the UE-specific search, 7 otherwise; or
 - if both MSB and LSB of the UL index is set to 1, k is given in Table 8-2i if the UE is configured with higher layer parameter *shortProcessingTime*, and the corresponding DCI format is mapped onto the UE-specific search space, in Table 8-2 otherwise.

For a serving cell c , when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, for

- FDD, if the UE is configured for subslot uplink transmissions, k is determined based on higher layer configuration from {4,6,8}, otherwise $k=4$.
- TDD, k is given by table 8-2m, 8-2n, 8-2p according to the corresponding special subframe configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration (defined in Subclause 8.0).

For a serving cell c that is a LAA SCell, when the CSI request field from an uplink DCI format is set to trigger a report,

- k corresponds to the scheduled PUSCH subframe determined in Subclause 8.0 if the uplink DCI format is 0A/4A,
- k corresponds to the N-th scheduled PUSCH subframe determined in Subclause 8.0 if the uplink DCI format is 0B/4B and $N \leq 2$,
- k corresponds to the (N-1)-th scheduled PUSCH subframe determined in Subclause 8.0 if the uplink DCI format is 0B/4B and $N > 2$,
- value of N is determined by the number of scheduled subframes field in the corresponding DCI format 0B/4B

For a non-BL/CE UE, when the CSI request field from a Random Access Response Grant is set to trigger a report and is not reserved, k is equal to k_1 if the UL delay field in Subclause 6.2 is set to zero, where k_1 is given in Subclause 6.1.1. The UE shall postpone aperiodic CSI reporting to the next available UL subframe if the UL delay field is set to 1.

For a BL/CE UE, when the CSI request field from a Random Access Response Grant is set to trigger a report and is not reserved, the subframe(s) in which the corresponding aperiodic CSI reporting is transmitted is determined according to Subclause 6.1.1.

The minimum reporting interval for aperiodic reporting of CQI and PMI and RI and CRI is 1 subframe. The subband size for CQI shall be the same for transmitter-receiver configurations with and without precoding.

If a UE is not configured for simultaneous PUSCH and PUCCH transmission, when aperiodic CSI report with no transport block associated as defined in Subclause 8.6.2 and positive SR is transmitted in the same subframe/slot/subslot, the UE shall transmit SR, and, if applicable, HARQ-ACK, on PUCCH resources as described in Subclause 10.1

A UE is semi-statically configured by higher layers to feed back CQI and PMI and corresponding RI and CRI on the same PUSCH using one of the following CSI reporting modes given in Table 7.2.1-1 and described below. For a BL/CE UE the UE shall not transmit the RI for any CSI reporting mode in Table 7.2.1-1.

If a UE is configured with higher layer parameter *FeCoMPCSIEnabled* for a CSI process the reported CRI value can take on values 0, 1, 2. For CRI value of 2, then 2 sets of PMI/CQI/RI are reported, one set for each of the configured CSI-RS resources. The combinations of the reported RIs are restricted to the following sets {1,1}, {1,2}, {2,1}, {2,2}, {2,3}, {3,2}, {3,3}, {3,4}, {4,3}, {4,4} where {x,y} indicates RI value of x corresponding to the first CSI-RS resource and RI value of y corresponding to the second CSI-RS resource.

If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, one of the following CSI reporting modes given in Table 7.2.1-1 is configured only for *eMIMO-Type2* and for any CSI reporting mode in Table 7.2.1-1,

- the UE shall not transmit CQI and second precoding matrix indicator i_2 for *eMIMO-Type*;
- the UE shall not transmit RI for *eMIMO-Type* except if the maximum number of supported layers for spatial multiplexing in DL by the UE is more than 2, then UE feeds back a 1-bit RI according to Table 7.2.1-1L;
- the UE shall transmit wideband first PMI for *eMIMO-Type*.

If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B' with more than one CSI-RS resource configured, and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, one of the following CSI reporting modes given in Table 7.2.1-1 is configured only for *eMIMO-Type2* and the UE shall not transmit CQI, PMI, RI for *eMIMO-Type* and the UE shall transmit CRI for *eMIMO-Type* for any CSI reporting mode in Table 7.2.1-1.

Table 7.2.1-1: CQI and PMI Feedback Types for PUSCH CSI reporting Modes

| | | PMI Feedback Type | | |
|-------------------------|---------------------------------------|-------------------|------------|--------------|
| | | No PMI | Single PMI | Multiple PMI |
| PUSCH CQI Feedback Type | Wideband (wideband CQI) | Mode 1-0 | Mode 1-1 | Mode 1-2 |
| | UE Selected (subband CQI) | Mode 2-0 | | Mode 2-2 |
| | Higher Layer-configured (subband CQI) | Mode 3-0 | Mode 3-1 | Mode 3-2 |

Table 7.2.1-1L: Mapping of RI field to RI

| Value of RI field | RI |
|-------------------|----|
| 0 | 1 |
| 1 | 3 |

For non-BL/CE UE and for each of the transmission modes defined in Subclause 7.1, the following reporting modes are supported on PUSCH:

- | | |
|---------------------|---------------------------------|
| Transmission mode 1 | : Modes 2-0, 3-0, 1-0 |
| Transmission mode 2 | : Modes 2-0, 3-0, 1-0 |
| Transmission mode 3 | : Modes 2-0, 3-0, 1-0 |
| Transmission mode 4 | : Modes 1-2, 2-2, 3-1, 3-2, 1-1 |
| Transmission mode 5 | : Mode 3-1, 1-1 |
| Transmission mode 6 | : Modes 1-2, 2-2, 3-1, 3-2, 1-1 |
| Transmission mode 7 | : Modes 2-0, 3-0, 1-0 |

- Transmission mode 8 : Modes 1-2, 2-2, 3-1, 3-2, 1-1 if the UE is configured with PMI/RI reporting; modes 2-0, 3-0, 1-0 if the UE is configured without PMI/RI reporting
- Transmission mode 9 : Modes 1-2, 2-2, 3-1, 3-2, 1-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports > 1 and the UE is not configured with higher layer parameter *advancedCodebookEnabled*; modes 1-2, 2-2, 3-1, 3-2 if the UE is configured with PMI/RI reporting and number of CSI-RS ports > 1 and the UE is configured with higher layer parameter *advancedCodebookEnabled*; modes 2-0, 3-0, 1-0 if the UE is configured without PMI/RI reporting or without PMI reporting or number of CSI-RS ports=1 or the number of CSI-RS ports in each of one or more CSI-RS resources in a CSI process is one when *eMIMO-Type* or *eMIMO-Type2* is set to 'CLASS B'; modes 1-1, 3-1 if the UE is configured with higher layer parameter *semiOpenLoop*.
- Transmission mode 10 : Modes 1-2, 2-2, 3-1, 3-2, 1-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports > 1 and the UE is not configured with higher layer parameter *advancedCodebookEnabled*; modes 1-2, 2-2, 3-1, 3-2 if the UE is configured with PMI/RI reporting and number of CSI-RS ports > 1 and the UE is configured with higher layer parameter *advancedCodebookEnabled*; modes 2-0, 3-0, 1-0 if the UE is configured without PMI/RI reporting or without PMI reporting or number of CSI-RS ports=1 or the number of CSI-RS ports in each of one or more CSI-RS resources in a CSI process is one when *eMIMO-Type* or *eMIMO-Type2* is set to 'CLASS B'; modes 1-1, 3-1 if the UE is configured with higher layer parameter *semiOpenLoop*.

For a BL/CE UE configured with CEModeA, the following reporting modes are supported on PUSCH:

- Transmission mode 1 : Mode 2-0
 Transmission mode 2 : Mode 2-0
 Transmission mode 6 : Mode 2-0
 Transmission mode 9 : Mode 2-0

For Transmission mode 6 and a BL/CE UE configured with a C-RNTI, the BL/CE UE reports CQI for the closed-loop with spatial multiplexing PDSCH transmission scheme.

The aperiodic CSI reporting mode is given by the parameter *cqi-ReportModeAperiodic* which is configured by higher-layer signalling.

For a non-BL/CE UE, a serving cell with $N_{\text{RB}}^{\text{DL}} \leq 7$, PUSCH reporting modes are not supported for that serving cell.
 For a non-BL/CE UE, RI is only reported for transmission modes 3 and 4, as well as transmission modes 8, 9 and 10 with PMI/RI reporting, and transmission modes 9 and 10 without PMI reporting.
 For a BL/CE UE, RI is not reported.

If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process, the higher layer parameter *eMIMO-Type* in the rest of this Subclause refers to higher layer configured eMIMO type associated with the value of CSI request field triggering aperiodic CSI reporting for the CSI process.

For serving cell c , a UE configured in transmission mode 10 with PMI/RI reporting or without PMI reporting for a CSI process can be configured with a 'RI-reference CSI process' for the CSI process. If the UE is configured with a 'RI-reference CSI process' for the CSI process, the reported RI for the CSI process shall be the same as the reported RI for the configured 'RI-reference CSI process'. The RI for the 'RI-reference CSI process' is not based on any other configured CSI process other than the 'RI-reference CSI process'. The UE is not expected to receive an aperiodic CSI report request for a given subframe/slot/subslot triggering a CSI report including CSI associated with the CSI process and not including CSI associated with the configured 'RI-reference CSI process'. If the UE is configured with a 'RI-reference CSI process' for a CSI process and if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers for only one of the CSI processes then the UE is not expected to receive configuration for the CSI process configured with the subframe subsets that have a different set of restricted RIs with precoder codebook subset restriction between the two subframe sets. The UE is not expected to receive configurations for the CSI process and the 'RI-reference CSI process' that have a different:

- Aperiodic CSI reporting mode, and/or
- number of CSI-RS antenna ports, and/or

- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are not configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for each subframe set if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for only one of the CSI processes, and the set of restricted RIs for the two subframe sets are the same, and/or
- number of CSI-RS antenna ports for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are not configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for each subframe set and for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for only one of the CSI processes, and the set of restricted RIs for the two subframe sets are the same.

For a non-BL/CE UE, a RI report for a serving cell on an aperiodic reporting mode is valid only for CQI/PMI report or CQI report without PMI reporting for that serving cell on that aperiodic reporting mode.

For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with parameter *eMIMO-Type* configured by higher layers, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B' and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, and the total number of antenna ports across all configured CSI-RS resources is more than 15, the UE on reception of an aperiodic CSI report request triggering a CSI report in uplink subframe n is not expected to update CRI corresponding to the CSI process if CRI for the CSI process has been reported and updated on or after subframe $n-5$.

- Wideband feedback
 - Mode 1-2 description:
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.
 - For each subband a preferred precoding matrix is selected from the codebook subset assuming transmission only in the subband
 - A UE shall report one wideband CQI value per codeword which is calculated assuming the use of the corresponding selected precoding matrix in each subband and transmission on set S

subbands. The UE shall report the selected precoding matrix indicator for each set S subband except with

- 8 CSI-RS ports configured for transmission modes 9 and 10 or with $alternativeCodeBookEnabledFor4TX-r12=TRUE$ configured for transmission modes 8, 9 and 10, in which case a first precoding matrix indicator i_1 is reported for the set S subbands and a second precoding matrix indicator i_2 is reported for each set S subband, if the UE is not configured with higher layer parameter $eMIMO-Type$ or $advancedCodebookEnabled$, or UE is configured in transmission mode 9 or 10 and $advancedCodebookEnabled=TRUE$, and reported $RI > 2$, or UE reports CRI, or UE is configured in transmission mode 9 or 10, and with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter $alternativeCodebookEnabledCLASSB_K1=TRUE$ configured.
- UE is configured in transmission mode 9 or 10, and with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS A', in which case a first precoding matrix indicator i_1 is reported for the set S subbands and a second precoding matrix indicator i_2 is reported for each set S subband, if the UE is not configured with higher layer parameter $advancedCodebookEnabled$, or UE is configured with higher layer parameter $advancedCodebookEnabled=TRUE$, and reported $RI > 2$.
- UE is configured in transmission mode 9 or 10, and with higher layer parameter $advancedCodebookEnabled=TRUE$, and reported $RI \leq 2$, in which case a first precoding matrix indicator i_1 is reported for the set S subbands, a relative power indicator I_p is reported for the set S subbands and a second precoding matrix indicator i_2 is reported for each set S subband.
- Subband size is given by Table 7.2.1-3A when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, Table 7.2.1-3 otherwise.
- For transmission modes 4, 8, 9 and 10, the reported PMI and CQI values and RPI value (if reported) are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported PMI, CQI, and RI values are calculated conditioned on the reported CRI.
- Mode 1-1 description:
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter $eMIMO-Type$, except with higher layer parameter $csi-RS-NZP-mode$ configured, and $eMIMO-Type$ is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter $eMIMO-Type$ set to 'CLASS B' and higher layer parameter $csi-RS-NZP-mode$ set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set S subbands
 - The UE shall report the selected single precoding matrix indicator except with
 - 8 CSI-RS ports configured for transmission modes 9 and 10 or with $alternativeCodeBookEnabledFor4TX-r12=TRUE$ configured for transmission modes 8, 9 and 10, in which case a first and second precoding matrix indicator are reported corresponding to the selected single precoding matrix, if the UE is not configured with higher layer parameter $eMIMO-Type$, or UE reports CRI, or UE is configured in transmission mode 9 or 10, and with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS B', and one CSI-

RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_KI=TRUE* configured or when higher layer parameter *semiOpenLoop* is configured and $RI < 3$, in which case a first precoding matrix indicator is reported corresponding to the selected single precoding matrix.

- UE is configured in transmission mode 9 or 10, and with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', in which case a first and second precoding matrix indicator are reported corresponding to the selected single precoding matrix, except when higher layer parameter *semiOpenLoop* is configured and $RI < 3$, in which case a first precoding matrix indicator is reported corresponding to the selected single precoding matrix.
- For transmission modes 4, 8, 9 and 10, the reported PMI and CQI values are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported PMI, CQI, and RI values are calculated conditioned on the reported CRI.
- Mode 1-0 description:
 - If a UE is configured in transmission mode 9 or 10, and UE is configured with higher layer parameter *eMIMO-Type* for a CSI process, and *eMIMO-Type* is set to 'CLASS B', and the number of CSI-RS antenna ports in at least one of the one or more configured CSI-RS resource is more than one,
 - If the UE is not configured with higher layer parameter *csi-RS-NZP-mode*, and the number of configured CSI-RS resources is more than one, or the UE is configured with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set S subbands
 - The selected precoding matrix, and reported CQI values are calculated conditioned on the reported RI. If CRI is reported, the selected precoding matrix, reported CQI, and RI values are calculated conditioned on the reported CRI

otherwise,

- For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.
- A UE shall report a wideband CQI value which is calculated assuming transmission on set S subbands
- The wideband CQI represents channel quality for the first codeword, even when $RI > 1$.
- For transmission mode 3 the reported CQI value is calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported CQI values are calculated conditioned on the reported CRI.

- Higher Layer-configured subband feedback
 - Mode 3-0 description:
 - If a UE is configured in transmission mode 9 or 10, and UE is configured with higher layer parameter *eMIMO-Type* for a CSI process, and *eMIMO-Type* is set to 'CLASS B', and the number of CSI-RS antenna ports in at least one of the one or more configured CSI-RS resource is more than one,
 - If the UE is not configured with higher layer parameter *csi-RS-NZP-mode*, and the number of configured CSI-RS resources is more than one, or the UE is configured with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set *S* subbands.
 - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands
 - A UE shall report one subband CQI value per codeword for each set *S* subband which are calculated assuming the use of the single precoding matrix in all subbands and assuming transmission in the corresponding subband.
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set *S* subbands
 - The selected precoding matrix, and reported CQI values are calculated conditioned on the reported RI. If CRI is reported, the selected precoding matrix, reported CQI, and RI values are calculated conditioned on the reported CRI
 - otherwise,
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode configured*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set *S* subbands.
 - A UE shall report a wideband CQI value which is calculated assuming transmission on set *S* subbands
 - The UE shall also report one subband CQI value for each set *S* subband. The subband CQI value is calculated assuming transmission only in the subband
 - Both the wideband and subband CQI represent channel quality for the first codeword, even when RI>1.
 - For transmission mode 3 the reported CQI values are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported CQI values are calculated conditioned on the reported CRI.
 - Mode 3-1 description:
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode configured*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one,

the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.

- A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
 - A UE shall report one subband CQI value per codeword for each set S subband which are calculated assuming the use of the single precoding matrix in all subbands and assuming transmission in the corresponding subband.
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set S subbands
 - The UE shall report the selected single precoding matrix indicator except with,
 - 8 CSI-RS ports configured for transmission modes 9 and 10 or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, in which case a first and second precoding matrix indicator are reported corresponding to the selected single precoding matrix, if the UE is not configured with higher layer parameter *eMIMO-Type* or *advancedCodebookEnabled*, or UE is configured in transmission mode 9 or 10 and *advancedCodebookEnabled=TRUE*, and reported $RI > 2$, or UE reports CRI, or UE is configured in transmission mode 9 or 10, and with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or when higher layer parameter *semiOpenLoop* is configured and $RI < 3$, in which case a first precoding matrix indicator is reported corresponding to the selected single precoding matrix.
 - UE is configured in transmission mode 9 or 10, and with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', in which case a first and second precoding matrix indicator are reported corresponding to the selected single precoding matrix if the UE is not configured with higher layer parameter *advancedCodebookEnabled*, or UE is configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and reported $RI > 2$, except when higher layer parameter *semiOpenLoop* is configured and $RI < 3$, in which case a first precoding matrix indicator is reported corresponding to the selected single precoding matrix.
 - UE is configured in transmission mode 9 or 10, and with higher layer parameter *advancedCodebookEnabled=TRUE*, and reported $RI \leq 2$, in which case a first and second precoding matrix indicator and relative power indicator are reported corresponding to the selected single precoding matrix.
 - For transmission modes 4, 8, 9 and 10, the reported PMI and CQI values and RPI value (if reported) are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported PMI, CQI, and RI values are calculated conditioned on the reported CRI.
- Mode 3-2 description:
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode configured*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.

- For each subband a preferred precoding matrix is selected from the codebook subset assuming transmission only in the subband
- A UE shall report one wideband CQI value per codeword which is calculated assuming the use of the corresponding selected precoding matrix in each subband and transmission on set S subbands.
- A UE shall report the selected single precoding matrix indicator for each set S subband except with,
 - 8 CSI-RS ports configured for transmission mode 9 and 10, or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, in which case the UE shall report a first precoding matrix indicator for all set S subbands and also report a second precoding matrix indicator for each set S subband, if the UE is not configured with higher layer parameter *eMIMO-Type* or *advancedCodebookEnabled*, or UE is configured in transmission mode 9 or 10 and *advancedCodebookEnabled=TRUE*, and reported $RI > 2$, or UE reports CRI, or UE is configured in transmission mode 9 or 10, and with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured.
 - UE is configured in transmission mode 9 or 10, and with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', in which case a first precoding matrix indicator i_1 is reported for the set S subbands and a second precoding matrix indicator i_2 is reported for each set S subband if the UE is not configured with higher layer parameter *advancedCodebookEnabled*, or UE is configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and reported $RI > 2$.
 - UE is configured in transmission mode 9 or 10, and with higher layer parameter *advancedCodebookEnabled=TRUE*, and reported $RI \leq 2$, in which case a first precoding matrix indicator i_1 is reported for the set S subbands, a relative power indicator I_p is reported for the set S subbands, and a second precoding matrix indicator i_2 is reported for each set S subband.
- A UE shall report one subband CQI value per codeword for each set S subband reflecting transmission over the single subband and using the selected precoding matrix in the corresponding subband.
- For transmission modes 4, 8, 9 and 10, the reported PMI and CQI values and RPI value (if reported) are calculated conditioned on the reported RI. For transmission mode 6 they are reported conditioned on rank 1. If CRI is reported, the reported PMI, CQI, and RI values are calculated conditioned on the reported CRI.
- Subband CQI value for each codeword are encoded differentially with respect to their respective wideband CQI using 2-bits as defined by
 - Subband differential CQI offset level = subband CQI index – wideband CQI index. The mapping from the 2-bit subband differential CQI value to the offset level is shown in Table 7.2.1-2.

Table 7.2.1-2: Mapping subband differential CQI value to offset level

| Subband differential CQI value | Offset level |
|--------------------------------|--------------|
| 0 | 0 |
| 1 | 1 |
| 2 | ≥ 2 |
| 3 | ≤ -1 |

- Supported subband size (k) is given in Table 7.2.1-3A when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, in Table 7.2.1-3 otherwise.

Table 7.2.1-3: Subband Size (k) vs. System Bandwidth

| System Bandwidth N_{RB}^{DL} | Subband Size (k) |
|-----------------------------------|-------------------------|
| 6 - 7 | NA |
| 8 - 10 | 4 |
| 11 - 26 | 4 |
| 27 - 63 | 6 |
| 64 - 110 | 8 |

Table 7.2.1-3A: Subband Size (k) vs. System Bandwidth when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report

| System Bandwidth N_{RB}^{DL} | Subband Size (k) |
|-----------------------------------|-------------------------|
| 6 - 7 | NA |
| 8 - 10 | 4 |
| 11 - 26 | 12 |
| 27 - 63 | 12 |
| 64 - 110 | 12 |

- UE-selected subband feedback
 - Mode 2-0 description:
 - If a UE is configured in transmission mode 9 or 10, and UE is configured with higher layer parameter *eMIMO-Type* for a CSI process, and *eMIMO-Type* is set to 'CLASS B', and the number of CSI-RS antenna ports in at least one of the one or more configured CSI-RS resource is more than one,
 - If the UE is not configured with higher layer parameter *csi-RS-NZP-mode*, and the number of configured CSI-RS resources is more than one, or the UE is configured with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set S subbands.
 - The UE shall perform joint selection of the set of M preferred subbands of size k within the set of subbands S and a preferred single precoding matrix selected from the codebook subset that is preferred to be used for transmission over the M selected subbands.
 - The UE shall report one CQI value per codeword reflecting transmission only over the selected M preferred subbands and using the same selected single precoding matrix in each of the M subbands.
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set S subbands
 - The selected precoding matrix, and reported CQI values are calculated conditioned on the reported RI. If CRI is reported, the selected precoding matrix, reported CQI, and RI values are calculated conditioned on the reported CRI.
 - otherwise,

- For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode configured*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set *S* subbands.
- The UE shall select a set of *M* preferred subbands of size *k* (where *k* and *M* are given in Table 7.2.1-5 for each system bandwidth range) within the set of subbands *S*.
- The UE shall also report one CQI value reflecting transmission only over the *M* selected subbands determined in the previous step. The CQI represents channel quality for the first codeword, even when RI>1.
- Additionally, the UE shall also report one wideband CQI value which is calculated assuming transmission on set *S* subbands. The wideband CQI represents channel quality for the first codeword, even when RI>1.
- For transmission mode 3 the reported CQI values are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported CQI values are calculated conditioned on the reported CRI.
- Mode 2-2 description:
 - For a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type*, except with higher layer parameter *csi-RS-NZP-mode configured*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, and for a UE configured in transmission mode 9 or 10, and for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, the UE shall report one wideband CRI which is calculated assuming transmission on set *S* subbands.
 - The UE shall perform joint selection of the set of *M* preferred subbands of size *k* within the set of subbands *S* and a preferred single precoding matrix selected from the codebook subset that is preferred to be used for transmission over the *M* selected subbands.
 - The UE shall report one CQI value per codeword reflecting transmission only over the selected *M* preferred subbands and using the same selected single precoding matrix in each of the *M* subbands.
 - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands
 - A UE shall report a wideband CQI value per codeword which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set *S* subbands
 - The UE shall report the selected single precoding matrix indicator preferred for the *M* selected subbands and the selected single precoding matrix indicator for all set *S* subbands except with,
 - 8 CSI-RS ports configured for transmission modes 9 and 10 or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, in which case the UE shall report a first precoding matrix indicator for all set *S* subbands, a second precoding matrix indicator for all set *S* subbands and another second precoding matrix indicator for the *M* selected subbands, if the UE is not configured with higher layer parameter *eMIMO-Type* or *advancedCodebookEnabled*, or UE is configured in transmission mode

9 or 10 and $advancedCodebookEnabled=TRUE$, and reported $RI > 2$, or UE reports CRI, or UE is configured in transmission mode 9 or 10, and with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter $alternativeCodebookEnabledCLASSB_KI=TRUE$ configured.

- UE is configured in transmission mode 9 or 10, and with higher layer parameter $eMIMO-Type$, and $eMIMO-Type$ is set to 'CLASS A', in which case the UE shall report a first precoding matrix indicator i_1 for all set S subbands, a second precoding matrix indicator i_2 for all set S subbands and another second precoding matrix indicator i_2 for or the M selected subbands if the UE is not configured with higher layer parameter $advancedCodebookEnabled$, or UE is configured with higher layer parameter $advancedCodebookEnabled=TRUE$, and reported $RI > 2$.
- UE is configured in transmission mode 9 or 10, and with higher layer parameter $advancedCodebookEnabled=TRUE$, and reported $RI \leq 2$, in which case the UE shall report a first precoding matrix indicator i_1 for all set S subbands, a relative power indicator I_p is reported for all set S subbands, a second precoding matrix indicator i_2 for all set S subbands and another second precoding matrix indicator i_2 for or the M selected subbands.
- For transmission modes 4, 8, 9 and 10, the reported PMI and CQI values and RPI value (if reported) are calculated conditioned on the reported RI. For other transmission modes they are reported conditioned on rank 1. If CRI is reported, the reported PMI, CQI, and RI values are calculated conditioned on the reported CRI.
- For all UE-selected subband feedback modes the UE shall report the positions of the M selected subbands using a combinatorial index r defined as
 - $$r = \sum_{i=0}^{M-1} \binom{N - s_i}{M - i}$$
 - where the set $\{s_i\}_{i=0}^{M-1}$, ($1 \leq s_i \leq N$, $s_i < s_{i+1}$) contains the M sorted subband indices and
$$\binom{x}{y} = \begin{cases} \binom{x}{y} & x \geq y \\ 0 & x < y \end{cases}$$
 is the extended binomial coefficient, resulting in unique label $r \in \left\{0, \dots, \binom{N}{M} - 1\right\}$.
- The CQI value for the M selected subbands for each codeword is encoded differentially using 2-bits relative to its respective wideband CQI as defined by
 - Differential CQI offset level = M selected subbands CQI index – wideband CQI index
 - The mapping from the 2-bit differential CQI value to the offset level is shown in Table 7.2.1-4.

Table 7.2.1-4: Mapping differential CQI value to offset level

| Differential CQI value | Offset level |
|------------------------|--------------|
| 0 | ≤ 1 |
| 1 | 2 |
| 2 | 3 |
| 3 | ≥ 4 |

- Supported subband size k and M values include those shown in Table 7.2.1-5A when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, in Table 7.2.1-5 otherwise. In Table 7.2.1-5 the k and M values are a function of system bandwidth.
- The number of bits to denote the position of the M selected subbands is $L = \left\lceil \log_2 \binom{N}{M} \right\rceil$.

For a BL/CE UE, the reported CQI values are calculated conditioned on rank 1.

- UE-selected subband feedback
 - Mode 2-0 description:
 - The UE shall report one wideband CQI value which is calculated assuming transmission on all narrowband(s) in the CSI reference resource.
 - If frequency hopping is configured for MPDCCH,
 - the UE shall select $M=1$ preferred narrowband defined in Subclause 6.2.7 of [3] within the set of narrowband(s) in which MPDCCH is monitored.
 - the UE shall also report one CQI value reflecting transmission only over the selected narrowband determined in the previous step.
 - The CQI value for the $M=1$ selected narrowband is encoded differentially using 2-bits relative to its respective wideband CQI as defined by
 - Differential CQI offset level = selected narrowband CQI index – wideband CQI index
 - The mapping from the 2-bit differential CQI value to the offset level is shown in Table 7.2.1-4.
 - the UE shall report the positions of the $M=1$ selected narrowband according to Table 7.2.1-6.
 - otherwise,
 - the UE shall report a Differential CQI value = 0 and a position of the $M=1$ selected narrowband according to Table 7.2.1-6.

Table 7.2.1-5: Subband Size (k) and Number of Subbands (M) in S vs. Downlink System Bandwidth

| System Bandwidth $N_{\text{RB}}^{\text{DL}}$ | Subband Size k (RBs) | M |
|---|------------------------|-----|
| 6 – 7 | NA | NA |
| 8 – 10 | 2 | 1 |
| 11 – 26 | 2 | 3 |
| 27 – 63 | 3 | 5 |
| 64 – 110 | 4 | 6 |

Table 7.2.1-5A: Subband Size (k) and Number of Subbands (M) in S vs. Downlink System Bandwidth when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report

| System Bandwidth $N_{\text{RB}}^{\text{DL}}$ | Subband Size k (RBs) | M |
|---|------------------------|-----|
| 6 – 7 | NA | NA |
| 8 – 11 | 4 | 1 |
| 12 – 26 | 12 | 1 |
| 27 – 63 | 12 | 2 |
| 64 – 110 | 12 | 4 |

Table 7.2.1-6: Reporting UE selected narrowband position for BL/CE UEs

| Number of narrowbands for MPDCCH monitoring | UE reported bit(s) for narrowband position (MSB, LSB) | MPDCCH Narrowband Reported |
|--|--|--|
| 1 | 0 | The narrowband used for MPDCCH monitoring |
| 2 | 0 | Narrowband with lowest narrowband index |
| | 1 | Narrowband with highest narrowband index |
| 4 | 00 | Narrowband with lowest narrowband index |
| | 01 | Narrowband with second lowest narrowband index |
| | 10 | Narrowband with third lowest narrowband index |
| | 11 | Narrowband with highest narrowband index |

7.2.2 Periodic CSI Reporting using PUCCH

A UE is semi-statically configured by higher layers to periodically feed back different CSI components (CQI, PMI, PTI, CRI, and/or RI) on the PUCCH using the reporting modes given in Table 7.2.2-1 and described below. A UE in transmission mode 10 can be configured by higher layers for multiple periodic CSI reports corresponding to one or more CSI processes per serving cell on PUCCH.

A BL/CE UE configured with CEModeB is not expected to be configured with periodic CSI report.

If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured,

- one of the following CSI reporting modes given in Table 7.2.2-1 is configured only for *eMIMO-Type2*
- the UE shall not transmit CQI, PTI, and second precoding matrix indicator i_2 for *eMIMO-Type* for any CSI reporting mode in Table 7.2.2-1
- the UE shall not transmit RI for *eMIMO-Type* and for any CSI reporting mode in Table 7.2.2-1 except if the maximum number of supported layers for spatial multiplexing in DL supported by the UE is more than 2, then UE feeds back a 1-bit RI according to Table 7.2.1-1L
- the UE shall report a type 2a report consisting of wideband first PMI if RI is not transmitted, otherwise type 5 report consisting of jointly coded RI and a wideband first PMI for *eMIMO-Type* for any CSI reporting mode in Table 7.2.2-1, as described below.

If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B' with more than one CSI-RS resource configured, and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, one of the following CSI reporting modes given in Table 7.2.2-1 is configured only for *eMIMO-Type2* and the UE shall not transmit CQI, PMI, PTI, RI for *eMIMO-Type* for any CSI reporting mode in Table 7.2.2-1 and the UE shall report a type10 report consisting of CRI as described below.

If a UE is configured with higher layer configured parameter *semiOpenLoop*, except with 2 CSI-RS ports or with 4 CSI-RS ports and *alternativeCodeBookEnabledFor4TX-r12=FALSE*, the UE shall report a type 2a report consisting of wideband first PMI for CSI reporting modes 1-1 and 2-1 in Table 7.2.2-1, as described below.

Table 7.2.2-1: CQI and PMI Feedback Types for PUCCH CSI reporting Modes

| | | PMI Feedback Type | |
|-------------------------|---------------------------|-------------------|------------|
| | | No PMI | Single PMI |
| PUCCH CQI Feedback Type | Wideband (wideband CQI) | Mode 1-0 | Mode 1-1 |
| | UE Selected (subband CQI) | Mode 2-0 | Mode 2-1 |

For a non-BL/CE UE and for each of the transmission modes defined in Subclause 7.1, the following periodic CSI reporting modes are supported on PUCCH:

- | | |
|---------------------|--|
| Transmission mode 1 | : Modes 1-0, 2-0 |
| Transmission mode 2 | : Modes 1-0, 2-0 |
| Transmission mode 3 | : Modes 1-0, 2-0 |
| Transmission mode 4 | : Modes 1-1, 2-1 |
| Transmission mode 5 | : Modes 1-1, 2-1 |
| Transmission mode 6 | : Modes 1-1, 2-1 |
| Transmission mode 7 | : Modes 1-0, 2-0 |
| Transmission mode 8 | : Modes 1-1, 2-1 if the UE is configured with PMI/RI reporting; modes 1-0, 2-0 if the UE is configured without PMI/RI reporting |
| Transmission mode 9 | : Modes 1-1, 2-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports>1 and the UE is not configured with higher layer parameter <i>advancedCodebookEnabled</i> , or the UE is configured with higher layer parameter <i>semiOpenLoop</i> ; mode 1-1 if the UE is configured with PMI/RI reporting and number of |

CSI-RS ports>1 and the UE is configured with higher layer parameter *advancedCodebookEnabled*; modes 1-0, 2-0 if the UE is configured without PMI/RI reporting or without PMI reporting or number of CSI-RS ports=1 or the number of CSI-RS ports in each of one or more CSI-RS resources in a CSI process is one when *eMIMO-Type* or *eMIMO-Type2* is set to be 'CLASS B'.

Transmission mode 10 : Modes 1-1, 2-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports>1 and the UE is not configured with higher layer parameter *advancedCodebookEnabled*, or the UE is configured with higher layer parameter *semiOpenLoop*; mode 1-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports>1 and the UE is configured with higher layer parameter *advancedCodebookEnabled*; modes 1-0, 2-0 if the UE is configured without PMI/RI reporting or without PMI reporting or number of CSI-RS ports=1 or the number of CSI-RS ports in each of one or more CSI-RS resources in a CSI process is one when *eMIMO-Type* or *eMIMO-Type2* is set to be 'CLASS B'.

For a BL/CE UE configured with CEModeA, the following periodic CSI reporting modes are supported on PUCCH:

- Transmission mode 1 : Mode 1-0
- Transmission mode 2 : Mode 1-0
- Transmission mode 6 : Mode 1-1
- Transmission mode 9 : Modes 1-1, 1-0.

For a UE configured in transmission mode 1-9, one periodic CSI reporting mode for each activated serving cell is configured by higher-layer signalling. Additionally, one periodic CSI reporting mode can be configured by higher-layer signalling for each dormant serving cell.

For a UE configured in transmission mode 10, one or more periodic CSI reporting modes for each serving cell are configured by higher-layer signalling. Additionally, one periodic CSI reporting mode can be configured by higher-layer signalling for each dormant serving cell.

For UE in transmission mode 9 and the UE configured with higher layer parameter *eMIMO-Type*, the term 'CSI process' in this Subclause refers to the CSI configured for the UE.

For a UE configured with transmission mode 9 or 10, and with 8 CSI-RS ports, if the UE is not configured with parameter *eMIMO-Type* by higher layers , or the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or the UE is configured with parameter *eMIMO-Type2* by higher layers, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured,or the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and more than one CSI-RS resource configured, and at least one CSI-RS resource with 8 CSI-RS ports, mode 1-1 is configured to be either submode 1 or submode 2 via higher-layer signaling using the parameter *PUCCH_format1-1_CSI_reporting_mode*.

For a UE configured with transmission mode 8, 9 or 10, and with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, if the UE is not configured with higher layer parameter *eMIMO-Type*, or the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or the UE is configured with parameter *eMIMO-Type2* by higher layers, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and more than one CSI-RS resource configured, and at least one CSI-RS resource with 4 CSI-RS ports, mode 1-1 is configured to be either submode 1 or submode 2 via higher-layer signaling using the parameter *PUCCH_format1-1_CSI_reporting_mode*.

For the UE-selected subband CQI, a CQI report in a certain subframe of a certain serving cell describes the channel quality in a particular part or in particular parts of the bandwidth of that serving cell described subsequently as bandwidth part (BP) or parts. The bandwidth parts shall be indexed in the order of increasing frequency and non-increasing sizes starting at the lowest frequency.

For each serving cell

- There are a total of N subbands for a serving cell system bandwidth given by $N_{\text{RB}}^{\text{DL}}$ where $\lfloor N_{\text{RB}}^{\text{DL}} / k \rfloor$ subbands are of size k . If $\lceil N_{\text{RB}}^{\text{DL}} / k \rceil - \lfloor N_{\text{RB}}^{\text{DL}} / k \rfloor > 0$ then one of the subbands is of size $N_{\text{RB}}^{\text{DL}} - k \cdot \lfloor N_{\text{RB}}^{\text{DL}} / k \rfloor$.
- A bandwidth part j is frequency-consecutive and consists of N_j subbands where J bandwidth parts span S or $N_{\text{RB}}^{\text{DL}}$ as given in Table 7.2.2-2. If $J=1$ then N_j is $\lceil N_{\text{RB}}^{\text{DL}} / k / J \rceil$. If $J>1$ then N_j is either $\lceil N_{\text{RB}}^{\text{DL}} / k / J \rceil$ or $\lceil N_{\text{RB}}^{\text{DL}} / k / J \rceil - 1$, depending on $N_{\text{RB}}^{\text{DL}}$, k and J .
- Each bandwidth part j , where $0 \leq j \leq J-1$, is scanned in sequential order according to increasing frequency.
- For UE selected subband feedback a single subband out of N_j subbands of a bandwidth part is selected along with a corresponding L -bit label indexed in the order of increasing frequency, where $L = \lceil \log_2 \lceil N_{\text{RB}}^{\text{DL}} / k / J \rceil \rceil$.

The CQI and PMI payload sizes of each PUCCH CSI reporting mode are given in Table 7.2.2-3.

The following CQI/PMI and RI reporting types with distinct periods and offsets are supported for the PUCCH CSI reporting modes given in Table 7.2.2-3:

- Type 1 report supports CQI feedback for the UE selected sub-bands
- Type 1a report supports subband CQI and second PMI feedback
- Type 2, Type 2b, and Type 2c report supports wideband CQI and PMI feedback
- Type 2a report supports wideband PMI feedback
- Type 3 report supports RI feedback
- Type 4 report supports wideband CQI
- Type 5 report supports RI and wideband PMI feedback
- Type 6 report supports RI and PTI feedback
- Type 7 report support CRI and RI feedback
- Type 8 report supports CRI, RI and wideband PMI feedback
- Type 9 report supports CRI, RI and PTI feedback
- Type 10 report supports CRI feedback
- Type 11 report supports RI and RPI feedback

For a UE configured in transmission mode 1-9 and for each serving cell, or for a UE configured in transmission mode 10 and for each CSI process in each serving cell, the periodicity N_{pa} (in subframes) and offset $N_{\text{OFFSET,CQI}}$ (in subframes) for CQI/PMI reporting are determined based on the parameter $cqi-pmi-\text{ConfigIndex}$ ($I_{\text{CQI/PMI}}$) for the activated serving cells, given in Table 7.2.2-1A for FDD or for FDD-TDD with primary cell frame structure 1 and Table 7.2.2-1C for TDD or for FDD-TDD and primary cell frame structure type 2. For the dormant serving cells, $I_{\text{CQI/PMI}}$ is given by the parameter $cqi-pmi-\text{ConfigIndexDormant}$. The periodicity M_{RI} and relative offset $N_{\text{OFFSET,RI}}$ for RI reporting are determined based on the parameter $ri-\text{ConfigIndex}$ (I_{RI}) for the activated serving cells, given in Table 7.2.2-1B. For the serving cells in the dormant state, I_{RI} is given by the parameter $ri-\text{ConfigIndexDormant}$. For a UE configured in transmission mode 9 and for each serving cell, or for a UE configured in transmission mode 10 and for each CSI process in each serving cell, if the UE is configured with parameter $eMIMO-\text{Type}$ by higher layers, except with higher layer parameter $csi-RS-NZP-\text{mode}$ configured, and $eMIMO-\text{Type}$ is set to 'CLASS B', and the number of configured CSI-RS resources is more than one, or the UE is configured with higher layer parameter $eMIMO-\text{Type}$ set to 'CLASS B' and higher layer parameter $csi-RS-NZP-\text{mode}$ set to 'multiShot', and the number of activated CSI-RS resources is more than one, when RI reporting is configured, the periodicity M_{CRI} for CRI

reporting is determined based on the parameter *cri-ConfigIndex* (I_{CRI}) given in Table 7.2.2-1J. When the number of antenna ports in each configured CSI-RS resource is one, the periodicity M_{CRI} and relative offset $N_{OFFSET,CRI}$ for CRI reporting are determined based on the parameter *cri-ConfigIndex* (I_{CRI}) given in Table 7.2.2-1K. If a UE is configured with parameter *eMIMO-Type* and *eMIMO-Type2*, the parameters *cqi-pmi-ConfigIndex*, *ri-ConfigIndex* are for *eMIMO-Type2*. If a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B' with more than one CSI-RS resource configured, and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, the parameter *cri-ConfigIndex* is for *eMIMO-Type*. If a UE is configured with parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, the periodicity $M_{PMI/RI}$ and relative offset $N_{OFFSET,PMI/RI}$ for wideband first PMI/RI reporting for *eMIMO-Type* are determined based on the parameter *periodicityOffsetIndex* ($I_{PMI/RI}$) given in Table 7.2.2-1L. The parameters *cqi-pmi-ConfigIndex*, *cqi-pmi-ConfigIndexDormant*, *ri-ConfigIndex*, *ri-ConfigIndexDormant*, *periodicityOffsetIndex*, and *cri-ConfigIndex* are configured by higher layer signalling. The relative reporting offset for RI $N_{OFFSET,RI}$ takes values from the set $\{0, -1, \dots, -(N_{pd} - 1)\}$. If a UE is configured to report for more than one CSI subframe set then parameter *cqi-pmi-ConfigIndex*, *ri-ConfigIndex*, *periodicityOffsetIndex*, and *cri-ConfigIndex* respectively correspond to the CQI/PMI, RI, PMI/RI, and CRI periodicity and relative reporting offset for subframe set 1 and *cqi-pmi-ConfigIndex2*, *cqi-pmi-ConfigIndex2Dormant*, *ri-ConfigIndex2*, *ri-ConfigIndex2Dormant*, *periodicityOffsetIndex2*, and *cri-ConfigIndex2* respectively correspond to the CQI/PMI, RI, PMI/RI, and CRI periodicity and relative reporting offset for subframe set 2. For a UE configured with transmission mode 10, the parameters *cqi-pmi-ConfigIndex*, *ri-ConfigIndex*, *periodicityOffsetIndex*, *cri-ConfigIndex*, *cqi-pmi-ConfigIndex2*, *ri-ConfigIndex2*, *periodicityOffsetIndex2*, and *cri-ConfigIndex2* can be configured for each CSI process. A BL/CE UE is not expected to be configured with the parameter *ri-ConfigIndex*.

In the case where wideband CQI/PMI reporting is configured:

- The reporting instances for wideband CQI/PMI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod (N_{pd}) = 0$.
- For a UE configured in transmission mode 9 or 10, and UE configured with the parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* set to 'CLASS A', and UE not configured with the parameter *eMIMO-Type2*, the reporting interval of wideband first PMI reporting is an integer multiple H' of period N_{pd} (in subframes).
 - The reporting instances for wideband first PMI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod (H' \cdot N_{pd}) = 0$.
- For a UE configured in transmission mode 9 or 10, if UE is configured with parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, and RI reporting for *eMIMO-Type2* is not configured, the reporting interval of wideband first PMI and RI reporting for *eMIMO-Type* is an integer multiple $M_{PMI/RI}$ of period N_{pd} (in subframes).
 - The reporting instances for wideband first PMI and RI for *eMIMO-Type* are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,PMI/RI}) \bmod (M_{PMI/RI} \cdot N_{pd}) = 0$.
- For a UE configured in transmission mode 9 or 10, if UE is configured with parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS B' with more than one CSI-RS resource configured, and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, and RI reporting for *eMIMO-Type2* is not configured, the reporting interval of CRI reporting for *eMIMO-Type* is an integer multiple M_{CRI} of period N_{pd} (in subframes)
 - The reporting instances for CRI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,CRI}) \bmod (N_{pd} \cdot M_{CRI}) = 0$.
- In case RI reporting is configured, the reporting interval of the RI reporting, or RI and RPI reporting if UE is configured in transmission mode 9 or 10, and with higher layer parameter *advancedCodebookEnabled=TRUE*, is an integer multiple M_{RI} of period N_{pd} (in subframes).
 - The reporting instances for RI or RI and RPI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}) \bmod (N_{pd} \cdot M_{RI}) = 0$.

- For a UE configured in transmission mode 9 or 10, and UE configured with parameter $eMIMO\text{-}Type$ and $eMIMO\text{-}Type2$, and $eMIMO\text{-}Type$ is set to 'CLASS A', and $eMIMO\text{-}Type2$ is set to 'CLASS B' with one CSI-RS resource configured, the reporting interval of wideband first PMI and RI reporting for $eMIMO\text{-}Type$ is an integer multiple $M_{PMI/RI}$ of period $N_{pd} \cdot M_{RI}$ (in subframes).
 - The reporting instances for wideband first PMI and RI for $eMIMO\text{-}Type$ are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI} - N_{OFFSET,PMI/RI}) \bmod (N_{pd} \cdot M_{RI} \cdot M_{PMI/RI}) = 0$.
- In case CRI reporting is configured,
 - if the number of antenna ports in each configured CSI-RS resource is one,
 - the reporting interval of the CRI reporting is an integer multiple M_{CRI} of period N_{pd} (in subframes)
 - The reporting instances for CRI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,CRI}) \bmod (N_{pd} \cdot M_{CRI}) = 0$.
 - otherwise
 - the reporting interval of the CRI reporting is an integer multiple M_{CRI} of period $N_{pd} \cdot M_{RI}$ (in subframes).
 - The reporting instances for CRI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}) \bmod (N_{pd} \cdot M_{RI} \cdot M_{CRI}) = 0$.

In the case where both wideband CQI/PMI and subband CQI (or subband CQI/second PMI for transmission modes 9 and 10) reporting are configured:

- The reporting instances for wideband CQI/PMI and subband CQI (or subband CQI/second PMI for transmission modes 9 and 10) are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod N_{pd} = 0$.
- For a UE configured in transmission mode 9 or 10, if UE is configured with parameter $eMIMO\text{-}Type$ and $eMIMO\text{-}Type2$, and $eMIMO\text{-}Type$ is set to 'CLASS A', and $eMIMO\text{-}Type2$ is set to 'CLASS B' with one CSI-RS resource configured, and RI reporting for $eMIMO\text{-}Type2$ is not configured, the reporting interval of wideband first PMI and RI reporting for $eMIMO\text{-}Type$ is an integer multiple $M_{PMI/RI}$ of period N_{pd} (in subframes).
 - The reporting instances for wideband first PMI and RI for $eMIMO\text{-}Type$ are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,PMI/RI}) \bmod (M_{PMI/RI} \cdot N_{pd}) = 0$.
 - For a UE configured in transmission mode 9 or 10, if UE is configured with parameter $eMIMO\text{-}Type$ and $eMIMO\text{-}Type2$, and $eMIMO\text{-}Type$ is set to 'CLASS B' with more than one CSI-RS resource configured, and $eMIMO\text{-}Type2$ is set to 'CLASS B' with one CSI-RS resource configured, and RI reporting for $eMIMO\text{-}Type2$ is not configured, the reporting interval of CRI reporting for $eMIMO\text{-}Type$ is an integer multiple M_{CRI} of period N_{pd} (in subframes)
 - The reporting instances for CRI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,CRI}) \bmod (N_{pd} \cdot M_{CRI}) = 0$.
 - When PTI is not transmitted (due to not being configured) or the most recently transmitted PTI is equal to 1 for a UE configured in transmission modes 8 and 9, or for a UE configured in transmission mode 10 without a 'RI-reference CSI process' for a CSI process, or the transmitted PTI is equal to 1 reported in the most recent RI reporting instance for a CSI process when a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for the CSI process, or the transmitted PTI is equal to 1 for a 'RI-reference CSI process' reported in the most recent RI reporting instance for a CSI process when a UE is configured in transmission mode 10 with the 'RI-reference CSI process' for the CSI process, and the most recent type 6 report for the CSI process is dropped:
 - The wideband CQI/ wideband PMI (or wideband CQI/wideband second PMI for transmission modes 8, 9 and 10) report has period $H \cdot N_{pd}$, and is reported on the subframes satisfying

$(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod (H \cdot N_{pd}) = 0$. The integer H is defined as $H = J \cdot K + 1$, where J is the number of bandwidth parts.

- Between every two consecutive wideband CQI/ wideband PMI (or wideband CQI/wideband second PMI for transmission modes 8, 9 and 10) reports, the remaining $J \cdot K$ reporting instances are used in sequence for subband CQI (or subband CQI/second PMI for transmission modes 9 and 10) reports on K full cycles of bandwidth parts except when the gap between two consecutive wideband CQI/PMI reports contains less than $J \cdot K$ reporting instances due to a system frame number transition to 0, in which case the UE shall not transmit the remainder of the subband CQI (or subband CQI/second PMI for transmission modes 9 and 10) reports which have not been transmitted before the second of the two wideband CQI/ wideband PMI (or wideband CQI/wideband second PMI for transmission modes 8, 9 and 10) reports. Each full cycle of bandwidth parts shall be in increasing order starting from bandwidth part 0 to bandwidth part $J-1$. The parameter K is configured by higher-layer signalling.
- When the most recently transmitted PTI is 0 for a UE configured in transmission modes 8 and 9 or for a UE configured in transmission mode 10 without a 'RI-reference CSI process' for a CSI process, or the transmitted PTI is 0 reported in the most recent RI reporting instance for a CSI process when a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for the CSI process, or the transmitted PTI is 0 for a 'RI-reference CSI process' reported in the most recent RI reporting instance for a CSI process when a UE is configured in transmission mode 10 with the 'RI-reference CSI process' for the CSI process, and the most recent type 6 report for the CSI process is dropped:
 - The wideband first precoding matrix indicator report has period $H' \cdot N_{pd}$, and is reported on the subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod (H' \cdot N_{pd}) = 0$, where H' is signalled by higher layers.
 - Between every two consecutive wideband first precoding matrix indicator reports, the remaining reporting instances are used for a wideband second precoding matrix indicator with wideband CQI as described below
- In case RI reporting is configured, the reporting interval of RI is M_{RI} times the wideband CQI/PMI period $H \cdot N_{pd}$, and RI is reported on the same PUCCH cyclic shift resource as both the wideband CQI/PMI and subband CQI reports.
 - The reporting instances for RI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}) \bmod (H \cdot N_{pd} \cdot M_{RI}) = 0$.
 - For a UE configured in transmission mode 9 or 10, and UE configured with parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, the reporting interval of wideband first PMI and RI reporting for *eMIMO-Type* is an integer multiple $M_{PMI/RI}$ of period $H \cdot N_{pd} \cdot M_{RI}$ (in subframes).
 - The reporting instances for wideband first PMI and RI for *eMIMO-Type* are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI} - N_{OFFSET,PMI/RI}) \bmod (H \cdot N_{pd} \cdot M_{RI} \cdot M_{PMI/RI}) = 0$.
- In case CRI reporting is configured,
 - if the number of antenna ports in each configured CSI-RS resource is one,
 - the reporting interval of the CRI reporting is M_{CRI} times the wideband CQI/PMI period $H \cdot N_{pd}$,
 - The reporting instances for CRI are subframes satisfying $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,CRI}) \bmod (H \cdot N_{pd} \cdot M_{CRI}) = 0$.
 - otherwise
 - the reporting interval of the CRI reporting is M_{CRI} times the RI period $H \cdot N_{pd} \cdot M_{RI}$ (in subframes).

- The reporting instances for CRI are subframes satisfying

$$(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}) \bmod (H \cdot N_{pd} \cdot M_{RI} \cdot M_{CRI}) = 0.$$

If the UE is configured with higher layer parameter *eMIMO-Type2* for a CSI process, at the CQI, PMI, RI, PTI reporting instances for *eMIMO-Type2* of the CSI process, the parameter *eMIMO-Type* in the rest of this Subclause refers to the parameter *eMIMO-Type2* for the CSI process.

If a UE is not configured with higher layer parameter *eMIMO-Type*, or for a CSI process a UE is configured with higher layer parameter *eMIMO-Type* and not configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS A', or for a CSI process a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type* is set to 'CLASS B', except with higher layer parameter *csi-RS-NZP-mode* configured, and one configured CSI-RS resource, or for a CSI process a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and one activated CSI-RS resource, in case of collision of a CSI report with PUCCH reporting type 3, 5, 6 or 11 of one serving cell with a CSI report with PUCCH reporting type 1, 1a, 2, 2a, 2b, 2c, or 4 of the same serving cell the latter CSI report with PUCCH reporting type (1, 1a, 2, 2a, 2b, 2c, or 4), except a CSI report with PUCCH reporting type 2a for *eMIMO-Type* of a CSI process of the same serving cell with configured higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, has lower priority and is dropped.

If a UE is configured with higher layer parameter *eMIMO-Type* and not configured with higher layer parameter *eMIMO-Type2* and *eMIMO-Type* is set to 'CLASS A' for a CSI process, in case of collision of a CSI report with PUCCH reporting type 2a of one serving cell with a CSI report with PUCCH reporting type 1, 1a, 2, 2b, 2c, or 4 of the same serving cell, the latter CSI report with PUCCH reporting type (1, 1a, 2, 2b, 2c, or 4) has lower priority and is dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, for a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B', and more than one configured CSI-RS resources, or a UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and more than one activated CSI-RS resources, in case of collision of a CSI report with PUCCH reporting type 7, 8, 9, or 10 of one serving cell with a CSI report with PUCCH reporting type 1, 1a, 2, 2a, 2b, 2c, 3, 4, 5, 6, or 11 of the same serving cell the latter CSI report with PUCCH reporting type (1, 1a, 2, 2a, 2b, 2c, 3, 4, 5, 6, or 11), except CSI report with PUCCH reporting type 2a or 5 for *eMIMO-Type* of a CSI process of the same serving cell with configured higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, has lower priority and is dropped.

For a CSI process, if a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, PUCCH reporting type 2a, or 5 for *eMIMO-Type* of the CSI process of one serving cell has the same priority with PUCCH reporting type (7, 8, 9, or 10) of the same serving cell.

For a serving cell and UE configured in transmission mode 10, in case of collision between CSI reports of same serving cell with PUCCH reporting type of the same priority, and the CSI reports corresponding to different CSI processes, the CSI reports corresponding to all CSI processes except the CSI process with the lowest *csi-ProcessId-r11* are dropped.

For a serving cell and UE configured in transmission mode 1-9 and configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubframePatternConfig-r12* for the serving cell, in case of collision between CSI reports of same serving cell with PUCCH reporting type of the same priority, the CSI report corresponding to CSI subframe set $C_{CSI,1}$ is dropped.

For a serving cell and UE configured in transmission mode 10 and configured with CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ by the higher layer parameter *csi-SubframePatternConfig-r12* for the serving cell, in case of collision between CSI reports of same serving cell with PUCCH reporting type of the same priority and the CSI reports corresponding to CSI processes with same *csi-ProcessId-r11*, the CSI report corresponding to CSI subframe set $C_{CSI,1}$ is dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, and if the UE is configured with more than one serving cell, the UE transmits a CSI report of only one serving cell in any given subframe. For a given subframe, in case of collision of a CSI report with PUCCH

reporting type 7, 8, 9, or 10 of one serving cell with a CSI report with PUCCH reporting type 1, 1a, 2, 2a, 2b, 2c, 3, 4, 5, 6, or 11 of another serving cell, the latter CSI with PUCCH reporting type (1, 1a, 2, 2a, 2b, 2c, 3, 4, 5, 6, or 11), except CSI report with PUCCH reporting type 2a or 5 for *eMIMO-Type* of a CSI process of the another serving cell with configured higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, has lower priority and is dropped. For a given subframe, in case of collision of a CSI report with PUCCH reporting type 3, 5, 6, 11, or 2a of one serving cell with a CSI report with PUCCH reporting type 1, 1a, 2, 2b, 2c, or 4 of another serving cell, the latter CSI with PUCCH reporting type (1, 1a, 2, 2b, 2c, or 4) has lower priority and is dropped. For a given subframe, in case of collision of CSI report with PUCCH reporting type 2, 2b, 2c, or 4 of one serving cell with CSI report with PUCCH reporting type 1 or 1a of another serving cell, the latter CSI report with PUCCH reporting type 1, or 1a has lower priority and is dropped. For a given subframe, if a UE is configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and *eMIMO-Type* is set to 'CLASS A', and *eMIMO-Type2* is set to 'CLASS B' with one CSI-RS resource configured, PUCCH reporting type 2a, or 5 for *eMIMO-Type* of the CSI process of one serving cell has the same priority with PUCCH reporting type (7, 8, 9, or 10) of the same serving cell in case of collision of type 2a, or 5 for *eMIMO-Type* of the CSI process of the serving cell with PUCCH reporting types of another serving cell.

For a given subframe and serving cells with UE configured in transmission mode 1-9, in case of collision between CSI reports of these different serving cells with PUCCH reporting type of the same priority, the CSI reports for all these serving cells except the serving cell with lowest *ServCellIndex* are dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, for a given subframe and serving cells with UE configured in transmission mode 10, in case of collision between CSI reports of different serving cells with PUCCH reporting type of the same priority and the CSI reports corresponding to CSI processes with same *csi-ProcessId-r11*, the CSI reports of all serving cells except the serving cell with lowest *ServCellIndex* are dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, for a given subframe and serving cells with UE configured in transmission mode 10, in case of collision between CSI reports of different serving cells with PUCCH reporting type of the same priority and the CSI reports corresponding to CSI processes with different *csi-ProcessId-r11*, the CSI reports of all serving cells except the serving cell with CSI reports corresponding to CSI process with the lowest *csi-ProcessId-r11* are dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, for a given subframe, in case of collision between CSI report of a given serving cell with UE configured in transmission mode 1-9, and CSI report(s) corresponding to CSI process(es) of a different serving cell with the UE configured in transmission mode 10, and the CSI reports of the serving cells with PUCCH reporting type of the same priority, the CSI report(s) corresponding to CSI process(es) with *csi-ProcessId-r11* > 1 of the different serving cell are dropped.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, for a given subframe, in case of collision between CSI report of a given serving cell with UE configured in transmission mode 1-9, and CSI report corresponding to CSI process with *csi-ProcessId-r11* = 1 of a different serving cell with the UE configured in transmission mode 10, and the CSI reports of the serving cells with PUCCH reporting type of the same priority, the CSI report of the serving cell with highest *ServCellIndex* is dropped.

See Subclause 10.1 for UE behaviour regarding collision between CSI and HARQ-ACK and the corresponding PUCCH format assignment.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and if a PUCCH format 4 or format 5 resource for HARQ-ACK according to Table 10.1.2.2.3-1 cannot be determined, the CSI report of a given PUCCH reporting type shall be transmitted on the PUCCH resource $n_{\text{PUCCH}}^{(2,\tilde{p})}$ as defined in [3], where $n_{\text{PUCCH}}^{(2,\tilde{p})}$ is UE specific and configured by higher layers for each serving cell.

If a UE is not configured with higher layer parameter *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, and

- if the UE is not configured for simultaneous PUSCH and PUCCH transmission or,

- if the UE is configured for simultaneous PUSCH and PUCCH transmission and not transmitting PUSCH, in case of collision between CSI and positive SR in a same subframe, CSI is dropped.

If a UE is configured with *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguration*, for a subframe in which only periodic CSI and SR (if any) is transmitted,

- if there is only one CSI report in the subframe,
 - o the CSI report of a given PUCCH reporting type shall be transmitted on the PUCCH resource $n_{\text{PUCCH}}^{(2,\tilde{p})}$ as defined in [3], where $n_{\text{PUCCH}}^{(2,\tilde{p})}$ is UE specific and configured by higher layers for each serving cell;
 - o In case of collision between CSI and positive SR in a same subframe, if the UE is not configured for simultaneous PUSCH and PUCCH transmission, or if the UE is configured for simultaneous PUSCH and PUCCH transmission and not transmitting PUSCH, CSI is dropped.
- if there are more than one CSI reports in the subframe,
 - o if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set TRUE, when a PUCCH format 4/5 transmission of CSI reports coincides with a sub-frame configured to the UE by higher layers for transmission of a scheduling request, the UE shall transmit the CSI and SR on the PUCCH; Otherwise, CSI is dropped;
 - o if the UE is configured with a single PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, the PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ is used for transmission of the CSI reports and SR (if any);
 - o if the UE is configured with a PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ according to higher layer parameter *format5-MultiCSI-resourceConfiguration*, the PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ is used for transmission of the CSI reports and SR (if any);
 - o if the UE is configured with two PUCCH format 4 resources $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, if $(O^{\text{SR}} + O_{\text{P-CSI}} + O_{\text{CRC}}) \leq \min(M_{\text{RB},1}^{\text{PUCCH4}}, M_{\text{RB},2}^{\text{PUCCH4}}) \cdot N_{\text{sc}}^{\text{RB}} \cdot N_{\text{symb}}^{\text{PUCCH4}} \cdot 2 \cdot r$, the PUCCH format 4 resource with the smaller $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the CSI reports; otherwise, the PUCCH format 4 resource with the larger $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the CSI reports, where
 - $O_{\text{P-CSI}}$ is the total number of CSI report bits in the subframe;
 - O_{CRC} is the number of CRC bits;
 - $O^{\text{SR}} = 0$ if there is no scheduling request bit in the subframe and $O^{\text{SR}} = 1$ otherwise;
 - $M_{\text{RB},i}^{\text{PUCCH4}}$, $i = 1, 2$, is the number of PRBs for $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ respectively, according to higher layer parameter *numberOfPRB-format4-r13* according to Table 10.1.1-2;
 - $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1) - 1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1)$ otherwise; and
 - r is the code rate given by higher layer parameter *maximumPayloadCodeRate-r13* according to Table 10.1.1-1.

If a UE transmits only periodic CSI and SR (if any) using either a PUCCH format 4 $n_{\text{PUCCH}}^{(4)}$ or PUCCH format 5 $n_{\text{PUCCH}}^{(5)}$ in a subframe and if $(O^{\text{SR}} + O_{\text{P-CSI}} + O_{\text{CRC}}) > 2 \cdot N_{\text{RE}} \cdot r$, the UE shall select the SR (if any) and $N_{\text{CSI,reported}}$ CSI report(s) for transmission in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$, where:

- $O_{\text{P-CSI}}$ is the total number of CSI report bits in the subframe;
- O_{CRC} is the number of CRC bits
- $O^{\text{SR}} = 0$ if there is no scheduling request bit in the subframe and $O^{\text{SR}} = 1$ otherwise;
- $N_{\text{RE}} = M_{\text{RB}}^{\text{PUCCH}4} \cdot N_{\text{sc}}^{\text{RB}} \cdot N_{\text{symb}}^{\text{PUCCH}}$ for PUCCH format 4 and $N_{\text{RE}} = N_{\text{sc}}^{\text{RB}} \cdot N_{\text{symb}}^{\text{PUCCH}} / 2$ for PUCCH format 5, where $N_{\text{symb}}^{\text{PUCCH}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1) - 1$ if shortened PUCCH format 4 or shortened PUCCH format 5 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1)$ otherwise;
- r is the code rate given by higher layer parameter *maximumPayloadCodelate-r13* according to Table 10.1.1-1;
- for a CSI report of a serving cell, $\text{Pri}_{\text{CSI}}(y, s, c, t)$ for the CSI report is defined as $\text{Pri}_{\text{CSI}}(y, s, c, t) = y \cdot 4 \cdot 32 \cdot 2 + s \cdot 32 \cdot 2 + c \cdot 2 + t$, where
 - $y = 0$ for CSI report type 7/8/9/10, $y = 1$ for CSI report type 3/5/6/2a/11, $y = 2$ for CSI report type 2/2b/2c/4, and $y = 3$ for CSI report type 1/1a;
 - s is the CSI process ID according to *csi-ProcessId-r11* if the serving cell is configured with transmission mode 10, and $s = 1$ if the serving cell configured with transmission mode 1-9;
 - c is the serving cell index;
 - $t = 0$ and $t = 1$ for CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ respectively if CSI subframe sets are configured for the serving cell, and $t = 0$ otherwise.
- The value of $N_{\text{CSI,reported}}$ satisfies $(O^{\text{SR}} + \sum_{n=1}^{N_{\text{CSI,reported}}} O_{\text{P-CSI},n} + O_{\text{CRC}}) \leq 2 \cdot N_{\text{RE}} \cdot r$ and $(O^{\text{SR}} + \sum_{n=1}^{N_{\text{CSI,reported}}+1} O_{\text{P-CSI},n} + O_{\text{CRC}}) > 2 \cdot N_{\text{RE}} \cdot r$, where $O^{\text{SR}} = 0$ if there no scheduling request bit in the subframe and $O^{\text{SR}} = 1$ otherwise. $O_{\text{P-CSI},n}$ is the number of CSI report bits for the n th CSI report in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$.

If a UE is configured with *format4-MultiCSI-resourceConfiguration* or *format5-MultiCSI-resourceConfiguratio* and if the UE is configured with more than N_y periodic CSI reports in a subframe, the UE is not required to update CSI for more than N_y CSI processes from the CSI processes corresponding to all the configured CSI reports, where the value of N_y is given by *maxNumberUpdatedCSI-Proc-r13*.

If a UE configured with PUCCH format 4 or PUCCH format 5 transmits UCI over PUSCH, that would have been transmitted over PUCCH format 4 or PUCCH format 5 if the UE did not have a PUSCH grant, then the UE shall select the CSI report(s) (if any) for transmission following the same procedure as for transmission over PUCCH.

Table 7.2.2-1A: Mapping of $I_{CQI/PMI}$ to N_{pd} and $N_{OFFSET,CQI}$ for FDD or for FDD-TDD and primary cell frame structure type 1

| $I_{CQI/PMI}$ | Value of N_{pd} | Value of $N_{OFFSET,CQI}$ |
|----------------------------------|-------------------|---------------------------|
| $0 \leq I_{CQI/PMI} \leq 1$ | 2 | $I_{CQI/PMI}$ |
| $2 \leq I_{CQI/PMI} \leq 6$ | 5 | $I_{CQI/PMI} - 2$ |
| $7 \leq I_{CQI/PMI} \leq 16$ | 10 | $I_{CQI/PMI} - 7$ |
| $17 \leq I_{CQI/PMI} \leq 36$ | 20 | $I_{CQI/PMI} - 17$ |
| $37 \leq I_{CQI/PMI} \leq 76$ | 40 | $I_{CQI/PMI} - 37$ |
| $77 \leq I_{CQI/PMI} \leq 156$ | 80 | $I_{CQI/PMI} - 77$ |
| $157 \leq I_{CQI/PMI} \leq 316$ | 160 | $I_{CQI/PMI} - 157$ |
| $I_{CQI/PMI} = 317$ | Reserved | |
| $318 \leq I_{CQI/PMI} \leq 349$ | 32 | $I_{CQI/PMI} - 318$ |
| $350 \leq I_{CQI/PMI} \leq 413$ | 64 | $I_{CQI/PMI} - 350$ |
| $414 \leq I_{CQI/PMI} \leq 541$ | 128 | $I_{CQI/PMI} - 414$ |
| $542 \leq I_{CQI/PMI} \leq 601$ | 60 | $I_{CQI/PMI} - 542$ |
| $602 \leq I_{CQI/PMI} \leq 1023$ | Reserved | |

Table 7.2.2-1B: Mapping of I_{RI} to M_{RI} and $N_{OFFSET,RI}$.

| I_{RI} | Value of M_{RI} | Value of $N_{OFFSET,RI}$ |
|-----------------------------|-------------------|--------------------------|
| $0 \leq I_{RI} \leq 160$ | 1 | $-I_{RI}$ |
| $161 \leq I_{RI} \leq 321$ | 2 | $-(I_{RI} - 161)$ |
| $322 \leq I_{RI} \leq 482$ | 4 | $-(I_{RI} - 322)$ |
| $483 \leq I_{RI} \leq 643$ | 8 | $-(I_{RI} - 483)$ |
| $644 \leq I_{RI} \leq 804$ | 16 | $-(I_{RI} - 644)$ |
| $805 \leq I_{RI} \leq 965$ | 32 | $-(I_{RI} - 805)$ |
| $966 \leq I_{RI} \leq 1023$ | Reserved | |

Table 7.2.2-1C: Mapping of $I_{CQI/PMI}$ to N_{pd} and $N_{OFFSET,CQI}$ for TDD or for FDD-TDD and primary cell frame structure type 2

| $I_{CQI/PMI}$ | Value of N_{pd} | Value of $N_{OFFSET,CQI}$ |
|----------------------------------|-------------------|---------------------------|
| $I_{CQI/PMI} = 0$ | 1 | $I_{CQI/PMI}$ |
| $1 \leq I_{CQI/PMI} \leq 5$ | 5 | $I_{CQI/PMI} - 1$ |
| $6 \leq I_{CQI/PMI} \leq 15$ | 10 | $I_{CQI/PMI} - 6$ |
| $16 \leq I_{CQI/PMI} \leq 35$ | 20 | $I_{CQI/PMI} - 16$ |
| $36 \leq I_{CQI/PMI} \leq 75$ | 40 | $I_{CQI/PMI} - 36$ |
| $76 \leq I_{CQI/PMI} \leq 155$ | 80 | $I_{CQI/PMI} - 76$ |
| $156 \leq I_{CQI/PMI} \leq 315$ | 160 | $I_{CQI/PMI} - 156$ |
| $316 \leq I_{CQI/PMI} \leq 375$ | 60 | $I_{CQI/PMI} - 316$ |
| $376 \leq I_{CQI/PMI} \leq 1023$ | Reserved | |

Table 7.2.2-1J: Mapping of I_{CRI} to M_{CRI} when RI reporting is configured

| I_{CRI} | Value of M_{CRI} |
|-------------------------|--------------------|
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |
| $7 < I_{CRI} \leq 1023$ | Reserved |

Table 7.2.2-1K: Mapping of I_{CRI} to M_{CRI} and $N_{OFFSET,CRI}$ when the number of antenna ports in each configured CSI-RS resource is one

| I_{CRI} | Value of M_{CRI} | Value of $N_{OFFSET,CRI}$ |
|------------------------------|--------------------|---------------------------|
| $0 \leq I_{CRI} \leq 160$ | 1 | $-I_{CRI}$ |
| $161 \leq I_{CRI} \leq 321$ | 2 | $-(I_{CRI} - 161)$ |
| $322 \leq I_{CRI} \leq 482$ | 4 | $-(I_{CRI} - 322)$ |
| $483 \leq I_{CRI} \leq 643$ | 8 | $-(I_{CRI} - 483)$ |
| $644 \leq I_{CRI} \leq 804$ | 16 | $-(I_{CRI} - 644)$ |
| $805 \leq I_{CRI} \leq 965$ | 32 | $-(I_{CRI} - 805)$ |
| $966 \leq I_{CRI} \leq 1023$ | Reserved | |

Table 7.2.2-1L: Mapping of $I_{PMI/RI}$ to $M_{PMI/RI}$ and $N_{OFFSET,PMI/RI}$

| $I_{PMI/RI}$ | Value of $M_{PMI/RI}$ | Value of $N_{OFFSET,PMI/RI}$ |
|---------------------------------|-----------------------|------------------------------|
| $0 \leq I_{PMI/RI} \leq 160$ | 1 | $-I_{PMI/RI}$ |
| $161 \leq I_{PMI/RI} \leq 321$ | 2 | $-(I_{PMI/RI} - 161)$ |
| $322 \leq I_{PMI/RI} \leq 482$ | 4 | $-(I_{PMI/RI} - 322)$ |
| $483 \leq I_{PMI/RI} \leq 643$ | 8 | $-(I_{PMI/RI} - 483)$ |
| $644 \leq I_{PMI/RI} \leq 804$ | 16 | $-(I_{PMI/RI} - 644)$ |
| $805 \leq I_{PMI/RI} \leq 965$ | 32 | $-(I_{PMI/RI} - 805)$ |
| $966 \leq I_{PMI/RI} \leq 1023$ | Reserved | |

For TDD or FDD-TDD and primary cell frame structure type 2 periodic CQI/PMI reporting, the following periodicity values apply for a serving cell c depending on the TDD UL/DL configuration of the primary cell [3], where the UL/DL configuration corresponds to the $eimta-HARQ-ReferenceConfig-r12$ for the primary cell if the UE is configured with the

parameter *EIMTA-MainConfigServCell-r12* for the primary cell, or to the *harq-ReferenceConfig-r14* for the primary cell when the UE is configured with the parameter *harq-ReferenceConfig-r14*:

- The reporting period of $N_{pd} = 1$ is applicable for the serving cell c only if TDD UL/DL configuration of the primary cell belongs to $\{0, 1, 3, 4, 6\}$, and where all UL subframes of the primary cell in a radio frame are used for CQI/PMI reporting.
- The reporting period of $N_{pd} = 5$ is applicable for the serving cell c only if TDD UL/DL configuration of the primary cell belongs to $\{0, 1, 2, 6\}$.
- The reporting periods of $N_{pd} = \{10, 20, 40, 80, 160\}$ are applicable for the serving cell c for any TDD UL/DL configuration of the primary cell.

For a serving cell with $N_{RB}^{\text{DL}} \leq 7$, Mode 2-0 and Mode 2-1 are not supported for that serving cell.

The sub-sampled codebook for PUCCH mode 1-1 submode 2 for 8 CSI-RS ports is defined in Table 7.2.2-1D for first and second precoding matrix indicator i_1 and i_2 . Joint encoding of rank and first precoding matrix indicator i_1 for PUCCH mode 1-1 submode 1 for 8 CSI-RS ports is defined in Table 7.2.2-1E. The sub-sampled codebook for PUCCH mode 2-1 for 8 CSI-RS ports is defined in Table 7.2.2-1F for PUCCH Reporting Type 1a.

For a UE configured with transmission mode 9 or 10, and the UE configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS A', and PUCCH Reporting Type 1a, the sub-sampled codebook for PUCCH mode 2-1 for value of parameter *codebookConfig* set to 2, 3, or 4 is defined in Table 7.2.2-1F, for value of parameter *codebookConfig* set to 1, the value of the second PMI, I_{PMI2} , is set to i_2 .

Table 7.2.2-1D: PUCCH mode 1-1 submode 2 codebook subsampling

| RI | Relationship between the first PMI value and codebook index i_1 | | Relationship between the second PMI value and codebook index i_2 | | total |
|----|---|----------------------|--|--|-------|
| | Value of the first PMI I_{PMI1} | Codebook index i_1 | Value of the second PMI I_{PMI2} | Codebook index i_2 | |
| 1 | 0-7 | $2I_{PMI1}$ | 0-1 | $2I_{PMI2}$ | 4 |
| 2 | 0-7 | $2I_{PMI1}$ | 0-1 | I_{PMI2} | 4 |
| 3 | 0-1 | $2I_{PMI1}$ | 0-7 | $4\lfloor I_{PMI2}/4 \rfloor + I_{PMI2}$ | 4 |
| 4 | 0-1 | $2I_{PMI1}$ | 0-7 | I_{PMI2} | 4 |
| 5 | 0-3 | I_{PMI1} | 0 | 0 | 2 |
| 6 | 0-3 | I_{PMI1} | 0 | 0 | 2 |
| 7 | 0-3 | I_{PMI1} | 0 | 0 | 2 |
| 8 | 0 | 0 | 0 | 0 | 0 |

Table 7.2.2-1E: Joint encoding of RI and i_1 for PUCCH mode 1-1 submode 1

| Value of joint encoding of RI and the first PMI $I_{RI/PMI1}$ | RI | Codebook index i_1 |
|---|-----------|--|
| 0-7 | 1 | $2I_{RI/PMI1}$ |
| 8-15 | 2 | $2(I_{RI/PMI1}-8)$ |
| 16-17 | 3 | $2(I_{RI/PMI1}-16)$ |
| 18-19 | 4 | $2(I_{RI/PMI1}-18)$ |
| 20-21 | 5 | $2(I_{RI/PMI1}-20)$ |
| 22-23 | 6 | $2(I_{RI/PMI1}-22)$ |
| 24-25 | 7 | $2(I_{RI/PMI1}-24)$ |
| 26 | 8 | 0 |
| 27-31 | reserved | NA |

Table 7.2.2-1F: PUCCH mode 2-1 codebook subsampling

| RI | Relationship between the second PMI value and codebook index i_2 | |
|-----------|--|---|
| | Value of the second PMI I_{PMI2} | Codebook index i_2 |
| 1 | 0-15 | I_{PMI2} |
| 2 | 0-3 | $2I_{PMI2}$ |
| 3 | 0-3 | $8 \cdot \lfloor I_{PMI2} / 2 \rfloor + (I_{PMI2} \bmod 2) + 2$ |
| 4 | 0-3 | $2I_{PMI2}$ |
| 5 | 0 | 0 |
| 6 | 0 | 0 |
| 7 | 0 | 0 |
| 8 | 0 | 0 |

The sub-sampled codebook for PUCCH mode 1-1 submode 2 for transmission modes 8, 9 and 10 configured with *alternativeCodeBookEnabledFor4TX-r12=TRUE* is defined in Table 7.2.2-1G for first and second precoding matrix indicator i_1 and i_2 . Joint encoding of rank and first precoding matrix indicator i_1 for PUCCH mode 1-1 submode 1 for transmission modes 8, 9 and 10 configured with *alternativeCodeBookEnabledFor4TX-r12=TRUE* is defined in Table 7.2.2-1H. The sub-sampled codebook for PUCCH mode 2-1 for transmission modes 8, 9 and 10 configured with *alternativeCodeBookEnabledFor4TX-r12=TRUE* is defined in Table 7.2.2-1I for PUCCH Reporting Type 1a.

Table 7.2.2-1G: PUCCH mode 1-1 submode 2 codebook subsampling with 4 antenna ports

| RI | Relationship between the first PMI value and codebook index i_1 | | Relationship between the second PMI value and codebook index i_2 | | total |
|-----------|---|--|--|--|--------------|
| | Value of the first PMI I_{PMI1} | Codebook index i_1 | Value of the second PMI I_{PMI2} | Codebook index i_2 | |
| 1 | 0-3 | $4I_{PMI1}$ | 0-3 | $2I_{PMI2} + 4 \cdot \lfloor I_{PMI2} / 2 \rfloor$ | 4 |
| 2 | 0-3 | $4I_{PMI1}$ | 0-3 | $I_{PMI2} + 2 \cdot \lfloor I_{PMI2} / 2 \rfloor$ | 4 |
| 3 | 0 | 0 | 0-15 | I_{PMI2} | 4 |
| 4 | 0 | 0 | 0-15 | I_{PMI2} | 4 |

Table 7.2.2-1 H: Joint encoding of RI and for PUCCH mode 1-1 submode 1 with 4 antenna ports

| Value of joint encoding of RI and the first PMI $I_{RI/PMI1}$ | RI | Codebook index i_1 |
|--|----------|----------------------|
| 0-7 | 1 | $I_{RI/PMI1}$ |
| 8-15 | 2 | $I_{RI/PMI1} - 8$ |
| 16 | 3 | 0 |
| 17 | 4 | 0 |
| 18-31 | reserved | NA |

Table 7.2.2-1 I: PUCCH mode 2-1 codebook subsampling with 4 antenna ports

| RI | Relationship between the second PMI value and codebook index i_2 | |
|----|--|--|
| | Value of the second PMI I_{PMI2} | Codebook index i_2 |
| 1 | 0-15 | I_{PMI2} |
| 2 | 0-3 | $I_{PMI2} + 2 \cdot \lfloor I_{PMI2} / 2 \rfloor$ |
| 3 | 0-3 | $2I_{PMI2} + 4 \cdot \lfloor I_{PMI2} / 2 \rfloor$ |
| 4 | 0-3 | $2I_{PMI2} + 4 \cdot \lfloor I_{PMI2} / 2 \rfloor$ |

For a UE configured with transmission mode 9 or 10, and the UE configured with parameter *advancedCodebookEnabled=TRUE* and $RI \leq 2$ and PUCCH Reporting Type 2b, the sub-sampled codebook for PUCCH mode 1-1 for value of $RI = 2$ is defined in Table 7.2.2-1H, and for value of $RI = 1$, the value of the second PMI, I_{PMI2} , is set to i_2 .

Table 7.2.2-1H: PUCCH mode 1-1 codebook subsampling, with parameter *advancedCodebookEnabled=TRUE*, $RI = 2$

| Relationship between the second PMI value and codebook index i_2 | |
|--|----------------------|
| Value of the second PMI I_{PMI2} | Codebook index i_2 |
| 0 | 2048 |
| 1 | 2113 |
| 2 | 2178 |
| 3 | 2243 |
| 4 | 2568 |
| 5 | 2633 |
| 6 | 2698 |
| 7 | 2763 |
| 8 | 3348 |
| 9 | 3413 |
| 10 | 3478 |
| 11 | 3543 |
| 12 | 3868 |
| 13 | 3933 |
| 14 | 3998 |
| 15 | 4063 |

An CRI or RI or PTI or any precoding matrix indicator reported for a serving cell in a periodic reporting mode is valid only for CSI reports for that serving cell on that periodic CSI reporting mode.

For serving cell c , a UE configured in transmission mode 10 with PMI/RI reporting or without PMI reporting for a CSI process can be configured with a 'RI-reference CSI process'. The RI for the 'RI-reference CSI process' is not based on any other configured CSI process other than the 'RI-reference CSI process'. If the UE is configured with a 'RI-reference CSI process' for a CSI process and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for only one of the CSI processes then the UE is not expected to receive configuration for the CSI process configured with the subframe subsets that have a different set of restricted RIs with precoder codebook subset restriction between the two subframe sets. The UE is not expected to receive configurations for the CSI process and the 'RI-reference CSI process' that have a different:

- periodic CSI reporting mode (including sub-mode if configured), and/or
- number of CSI-RS antenna ports, and/or
- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are not configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for each subframe set if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for only one of the CSI processes, and the set of restricted RIs for the two subframe sets are the same, and/or
- number of CSI-RS antenna ports for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are not configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for each subframe set and for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction for any two CSI-RS resources for the two CSI processes, if a UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for at least one of the two CSI processes and if subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers for only one of the two CSI processes, and the set of restricted RIs for the two subframe sets are the same.

If a UE is configured for CRI reporting,

- For the calculation of CQI/PMI/RI conditioned on the last reported CRI, in the absence of a last reported CRI the UE shall conduct the CQI/PMI/RI calculation conditioned on the lowest possible CRI. If reporting for more than one CSI subframe set is configured, CQI/PMI/RI is conditioned on the last reported CRI linked to the same subframe set as the CSI report.
- For the calculation of CQI/PMI conditioned on the last reported RI and CRI, in the absence of a last reported RI and CRI, the UE shall conduct the CQI/PMI calculation conditioned on the lowest possible RI associated with the lowest possible CRI and as given by the bitmap parameter *codebookSubsetRestriction* and the parameter *alternativeCodeBookEnabledFor4TX-r12* if configured. If reporting for more than one CSI subframe set is configured, CQI/PMI is conditioned on the last reported RI associated with the last reported CRI and linked to the same subframe set as the CSI report

otherwise,

- For the calculation of CQI/PMI conditioned on the last reported RI, in the absence of a last reported RI the UE shall conduct the CQI/PMI calculation conditioned on the lowest possible RI as given by the bitmap parameter *codebookSubsetRestriction* and the parameter *alternativeCodeBookEnabledFor4TX-r12* if configured. If reporting for more than one CSI subframe set is configured, CQI/PMI is conditioned on the last reported RI linked to the same subframe set as the CSI report.
- For a non-BL/CE UE, the periodic CSI reporting modes are described as following:
 - Wideband feedback
 - Mode 1-0 description:
 - In the subframe where RI is reported (only for transmission mode 3, and transmission mode 9 or 10 without PMI reporting with one configured CSI-RS resource or with more than one configured CSI-RS resource and the number of CSI-RS ports of the selected CSI-RS resource is more than one):
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, for transmission mode 3 the UE shall determine a RI assuming transmission on set S subbands, and for transmission mode 9 or 10 without PMI reporting, the UE shall determine a RI assuming transmission on set S subbands, and conditioned on the last reported periodic CRI if the UE is configured with CRI reporting.
 - The UE shall report a type 3 report consisting of one RI.
 - In the subframe where RI and CRI is reported (for transmission mode 9 or 10 without PMI reporting and without higher layer parameter *csi-RS-NZP-mode* configured, and number of configured CSI-RS resources more than one, and for transmission mode 9 or 10 without PMI reporting and with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and number of activated CSI-RS resources more than one):
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the reported CRI.
 - The UE shall report a type 7 report consisting of one RI and one CRI.
 - In the subframe where CRI is reported (only for transmission mode 9 or 10 with CRI reporting and the number of antenna ports in each of configured CSI-RS resources is one):
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - The UE shall report a type10 report consisting of one CRI.
 - In the subframe where CQI is reported:
 - If the UE is configured without PMI reporting (only for transmission mode 9 or 10):
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands.
 - A UE shall report a type 4 report consisting of
 - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set S subbands.

- When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process and last reported periodic CRI for the CSI process; otherwise the selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.
 - otherwise,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process; otherwise the selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI.
 - otherwise,
 - A UE shall report a type 4 report consisting of one wideband CQI value which is calculated assuming transmission on set S subbands. The wideband CQI represents channel quality for the first codeword, even when RI>1.
 - For transmission mode 3 the CQI is calculated conditioned on the last reported periodic RI. For other transmission modes it is calculated conditioned on transmission rank 1. If the UE is configured with CRI reporting, the CQI is calculated conditioned on the last reported periodic CRI.
- Mode 1-1 description:
 - In the subframe where RI is reported (only for transmission modes 4, 8, 9 and 10):
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the last reported periodic CRI.
 - otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands.
 - The UE shall report a type 3 report consisting of one RI.

- In the subframe where RI and CRI is reported for transmission modes 9 and 10:
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the reported CRI for the CSI process.
 - The UE shall report a type 7 report consisting of one RI and one CRI.
- In the subframe where RI and RPI is reported for transmission modes 9 and 10:
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands.
 - If the determined $RI > 2$, RPI is set to 0; otherwise UE shall determine a RPI assuming transmission on set S subbands.
 - The UE shall report a type 11 report consisting of one RI and one RPI.
- In the subframe where RI and a first PMI are reported for transmission modes 9 and 10 configured with submode 1 and 8 CSI-RS ports without CRI reporting and not configured with *advancedCodebookEnabled* or 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, and for transmission modes 8, 9 and 10 configured with submode 1 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* without CRI reporting and not configured with *advancedCodebookEnabled*:
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the last reported periodic CRI.
 - otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands.
 - The UE shall report a type 5 report consisting of jointly coded RI and a first PMI corresponding to a set of precoding matrices selected from the codebook subset assuming transmission on set S subbands.
 - If the UE is configured with CRI reporting,
 - If the UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process and in case of collision of type 5 report for the CSI process with type 5 report for the 'RI-reference CSI process', the wideband first PMI for the CSI process shall be the same as the wideband first PMI in the most recent type 5 report for the configured 'RI-reference CSI process'; otherwise, the wideband first

PMI value is calculated conditioned on the reported periodic RI and last reported periodic CRI.

- otherwise,
 - If the UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process and in case of collision of type 5 report for the CSI process with type 5 report for the 'RI-reference CSI process', the wideband first PMI for the CSI process shall be the same as the wideband first PMI in the most recent type 5 report for the configured 'RI-reference CSI process'; otherwise, the wideband first PMI value is calculated conditioned on the reported periodic RI.
- In the subframe where CRI, RI and a first PMI are reported for transmission modes 9, and 10 configured with submode 1 and 8 CSI-RS ports in at least one of the configured CSI-RS resources, or for transmission modes 8, 9 and 10 configured with submode 1 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* and 4 CSI-RS ports in at least one of configured CSI-RS resources:
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the reported CRI.
 - If the configured CSI-RS resource corresponding to the determined CRI comprises 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE*, the UE shall report a type 8 report consisting of jointly coded CRI, RI and a first PMI corresponding to a set of precoding matrices selected from the codebook subset assuming transmission on set S subbands. Otherwise, the UE shall report a type 8 report consisting of jointly coded CRI, RI and a first PMI fixed to zero.
 - If the UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process and in case of collision of type 5 report for the CSI process with type 5 report for the 'RI-reference CSI process', the wideband first PMI for the CSI process shall be the same as the wideband first PMI in the most recent type 5 report for the configured 'RI-reference CSI process'; otherwise, the wideband first PMI value is calculated conditioned on the reported periodic RI and last reported periodic CRI conditioned on the reported CRI.
- In the subframe where the wideband first PMI is reported, for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 9 and 10 with higher layer parameter *advancedCodebookEnabled =TRUE* configured, and last reported periodic $RI \leq 2$,
 - A set of precoding matrices corresponding to the wideband first PMI is selected from the codebook assuming transmission on set S subbands.
 - A UE shall report a type 2a report consisting of the wideband first PMI corresponding to the selected set of precoding matrices.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the wideband first PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process; otherwise the wideband first PMI value is calculated conditioned on the last reported periodic RI.

- In the subframe where CQI/PMI is reported for all transmission modes except with,
 - UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', or
 - UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and last reported periodic $RI \leq 2$, or
 - 8 CSI-RS ports configured for transmission modes 9 and 10, or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, if the UE is not configured with higher layer parameter *eMIMO-Type*, or UE configured with CRI reporting, or UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured:
 - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands.
 - A UE shall report a type 2 report consisting of
 - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set *S* subbands.
 - The selected single PMI (wideband PMI).
 - When $RI > 1$, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the PMI and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process; otherwise the PMI and CQI are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.
 - otherwise,
 - For transmission modes 4, 8, 9 and 10,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the PMI and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process; otherwise the PMI and CQI are calculated conditioned on the last reported periodic RI.
 - For other transmission modes the PMI and CQI are calculated conditioned on transmission rank 1.
 - In the subframe where wideband CQI/second PMI is reported for transmission modes 9 and 10 with 8 CSI-RS ports and submode 1 without CRI reporting, or for 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 8, 9 and 10 with submode 1 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* without CRI reporting, or for transmission modes 9 and 10 with higher layer

parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 9 and 10 with higher layer parameter *advancedCodebookEnabled* =*TRUE* configured, and last reported periodic $RI \leq 2$:

- A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands.
- A UE shall report a type 2b report consisting of
 - A single wideband CQI value which is calculated assuming the use of the single precoding matrix in all subbands and transmission on set *S* subbands.
 - The wideband second PMI corresponding to the selected single precoding matrix.
 - When $RI > 1$, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 5 report for the CSI process is dropped, and a type 5 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI and the wideband first PMI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process.
 - Otherwise,
 - The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI and the last reported periodic CRI.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI and the last reported periodic CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 5 report for the CSI process is dropped, and a type 5 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI and the wideband first PMI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process.
 - Otherwise,

- The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI.
- The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI.
- In the subframe where wideband CQI/first PMI/second PMI is reported for transmission modes 9 and 10 with submode 2 and 8 CSI-RS ports configured without CRI reporting and not configured with *advancedCodebookEnabled*, or 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, and for transmission modes 8, 9 and 10 with submode 2 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting and not configured with *advancedCodebookEnabled*:
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands.
 - A UE shall report a type 2c report consisting of
 - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set S subbands.
 - The wideband first PMI and the wideband second PMI corresponding to the selected single precoding matrix as defined in Subclause 7.2.4.
 - When $RI>1$, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the wideband first PMI, the wideband second PMI and the wideband CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise the wideband first PMI, the wideband second PMI and the wideband CQI are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.
 - otherwise
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the wideband first PMI, the wideband second PMI and the wideband CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process; otherwise the wideband first PMI, the wideband second PMI and the wideband CQI are calculated conditioned on the last reported periodic RI.
 - UE Selected subband feedback
 - Mode 2-0 description:
 - In the subframe where RI is reported (only for transmission mode 3, and transmission mode 9 or 10 without PMI reporting with one configured CSI-RS resource or with more than one configured CSI-RS resource and the number of CSI-RS ports of the selected CSI-RS is more than one):
 - The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI.

- If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, for transmission mode 3 the UE shall determine a RI assuming transmission on set S subbands, and for transmission mode 9 or 10 without PMI reporting, the UE shall determine a RI assuming transmission on set S subbands, and conditioned on the last reported periodic CRI if the UE is configured with CRI reporting.
 - The UE shall report a type 3 report consisting of one RI.
- In the subframe where RI and CRI is reported (for transmission mode 9 or 10 without PMI reporting and without higher layer parameter *csi-RS-NZP-mode* configured, and number of configured CSI-RS resources more than one and the number of antenna ports in at least one of the configured CSI-RS resources is more than one, and for transmission mode 9 or 10 without PMI reporting and with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources more than one and the number of antenna ports in at least one of the activated CSI-RS resources is more than one):
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the reported CRI.
 - The UE shall report a type 7 report consisting of one RI and one CRI.
 - In the subframe where CRI is reported (only for transmission mode 9 or 10 with CRI reporting and the number of antenna ports in each of configured CSI-RS resources is one):
 - A UE shall determine a CRI assuming transmission on set S subbands.
 - The UE shall report a type10 report consisting of one CRI.
 - In the subframe where wideband CQI is reported:
 - If the UE is configured without PMI reporting (only for transmission mode 9 or 10):
 - A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands.
 - A UE shall report a type 4 report on each respective successive reporting opportunity consisting of
 - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set S subbands.
 - When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the subband selection, selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in

the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise the subband selection, selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.

- otherwise
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the subband selection, selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process; otherwise the subband selection, selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI.
- otherwise,
 - The UE shall report a type 4 report on each respective successive reporting opportunity consisting of one wideband CQI value which is calculated assuming transmission on set S subbands. The wideband CQI represents channel quality for the first codeword, even when $RI > 1$.
 - For transmission mode 3 the CQI is calculated conditioned on the last reported periodic RI. For other transmission modes it is calculated conditioned on transmission rank 1. If the UE is configured with CRI reporting, the CQI is calculated conditioned on the last reported periodic CRI.
- In the subframe where CQI for the selected subbands is reported:
 - If the UE is configured without PMI reporting (only for transmission mode 9 or 10):
 - The UE shall select the preferred subband within the set of N_j subbands in each of the J bandwidth parts where J is given in Table 7.2.2-2.
 - A single precoding matrix is selected from the codebook subset assuming transmission on the selected subband within the applicable bandwidth part.
 - The UE shall report a type 1 report per bandwidth part on each respective successive reporting opportunity consisting of:
 - CQI value for codeword 0 reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding preferred subband L -bit label.
 - When $RI > 1$, an additional 3-bit subband spatial differential CQI value for codeword 1 offset level
 - Codeword 1 offset level = subband CQI index for codeword 0 – subband CQI index for codeword 1.
 - The mapping from the 3-bit subband spatial differential CQI value to the offset level is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,

- If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise the selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a "RI-reference CSI process" for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the "RI-reference CSI process" is reported in the most recent RI reporting instance for the CSI process, the selected precoding matrix and CQI for the CSI process are calculated conditioned on the reported periodic RI for the configured "RI-reference CSI process" in the most recent RI reporting instance for the CSI process; otherwise the selected precoding matrix and CQI are calculated conditioned on the last reported periodic RI.
- otherwise,
 - The UE shall select the preferred subband within the set of N_j subbands in each of the J bandwidth parts where J is given in Table 7.2.2-2.
 - The UE shall report a type 1 report consisting of one CQI value reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding preferred subband L -bit label. A type 1 report for each bandwidth part will in turn be reported in respective successive reporting opportunities. The CQI represents channel quality for the first codeword, even when RI>1.
 - For transmission mode 3 the preferred subband selection and CQI values are calculated conditioned on the last reported periodic RI. For other transmission modes they are calculated conditioned on transmission rank 1. If the UE is configured with CRI reporting, the preferred subband selection and CQI values are calculated conditioned on the last reported periodic CRI.
- Mode 2-1 description:
 - In the subframe where RI is reported for transmission mode 4, transmission mode 8 except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, transmission modes 9 and 10 with 2 CSI-RS ports, and transmission modes 9 and 10 with 4 CSI-RS ports except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, and for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, *eMIMO-Type* set to 'CLASS B', one CSI-RS resource configured, with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*:
 - If a UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming

transmission on set S subbands conditioned on the last reported periodic CRI.

- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands.
 - The UE shall report a type 3 report consisting of one RI.
- In the subframe where RI and PTI are reported, for transmission modes 9 and 10 with 8 CSI-RS ports configured and higher layer parameter *eMIMO-Type* not configured, or for transmission modes 9 and 10 with 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 9 and 10 with 8 CSI-RS ports configured and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting then:
 - If a UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands conditioned on the last reported periodic CRI.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the PTI for the CSI process shall be the same as the PTI in the most recent type 6 report for the configured 'RI-reference CSI process'; otherwise, the UE shall determine a precoder type indication (PTI) conditioned on the last reported periodic CRI.
 - otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set S subbands.
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the PTI for the CSI process shall be the same as the PTI in the most recent type 6 report for the configured 'RI-reference CSI process'; otherwise, the UE shall determine a precoder type indication (PTI).
 - The PTI for the CSI process shall be equal to 1 if the RI reported jointly with the PTI is greater than 2 for transmission modes 8, 9, 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured.
 - The UE shall report a type 6 report consisting of one RI and the PTI.
- In the subframe where RI and CRI are reported for transmission modes 9 and 10 with parameter *eMIMO-Type* configured by higher layers, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one and RI and CRI is reported for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* set to 'CLASS

B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one:

- A UE shall determine a CRI assuming transmission on set *S* subbands.
- If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the RI for the CSI process shall be the same as the RI in the most recent CSI report comprising RI for the configured 'RI-reference CSI process' irrespective of subframe sets if configured; otherwise, the UE shall determine a RI assuming transmission on set *S* subbands conditioned on the reported CRI for the CSI process.
- If each of the maximum number of ports in the configured CSI-RS resources is 2, or 4 except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured,
 - The UE shall report a type 7 report consisting of one RI and one CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, the PTI for the CSI process shall be the same as the PTI in the most recent type 6 report for the configured 'RI-reference CSI process'; otherwise, the UE shall determine a precoder type indication (PTI) conditioned on the reported CRI for the CSI process.
 - If the configured CSI-RS resource corresponding to the determined CRI comprises 2 CSI-RS ports or 4 CSI-RS ports except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, PTI is fixed to zero.
 - The PTI for the CSI process shall be equal to 1 if the RI reported jointly with the PTI is greater than 2 for transmission modes 9, 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured.
 - The UE shall report a type 9 report consisting of one CRI, RI, and the PTI.
- In the subframe where wideband CQI/PMI is reported for all transmission modes except with
 - UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', or
 - 8 CSI-RS ports configured for transmission modes 9 and 10, or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, if the UE is not configured with higher layer parameter *eMIMO-Type*, or UE is configured with CRI reporting, or UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured:
 - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands.
 - A UE shall report a type 2 report on each respective successive reporting opportunity consisting of:
 - A wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set *S* subbands.
 - The selected single PMI (wideband PMI).
 - When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,

- If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the PMI and CQI values for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise the PMI and CQI values are calculated conditioned on the last reported periodic RI and the last reported periodic CRI.
- otherwise,
 - For transmission modes 4, 8, 9 and 10,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the PMI and CQI values for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process; otherwise the PMI and CQI values are calculated conditioned on the last reported periodic RI.
 - For other transmission modes the PMI and CQI values are calculated conditioned on transmission rank 1.
 - In the subframe where the wideband first PMI is reported for transmission modes 9 and 10 with 8 CSI-RS ports configured and higher layer parameter *eMIMO-Type* not configured, or for transmission modes 9 and 10 with 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 9 and 10 with 8 CSI-RS ports configured and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting:
 - A set of precoding matrices corresponding to the wideband first PMI is selected from the codebook subset assuming transmission on set *S* subbands.
 - A UE shall report a type 2a report on each respective successive reporting opportunity consisting of the wideband first PMI corresponding to the selected set of precoding matrices.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=0 is reported in the most recent RI reporting instance for the CSI process, the wideband first PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise with the last reported PTI=0, the wideband first PMI value is calculated conditioned on the last reported periodic RI and the last reported periodic CRI.

- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=0 is reported in the most recent RI reporting instance for the CSI process, the wideband first PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process; otherwise with the last reported PTI=0, the wideband first PMI value is calculated conditioned on the last reported periodic RI.
- In the subframe where wideband CQI/second PMI is reported, for transmission modes 9 and 10 with 8 CSI-RS ports configured and higher layer parameter *eMIMO-Type* not configured, or for transmission modes 9 and 10 with 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 9 and 10 with 8 CSI-RS ports configured and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 8,9, and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting:
 - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands.
 - A UE shall report a type 2b report on each respective successive reporting opportunity consisting of:
 - A wideband CQI value which is calculated assuming the use of the selected single precoding matrix in all subbands and transmission on set *S* subbands.
 - The wideband second PMI corresponding to the selected single precoding matrix.
 - When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=1 is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process and the last reported periodic CRI for the CSI process,
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process.
 - Otherwise, with the last reported PTI=1,

- The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI and the last reported periodic CRI.
- The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI and the last reported periodic CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=1 is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process,
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process.
 - Otherwise, with the last reported PTI=1,
 - The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI.
- If the last reported first PMI was computed under an RI assumption that differs from the last reported periodic RI, or in the absence of a last reported first PMI, the conditioning of the second PMI value is not specified.
- In the subframe where CQI for the selected subband is reported for all transmission modes except with
 - UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', or
 - 8 CSI-RS ports configured for transmission modes 9 and 10, or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 10, if the UE is not configured with higher layer parameter *eMIMO-Type*, or UE is configured with CRI reporting, or UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured:
 - The UE shall select the preferred subband within the set of N_j subbands in each of the J bandwidth parts where J is given in Table 7.2.2-2.
 - The UE shall report a type 1 report per bandwidth part on each respective successive reporting opportunity consisting of:
 - CQI value for codeword 0 reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding preferred subband L -bit label.

- When RI>1, an additional 3-bit subband spatial differential CQI value for codeword 1 offset level
 - Codeword 1 offset level = subband CQI index for codeword 0 – subband CQI index for codeword 1.
 - Assuming the use of the most recently reported single precoding matrix in all subbands and transmission on the selected subband within the applicable bandwidth part.
- The mapping from the 3-bit subband spatial differential CQI value to the offset level is shown in Table 7.2-2.
- If the UE is configured with CRI reporting,
 - F If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the subband selection and CQI values for the CSI process are calculated conditioned on the last reported periodic wideband PMI for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process; otherwise the subband selection and CQI values are calculated conditioned on the last reported periodic wideband PMI, RI and CRI.
 - For transmission modes 4, 8, 9 and 10,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 3 report for the CSI process is dropped, and a type 3 report for the 'RI-reference CSI process' is reported in the most recent RI reporting instance for the CSI process, the subband selection and CQI values for the CSI process are calculated conditioned on the last reported periodic wideband PMI for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process; otherwise the subband selection and CQI values are calculated conditioned on the last reported periodic wideband PMI and RI.
 - For other transmission modes the subband selection and CQI values are calculated conditioned on the last reported PMI and transmission rank 1.
 - In the subframe where wideband CQI/second PMI is reported, for transmission modes 9 and 10 with 8 CSI-RS ports configured and higher layer parameter *eMIMO-Type* not configured, or for transmission modes 9 and 10 with 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 9 and 10 with 8 CSI-RS ports configured and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting:

- A single precoding matrix is selected from the codebook subset assuming transmission on set S subbands.
- The UE shall report a type 2b report on each respective successive reporting opportunity consisting of:
 - A wideband CQI value which is calculated assuming the use of the selected single precoding matrix in all subbands and transmission on set S subbands.
 - The wideband second PMI corresponding to the selected single precoding matrix.
 - When $RI > 1$, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with $PTI=0$ is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process and the last reported periodic CRI for the CSI process.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process.
 - otherwise, with the last reported $PTI=0$,
 - The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI and the last reported periodic CRI.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI process and the last reported periodic CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with $PTI=0$ is reported in the most recent RI reporting instance for the CSI process,
 - The wideband second PMI value for the CSI process is calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI

'process' in the most recent RI reporting instance for the CSI process.

- Otherwise, with the last reported PTI=0,
 - The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI.
 - The wideband CQI value is calculated conditioned on the selected precoding matrix and the last reported periodic RI.
- If the last reported first PMI was computed under an RI assumption that differs from the last reported periodic RI, or in the absence of a last reported first PMI, the conditioning of the second PMI value is not specified.
- In the subframe where subband CQI/second PMI for the selected subband is reported, for transmission modes 9 and 10 with 8 CSI-RS ports configured and higher layer parameter *eMIMO-Type* not configured, or for transmission modes 9 and 10 with 8 CSI-RS ports or 4 CSI-RS ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* in the selected CSI-RS resource and UE is configured with CRI reporting, or for transmission modes 9 and 10 with 8 CSI-RS ports configured and UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and except with higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or for transmission modes 9 and 10 with higher layer parameter *eMIMO-Type* configured, and *eMIMO-Type* set to 'CLASS A', or for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured without CRI reporting:
 - The UE shall select the preferred subband within the set of N_j subbands in each of the J bandwidth parts where J is given in Table 7.2.2-2.
 - The UE shall report a type 1a report per bandwidth part on each respective successive reporting opportunity consisting of:
 - CQI value for codeword 0 reflecting transmission only over the selected subband of a bandwidth part determined in the previous step along with the corresponding preferred subband L -bit label.
 - When RI>1, an additional 3-bit subband spatial differential CQI value for codeword 1 offset level
 - Codeword 1 offset level = subband CQI index for codeword 0 – subband CQI index for codeword 1.
 - Assuming the use of the precoding matrix corresponding to the selected second PMI and the most recently reported first PMI and transmission on the selected subband within the applicable bandwidth part.
 - The mapping from the 3-bit subband spatial differential CQI value to the offset level is shown in Table 7.2-2.
 - A second PMI of the preferred precoding matrix selected from the codebook subset assuming transmission only over the selected subband within the applicable bandwidth part determined in the previous step.
 - If the UE is configured with CRI reporting,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=1 is reported in the most recent RI reporting instance for the CSI process,

- The subband second PMI values for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process and the last reported periodic CRI for the CSI process.
- The subband selection and CQI values are calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported periodic CRI for the CSI process.
- Otherwise, with the last reported PTI=1
 - The subband second PMI values are calculated conditioned on the last reported periodic RI and the wideband first PMI and the last reported periodic CRI.
 - The subband selection and CQI values are calculated conditioned on the selected precoding matrix and the last reported periodic RI and the last reported periodic CRI.
- otherwise,
 - If a UE is configured in transmission mode 10 with a 'RI-reference CSI process' for a CSI process, and the most recent type 6 report for the CSI process is dropped, and a type 6 report for the 'RI-reference CSI process' with PTI=1 is reported in the most recent RI reporting instance for the CSI process,
 - The subband second PMI values for the CSI process are calculated conditioned on the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process and the last reported wideband first PMI for the CSI process.
 - The subband selection and CQI values are calculated conditioned on the selected precoding matrix for the CSI process and the reported periodic RI for the configured 'RI-reference CSI process' in the most recent RI reporting instance for the CSI process.
 - Otherwise, with the last reported PTI=1
 - The subband second PMI values are calculated conditioned on the last reported periodic RI and the wideband first PMI.
 - The subband selection and CQI values are calculated conditioned on the selected precoding matrix and the last reported periodic RI.
 - If the last reported first PMI was computed under an RI assumption that differs from the last reported periodic RI, or in the absence of a last reported first PMI, the conditioning of the second PMI value is not specified.

Table 7.2.2-2: Subband Size (k) and Bandwidth Parts (J) vs. Downlink System Bandwidth

| System Bandwidth $N_{\text{RB}}^{\text{DL}}$ | Subband Size k (RBs) | Bandwidth Parts (J) |
|--|------------------------|-------------------------|
|--|------------------------|-------------------------|

| | | |
|----------|----|----|
| 6 – 7 | NA | NA |
| 8 – 10 | 4 | 1 |
| 11 – 26 | 4 | 2 |
| 27 – 63 | 6 | 3 |
| 64 – 110 | 8 | 4 |

For a BL/CE UE, the periodic CSI reporting modes are described as following:

- Wideband feedback
 - Mode 1-0 description:
 - In the subframe where CQI is reported:
 - A UE shall report a type 4 report consisting of one wideband CQI value which is calculated assuming transmission on all narrowband(s) in the CSI reference resource. The wideband CQI is calculated conditioned on transmission rank 1.
 - Mode 1-1 description:
 - In the subframe where CQI/PMI is reported:
 - A single precoding matrix is selected from the codebook subset assuming transmission on all narrowband(s) in the CSI reference resource. The PMI is calculated conditioned on transmission rank 1.
 - A UE shall report a type 2 report consisting of
 - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all narrowband(s) in the CSI reference resource and transmission on all narrowband(s) in the CSI reference resource. The wideband CQI is calculated conditioned on transmission rank 1.
 - The selected single PMI (wideband PMI).

If parameter *ttiBundling* provided by higher layers is set to *TRUE* and if an UL-SCH in subframe bundling operation collides with a periodic CSI reporting instance, then the UE shall drop the periodic CSI report of a given PUCCH reporting type in that subframe and shall not multiplex the periodic CSI report payload in the PUSCH transmission in that subframe. A UE is not expected to be configured with simultaneous PUCCH and PUSCH transmission when UL-SCH subframe bundling is configured.

If the UE is configured with higher layer parameter *pusch-EnhancementsConfig*, and if a PUSCH transmission spans more than one subframe as indicated by the *repetition number* field in DCI 0C, the UE shall drop the periodic CSI report of a given PUCCH reporting type in that subframe and shall not multiplex the periodic CSI report payload in the PUSCH transmission in that subframe. A UE is not expected to be configured with simultaneous PUCCH and PUSCH transmission when *pusch-EnhancementsConfig* is configured.

Table 7.2.2-3: PUCCH Reporting Type Payload size per PUCCH Reporting Mode and Mode State

| PUCCH Reporting Type | Reported | Mode State | PUCCH Reporting Modes | | | |
|----------------------|---------------------------|---|-----------------------|---------------------|---------------------|--------------------------------------|
| | | | Mode 1-1 (bits/BP*) | Mode 2-1 (bits/BP*) | Mode 1-0 (bits/BP*) | Mode 2-0 (bits/BP*) |
| 1 | Sub-band CQI | RI = 1 | NA | 4+L | NA | 4+L |
| | | RI > 1 | NA | 7+L | NA | 4+L ¹ 7+L ² |
| 1a | Sub-band CQI / second PMI | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> ={2,3,4}, RI = 1 | NA | 8+L | NA | NA |
| | | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> ={2,3,4}, 1 < RI < 5 | NA | 9+L | NA | NA |
| | | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> ={1,2,3,4} RI > 4 | NA | 7+L | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, RI = 1 | NA | 6+L | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, RI = 2 | NA | 9+L | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, 2<RI<5 | NA | 8+L | NA | NA |
| | | 4 antenna ports RI=1 | NA | 8+L | NA | NA |
| | | 4 antenna ports 1<RI≤4 | NA | 9+L | NA | NA |
| 2 | Wideband CQI/PMI | 2 antenna ports RI = 1 | 6 | 6 | NA | NA |
| | | 4 antenna ports RI = 1, Note ⁵ | 8 | 8 | NA | NA |
| | | 2 antenna ports RI > 1 | 8 | 8 | NA | NA |
| | | 4 antenna ports RI > 1, Note ⁵ | 11 | 11 | NA | NA |
| | | 4 antenna ports RI = 1, Note ⁶ | 7 | 7 | NA | NA |
| | | 4 antenna ports RI = 2, Note ⁶ | 10 | 10 | NA | NA |
| | | 4 antenna ports RI = 3, Note ⁶ | 9 | 9 | NA | NA |
| | | 4 antenna ports RI = 4, Note ⁶ | 8 | 8 | NA | NA |
| | | 8 antenna ports RI = 1 | 8 | 8 | NA | NA |
| | | 8 antenna ports 1<RI<4 | 11 | 11 | NA | NA |
| | | 8 antenna ports RI = 4 | 10 | 10 | NA | NA |
| | | 8 antenna ports RI > 4 | 7 | 7 | NA | NA |
| 2a | Wideband first PMI | 8 antenna ports RI < 3 | NA | 4 | NA | NA |
| | | 8 antenna ports 2 < RI < 8 | NA | 2 | NA | NA |
| | | 8 antenna ports RI = 8 | NA | 0 | NA | NA |
| | | 4 antenna ports 1≤RI≤2 | NA | 4 | NA | NA |
| | | 4 antenna ports 2≤RI≤4 | NA | NA | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, 1≤RI≤8 | Note ³ | Note ³ | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> ={2,3,4} | Note ⁴ | Note ⁴ | NA | NA |
| | | 4 antenna ports with <i>advancedCodebookEnabled</i> =True, 1≤RI≤2 | 3 | NA | NA | NA |
| | | 4 antenna ports with <i>advancedCodebookEnabled</i> =True, 3≤RI≤4 | 0 | NA | NA | NA |
| | | 8 antenna ports with <i>advancedCodebookEnabled</i> =True, 1≤RI≤2 | 6 | NA | NA | NA |
| | | 8 antenna ports with <i>advancedCodebookEnabled</i> =True, 3≤RI≤7 | 2 | NA | NA | NA |
| | | 8 antenna ports with <i>advancedCodebookEnabled</i> =True, RI=8 | 0 | NA | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>advancedCodebookEnabled</i> =True and eMIMO-Type is set to 'CLASS A', 1≤RI≤8 | Note ⁷ | NA | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports, eMIMO-Type and eMIMO-Type2 configured by higher layers, eMIMO-Type is set to 'CLASS A', eMIMO-Type2 is set to 'CLASS B', and maximum 1 or 2 layers are supported by the UE | Note ⁸ | Note ⁸ | Note ⁸ | Note ⁸ |
| 2b | Wideband CQI / second PMI | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> = {2,3,4}, RI = 1 | 8 | 8 | NA | NA |
| | | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> = {2,3,4}, 1 < RI < 4 | 11 | 11 | NA | NA |
| | | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> = {2,3,4}, RI = 4 | 10 | 10 | NA | NA |

| | | | | | | |
|----|---------------------------------------|---|-------------------|-------------------|-----------------------------------|-----------------------------------|
| | | 8 antenna ports or 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> = {1,2,3,4}, RI > 4 | 7 | 7 | NA | NA |
| | | 4 antenna ports RI=1 | 8 | 8 | NA | NA |
| | | 4 antenna port $1 < \text{RI} \leq 4$ | 11 | 11 | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, RI = 1 | 6 | 6 | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, RI = 2 | 9 | 9 | NA | NA |
| | | 8/12/16/20/24/28/32 antenna ports with <i>codebookConfig</i> =1, $2 < \text{RI} \leq 5$ | 8 | 8 | NA | NA |
| | | 4/8 antenna ports with <i>advancedCodebookEnabled</i> =True or 8/12/16/20/24/28/32 antenna ports with <i>advancedCodebookEnabled</i> =True and <i>eMIMO-Type</i> is set to 'CLASS A', RI = 1 | 10 | NA | NA | NA |
| | | 4/8 antenna ports with <i>advancedCodebookEnabled</i> =True or 8/12/16/20/24/28/32 antenna ports with <i>advancedCodebookEnabled</i> =True and <i>eMIMO-Type</i> is set to 'CLASS A', RI = 2 | 11 | NA | NA | NA |
| 2c | Wideband CQI / first PMI / second PMI | 8 antenna ports RI = 1 | 8 | NA | NA | NA |
| | | 8 antenna ports $1 < \text{RI} \leq 4$ | 11 | NA | NA | NA |
| | | 8 antenna ports $4 < \text{RI} \leq 7$ | 9 | NA | NA | NA |
| | | 8 antenna ports RI = 8 | 7 | NA | NA | NA |
| | | 4 antenna ports RI=1 | 8 | NA | NA | NA |
| | | 4 antenna port $1 < \text{RI} \leq 4$ | 11 | NA | NA | NA |
| 3 | RI | 2/4 antenna ports, 2-layer spatial multiplexing | 1 | 1 | 1 | 1 |
| | | 8 antenna ports, 2-layer spatial multiplexing | 1 | NA | NA ¹ 1 ² | NA ¹ 1 ² |
| | | 4 antenna ports, 4-layer spatial multiplexing | 2 | 2 | 2 | 2 |
| | | 8 antenna ports, 4-layer spatial multiplexing | 2 | NA | NA ¹ 2 ² | NA ¹ 2 ² |
| | | 8-layer spatial multiplexing | 3 | NA | NA ¹ 3 ² | NA ¹ 3 ² |
| | | 12/16/20/24/28/32 antenna ports, 2-layer spatial multiplexing | 1 | NA | NA | NA |
| | | 12/16/20/24/28/32 antenna ports, 4-layer spatial multiplexing | 2 | NA | NA | NA |
| | | 12/16/20/24/28/32 antenna ports, 8-layer spatial multiplexing | 3 | NA | NA | NA |
| | | RI = 1 or RI>1, without PMI/RI reporting | NA | NA | 4 | 4 |
| 4 | Wideband CQI | RI = 1 without PMI reporting | NA | NA | 4 | 4 |
| | | RI>1 without PMI reporting | NA | NA | 7 | 7 |
| | | 8 antenna ports, 2-layer spatial multiplexing | 4 | NA | NA | NA |
| 5 | RI/ first PMI | 8 antenna ports, 4 and 8-layer spatial multiplexing | 5 | | | |
| | | 4 antenna ports, 2-layer spatial multiplexing | 4 | | | |
| | | 4 antenna ports, 4-layer spatial multiplexing | 5 | | | |
| | | 8/12/16/20/24/28/32 antenna ports, <i>eMIMO-Type</i> and <i>eMIMO-Type2</i> configured by higher layers, <i>eMIMO-Type</i> is set to 'CLASS A', <i>eMIMO-Type2</i> is set to 'CLASS B', and maximum 4 or 8 layers are supported by the UE | Note ⁹ | Note ⁹ | Note ⁹ | Note ⁹ |
| 6 | RI/PTI | 8 antenna ports, 2-layer spatial multiplexing | NA | 2 | NA | NA |
| | | 8 antenna ports, 4-layer spatial multiplexing | NA | 3 | NA | NA |
| | | 8 antenna ports, 8-layer spatial multiplexing | NA | 4 | NA | NA |
| | | 4 antenna ports, 2-layer spatial multiplexing | NA | 2 | NA | NA |
| | | 4 antenna ports, 4-layer spatial multiplexing | NA | 3 | NA | NA |
| | | 12/16/20/24/28/32 antenna ports, 2-layer spatial multiplexing | NA | 2 | NA | NA |
| | | 12/16/20/24/28/32 antenna ports, 4-layer spatial multiplexing | NA | 3 | NA | NA |
| | | 12/16/20/24/28/32 antenna ports, 8-layer spatial multiplexing | NA | 4 | NA | NA |
| | | 2-layer spatial multiplexing | $k+1$ | $k+1$ | $k+1$ | $k+1$ |
| 7 | CRI/RI | 4-layer spatial multiplexing | $k+2$ | $k+2$ | $k+2$ | $k+2$ |
| | | 8-layer spatial multiplexing | $k+3$ | $k+3$ | $k+3$ | $k+3$ |
| | | 2-layer spatial multiplexing | $k+4$ | NA | NA | NA |
| 8 | CRI/RI/first PMI | 4 and 8-layer spatial multiplexing | $k+5$ | NA | NA | NA |
| | | 2-layer spatial multiplexing | NA | $k+2$ | NA | NA |
| 9 | CRI/RI/PTI | 4-layer spatial multiplexing | NA | $k+3$ | NA | NA |
| | | 8-layer spatial multiplexing | NA | $k+4$ | NA | NA |

| | | | | | | |
|----|--------|------------------------------|----|----|-----|-----|
| 10 | CRI | Without PMI/RI reporting | NA | NA | k | k |
| 11 | RI/RPI | 2-layer spatial multiplexing | 3 | NA | NA | NA |
| | | 4-layer spatial multiplexing | 4 | NA | NA | NA |
| | | 8-layer spatial multiplexing | 5 | NA | NA | NA |

NOTE 1: For wideband CQI reporting types, the stated payload size applies to the full bandwidth.

NOTE 1: Without PMI/RI reporting

NOTE 2: Without PMI reporting and without *csi-RS-NZP-mode*, $k = \lceil \log_2(K) \rceil$ where K is the number of configured CSI-RS resources or without PMI reporting and with higher layer parameter *csi-RS-NZP-mode* set to 'multiShot' and *activatedResources>1*, $k = \lceil \log_2(N) \rceil$ where N is the number of activated CSI-RS resources.

NOTE 3: Sum of Wideband first PMI i1,1 bit width and Wideband first PMI i1,2 bit width in Table 5.2.3.3.2-3B-1 of [4] with PTI=0

NOTE 4: Sum of Wideband first PMI i1,1 bit width and Wideband first PMI i1,2 bit width in Table 5.2.3.3.2-3B-2 of [4] with PTI=0

NOTE 5: Not configured with parameter *eMIMO-Type* by higher-layers

NOTE 6: Configured with parameter *eMIMO-Type* by higher-layers

NOTE 7: Sum of Wideband first PMI i1,1 bit width, Wideband first PMI i1,2 bit width, Wideband first PMI i1,3 bit width in Table 5.2.3.3.1-4C of [4]

NOTE 8: Sum of Wideband first PMI i1,1 bit width and Wideband first PMI i1,2 bit width in Table 5.2.3.3.1-4D of [4] with Max 1 or 2 layers.

NOTE 9: Sum of Wideband first PMI i1,1 bit width, Wideband first PMI i1,2 bit width and RI bit width in Table 5.2.3.3.1-4D of [4] with Max 4 or 8 layers.

7.2.3 Channel Quality Indicator (CQI) definition

The CQI indices and their interpretations are given in Table 7.2.3-1, Table 7.2.3-5, Table 7.2.3-6 for reporting CQI based on QPSK, 16QAM and 64QAM. The CQI indices and their interpretations are given in Table 7.2.3-2 for reporting CQI based on QPSK, 16QAM, 64QAM and 256QAM. The CQI indices and their interpretations are given in Table 7.2.3-3 for reporting CQI based on QPSK and 16QAM. The CQI indices and their interpretations are given in Table 7.2.3-4 for reporting CQI based on QPSK, 16QAM, 64QAM, 256QAM, and 1024QAM.

For a non-BL/CE UE, based on an unrestricted observation interval in time unless specified otherwise in this Subclause, and an unrestricted observation interval in frequency, the UE shall derive for each CQI value reported in uplink subframe/slot/subslot n the highest CQI index between 1 and 15 in Table 7.2.3-1, Table 7.2.3-2 or Table 7.2.3-4 which satisfies the following condition, or CQI index 0 if CQI index 1 does not satisfy the condition:

- A single PDSCH transport block with a combination of modulation scheme and transport block size corresponding to the CQI index, and occupying a group of downlink physical resource blocks termed the CSI reference resource, could be received with a transport block error probability not exceeding 0.1.

For a BL/CE UE, based on an unrestricted observation interval in time and frequency, the UE shall derive for each CQI value the highest CQI index in Table 7.2.3-3, Table 7.2.3-5 or Table 7.2.3-6 which satisfies the following condition, or CQI index 0 if CQI index 1 does not satisfy the condition:

- A single PDSCH transport block with a combination of modulation scheme and transport block size corresponding to the CQI index, and occupying a group of downlink physical resource blocks termed the CSI reference resource, could be received with a transport block error probability not exceeding 0.1.

If CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers, each CSI reference resource belongs to either $C_{CSI,0}$ or $C_{CSI,1}$ but not to both. When CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ are configured by higher layers a UE is not expected to receive a trigger for which the CSI reference resource is in subframe that does not belong to either subframe set. For a UE in transmission mode 10 and periodic CSI reporting, the CSI subframe set for the CSI reference resource is configured by higher layers for each CSI process.

If the UE is configured with parameter *eMIMO-Type2* by higher layers for a CSI process, for computing the CQI value for *eMIMO-Type2* of the CSI process, the parameter *eMIMO-Type* in the rest of this Subclause refers to the parameter *eMIMO-Type2* for the CSI process.

For a UE in transmission mode 9 when parameter *pmi-RI-Report* is configured by higher layers and parameter *eMIMO-Type* is not configured by higher layers, the UE shall derive the channel measurements for computing the CQI value reported in uplink subframe/slot/subslot n based on only the Channel-State Information (CSI) reference signals (CSI-RS) defined in [3] for which the UE is configured to assume non-zero power for the CSI-RS. For a non-BL/CE UE in transmission mode 9 when the parameter *pmi-RI-Report* is not configured by higher layers or in transmission modes 1-8 the UE shall derive the channel measurements for computing CQI based on CRS. For a BL/CE UE the UE shall derive the channel measurements for computing CQI based on CRS.

For a UE in transmission mode 10, when parameter *eMIMO-Type* is not configured by higher layers, the UE shall derive the channel measurements for computing the CQI value reported in uplink subframe/slot/subslot n and corresponding to a CSI process, based on only the non-zero power CSI-RS (defined in [3]) within a configured CSI-RS resource associated with the CSI process.

For a UE in transmission mode 9 and the UE configured with parameter *eMIMO-Type* by higher layers, the term 'CSI process' in this clause refers to the CSI configured for the UE.

For a UE in transmission mode 9 or 10 and for a CSI process, if the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS A', and one CSI-RS resource configured, or the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and parameter *channelMeasRestriction* is not configured by higher layers, the UE shall derive the channel measurements for computing the CQI value reported in uplink subframe n and corresponding to the CSI process, based on only the non-zero power CSI-RS (defined in [3]) within a configured CSI-RS resource associated with the CSI process. If the UE is configured with parameter *eMIMO-Type* by higher layers, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B' and the number of configured CSI-RS resources is $K > 1$, and parameter *channelMeasRestriction* is not configured by higher layers, the UE shall derive the channel measurements for computing the CQI value using only the configured CSI-RS resource indicated by the CRI. If the UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, and parameter *channelMeasRestriction* is not configured by higher layers, the UE shall

derive the channel measurements for computing the CQI value using only the activated CSI-RS resource indicated by CRI.

For a UE in transmission mode 9 or 10 and for a CSI process, if the UE is configured with parameter *eMIMO-Type* by higher layers, and *eMIMO-Type* is set to 'CLASS B', and parameter *channelMeasRestriction* is configured by higher layers, the UE shall derive the channel measurements for computing the CQI value reported in uplink subframe *n* and corresponding to the CSI process, based on only the most recent, no later than the CSI reference resource, non-zero power CSI-RS (defined in [3]) within a configured CSI-RS resource associated with the CSI process. If the UE is configured with parameter *eMIMO-Type* by higher layers, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B' and the number of configured CSI-RS resources is $K > 1$, and parameter *channelMeasRestriction* is configured by higher layers, the UE shall derive the channel measurements for computing the CQI value using only the most recent, no later than the CSI reference resource, non-zero power CSI-RS within the configured CSI-RS resource indicated by the CRI. If the UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is more than one, and parameter *channelMeasRestriction* is configured by higher layers, the UE shall derive the channel measurements for computing the CQI value using only the most recent, no later than the CSI reference resource, non-zero power CSI-RS within the activated CSI-RS resource indicated by the CRI.

For a UE in transmission mode 10, when parameter *eMIMO-Type* is not configured by higher layers, the UE shall derive the interference measurements for computing the CQI value reported in uplink subframe/slot/subslot *n* and corresponding to a CSI process, based on only the configured CSI-IM resource associated with the CSI process.

For a UE in transmission mode 10 and for a CSI process, when parameters *eMIMO-Type* and *interferenceMeasRestriction* is configured by higher layers, the UE shall derive the interference measurements for computing the CQI value reported in uplink subframe *n* and corresponding to the CSI process, based on only the most recent, no later than the CSI reference resource, configured CSI-IM resource associated with the CSI process. If the UE is configured with parameter *eMIMO-Type* by higher layers, except with higher layer parameter *csi-RS-NZP-mode* configured, and *eMIMO-Type* is set to 'CLASS B' and the number of configured CSI-RS resources is $K > 1$, and *interferenceMeasRestriction* is configured, the UE shall derive interference measurement for computing the CQI value based on only the most recent, no later than the CSI reference resource, the configured CSI-IM resource associated with the CSI-RS resource indicated by the CRI. If the UE is configured with higher layer parameter *eMIMO-Type* set to 'CLASS B' and higher layer parameter *csi-RS-NZP-mode* set to 'multiShot', and the number of activated CSI-RS resources is $K > 1$, and *interferenceMeasRestriction* is configured, the UE shall derive interference measurement for computing the CQI value based on only the most recent, no later than the CSI reference resource, the configured CSI-IM resource associated with the activated CSI-RS resource indicated by the CRI. If *interferenceMeasRestriction* is not configured, the UE shall derive the interference measurement for computing the CQI value based on the CSI-IM associated with the CSI-RS resource indicated by the CRI.

If the UE in transmission mode 10 is configured by higher layers for CSI subframe sets $C_{CSI,0}$ and $C_{CSI,1}$ for the CSI process, the configured CSI-IM resource within the subframe subset belonging to the CSI reference resource is used to derive the interference measurement.

For a UE configured with the parameter *EIMTA-MainConfigServCell-r12* for a serving cell, configured CSI-IM resource(s) within only downlink subframe(s) of a radio frame that are indicated by UL/DL configuration of the serving cell can be used to derive the interference measurement for the serving cell.

For a LAA Scell,

- for channel measurements, if the UE averages CRS/CSI-RS measurements from multiple subframes
- the UE should not average CSI-RS measurement in subframe *n1* with CSI-RS measurement in a later subframe *n2*, if any OFDM symbol of subframe *n1* or any subframe from subframe *n1+1* to subframe *n2*, is not occupied.
- the UE should not average CRS measurement in subframe *n1* with CRS measurement in a later subframe *n2*, if any OFDM symbol of the second slot of subframe *n1* or any OFDM symbol of any subframe from subframe *n1+1* to subframe *n2-1*, or any of the first 3 OFDM symbols in subframe *n2*, is not occupied.
- for interference measurements, the UE shall derive the interference measurements for computing the CQI value based on only measurements in subframes with occupied OFDM symbols.

A combination of modulation scheme and transport block size corresponds to a CQI index if:

- the combination could be signalled for transmission on the PDSCH in the CSI reference resource according to the relevant Transport Block Size table, and
- the modulation scheme is indicated by the CQI index, and
- the combination of transport block size and modulation scheme when applied to the reference resource results in the effective channel code rate which is the closest possible to the code rate indicated by the CQI index. If more than one combination of transport block size and modulation scheme results in an effective channel code rate equally close to the code rate indicated by the CQI index, only the combination with the smallest of such transport block sizes is relevant.

The CSI reference resource for a serving cell is defined as follows:

- For a non-BL/CE UE, in the frequency domain, the CSI reference resource is defined by the group of downlink physical resource blocks corresponding to the band to which the derived CQI value relates. For a BL/CE UE, in the frequency domain, the CSI reference resource includes all downlink physical resource blocks for any of the narrowband to which the derived CQI value relates.
- In the time domain and for a non-BL/CE UE,
 - for a UE configured in transmission mode 1-9 or transmission mode 10 with a single configured CSI process for the serving cell, the CSI reference resource is defined by a single downlink subframe/slot/subslot or special subframe or a slot in a special subframe $n-n_{CQI_ref}$,
 - where for periodic CSI reporting n_{CQI_ref} is the smallest value greater than or equal to k_p , such that it corresponds to a valid downlink or valid special subframe,
 - where for aperiodic CSI reporting, if the UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12*, and
 - where for LAA serving cell,
 - if aperiodic CSI reporting is triggered by DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 1,
 - n_{CQI_ref} is the smallest value greater than or equal to k_p , such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe no later than the subframe in which DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 1 is received.
 - if aperiodic CSI reporting is triggered by DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 0,
 - n_{CQI_ref} is the smallest value greater than or equal to k_p , such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe.
 - otherwise,
 - n_{CQI_ref} is the smallest value greater than or equal to k_p , such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe.
 - where for FDD serving cell or TDD serving cell,
 - n_{CQI_ref} is such that the reference resource is in the same valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe as the corresponding CSI request in an uplink DCI format.
 - n_{CQI_ref} is equal to 4 and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant.
 - where for aperiodic CSI reporting, and the UE configured with the higher layer parameter *csi-SubframePatternConfig-r12*,

- for the UE configured in transmission mode 1-9,
 - n_{CQI_ref} is the smallest value greater than or equal to
 - k_p for aperiodic CSI reporting on subframe-PUSCH
 - 4 for aperiodic CSI reporting on slot-PUSCH if the higher layer parameter *dl-TTI-Length* is set to slot
 - X_p for aperiodic CSI reporting on subslot-PUSCH
 - Subslot n_{CQI_ref} is not later than
 - subslot 0 of subframe $n-2$ for aperiodic CSI reporting on slot 0 of subframe n
 - subslot 3 of subframe $n-2$ for aperiodic CSI reporting on slot 1 of subframe n
- if the higher layer parameter *dl-TTI-Length* is set to 'subslot', and the higher layer parameter *ul-TTI-Length* is set to 'slot'

and subframe/slot/subslot $n-n_{CQI_ref}$ corresponds to a valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe, where subframe/slot/subslot $n-n_{CQI_ref}$ is received on or after the subframe/slot/subslot with the corresponding CSI request in an uplink DCI format;

- n_{CQI_ref} is the smallest value greater than or equal to 4, and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant;
- if there is no valid value for n_{CQI_ref} based on the above conditions, then n_{CQI_ref} is the smallest value such that the reference resource is in a valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe $n-n_{CQI_ref}$ prior to the subframe/slot/subslot with the corresponding CSI request, where subframe/slot/subslot $n-n_{CQI_ref}$ is the lowest indexed valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe within a radio frame;
- for the UE configured in transmission mode 10,
 - n_{CQI_ref} is the smallest value greater than or equal to
 - k_p for aperiodic CSI reporting on subframe-PUSCH,
 - 4 for aperiodic CSI reporting on slot-PUSCH if the higher layer parameter *dl-TTI-Length* is set to slot
 - X_p for aperiodic CSI reporting on subslot-PUSCH
 - Subslot n_{CQI_ref} is not later than
 - subslot 0 of subframe $n-2$ for aperiodic CSI reporting on slot 0 of subframe n
 - subslot 3 of subframe $n-2$ for aperiodic CSI reporting on slot 1 of subframe n

if the higher layer parameter *dl-TTI-Length* is set to 'subslot', and the higher layer parameter *ul-TTI-Length* is set to 'slot' such that it corresponds to a valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe, and the corresponding CSI request is in an uplink DCI format;

- n_{CQI_ref} is the smallest value greater than or equal to 4, and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant;

- for a UE configured in transmission mode 10 with multiple configured CSI processes for the serving cell, the CSI reference resource for a given CSI process is defined by a single downlink subframe/slot/subslot or special subframe or a valid slot in a special subframe $n-n_{CQI_ref}$,
 - where for FDD serving cell subslot n_{CQI_ref} is not later than
 - subslot 5 of subframe $n-3$ for aperiodic CSI reporting on slot 0 of subframe n
 - subslot 2 of subframe $n-2$ for aperiodic CSI reporting on slot 1 of subframe n
 - if the higher layer parameter *dl-TTI-Length* is set to subslot, and the higher layer parameter *ul-TTI-Length* is set to slot
 - n_{CQI_ref} is the smallest value greater than or equal to
 - 5 for aperiodic CSI reporting on slot-PUSCH if the higher layer parameter *dl-TTI-Length* is set to 'slot'
 - X_p for aperiodic CSI reporting on subslot-PUSCH,
 - $k_p + 1$, otherwise
- such that it corresponds to a valid downlink subframe/slot/subslot or valid special subframe or a valid slot in a special subframe, and for aperiodic CSI reporting the corresponding CSI request is in an uplink DCI format;
- where for FDD serving cell and aperiodic CSI reporting n_{CQI_ref} is equal to 5 and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant.
- where for TDD serving cell, and 2 or 3 configured CSI processes, and periodic or aperiodic CSI reporting, n_{CQI_ref} is the smallest value greater than or equal to 4 for aperiodic CSI reporting on slot-based PUSCH, and k_p otherwise, such that it corresponds to a valid downlink or valid special subframe or a valid slot in a special subframe, and for aperiodic CSI reporting the corresponding CSI request is in an uplink DCI format;
- where for TDD serving cell, and 2 or 3 configured CSI processes, and aperiodic CSI reporting, n_{CQI_ref} is equal to 4 and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant;
- where for TDD serving cell, and 4 configured CSI processes, and periodic or aperiodic CSI reporting, n_{CQI_ref} is the smallest value greater than or equal to 5 for aperiodic CSI reporting on slot-based PUSCH, and $k_p + 1$ otherwise, such that it corresponds to a valid downlink or valid special subframe or a valid slot in a special subframe, and for aperiodic CSI reporting the corresponding CSI request is in an uplink DCI format;
- where for TDD serving cell, and 4 configured CSI processes, and aperiodic CSI reporting, n_{CQI_ref} is equal to 5 and subframe $n-n_{CQI_ref}$ corresponds to a valid downlink or valid special subframe, where subframe $n-n_{CQI_ref}$ is received after the subframe with the corresponding CSI request in a Random Access Response Grant.
- where for LAA serving cell and periodic CSI reporting, n_{CQI_ref} is the smallest value greater than or equal to $k_p + 1$, such that it corresponds to a valid downlink subframe.
- where for LAA serving cell and aperiodic CSI reporting, and
 - if aperiodic CSI reporting is triggered by DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 1,
 - n_{CQI_ref} is the smallest value greater than or equal to $k_p + 1$, such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe no later than the subframe in which DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 1 is received.

- if aperiodic CSI reporting is triggered by DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 0,
- n_{CQI_ref} is the smallest value greater than or equal to $k_p + I$, such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe.
- otherwise,
 - n_{CQI_ref} is the smallest value greater than or equal to 5, such that subframe $n-n_{CQI_ref}$ corresponds to a valid downlink subframe.
- In the time domain and for a BL/CE UE, the CSI reference resource is defined by a set of BL/CE downlink or special subframes where the last subframe is subframe $n-n_{CQI_ref}$,
 - where for periodic CSI reporting n_{CQI_ref} is ≥ 4 ;
 - where for aperiodic CSI reporting n_{CQI_ref} is ≥ 4 ;
 - where each subframe in the CSI reference resource is a valid downlink or valid special subframe;
 - where for wideband CSI reports:
 - The set of BL/CE downlink or special subframes is the set of the last $\text{ceil}\left(\frac{R^{\text{CSI}}}{N_{\text{NB},\text{hop}}^{\text{ch},\text{DL}}}\right)$ subframes before $n-n_{CQI_ref}$ used for MPDCCH monitoring by the BL/CE UE in each of the narrowbands where the BL/CE UE monitors MPDCCH, where $N_{\text{NB},\text{hop}}^{\text{ch},\text{DL}}$ is the number of narrowbands where the BL/CE UE monitors MPDCCH.
 - where for subband CSI reports:
 - The set of BL/CE downlink or special subframes is the set of the last R^{CSI} subframes used for MPDCCH monitoring by the BL/CE UE in the corresponding narrowband before $n-n_{CQI_ref}$;
 - where R^{CSI} is given by the "repetition" column when UE is configured to report the CQI according to Table 7.2.3-6, otherwise by the higher layer parameter *csi-NumRepetitionCE*.

A subframe/slot/subslot in a serving cell shall be considered to be a valid downlink subframe/slot/subslot or a valid special subframe or a valid slot in a special subframe if:

- it is configured as a downlink subframe/slot/subslot or a special subframe or a slot in a special subframe for that UE, and
- in case multiple cells with different uplink-downlink configurations are aggregated and the UE is not capable of simultaneous reception and transmission in the aggregated cells, the subframe/slot/subslot in the primary cell is a downlink subframe or a special subframe with the length of DwPTS more than $7680 \cdot T_s$ for subframe-based transmissions, or the slot is a first slot of DwPTS for special subframe configurations 1,2,3,4,6,7,8,9,10, or the second slot of DwPTS for special subframe configurations 3,4,8 for slot-based transmissions, and
- except for a non-BL/CE UE in transmission mode 9 or 10, the subframe/slot/subslot is not in an MBSFN subframe, and
- in case of TDD
 - and subframe-based transmissions, the subframe does not contain a DwPTS field in case the length of DwPTS is $7680 \cdot T_s$ and less,
 - and slot-based transmission,
 - the slot is not a slot of DwPTS for special subframe configurations 0, 5,
 - the slot is not the second slot of DwPTS for special subframe configurations 1, 2, 6, 7.

- it is not a special subframe with special subframe configuration 10 configured by *ssp10-CRS-LessDwPTS*, and
- it does not fall within a configured measurement gap for that UE, and
- for periodic CSI reporting, it is an element of the CSI subframe set linked to the periodic CSI report when that UE is configured with CSI subframe sets, and
- for a UE configured in transmission mode 10 with multiple configured CSI processes, and aperiodic CSI reporting for a CSI process, it is an element of the CSI subframe set linked to the downlink or special subframe containing the subframe/slot/subslot with the corresponding CSI request in an uplink DCI format, when that UE is configured with CSI subframe sets for the CSI process and UE is not configured with the higher layer parameter *csi-SubframePatternConfig-r12*, and
- for a UE configured in transmission mode 1-9, and aperiodic CSI reporting, it is an element of the CSI subframe set associated with the corresponding CSI request in an uplink DCI format, when that UE is configured with CSI subframe sets by the higher layer parameter *csi-SubframePatternConfig-r12*, and
- for a UE configured in transmission mode 10, and aperiodic CSI reporting for a CSI process, it is an element of the CSI subframe set associated with the corresponding CSI request in an uplink DCI format, when that UE is configured with CSI subframe sets by the higher layer parameter *csi-SubframePatternConfig-r12* for the CSI process.
- except if the serving cell is a LAA Scell, and at least one OFDM symbol in the subframe is not occupied.
- except if the serving cell is a LAA Scell, and $n'_s \neq n_s$ as described in sub clause 6.10.1.1 in [3].
- except if the serving cell is a LAA Scell, and for a UE configured in transmission mode 9 or 10, the configured CSI-RS resource associated with the CSI process is not in the subframe.

For a non-BL/CE UE, if there is no valid downlink subframe/slot/subslot or no valid special subframe or no valid slot in a special subframe for the CSI reference resource in a serving cell, CSI reporting is omitted for the serving cell in uplink subframe/slot/subslot n .

- In the layer domain, the CSI reference resource is defined by any RI and PMI on which the CQI is conditioned.

In the CSI reference resource, the UE shall assume the following for the purpose of deriving the CQI index, and if also configured, PMI and RI except when the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report:

- The first 3 OFDM symbols are occupied by control signalling
- No resource elements used by primary or secondary synchronization signals or PBCH or EPDCCH
- CP length of the non-MBSFN subframes
- Redundancy Version 0
- If CSI-RS is used for channel measurements, the ratio of PDSCH EPRE to CSI-RS EPRE is as given in Subclause 7.2.5
- For transmission mode 9 CSI reporting of a non-BL/CE UE:
 - CRS REs are as in non-MBSFN subframes;
 - If the UE is configured for PMI/RI reporting or without PMI reporting, the UE-specific reference signal overhead is consistent with the most recent reported rank if more than one CSI-RS port is configured, and is consistent with rank 1 transmission if only one CSI-RS port is configured; and PDSCH signals on antenna ports $\{7 \dots 6 + \nu\}$ for \mathcal{V} layers would result in signals equivalent to corresponding symbols transmitted on antenna ports $\{15 \dots 14 + P\}$, as given by,

if the UE is configured with higher layer parameter *semiOpenLoop*,

$$\begin{bmatrix} y^{(15)}(2i) \\ \vdots \\ y^{(14+P)}(2i) \\ y^{(15)}(2i+1) \\ \vdots \\ y^{(14+P)}(2i+1) \end{bmatrix} = \begin{bmatrix} W(i) & 0 \\ 0 & W(i) \end{bmatrix} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \text{Re}(x^{(0)}(i)) \\ \text{Re}(x^{(1)}(i)) \\ \text{Im}(x^{(0)}(i)) \\ \text{Im}(x^{(1)}(i)) \end{bmatrix} \text{ for } v=1$$

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = \frac{1}{\sqrt{2}} W(i) \begin{bmatrix} 1 & 1 \\ \phi_i & -\phi_i \end{bmatrix} \begin{bmatrix} x^{(0)}(i) \\ x^{(1)}(i) \end{bmatrix}, \quad \phi_i = e^{j\pi(i \bmod 2)/2} \text{ for } v=2$$

where $x(i) = [x^{(0)}(i) \dots x^{(v-1)}(i)]^T$ is a vector of symbols from the layer mapping in subclause 6.3.3.2 of [3], $P \in \{2, 4, 8, 12, 16, 20, 24, 28, 32\}$ is the number of CSI-RS ports configured, and if UE reports a PMI,

$W(i) = \frac{1}{\sqrt{P}} \begin{bmatrix} w & 0 \\ 0 & w \end{bmatrix}$ where $w = v_m$ associated with PMI codebook Table 7.2.4-0A and Table 7.2.4-0B

for 4 antenna ports when *alternativeCodeBookEnabledFor4TX-r12=TRUE* is configured, $w = v_m$ associated with PMI codebook Table 7.2.4-1 and Table 7.2.4-2 for 8 antenna ports when higher layer parameter *eMIMO-Type* is not configured, $w = v_{l,m}$ associated with PMI codebook Table 7.2.4-10 and Table 7.2.4-11 for 8/12/16/20/24/28/32 antenna ports when higher layer parameter *eMIMO-Type* is configured, and where w is the column vector associated with the reported first PMI i_1 and the second PMI i_2 configured according to codebook subset restriction, and otherwise $W(i)$ is the selected precoding matrix corresponding to the reported CQI applicable to $x(i)$. The corresponding PDSCH signals transmitted on antenna ports $\{15 \dots 14 + P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in subclause 7.2.5,

otherwise,

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(v-1)}(i) \end{bmatrix},$$

where $x(i) = [x^{(0)}(i) \dots x^{(v-1)}(i)]^T$ is a vector of symbols from the layer mapping in Subclause 6.3.3.2 of [3], $P \in \{1, 2, 4, 8, 12, 16, 20, 24, 28, 32\}$ is the number of CSI-RS ports configured, and if only one CSI-RS port is configured, $W(i)$ is 1, otherwise for UE configured for PMI/RI reporting $W(i)$ is the precoding matrix corresponding to the reported PMI applicable to $x(i)$ and for UE configured without PMI reporting $W(i)$ is the selected precoding matrix corresponding to the reported CQI applicable to $x(i)$. The corresponding PDSCH signals transmitted on antenna ports $\{15 \dots 14 + P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in Subclause 7.2.5.

- For transmission mode 10 CSI reporting, if a CSI process is configured without PMI/RI reporting:
 - If the number of antenna ports of the associated CSI-RS resource is one, a PDSCH transmission is on single-antenna port, port 7. The channel on antenna port {7} is inferred from the channel on antenna port {15} of the associated CSI-RS resource.
 - CRS REs are as in non-MBSFN subframes. The CRS overhead is assumed to be the same as the CRS overhead corresponding to the number of CRS antenna ports of the serving cell;
 - The UE-specific reference signal overhead is 12 REs per PRB pair.

- Otherwise,
 - If the number of antenna ports of the associated CSI-RS resource is 2, the PDSCH transmission scheme assumes the transmit diversity scheme defined in Subclause 7.1.2 on antenna ports {0,1} except that the channels on antenna ports {0,1} are inferred from the channels on antenna port {15, 16} of the associated CSI resource respectively.
 - If the number of antenna ports of the associated CSI-RS resource is 4, the PDSCH transmission scheme assumes the transmit diversity scheme defined in Subclause 7.1.2 on antenna ports {0,1,2,3} except that the channels on antenna ports {0,1,2,3} are inferred from the channels on antenna ports {15, 16, 17, 18} of the associated CSI-RS resource respectively.
 - The UE is not expected to be configured with more than 4 antenna ports for the CSI-RS resource associated with the CSI process configured without PMI/RI reporting.
 - The overhead of CRS REs is assuming the same number of antenna ports as that of the associated CSI-RS resource.
 - UE-specific reference signal overhead is zero.
- For transmission mode 10 CSI reporting, if a CSI process is configured with PMI/RI reporting or without PMI reporting:
 - CRS REs are as in non-MBSFN subframes. The CRS overhead is assumed to be the same as the CRS overhead corresponding to the number of CRS antenna ports of the serving cell;
 - The UE-specific reference signal overhead is consistent with the most recent reported rank for the CSI process if more than one CSI-RS port is configured, and is consistent with rank 1 transmission if only one CSI-RS port is configured; and PDSCH signals on antenna ports {7...6+v} for v layers would result in signals equivalent to corresponding symbols transmitted on antenna ports {15...14+P}, as given by,

if the UE is configured with higher layer parameter *semiOpenLoop* and not configured with higher layer parameter *FeCoMPCSIEnabled*,

$$\begin{bmatrix} y^{(15)}(2i) \\ \vdots \\ y^{(14+P)}(2i) \\ y^{(15)}(2i+1) \\ \vdots \\ y^{(14+P)}(2i+1) \end{bmatrix} = \begin{bmatrix} W(i) & 0 \\ 0 & W(i) \end{bmatrix} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \operatorname{Re}(x^{(0)}(i)) \\ \operatorname{Re}(x^{(1)}(i)) \\ \operatorname{Im}(x^{(0)}(i)) \\ \operatorname{Im}(x^{(1)}(i)) \end{bmatrix} \quad \text{for } v=1$$

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = \frac{1}{\sqrt{2}} W(i) \begin{bmatrix} 1 & 1 \\ \phi_i & -\phi_i \end{bmatrix} \begin{bmatrix} x^{(0)}(i) \\ x^{(1)}(i) \end{bmatrix}, \quad \phi_i = e^{j\pi(i \bmod 2)/2} \quad \text{for } v=2$$

where $x(i) = [x^{(0)}(i) \dots x^{(v-1)}(i)]^T$ is a vector of symbols from the layer mapping in subclause 6.3.3.2 of [3], $P \in \{2, 4, 8, 12, 16, 20, 24, 28, 32\}$ is the number of CSI-RS ports configured, and if UE reports a PMI,

$$W(i) = \frac{1}{\sqrt{P}} \begin{bmatrix} w & 0 \\ 0 & w \end{bmatrix} \quad \text{where } w = v_m \quad \text{associated with PMI codebook Table 7.2.4-0A and Table 7.2.4-0B}$$

for 4 antenna ports when *alternativeCodeBookEnabledFor4TX-r12=TRUE* is configured, $w = v_m$ associated with PMI codebook Table 7.2.4-1 and Table 7.2.4-2 for 8 antenna ports when higher layer parameter *eMIMO-Type* is not configured, $w = v_{l,m}$ associated with PMI codebook Table 7.2.4-10 and Table 7.2.4-11 for 8/12/16/20/24/28/32 antenna ports when higher layer parameter *eMIMO-Type* is configured, and where w is the column vector associated with the reported first PMI i_1 and the second PMI

i_2 configured according to codebook subset restriction, and otherwise $W(i)$ is the selected precoding matrix corresponding to the reported CQI applicable to $x(i)$. The corresponding PDSCH signals transmitted on antenna ports $\{15\dots14+P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in subclause 7.2.5,

otherwise if the UE is not configured with higher layer parameter *FeCoMPCSIEnabled* or the UE is configured with higher layer parameter *FeCoMPCSIEnabled* and UE reports *CRI* with value of 0 or 1,

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(v-1)}(i) \end{bmatrix},$$

where $x(i) = [x^{(0)}(i) \dots x^{(v-1)}(i)]^T$ is a vector of symbols from the layer mapping in Subclause 6.3.3.2 of [3], $P \in \{1,2,4,8,12,16,20,24,28,32\}$ is the number of antenna ports of the associated CSI-RS resource, and if $P=1$, $W(i)$ is 1, otherwise for UE configured for PMI/RI reporting $W(i)$ is the precoding matrix corresponding to the reported PMI applicable to $x(i)$ and for UE configured without PMI reporting $W(i)$ is the selected precoding matrix corresponding to the reported CQI applicable to $x(i)$. The corresponding PDSCH signals transmitted on antenna ports $\{15\dots14+P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in Subclause 7.2.5,

otherwise if the UE is configured with higher layer parameter *FeCoMPCSIEnabled* and UE reports *CRI*=2 then the PDSCH signals on antenna ports corresponding to V_k layers of codeword k would result in signals equivalent to corresponding symbols transmitted on antenna ports $\{15\dots14+P_k\}$ corresponding to the $(k+1)$ th CSI-RS resource, where $P_k \in \{1,2,4,8\}$ are the number of antenna ports for the $(k+1)$ th CSI-RS resource, as given by

$$\begin{bmatrix} y_k^{(15)}(i) \\ \vdots \\ y_k^{(14+P_k)}(i) \end{bmatrix} = W_k(i) \begin{bmatrix} x_k^{(0)}(i) \\ \vdots \\ x_k^{(v_k-1)}(i) \end{bmatrix}, k = 0,1$$

where $x_k(i) = [x^{(0)}(i) \dots x^{(v_k-1)}(i)]^T$ is a vector of symbols from the layer mapping in Subclause 6.3.3.2 of [3] for codeword $k=0, 1$ and where the CSI corresponding to a codeword is calculated based on the assumption that inter-codeword interference is derived from channel measurement obtained from the NZP CSI-RS resource and the precoding matrix corresponding to the other codeword. The corresponding PDSCH signals transmitted on antenna ports $\{15\dots14+P_k\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in Subclause 7.2.5 for the $(k+1)$ th CSI-RS resource. If $P_k=1$, then $W_k(i)$ is 1 otherwise for UE configured for PMI/RI reporting $W_k(i)$ is the precoding matrix corresponding to the reported PMI applicable to $x_k(i)$ and for UE configured without PMI reporting $W_k(i)$ is the selected precoding matrix corresponding to the reported CQI applicable to $x_k(i)$.

- Assume no REs allocated for CSI-RS and zero-power CSI-RS
- Assume no REs allocated for PRS
 - The PDSCH transmission scheme given by Table 7.2.3-0 depending on the transmission mode currently configured for the UE (which may be the default mode).
 - If CRS is used for channel measurements, the ratio of PDSCH EPRE to cell-specific RS EPRE is as given in Subclause 5.2 with the exception of ρ_A which shall be assumed to be

- $\rho_A = P_A + \Delta_{offset} + 10 \log_{10}(2)$ [dB] for any modulation scheme, if the UE is configured with transmission mode 2 with 4 cell-specific antenna ports, or transmission mode 3 with 4 cell-specific antenna ports and the associated RI is equal to one;
- $\rho_A = P_A + \Delta_{offset}$ [dB] for any modulation scheme and any number of layers, otherwise.

The shift Δ_{offset} is given by the parameter *nomPDSCH-RS-EPRE-Offset* which is configured by higher-layer signalling.

When the CSI request field from an uplink DCI format 7-0A/7-0B is set to trigger a report, the UE shall assume the number of available REs assumed for the reference resource for the purpose of deriving the CQI index, and if also configured, PMI and RI is:

- half of the number of available REs assumed for the reference resource when the CSI request field from an uplink DCI format other than 7-0A/7-0B is set to trigger a report if the UE is configured for slot-based uplink transmissions,
- one sixth of the number of available REs assumed for the reference resource when the CSI request field from an uplink DCI format other than 7-0A/7-0B is set to trigger a report if the UE is configured for subslot-based uplink transmissions

Table 7.2.3-0: PDSCH transmission scheme assumed for CSI reference resource

| Transmission mode | Transmission scheme of PDSCH |
|--------------------------|---|
| 1 | Single-antenna port, port 0 |
| 2 | Transmit diversity |
| 3 | Transmit diversity if the associated rank indicator is 1, otherwise large delay CDD |
| 4 | Closed-loop spatial multiplexing |
| 5 | Multi-user MIMO |
| 6 | Closed-loop spatial multiplexing with a single transmission layer |
| 7 | If the number of PBCH antenna ports is one, Single-antenna port, port 0; otherwise Transmit diversity |
| 8 | If the UE is configured without PMI/RI reporting: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise transmit diversity. If the UE is configured with PMI/RI reporting: closed-loop spatial multiplexing. |
| 9 | For activated serving cells, and a non-BL/CE UE, if the UE is configured without PMI/RI reporting: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise transmit diversity. For activated serving cells, and a non-BL/CE UE, if the UE is configured with PMI/RI reporting or without PMI reporting: if the number of CSI-RS ports is one, single-antenna port, port 7; otherwise up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B). For activated serving cells, and a BL/CE UE, if the UE is not configured with periodic CSI reporting mode 1-1: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise transmit diversity. For activated serving cells, and a BL/CE UE, if the UE is configured with periodic CSI reporting mode 1-1: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise closed-loop spatial multiplexing with a single transmission layer. For dormant serving cells: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise transmit diversity. |
| 10 | For activated serving cells, if a CSI process of the UE is configured without PMI/RI reporting: if the number of CSI-RS ports is one, single-antenna port, port 7; otherwise transmit diversity. For activated serving cells, and if a CSI process of the UE is configured with PMI/RI reporting or without PMI reporting: if the number of CSI-RS ports is one, single-antenna port, port 7; otherwise up to 8 layer transmission, ports 7-14 (see Subclause 7.1.5B). For dormant serving cells: if the number of PBCH antenna ports is one, single-antenna port, port 0; otherwise transmit diversity. |

Table 7.2.3-1: 4-bit CQI Table

| CQI index | modulation | code rate x 1024 | efficiency |
|------------------|-------------------|-------------------------|-------------------|
| 0 | | out of range | |
| 1 | QPSK | 78 | 0.1523 |
| 2 | QPSK | 120 | 0.2344 |
| 3 | QPSK | 193 | 0.3770 |
| 4 | QPSK | 308 | 0.6016 |
| 5 | QPSK | 449 | 0.8770 |
| 6 | QPSK | 602 | 1.1758 |
| 7 | 16QAM | 378 | 1.4766 |
| 8 | 16QAM | 490 | 1.9141 |
| 9 | 16QAM | 616 | 2.4063 |
| 10 | 64QAM | 466 | 2.7305 |
| 11 | 64QAM | 567 | 3.3223 |
| 12 | 64QAM | 666 | 3.9023 |
| 13 | 64QAM | 772 | 4.5234 |
| 14 | 64QAM | 873 | 5.1152 |
| 15 | 64QAM | 948 | 5.5547 |

Table 7.2.3-2: 4-bit CQI Table 2

| CQI index | modulation | code rate x 1024 | efficiency |
|-----------|--------------|------------------|------------|
| 0 | out of range | | |
| 1 | QPSK | 78 | 0.1523 |
| 2 | QPSK | 193 | 0.3770 |
| 3 | QPSK | 449 | 0.8770 |
| 4 | 16QAM | 378 | 1.4766 |
| 5 | 16QAM | 490 | 1.9141 |
| 6 | 16QAM | 616 | 2.4063 |
| 7 | 64QAM | 466 | 2.7305 |
| 8 | 64QAM | 567 | 3.3223 |
| 9 | 64QAM | 666 | 3.9023 |
| 10 | 64QAM | 772 | 4.5234 |
| 11 | 64QAM | 873 | 5.1152 |
| 12 | 256QAM | 711 | 5.5547 |
| 13 | 256QAM | 797 | 6.2266 |
| 14 | 256QAM | 885 | 6.9141 |
| 15 | 256QAM | 948 | 7.4063 |

Table 7.2.3-3: 4-bit CQI Table 3

| CQI index | modulation | code rate x 1024 x R^{CSI} | efficiency x R^{CSI} |
|-----------|--------------|--|----------------------------------|
| 0 | out of range | | |
| 1 | QPSK | 40 | 0.0781 |
| 2 | QPSK | 78 | 0.1523 |
| 3 | QPSK | 120 | 0.2344 |
| 4 | QPSK | 193 | 0.3770 |
| 5 | QPSK | 308 | 0.6016 |
| 6 | QPSK | 449 | 0.8770 |
| 7 | QPSK | 602 | 1.1758 |
| 8 | 16QAM | 378 | 1.4766 |
| 9 | 16QAM | 490 | 1.9141 |
| 10 | 16QAM | 616 | 2.4063 |
| 11 | Reserved | Reserved | Reserved |
| 12 | Reserved | Reserved | Reserved |
| 13 | Reserved | Reserved | Reserved |
| 14 | Reserved | Reserved | Reserved |
| 15 | Reserved | Reserved | Reserved |

Table 7.2.3-4: 4-bit CQI Table 4

| CQI index | modulation | code rate x 1024 | Efficiency |
|-----------|--------------|------------------|------------|
| 0 | out of range | | |
| 1 | QPSK | 78 | 0.1523 |
| 2 | QPSK | 193 | 0.3770 |
| 3 | QPSK | 449 | 0.8770 |
| 4 | 16QAM | 378 | 1.4766 |
| 5 | 16QAM | 616 | 2.4063 |
| 6 | 64QAM | 567 | 3.3223 |
| 7 | 64QAM | 666 | 3.9023 |
| 8 | 64QAM | 772 | 4.5234 |
| 9 | 64QAM | 873 | 5.1152 |
| 10 | 256QAM | 711 | 5.5547 |
| 11 | 256QAM | 797 | 6.2266 |
| 12 | 256QAM | 885 | 6.9141 |
| 13 | 256QAM | 948 | 7.4063 |
| 14 | 1024QAM | 853 | 8.3321 |
| 15 | 1024QAM | 948 | 9.2578 |

Table 7.2.3-5: 4-bit CQI Table 5

| CQI index | modulation | code rate x 1024 | efficiency |
|-----------|--------------|------------------|------------|
| 0 | out of range | | |
| 1 | QPSK | 40 | 0.0781 |
| 2 | QPSK | 78 | 0.1523 |
| 3 | QPSK | 120 | 0.2344 |
| 4 | QPSK | 193 | 0.3770 |
| 5 | QPSK | 308 | 0.6016 |
| 6 | QPSK | 449 | 0.8770 |
| 7 | QPSK | 602 | 1.1758 |
| 8 | 16QAM | 378 | 1.4766 |
| 9 | 16QAM | 490 | 1.9141 |
| 10 | 16QAM | 616 | 2.4063 |
| 11 | 64QAM | 466 | 2.7305 |
| 12 | 64QAM | 567 | 3.3223 |
| 13 | 64QAM | 666 | 3.9023 |
| 14 | 64QAM | 772 | 4.5234 |
| 15 | 64QAM | 873 | 5.1152 |

Table 7.2.3-6: 4-bit CQI Table 6

| CQI index | modulation | code rate x 1024 | repetition |
|-----------|--------------|------------------|------------|
| 0 | out of range | | |
| 1 | QPSK | 56 | 32 |
| 2 | QPSK | 207 | 16 |
| 3 | QPSK | 266 | 4 |
| 4 | QPSK | 195 | 2 |
| 5 | QPSK | 142 | 1 |
| 6 | QPSK | 266 | 1 |
| 7 | QPSK | 453 | 1 |
| 8 | QPSK | 637 | 1 |
| 9 | 16QAM | 423 | 1 |
| 10 | 16QAM | 557 | 1 |
| 11 | 16QAM | 696 | 1 |
| 12 | 16QAM | 845 | 1 |
| 13 | 64QAM | 651 | 1 |
| 14 | 64QAM | 780 | 1 |
| 15 | 64QAM | 888 | 1 |

7.2.4 Precoding Matrix Indicator (PMI) definition

For transmission modes 4, 5 and 6, precoding feedback is used for channel dependent codebook based precoding and relies on UEs reporting precoding matrix indicator (PMI). For transmission mode 8, the UE shall report PMI if configured with PMI/RI reporting. For transmission modes 9 and 10, the non-BL/CE UE shall report PMI if configured with PMI/RI reporting and the number of CSI-RS ports is larger than 1. For transmission modes 9, the BL/CE UE shall report PMI based on CRS. A UE shall report PMI based on the feedback modes described in 7.2.1 and 7.2.2. For other transmission modes, PMI reporting is not supported.

For 2 antenna ports, except with,

- UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*, or
- UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*,

each PMI value corresponds to a codebook index given in Table 6.3.4.2.3-1 of [3] as follows:

- For 2 antenna ports $\{0,1\}$ or $\{15,16\}$ and an associated RI value of 1, a PMI value of $n \in \{0,1,2,3\}$ corresponds to the codebook index \mathcal{N} given in Table 6.3.4.2.3-1 of [3] with $v = 1$.
- For 2 antenna ports $\{0,1\}$ or $\{15,16\}$ and an associated RI value of 2, a PMI value of $n \in \{0,1\}$ corresponds to the codebook index $n+1$ given in Table 6.3.4.2.3-1 of [3] with $v = 2$.
- For 2 antenna ports $\{15,16\}$, UE shall only use the precoding matrix corresponding to codebook index 0 in Table 6.3.4.2.3-1 of [3] with $v = 2$ and shall not report a PMI value if the UE is configured with higher layer parameter *semiOpenLoop=TRUE*.

For 4 antenna ports $\{0,1,2,3\}$ or $\{15,16,17,18\}$, except with,

- UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or
- UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE*, or
- UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and $v \leq 2$ with v equal to the associated RI value,

each PMI value corresponds to a codebook index given in Table 6.3.4.2.3-2 of [3] or a pair of codebook indices given in Table 7.2.4-0A, 7.2.4-0B, 7.2.4-0C, or 7.2.4-0D as follows:

- A PMI value of $n \in \{0,1,\dots,15\}$ corresponds to the codebook index \mathcal{N} given in Table 6.3.4.2.3-2 of [3] with v equal to the associated RI value except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured.
- If higher layer parameter *semiOpenLoop=TRUE* configured except with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, UE shall not report a PMI value and shall use the precoding matrix for REs of j^{th} PRB pair according to $W(j) = C_k$, where k is the precoder index given by $k = (j \bmod 4) + 1 \in \{1,2,3,4\}$ and C_1, C_2, C_3, C_4 denote precoder matrices corresponding to precoder indices 12,13,14 and 15, respectively, in Table 6.3.4.2.3-2 of [3] with $v = 2$.
- If *alternativeCodeBookEnabledFor4TX-r12=TRUE* is configured, each PMI value corresponds to a pair of codebook indices given in Table 7.2.4-0A, 7.2.4-0B, 7.2.4-0C, or 7.2.4-0D, where the quantities φ_n , φ'_n and v'_m in Table 7.2.4-0A and Table 7.2.4-0B are given by

$$\begin{aligned}\varphi_n &= e^{j\pi n/2} \\ \varphi'_n &= e^{j2\pi n/32} \\ v'_m &= [1 \quad e^{j2\pi m/32}]^T\end{aligned}$$

- A first PMI value of $i_1 \in \{0, 1, \dots, f(\nu) - 1\}$ and a second PMI value of $i_2 \in \{0, 1, \dots, g(\nu) - 1\}$ correspond to the codebook indices i_1 and i_2 respectively given in Table 7.2.4-0j with ν equal to the associated RI value and where $j = \{\text{A,B,C,D}\}$ respectively when $\nu = \{1, 2, 3, 4\}$, $f(\nu) = \{16, 16, 1, 1\}$ and $g(\nu) = \{16, 16, 16, 16\}$.
- The quantity $W_n^{\{s\}}$ in Table 7.2.4-0C and Table 7.2.4-0D denotes the matrix defined by the columns given by the set $\{s\}$ from the expression $W_n = I - 2u_n u_n^H / u_n^H u_n$ where I is the 4×4 identity matrix and the vector u_n is given by Table 6.3.4.2.3-2 in [3] and $n = i_2$.
- In some cases codebook subsampling is supported. The sub-sampled codebook for PUCCH mode 1-1 submode 2 is defined in Table 7.2.2-1G for first and second precoding matrix indicators i_1 and i_2 . Joint encoding of rank and first precoding matrix indicator i_1 for PUCCH mode 1-1 submode 1 is defined in Table 7.2.2-1H. The sub-sampled codebook for PUCCH mode 2-1 is defined in Table 7.2.2-1I for PUCCH Reporting Type 1a.
- UE shall only use the value of i_2 according to the configured codebook subset restriction, where the UE is expected to be configured with a single value of i_2 in $\{0, 1, 2, \dots, 15\}$ for 1 layer and in $\{0, 1, 2, \dots, 7\}$ for 2 layers, and shall not report i_2 if the UE is configured with higher layer parameter $semiOpenLoop=TRUE$.

Table 7.2.4-0A: Codebook for 1-layer CSI reporting using antenna ports 0 to 3 or 15 to 18

| i_1 | i_2 | | | | | | | |
|---|----------------------|-----------------------|-----------------------|-----------------------|----------------------|-----------------------|-----------------------|-----------------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 – 15 | $W_{i_1,0}^{(1)}$ | $W_{i_1,8}^{(1)}$ | $W_{i_1,16}^{(1)}$ | $W_{i_1,24}^{(1)}$ | $W_{i_1+8,2}^{(1)}$ | $W_{i_1+8,10}^{(1)}$ | $W_{i_1+8,18}^{(1)}$ | $W_{i_1+8,26}^{(1)}$ |
| i_1 | i_2 | | | | | | | |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 – 15 | $W_{i_1+16,4}^{(1)}$ | $W_{i_1+16,12}^{(1)}$ | $W_{i_1+16,20}^{(1)}$ | $W_{i_1+16,28}^{(1)}$ | $W_{i_1+24,6}^{(1)}$ | $W_{i_1+24,14}^{(1)}$ | $W_{i_1+24,22}^{(1)}$ | $W_{i_1+24,30}^{(1)}$ |
| where $W_{m,n}^{(1)} = \frac{1}{2} \begin{bmatrix} v'_m \\ \varphi'_n v'_m \end{bmatrix}$ | | | | | | | | |

Table 7.2.4-0B: Codebook for 2-layer CSI reporting using antenna ports 0 to 3 or 15 to 18

| i_1 | i_2 | | | |
|--------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | 0 | 1 | 2 | 3 |
| 0 – 15 | $W_{i_1,i_1,0}^{(2)}$ | $W_{i_1,i_1,1}^{(2)}$ | $W_{i_1+8,i_1+8,0}^{(2)}$ | $W_{i_1+8,i_1+8,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| 0 – 15 | $W_{i_1+16,i_1+16,0}^{(2)}$ | $W_{i_1+16,i_1+16,1}^{(2)}$ | $W_{i_1+24,i_1+24,0}^{(2)}$ | $W_{i_1+24,i_1+24,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| 0 – 15 | $W_{i_1,i_1+8,0}^{(2)}$ | $W_{i_1,i_1+8,1}^{(2)}$ | $W_{i_1+8,i_1+16,0}^{(2)}$ | $W_{i_1+8,i_1+16,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 12 | 13 | 14 | 15 |

| $0 - 15$ | $W_{i_1, i_1+24, 0}^{(2)}$ | $W_{i_1, i_1+24, 1}^{(2)}$ | $W_{i_1+8, i_1+24, 0}^{(2)}$ | $W_{i_1+8, i_1+24, 1}^{(2)}$ |
|---|----------------------------|----------------------------|------------------------------|------------------------------|
| where $W_{m, m', n}^{(2)} = \frac{1}{\sqrt{8}} \begin{bmatrix} v_m' & v_{m'}' \\ \varphi_n v_m' & -\varphi_n v_{m'}' \end{bmatrix}$ | | | | |

Table 7.2.4-0C: Codebook for 3-layer CSI reporting using antenna ports 15 to 18

| i_1 | i_2 | | | | | | | |
|-------|----------------------------|----------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | $W_0^{\{124\}} / \sqrt{3}$ | $W_1^{\{123\}} / \sqrt{3}$ | $W_2^{\{123\}} / \sqrt{3}$ | $W_3^{\{123\}} / \sqrt{3}$ | $W_4^{\{124\}} / \sqrt{3}$ | $W_5^{\{124\}} / \sqrt{3}$ | $W_6^{\{134\}} / \sqrt{3}$ | $W_7^{\{134\}} / \sqrt{3}$ |
| i_1 | i_2 | | | | | | | |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | $W_8^{\{124\}} / \sqrt{3}$ | $W_9^{\{134\}} / \sqrt{3}$ | $W_{10}^{\{123\}} / \sqrt{3}$ | $W_{11}^{\{134\}} / \sqrt{3}$ | $W_{12}^{\{123\}} / \sqrt{3}$ | $W_{13}^{\{123\}} / \sqrt{3}$ | $W_{14}^{\{123\}} / \sqrt{3}$ | $W_{15}^{\{123\}} / \sqrt{3}$ |

Table 7.2.4-0D: Codebook for 4-layer CSI reporting using antenna ports 15 to 18

| i_1 | i_2 | | | | | | | |
|-------|----------------------|----------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | $W_0^{\{1234\}} / 2$ | $W_1^{\{1234\}} / 2$ | $W_2^{\{3214\}} / 2$ | $W_3^{\{3214\}} / 2$ | $W_4^{\{1234\}} / 2$ | $W_5^{\{1234\}} / 2$ | $W_6^{\{1324\}} / 2$ | $W_7^{\{1324\}} / 2$ |
| i_1 | i_2 | | | | | | | |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | $W_8^{\{1234\}} / 2$ | $W_9^{\{1234\}} / 2$ | $W_{10}^{\{1324\}} / 2$ | $W_{11}^{\{1324\}} / 2$ | $W_{12}^{\{1234\}} / 2$ | $W_{13}^{\{1324\}} / 2$ | $W_{14}^{\{3214\}} / 2$ | $W_{15}^{\{1234\}} / 2$ |

For a non-BL/CE UE, the UE is not expected to receive the configuration of *alternativeCodeBookEnabledFor4TX-r12* except for transmission mode 8 configured with 4 CRS ports, and transmission modes 9 and 10 configured with 4 CSI-RS ports. For a UE configured in transmission mode 10, the parameter *alternativeCodeBookEnabledFor4TX-r12* may be configured for each CSI process.

For a BL/CE UE, the UE is not expected to receive the configuration of *alternativeCodeBookEnabledFor4TX-r12*.

For 8 antenna ports, except with,

- UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', or
- UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or
- UE is configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_K1=TRUE* configured, or
- UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and $v \leq 2$ with v equal to the associated RI value,

each PMI value corresponds to a pair of codebook indices given in Table 7.2.4-1, 7.2.4-2, 7.2.4-3, 7.2.4-4, 7.2.4-5, 7.2.4-6, 7.2.4-7, or 7.2.4-8, where the quantities φ_n and v_m are given by

$$\varphi_n = e^{j\pi n/2}$$

$$v_m = [1 \quad e^{j2\pi n/32} \quad e^{j4\pi n/32} \quad e^{j6\pi n/32}]^\top$$

- as follows: For 8 antenna ports $\{15, 16, 17, 18, 19, 20, 21, 22\}$, a first PMI value of $i_1 \in \{0, 1, \dots, f(v)-1\}$ and a second PMI value of $i_2 \in \{0, 1, \dots, g(v)-1\}$ corresponds to the codebook indices i_1 and i_2 given in

Table 7.2.4-j with v equal to the associated RI value and where $j = v$, $f(v) = \{16, 16, 4, 4, 4, 4, 4, 1\}$ and $g(v) = \{16, 16, 16, 8, 1, 1, 1, 1\}$.

- In some cases codebook subsampling is supported. The sub-sampled codebook for PUCCH mode 1-1 submode 2 is defined in Table 7.2.2-1D for first and second precoding matrix indicator i_1 and i_2 . Joint encoding of rank and first precoding matrix indicator i_1 for PUCCH mode 1-1 submode 1 is defined in Table 7.2.2-1E. The sub-sampled codebook for PUCCH mode 2-1 is defined in Table 7.2.2-1F for PUCCH Reporting Type 1a.
- UE shall only use the value of i_2 according to the configured codebook subset restriction, where the UE is expected to be configured with a single value of i_2 in $\{0, 1, 2, \dots, 15\}$ for 1 layer and in $\{0, 1, 2, \dots, 7\}$ for 2 layers, and shall not report i_2 if the UE is configured with higher layer parameter $semiOpenLoop=TRUE$.

Table 7.2.4-1: Codebook for 1-layer CSI reporting using antenna ports 15 to 22

| i_1 | i_2 | | | | | | | |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 - 15 | $W_{2i_1,0}^{(1)}$ | $W_{2i_1,1}^{(1)}$ | $W_{2i_1,2}^{(1)}$ | $W_{2i_1,3}^{(1)}$ | $W_{2i_1+1,0}^{(1)}$ | $W_{2i_1+1,1}^{(1)}$ | $W_{2i_1+1,2}^{(1)}$ | $W_{2i_1+1,3}^{(1)}$ |
| i_1 | i_2 | | | | | | | |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 - 15 | $W_{2i_1+2,0}^{(1)}$ | $W_{2i_1+2,1}^{(1)}$ | $W_{2i_1+2,2}^{(1)}$ | $W_{2i_1+2,3}^{(1)}$ | $W_{2i_1+3,0}^{(1)}$ | $W_{2i_1+3,1}^{(1)}$ | $W_{2i_1+3,2}^{(1)}$ | $W_{2i_1+3,3}^{(1)}$ |
| where $W_{m,n}^{(1)} = \frac{1}{\sqrt{8}} \begin{bmatrix} v_m \\ \varphi_n v_m \end{bmatrix}$ | | | | | | | | |

Table 7.2.4-2: Codebook for 2-layer CSI reporting using antenna ports 15 to 22

| i_1 | i_2 | | | |
|--|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| | 0 | 1 | 2 | 3 |
| 0 - 15 | $W_{2i_1,2i_1,0}^{(2)}$ | $W_{2i_1,2i_1,1}^{(2)}$ | $W_{2i_1+1,2i_1+1,0}^{(2)}$ | $W_{2i_1+1,2i_1+1,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| 0 - 15 | $W_{2i_1+2,2i_1+2,0}^{(2)}$ | $W_{2i_1+2,2i_1+2,1}^{(2)}$ | $W_{2i_1+3,2i_1+3,0}^{(2)}$ | $W_{2i_1+3,2i_1+3,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| 0 - 15 | $W_{2i_1,2i_1+1,0}^{(2)}$ | $W_{2i_1,2i_1+1,1}^{(2)}$ | $W_{2i_1+1,2i_1+2,0}^{(2)}$ | $W_{2i_1+1,2i_1+2,1}^{(2)}$ |
| i_1 | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| 0 - 15 | $W_{2i_1,2i_1+3,0}^{(2)}$ | $W_{2i_1,2i_1+3,1}^{(2)}$ | $W_{2i_1+1,2i_1+3,0}^{(2)}$ | $W_{2i_1+1,2i_1+3,1}^{(2)}$ |
| where $W_{m,m',n}^{(2)} = \frac{1}{4} \begin{bmatrix} v_m & v_{m'} \\ \varphi_n v_m & -\varphi_n v_{m'} \end{bmatrix}$ | | | | |

Table 7.2.4-3: Codebook for 3-layer CSI reporting using antenna ports 15 to 22

| i_1 | i_2 | | | |
|--|-------------------------------------|--------------------------------------|--|---|
| | 0 | 1 | 2 | 3 |
| 0 - 3 | $W_{8i_1, 8i_1+8}^{(3)}$ | $W_{8i_1+8, 8i_1+8}^{(3)}$ | $\tilde{W}_{8i_1, 8i_1+8, 8i_1+8}^{(3)}$ | $\tilde{W}_{8i_1+8, 8i_1, 8i_1}^{(3)}$ |
| i_1 | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| 0 - 3 | $W_{8i_1+2, 8i_1+2, 8i_1+10}^{(3)}$ | $W_{8i_1+10, 8i_1+2, 8i_1+10}^{(3)}$ | $\tilde{W}_{8i_1+2, 8i_1+10, 8i_1+10}^{(3)}$ | $\tilde{W}_{8i_1+10, 8i_1+2, 8i_1+2}^{(3)}$ |
| i_1 | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| 0 - 3 | $W_{8i_1+4, 8i_1+4, 8i_1+12}^{(3)}$ | $W_{8i_1+12, 8i_1+4, 8i_1+12}^{(3)}$ | $\tilde{W}_{8i_1+4, 8i_1+12, 8i_1+12}^{(3)}$ | $\tilde{W}_{8i_1+12, 8i_1+4, 8i_1+4}^{(3)}$ |
| i_1 | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| 0 - 3 | $W_{8i_1+6, 8i_1+6, 8i_1+14}^{(3)}$ | $W_{8i_1+14, 8i_1+6, 8i_1+14}^{(3)}$ | $\tilde{W}_{8i_1+6, 8i_1+14, 8i_1+14}^{(3)}$ | $\tilde{W}_{8i_1+14, 8i_1+6, 8i_1+6}^{(3)}$ |
| where $W_{m,m',m''}^{(3)} = \frac{1}{\sqrt{24}} \begin{bmatrix} v_m & v_{m'} & v_{m''} \\ v_m & -v_{m'} & -v_{m''} \end{bmatrix}$, $\tilde{W}_{m,m',m''}^{(3)} = \frac{1}{\sqrt{24}} \begin{bmatrix} v_m & v_{m'} & v_{m''} \\ v_m & v_{m'} & -v_{m''} \end{bmatrix}$ | | | | |

Table 7.2.4-4: Codebook for 4-layer CSI reporting using antenna ports 15 to 22

| i_1 | i_2 | | | |
|---|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| | 0 | 1 | 2 | 3 |
| 0 - 3 | $W_{8i_1, 8i_1+8, 0}^{(4)}$ | $W_{8i_1, 8i_1+8, 1}^{(4)}$ | $W_{8i_1+2, 8i_1+10, 0}^{(4)}$ | $W_{8i_1+2, 8i_1+10, 1}^{(4)}$ |
| i_1 | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| 0 - 3 | $W_{8i_1+4, 8i_1+12, 0}^{(4)}$ | $W_{8i_1+4, 8i_1+12, 1}^{(4)}$ | $W_{8i_1+6, 8i_1+14, 0}^{(4)}$ | $W_{8i_1+6, 8i_1+14, 1}^{(4)}$ |
| where $W_{m,m',n}^{(4)} = \frac{1}{\sqrt{32}} \begin{bmatrix} v_m & v_{m'} & v_m & v_{m'} \\ \varphi_n v_m & \varphi_n v_{m'} & -\varphi_n v_m & -\varphi_n v_{m'} \end{bmatrix}$ | | | | |

Table 7.2.4-5: Codebook for 5-layer CSI reporting using antenna ports 15 to 22.

| i_1 | i_2 | | | | |
|-------|--|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 |
| 0 - 3 | $W_{i_1}^{(5)} = \frac{1}{\sqrt{40}} \begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} \end{bmatrix}$ | | | | |

Table 7.2.4-6: Codebook for 6-layer CSI reporting using antenna ports 15 to 22.

| i_1 | i_2 | | | | | |
|-------|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 |
| 0 - 3 | $W_{i_1}^{(6)} = \frac{1}{\sqrt{48}} \begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} & v_{2i_1+16} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} & -v_{2i_1+16} \end{bmatrix}$ | | | | | |

Table 7.2.4-7: Codebook for 7-layer CSI reporting using antenna ports 15 to 22.

| i_1 | i_2 | | | | | | |
|-------|---|--|--|--|--|--|--|
| | 0 | | | | | | |
| 0 - 3 | $W_{i_1}^{(7)} = \frac{1}{\sqrt{56}} \begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} & v_{2i_1+16} & v_{2i_1+24} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} & -v_{2i_1+16} & v_{2i_1+24} \end{bmatrix}$ | | | | | | |

Table 7.2.4-8: Codebook for 8-layer CSI reporting using antenna ports 15 to 22.

| i_1 | i_2 | | | | | | | |
|-------|--|--|--|--|--|--|--|--|
| | 0 | | | | | | | |
| 0 | $W_{i_1}^{(8)} = \frac{1}{8} \begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} & v_{2i_1+16} & v_{2i_1+24} & v_{2i_1+24} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} & -v_{2i_1+16} & v_{2i_1+24} & -v_{2i_1+24} \end{bmatrix}$ | | | | | | | |

For 8 antenna ports $\{15,16,17,18,19,20,21,22\}$, 12 antenna ports $\{15,16,17,18,19,20,21,22,23,24,25,26\}$, 16 antenna ports $\{15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30\}$, 20 antenna ports $\{15,16,17,\dots,34\}$, 24 antenna ports $\{15,16,17,\dots,38\}$, 28 antenna ports $\{15,16,17,\dots,42\}$, 32 antenna ports $\{15,16,17,\dots,46\}$, and UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', except with UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and $v \leq 2$ with V equal to the associated RI value, each PMI value corresponds to three codebook indices given in Table 7.2.4-10, 7.2.4-11, 7.2.4-12, 7.2.4-13, 7.2.4-14, 7.2.4-15, 7.2.4-16, or 7.2.4-17, where the quantities φ_n , u_m and $v_{l,m}$ are given by

$$\varphi_n = e^{j\pi n/2}$$

$$u_m = \begin{bmatrix} 1 & e^{j\frac{2\pi m}{O_2 N_2}} & \dots & e^{j\frac{2\pi m(N_2-1)}{O_2 N_2}} \end{bmatrix}$$

$$v_{l,m} = \begin{bmatrix} u_m & e^{j\frac{2\pi l}{O_1 N_1} u_m} & \dots & e^{j\frac{2\pi l(N_1-1)}{O_1 N_1} u_m} \end{bmatrix}^T$$

- The values of N_1 , N_2 , O_1 , and O_2 are configured with the higher-layer parameter *codebookConfig-N1*, *codebookConfig-N2*, *codebook-Over-Sampling-RateConfig-O1*, and *codebook-Over-Sampling-RateConfig-O2*, respectively. The supported configurations of (O_1, O_2) and (N_1, N_2) for a given number of CSI-RS ports are given in Table 7.2.4-9. The number of CSI-RS ports, P , is $2N_1N_2$.
- UE is not expected to be configured with value of *codebookConfig* set to 2 or 3, if the value of *codebookConfigN2* is set to 1.
- UE shall only use $i_{1,2} = 0$ and shall not report $i_{1,2}$ if the value of *codebookConfig-N2* is set to 1.
- A first PMI value i_1 corresponds to the codebook indices pair $\{i_{1,1}, i_{1,2}\}$, and a second PMI value i_2 corresponds to the codebook index i_2 given in Table 7.2.4- j with v equal to the associated RI value and where $j = v + 9$.
- In some cases codebook subsampling is supported. The sub-sampled codebook for PUCCH mode 2-1 for value of parameter *codebookConfig* set to 2, 3, or 4 is defined in Table 7.2.2-1F for PUCCH Reporting Type 1a.
- UE shall only use the value of i_2 according to the configured codebook subset restriction, where the UE is expected to be configured with a single value of i_2 in $\{0,1,2,\dots,15\}$ for 1 layer and in $\{0,1,2,\dots,7\}$ for 2 layers, and shall not report i_2 if the UE is configured with higher layer parameter *semiOpenLoop=TRUE*

Table 7.2.4-9: Supported configurations of (O_1, O_2) and (N_1, N_2)

| Number of CSI-RS antenna ports, P | (N_1, N_2) | (O_1, O_2) |
|---|--------------|--------------|
| 8 | (2,2) | (4,4), (8,8) |
| 12 | (2,3) | (8,4), (8,8) |
| | (3,2) | (8,4), (4,4) |
| | (2,4) | (8,4), (8,8) |
| 16 | (4,2) | (8,4), (4,4) |
| | (8,1) | (4,-), (8,-) |
| | (2,5) | (8,4) |
| 20 | (5,2) | (4,4) |
| | (10,1) | (4,-) |
| | (2,6) | (8,4) |
| 24 | (3,4) | (8,4) |
| | (4,3) | (4,4) |
| | (6,2) | (4,4) |
| | (12,1) | (4,-) |
| | (2,7) | (8,4) |
| 28 | (7,2) | (4,4) |
| | (14,1) | (4,-) |
| | (2,8) | (8,4) |
| 32 | (4,4) | (8,4) |
| | (8,2) | (4,4) |
| | (16,1) | (4,-) |

Table 7.2.4-10: Codebook for 1-layer CSI reporting using antenna ports 15 to 14+P

| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
|---|------------------------|------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| | | | 0 | 1 | 2 | 3 |
| 1 | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,2},0}^{(1)}$ | $W_{i_{1,1},i_{1,2},1}^{(1)}$ | $W_{i_{1,1},i_{1,2},2}^{(1)}$ | $W_{i_{1,1},i_{1,2},3}^{(1)}$ |
| where $W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$ | | | | | | |

| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
|---|----------------------------------|----------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| | | | 0 | 1 | 2 | 3 |
| 2 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2i_{1,1},2i_{1,2},0}^{(1)}$ | $W_{2i_{1,1},2i_{1,2},1}^{(1)}$ | $W_{2i_{1,1},2i_{1,2},2}^{(1)}$ | $W_{2i_{1,1},2i_{1,2},3}^{(1)}$ |
| Value of Codebook- Config | | | | | | |
| 2 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2i_{1,1}+1,2i_{1,2},0}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2},1}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2},2}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2},3}^{(1)}$ |
| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
| | | | 8 | 9 | 10 | 11 |
| 2 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2i_{1,1},2i_{1,2}+1,0}^{(1)}$ | $W_{2i_{1,1},2i_{1,2}+1,1}^{(1)}$ | $W_{2i_{1,1},2i_{1,2}+1,2}^{(1)}$ | $W_{2i_{1,1},2i_{1,2}+1,3}^{(1)}$ |
| Value of Codebook- Config | | | | | | |
| 2 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2i_{1,1}+1,2i_{1,2}+1,0}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2}+1,1}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2}+1,2}^{(1)}$ | $W_{2i_{1,1}+1,2i_{1,2}+1,3}^{(1)}$ |
| where $W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$ | | | | | | |

| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
|---|----------------------------------|----------------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| | | | 0 | 1 | 2 | 3 |
| 3 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2x,2y,0}^{(1)}$ | $W_{2x,2y,1}^{(1)}$ | $W_{2x,2y,2}^{(1)}$ | $W_{2x,2y,3}^{(1)}$ |
| Value of Codebook- Config | | | | | | |
| 3 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2x+2,2y,0}^{(1)}$ | $W_{2x+2,2y,1}^{(1)}$ | $W_{2x+2,2y,2}^{(1)}$ | $W_{2x+2,2y,3}^{(1)}$ |
| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
| | | | 8 | 9 | 10 | 11 |
| 3 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2x+1,2y+1,0}^{(1)}$ | $W_{2x+1,2y+1,1}^{(1)}$ | $W_{2x+1,2y+1,2}^{(1)}$ | $W_{2x+1,2y+1,3}^{(1)}$ |
| Value of Codebook- Config | | | | | | |
| 3 | $0,1,\dots,\frac{N_1O_1}{2} - 1$ | $0,1,\dots,\frac{N_2O_2}{2} - 1$ | $W_{2x+3,2y+1,0}^{(1)}$ | $W_{2x+3,2y+1,1}^{(1)}$ | $W_{2x+3,2y+1,2}^{(1)}$ | $W_{2x+3,2y+1,3}^{(1)}$ |
| where $x = i_{1,1}$, $y = i_{1,2}$, $W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$, if $N_1 \geq N_2$ | | | | | | |
| $x = i_{1,2}$, $y = i_{1,1}$, $W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{m,l} \\ \varphi_n v_{m,l} \end{bmatrix}$, if $N_1 < N_2$ | | | | | | |

| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
|--|--------------------------------|--------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | | | 0 | 1 | 2 | 3 |
| 4 | $0,1,\dots,\frac{N_1O_1}{2}-1$ | $0,1,\dots,\frac{N_2O_2}{2}-1$ | $W_{2x,2y,0}^{(1)}$ | $W_{2x,2y,1}^{(1)}$ | $W_{2x,2y,2}^{(1)}$ | $W_{2x,2y,3}^{(1)}$ |
| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
| | | | 4 | 5 | 6 | 7 |
| 4 | $0,1,\dots,\frac{N_1O_1}{2}-1$ | $0,1,\dots,\frac{N_2O_2}{2}-1$ | $W_{2x+1,2y,0}^{(1)}$ | $W_{2x+1,2y,1}^{(1)}$ | $W_{2x+1,2y,2}^{(1)}$ | $W_{2x+1,2y,3}^{(1)}$ |
| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
| | | | 8 | 9 | 10 | 11 |
| 4 | $0,1,\dots,\frac{N_1O_1}{2}-1$ | $0,1,\dots,\frac{N_2O_2}{2}-1$ | $W_{2x+2,2y,0}^{(1)}$ | $W_{2x+2,2y,1}^{(1)}$ | $W_{2x+2,2y,2}^{(1)}$ | $W_{2x+2,2y,3}^{(1)}$ |
| Value of Codebook- Config | $i_{1,1}$ | $i_{1,2}$ | i_2 | | | |
| | | | 12 | 13 | 14 | 15 |
| 4 | $0,1,\dots,\frac{N_1O_1}{2}-1$ | $0,1,\dots,\frac{N_2O_2}{2}-1$ | $W_{2x+3,2y,0}^{(1)}$ | $W_{2x+3,2y,1}^{(1)}$ | $W_{2x+3,2y,2}^{(1)}$ | $W_{2x+3,2y,3}^{(1)}$ |
| $\text{where } x = i_{1,1}, \quad y = i_{1,2}, \quad W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}, \text{ if } N_1 \geq N_2$ $x = i_{1,2}, \quad y = i_{1,1}, \quad W_{l,m,n}^{(1)} = \frac{1}{\sqrt{P}} \begin{bmatrix} v_{m,l} \\ \varphi_n v_{m,l} \end{bmatrix}, \text{ if } N_1 < N_2$ | | | | | | |

Table 7.2.4-11: Codebook for 2-layer CSI reporting using antenna ports 15 to 14+P

| 2 Layers, Codebook-Config = 1 | | | | | | |
|--|---|---|---|---|---|---|
| $i_{1,2} = 0, \dots, N_2 O_2 - 1$ | | | | | | |
| $i_{1,1}$ | i_2 | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| $0, \dots, N_1 O_1 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},0}^{(2)}$ | $W_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},1}^{(2)}$ | $W_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},2}^{(2)}$ | $W_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},3}^{(2)}$ | | |
| $\text{where } W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}.$ | | | | | | |

| 2 Layers, Codebook-Config = 2 | | | | | | |
|---|---|---|---|---|----|----|
| If $N_1 > N_2, p = 1$ otherwise $p = O_1$ | | | | | | |
| $i_{1,2} = 0, \dots, N_2 O_2 / 2 - 1$ | | | | | | |
| $i_{1,1}$ | i_2 | | | | | |
| | 0 | 1 | 2 | 3 | 4 | 5 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2},0}^{(2)}$ | $W_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2},1}^{(2)}$ | $W_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2},0}^{(2)}$ | $W_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2},1}^{(2)}$ | | |
| $i_{1,1}$ | i_2 | | | | | |
| | 4 | 5 | 6 | 7 | 8 | 9 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,0}^{(2)}$ | $W_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,1}^{(2)}$ | $W_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+1,0}^{(2)}$ | $W_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+1,1}^{(2)}$ | | |
| $i_{1,1}$ | i_2 | | | | | |
| | 10 | 11 | 12 | 13 | 14 | 15 |

| | | | | |
|---|---|---|---|---|
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2}, 0}^{(2)}$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2}, 1}^{(2)}$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2} + 1, 2i_{1,2} + 1, 0}^{(2)}$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2} + 1, 2i_{1,2} + 1, 1}^{(2)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2} + 1, 0}^{(2)}$ | $W_{2i_{1,1}, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2} + 1, 1}^{(2)}$ | $W_{2i_{1,1} + p, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2} + 1, 0}^{(2)}$ | $W_{2i_{1,1} + p, 2i_{1,1} + p, 2i_{1,2}, 2i_{1,2} + 1, 1}^{(2)}$ |
| where $W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$. | | | | |

| 2 Layers, Codebook-Config = 3 | | | | |
|---|-----------------------------------|-----------------------------------|---------------------------------------|---------------------------------------|
| $i_{1,2} = 0, \dots, N_2 O_2 / 2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x, 2x, 2y, 2y, 0}^{(2)}$ | $W_{2x, 2x, 2y, 2y, 1}^{(2)}$ | $W_{2x+1, 2x+1, 2y+1, 2y+1, 0}^{(2)}$ | $W_{2x+1, 2x+1, 2y+1, 2y+1, 1}^{(2)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x+2, 2x+2, 2y, 2y, 0}^{(2)}$ | $W_{2x+2, 2x+2, 2y, 2y, 1}^{(2)}$ | $W_{2x+3, 2x+3, 2y+1, 2y+1, 0}^{(2)}$ | $W_{2x+3, 2x+3, 2y+1, 2y+1, 1}^{(2)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x, 2x+1, 2y, 2y+1, 0}^{(2)}$ | $W_{2x, 2x+1, 2y, 2y+1, 1}^{(2)}$ | $W_{2x+1, 2x+2, 2y+1, 2y, 0}^{(2)}$ | $W_{2x+1, 2x+2, 2y+1, 2y, 1}^{(2)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x, 2x+3, 2y, 2y+1, 0}^{(2)}$ | $W_{2x, 2x+3, 2y, 2y+1, 1}^{(2)}$ | $W_{2x+1, 2x+3, 2y+1, 2y+1, 0}^{(2)}$ | $W_{2x+1, 2x+3, 2y+1, 2y+1, 1}^{(2)}$ |
| where $x = i_{1,1}, y = i_{1,2}, W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$ if $N_1 \geq N_2$ and | | | | |
| $x = i_{1,2}, y = i_{1,1}, W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{m,l} & v_{m',l'} \\ \varphi_n v_{m,l} & -\varphi_n v_{m',l'} \end{bmatrix}$, if $N_1 < N_2$ | | | | |

| 2 Layers, Codebook-Config = 4 | | | | |
|---------------------------------------|-------------------------------|-------------------------------|-----------------------------------|-----------------------------------|
| $i_{1,2} = 0, \dots, N_2 O_2 / 2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x, 2x, 2y, 2y, 0}^{(2)}$ | $W_{2x, 2x, 2y, 2y, 1}^{(2)}$ | $W_{2x+1, 2x+1, 2y, 2y, 0}^{(2)}$ | $W_{2x+1, 2x+1, 2y, 2y, 1}^{(2)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |

| | | | | |
|--|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x+2,2x+2,2y,2y,0}^{(2)}$ | $W_{2x+2,2x+2,2y,2y,1}^{(2)}$ | $W_{2x+3,2x+3,2y,2y,0}^{(2)}$ | $W_{2x+3,2x+3,2y,2y,1}^{(2)}$ |
| $i_{1,1}$ | | | i_2 | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x,2x+1,2y,2y,0}^{(2)}$ | $W_{2x,2x+1,2y,2y,1}^{(2)}$ | $W_{2x+1,2x+2,2y,2y,0}^{(2)}$ | $W_{2x+1,2x+2,2y,2y,1}^{(2)}$ |
| $i_{1,1}$ | | | i_2 | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, \frac{N_1 O_1}{2} - 1$ | $W_{2x,2x+3,2y,2y,0}^{(2)}$ | $W_{2x,2x+3,2y,2y,1}^{(2)}$ | $W_{2x+1,2x+3,2y,2y,0}^{(2)}$ | $W_{2x+1,2x+3,2y,2y,1}^{(2)}$ |
| <p>where $x = i_{1,1}, y = i_{1,2}, W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$ if $N_1 \geq N_2$ and</p> <p>$x = i_{1,2}, y = i_{1,1}, W_{l,l',m,m',n}^{(2)} = \frac{1}{\sqrt{2P}} \begin{bmatrix} v_{m,l} & v_{m',l'} \\ \varphi_n v_{m,l} & -\varphi_n v_{m',l'} \end{bmatrix}$, if $N_1 < N_2$</p> | | | | |

Table 7.2.4-12: Codebook for 3-layer CSI reporting using antenna ports 15 to 14+P

| 3 Layers, Codebook-Config = 1, $N_1 > 1, N_2 > 1$ | | |
|---|---|---|
| $i_{1,2} = 0, 1, \dots, N_2 O_2 - 1$ | | |
| $i_{1,1}$ | | i_2 |
| | 0 | 1 |
| $0, \dots, O_1 N_1 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2}}^{(3)}$ | $\tilde{W}_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2}}^{(3)}$ |
| $O_1 N_1, \dots, 2O_1 N_1 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2}^{(3)}$ | $\tilde{W}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2}^{(3)}$ |
| where $W_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} \\ v_{l,m} & -v_{l,m} & -v_{l',m'} \end{bmatrix}, \tilde{W}_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l',m'} \\ v_{l,m} & v_{l',m'} & -v_{l',m'} \end{bmatrix}$ | | |

| 3 Layers, Codebook-Config = 1, $N_2 = 1$ | | |
|---|--------------------------------------|--|
| $i_{1,2} = 0$ | | |
| $i_{1,1}$ | | i_2 |
| | 0 | 1 |
| $0, \dots, O_1 N_1 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,0,0}^{(3)}$ | $\tilde{W}_{i_{1,1},i_{1,1}+O_1,0,0}^{(3)}$ |
| $O_1 N_1, \dots, 2O_1 N_1 - 1$ | $W_{i_{1,1},i_{1,1}+2O_1,0,0}^{(3)}$ | $\tilde{W}_{i_{1,1},i_{1,1}+2O_1,0,0}^{(3)}$ |
| $2O_1 N_1, \dots, 3O_1 N_1 - 1$ | $W_{i_{1,1},i_{1,1}+3O_1,0,0}^{(3)}$ | $\tilde{W}_{i_{1,1},i_{1,1}+3O_1,0,0}^{(3)}$ |
| where $W_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} \\ v_{l,m} & -v_{l,m} & -v_{l',m'} \end{bmatrix}, \tilde{W}_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l',m'} \\ v_{l,m} & v_{l',m'} & -v_{l',m'} \end{bmatrix}$ | | |

| 3 Layers, Codebook-Config = 2 | | | | |
|--------------------------------------|----------|----------|----------|----------|
| $i_{1,2} = 0, 1, \dots, 2N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |

| | | | | |
|---|--|--|--|--|
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $W_{2i_{1,1} + 4, 2i_{1,1}, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 4, 2i_{1,1}, 2i_{1,2}, 2i_{1,2}}^{(3)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1}, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $W_{2i_{1,1} + 5, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 5, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2}}^{(3)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $W_{2i_{1,1} + 4, 2i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 4, 2i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 5}^{(3)}$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1}, 2i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $W_{2i_{1,1} + 5, 2i_{1,1} + 1, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 5, 2i_{1,1} + 1, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2} + 1, 2i_{1,2} + 5}^{(3)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ |
| where $W_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \end{bmatrix}, \quad \tilde{W}_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \end{bmatrix}$ | | | | |

| 3 Layers, Codebook-Config =3 | | | | |
|-------------------------------------|--|--|--|--|
| $i_{1,2} = 0, 1, \dots, 2N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 6, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $W_{4i_{1,1} + 6, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 2, 4i_{1,1} + 6, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 6, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 7, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $W_{4i_{1,1} + 7, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 3, 4i_{1,1} + 7, 2i_{1,2}, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 7, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2} + 4}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2} + 4, 2i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $W_{4i_{1,1} + 4, 4i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{4i_{1,1} + 4, 4i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 1}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}, 2i_{1,2} + 1, 2i_{1,2} + 5}^{(3)}$ | $W_{4i_{1,1}, 4i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1}, 2i_{1,2} + 5, 2i_{1,2} + 1}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |

| | | | | |
|---|--|--|--|--|
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 2i_{1,2}+1, 2i_{1,2}+1}^{(3)}$ | $W_{4i_{1,1}+5, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+1}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+5, 2i_{1,2}+1, 2i_{1,2}+1}^{(3)}$ | $\tilde{W}_{4i_{1,1}+5, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+1}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+5}^{(3)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+5, 2i_{1,2}+1}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+5}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+5, 2i_{1,2}+1}^{(3)}$ |
| where $W_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} \end{bmatrix}$ | | | $\tilde{W}_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} \end{bmatrix}$ | |

| 3 Layers, Codebook-Config =4, $N_1 > 1, N_2 > 1$ | | | | |
|---|--|--|--|--|
| $i_{1,2} = 0, 1, \dots, 4N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+4, i_{1,2}, i_{1,2}}^{(3)}$ | $W_{4i_{1,1}+4, 4i_{1,1}+4, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+4, 4i_{1,1}+4, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+4, 4i_{1,1}+4, i_{1,2}, i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}, i_{1,2}, i_{1,2}+4}^{(3)}$ | $W_{4i_{1,1}+1, 4i_{1,1}, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}, i_{1,2}+4, i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, i_{1,2}, i_{1,2}}^{(3)}$ | $W_{4i_{1,1}+5, 4i_{1,1}+1, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+5, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+5, 4i_{1,1}+1, i_{1,2}, i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}, i_{1,2}+4}^{(3)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}+4, i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, i_{1,2}, i_{1,2}}^{(3)}$ | $W_{4i_{1,1}+6, 4i_{1,1}+2, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+6, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+6, 4i_{1,1}+2, i_{1,2}, i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}, i_{1,2}+4}^{(3)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}+4, i_{1,2}}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, i_{1,2}, i_{1,2}}^{(3)}$ | $W_{4i_{1,1}+7, 4i_{1,1}+3, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+7, i_{1,2}, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+7, 4i_{1,1}+3, i_{1,2}, i_{1,2}}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}, i_{1,2}+4}^{(3)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}+4, i_{1,2}}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}+4, i_{1,2}}^{(3)}$ |
| where $W_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} \end{bmatrix}$ | | | $\tilde{W}_{l,l',m,m'}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_l}{4}, \frac{O_{2m}}{4}} \\ v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} & -v_{\frac{O_{l'}}{4}, \frac{O_{2m}}{4}} \end{bmatrix}$ | |

| 3 Layers, Codebook-Config =4, $N_2 = 1$ | | | | |
|---|---|---|---|---|
| $i_{1,2} = 0$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+4, 0, 0}^{(3)}$ | $W_{4i_{1,1}+4, 4i_{1,1}, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1}+4, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+4, 4i_{1,1}, 0, 0}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+8, 0, 0}^{(3)}$ | $W_{4i_{1,1}+8, 4i_{1,1}, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1}+8, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+8, 4i_{1,1}, 0, 0}^{(3)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+12, 0, 0}^{(3)}$ | $W_{4i_{1,1}+12, 4i_{1,1}, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}, 4i_{1,1}+12, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+12, 4i_{1,1}, 0, 0}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |

| | | | | |
|---|--|---|---|---|
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 0, 0}^{(3)}$ | $W_{4i_{1,1}+5, 4i_{1,1}+1, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+5, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+5, 4i_{1,1}+1, 0, 0}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+9, 0, 0}^{(3)}$ | $W_{4i_{1,1}+9, 4i_{1,1}+1, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+9, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+9, 4i_{1,1}+1, 0, 0}^{(3)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}+1, 4i_{1,1}+13, 0, 0}^{(3)}$ | $W_{4i_{1,1}+13, 4i_{1,1}+1, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+1, 4i_{1,1}+13, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+13, 4i_{1,1}+1, 0, 0}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 8 | 9 | 10 | 11 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, 0, 0}^{(3)}$ | $W_{4i_{1,1}+6, 4i_{1,1}+2, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+6, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+6, 4i_{1,1}+2, 0, 0}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+10, 0, 0}^{(3)}$ | $W_{4i_{1,1}+10, 4i_{1,1}+2, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+10, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+10, 4i_{1,1}+2, 0, 0}^{(3)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+14, 0, 0}^{(3)}$ | $W_{4i_{1,1}+14, 4i_{1,1}+2, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+2, 4i_{1,1}+14, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+14, 4i_{1,1}+2, 0, 0}^{(3)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 12 | 13 | 14 | 15 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, 0, 0}^{(3)}$ | $W_{4i_{1,1}+7, 4i_{1,1}+3, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+7, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+7, 4i_{1,1}+3, 0, 0}^{(3)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+3, 4i_{1,1}+11, 0, 0}^{(3)}$ | $W_{4i_{1,1}+11, 4i_{1,1}+3, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+11, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+11, 4i_{1,1}+3, 0, 0}^{(3)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}+3, 4i_{1,1}+15, 0, 0}^{(3)}$ | $W_{4i_{1,1}+15, 4i_{1,1}+3, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+3, 4i_{1,1}+15, 0, 0}^{(3)}$ | $\tilde{W}_{4i_{1,1}+15, 4i_{1,1}+3, 0, 0}^{(3)}$ |
| where $W_{l,l,m,m}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \end{bmatrix}$ | $\tilde{W}_{l,l,m,m}^{(3)} = \frac{1}{\sqrt{3P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} \end{bmatrix}$ | | | |

Table 7.2.4-13: Codebook for 4-layer CSI reporting using antenna ports 15 to 14+P

| 4 Layers, Codebook-Config = 1, $N_1 > 1, N_2 > 1$ | | |
|--|---|---|
| $i_{1,2} = 0, 1, \dots, N_2 O_2 - 1$ | | |
| $i_{1,1}$ | i_2 | |
| | 0 | 1 |
| $0, \dots, N_1 O_1 - 1$ | $W_{i_{1,1}, i_{1,1} + O_1, i_{1,2}, i_{1,2}, 0}^{(4)}$ | $W_{i_{1,1}, i_{1,1} + O_1, i_{1,2}, i_{1,2}, 1}^{(4)}$ |
| $O_1 N_1, \dots, 2O_1 N_1 - 1$ | $W_{i_{1,1}, i_{1,1}, i_{1,2}, i_{1,2} + O_2, 0}^{(4)}$ | $W_{i_{1,1}, i_{1,1}, i_{1,2}, i_{1,2} + O_2, 1}^{(4)}$ |
| where $W_{l,l,m,m,n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l,m} & v_{l,m} \\ \varphi_n v_{l,m} & \varphi_n v_{l,m} & -\varphi_n v_{l,m} & -\varphi_n v_{l,m} \end{bmatrix}$ | | |

| 4 Layers, Codebook-Config = 1, $N_2 = 1$ | | | |
|--|--|--|--|
| $i_{1,2} = 0$ | | | |
| $i_{1,1}$ | i_2 | | |
| | 0 | 1 | |
| $0, \dots, O_1 N_1 - 1$ | $W_{i_{1,1}, i_{1,1} + O_1, 0, 0, 0}^{(4)}$ | $W_{i_{1,1}, i_{1,1} + O_1, 0, 0, 1}^{(4)}$ | |
| $O_1 N_1, \dots, 2O_1 N_1 - 1$ | $W_{i_{1,1}, i_{1,1} + 2O_1, 0, 0, 0}^{(4)}$ | $W_{i_{1,1}, i_{1,1} + 2O_1, 0, 0, 1}^{(4)}$ | |
| $2O_1 N_1, \dots, 3O_1 N_1 - 1$ | $W_{i_{1,1}, i_{1,1} + 3O_1, 0, 0, 0}^{(4)}$ | $W_{i_{1,1}, i_{1,1} + 3O_1, 0, 0, 1}^{(4)}$ | |
| $W_{l,l',m,m',n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & \varphi_n v_{l',m'} & -\varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$ | | | |

| 4 Layers, Codebook-Config = 2 | | | | |
|--|---|---|---|---|
| $i_{1,2} = 0, 1, \dots, 2N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2}, 2i_{1,2}, 0}^{(4)}$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2}, 2i_{1,2}, 1}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2}, 2i_{1,2}, 0}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2}, 2i_{1,2}, 1}^{(4)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 4, 0}^{(4)}$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 4, 1}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 4, 0}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 4, 1}^{(4)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, 2N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1, 0}^{(4)}$ | $W_{2i_{1,1}, 2i_{1,1} + 4, 2i_{1,2} + 1, 2i_{1,2} + 1, 1}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2} + 1, 2i_{1,2} + 1, 0}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 5, 2i_{1,2} + 1, 2i_{1,2} + 1, 1}^{(4)}$ |
| $2N_1, \dots, 4N_1 - 1$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 1, 2i_{1,2} + 5, 0}^{(4)}$ | $W_{2i_{1,1}, 2i_{1,1}, 2i_{1,2}, 2i_{1,2} + 1, 2i_{1,2} + 5, 1}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 1, 2i_{1,2} + 5, 0}^{(4)}$ | $W_{2i_{1,1} + 1, 2i_{1,1} + 1, 2i_{1,2}, 2i_{1,2} + 1, 2i_{1,2} + 5, 1}^{(4)}$ |
| $W_{l,l',m,m',n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \\ \varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & \varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & -\varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \end{bmatrix}$ | | | | |

| 4 Layers, Codebook-Config = 3 | | | | |
|--------------------------------------|---|---|---|---|
| $i_{1,2} = 0, 1, \dots, 2N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 6, 2i_{1,2}, 2i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 6, 2i_{1,2}, 2i_{1,2}, 1}^{(4)}$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 7, 2i_{1,2}, 2i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 7, 2i_{1,2}, 2i_{1,2}, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2} + 4, 0}^{(4)}$ | $W_{4i_{1,1} + 2, 4i_{1,1} + 2, 2i_{1,2}, 2i_{1,2} + 4, 1}^{(4)}$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2} + 4, 0}^{(4)}$ | $W_{4i_{1,1} + 3, 4i_{1,1} + 3, 2i_{1,2}, 2i_{1,2} + 4, 1}^{(4)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |

| | | | | |
|------------------------|--|---|---|---|
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+4, 2i_{1,2}+1, 2i_{1,2}+1, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}+4, 2i_{1,2}+1, 2i_{1,2}+1, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 2i_{1,2}+1, 2i_{1,2}+1, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 2i_{1,2}+1, 2i_{1,2}+1, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}, 2i_{1,2}+1, 2i_{1,2}+5, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}, 2i_{1,2}+1, 2i_{1,2}+5, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+5, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, 2i_{1,2}+1, 2i_{1,2}+5, 1}^{(4)}$ |
| | $W_{l,l',m,m',n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \\ \varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & \varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \end{bmatrix}$ | | | |

| 4 Layers, Codebook-Config =4, $N_1 > 1, N_2 > 1$ | | | | |
|--|--|---|---|---|
| $i_{1,2} = 0, 1, \dots, 4N_2 - 1$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+4, i_{1,2}, i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}+4, i_{1,2}, i_{1,2}, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, i_{1,2}, i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, i_{1,2}, i_{1,2}, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}, i_{1,2}, i_{1,2}, +4, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}, i_{1,2}, i_{1,2}, +4, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}, i_{1,2}, +4, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+1, i_{1,2}, i_{1,2}, +4, 1}^{(4)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, i_{1,2}, i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, i_{1,2}, i_{1,2}, 1}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, i_{1,2}, i_{1,2}, 0}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, i_{1,2}, i_{1,2}, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}, i_{1,2}, +4, 0}^{(4)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+2, i_{1,2}, i_{1,2}, +4, 1}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}, i_{1,2}, +4, 0}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+3, i_{1,2}, i_{1,2}, +4, 1}^{(4)}$ |
| | $W_{l,l',m,m',n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \\ \varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & \varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \end{bmatrix}$ | | | |

| 4 Layers, Codebook-Config =4, $N_2 = 1$ | | | | |
|---|--|--|--|--|
| $i_{1,2} = 0$ | | | | |
| $i_{1,1}$ | i_2 | | | |
| | 0 | 1 | 2 | 3 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+4, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}+4, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+5, 0, 0, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+8, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}+8, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+9, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+9, 0, 0, 1}^{(4)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}, 4i_{1,1}+12, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}, 4i_{1,1}+12, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+13, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+1, 4i_{1,1}+13, 0, 0, 1}^{(4)}$ |
| $i_{1,1}$ | i_2 | | | |
| | 4 | 5 | 6 | 7 |
| $0, \dots, N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+6, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+7, 0, 0, 1}^{(4)}$ |
| $N_1, \dots, 2N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+10, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+10, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+11, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+11, 0, 0, 1}^{(4)}$ |
| $2N_1, \dots, 3N_1 - 1$ | $W_{4i_{1,1}+2, 4i_{1,1}+14, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+2, 4i_{1,1}+14, 0, 0, 1}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+15, 0, 0, 0}^{(4)}$ | $W_{4i_{1,1}+3, 4i_{1,1}+15, 0, 0, 1}^{(4)}$ |
| | $W_{l,l',m,m',n}^{(4)} = \frac{1}{\sqrt{4P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \\ \varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & \varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -\varphi_n v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} \end{bmatrix}$ | | | |

Table 7.2.4-14: Codebook for 5-layer CSI reporting using antenna ports 15 to 14+P

| 5 Layers, P=8, N_I=N₂ | | | | |
|---|--|---|---|--|
| Value of Codebook-Config | <i>i</i> _{1,1} | <i>i</i> _{1,2} | | |
| 1 | 0,1,⋯,O ₁ N ₁ − 1 | 0,1,⋯,O ₂ N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+O₁,i_{1,1}+O₁,i_{1,2},i_{1,2},i_{1,2}+O₂} | |
| 2-4 | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4} | |
| W ⁽⁵⁾ _{l,l',m,m',m''} | $\frac{1}{\sqrt{5P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \end{bmatrix}$ | for Codebook-Config = 2-4 | | |
| W ⁽⁵⁾ _{l,l',m,m',m''} | $\frac{1}{\sqrt{5P}} \begin{bmatrix} v_{l,m} & v_{l,m'} & v_{l,m''} & v_{l',m} & v_{l',m'} \\ v_{l,m} & -v_{l,m'} & v_{l,m''} & -v_{l',m} & v_{l',m'} \end{bmatrix}$ | for Codebook-Config = 1 | | |

| 5 Layers, P=12 | | | | |
|---------------------------------|--|---|---|---|
| Value of Codebook-Config | Configuration | <i>i</i> _{1,1} | <i>i</i> _{1,2} | |
| 1 | N ₁ > 1, N ₂ ≥ 1 | 0,1,⋯,O ₁ N ₁ − 1 | 0,1,⋯,O ₂ N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+O₁,i_{1,1}+O₁,i_{1,2},i_{1,2},i_{1,2}+O₂} |
| 2 | N ₁ > 1, N ₂ > 1 | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4} |
| 3 | N ₁ ≥ N ₂ | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4} |
| | N ₁ < N ₂ | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+8} |
| 4 | N ₁ ≥ N ₂ | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}} |
| | N ₁ < N ₂ | 0,1,⋯,4N ₁ − 1 | 0,1,⋯,4N ₂ − 1 | W ⁽⁵⁾ _{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8} |

where

$$W^{(5)}_{l,l',m,m',m''} = \frac{1}{\sqrt{5P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} \end{bmatrix} \text{ for Codebook-Config = 2-4}$$

$$W^{(5)}_{l,l',m,m',m''} = \frac{1}{\sqrt{5P}} \begin{bmatrix} v_{l,m} & v_{l,m'} & v_{l,m''} & v_{l',m} & v_{l',m'} \\ v_{l,m} & -v_{l,m'} & v_{l,m''} & -v_{l',m} & v_{l',m'} \end{bmatrix} \text{ for Codebook-Config = 1}$$

| 5 Layers, P ∈ {16,20,24,28,32} | | | | |
|---------------------------------------|-------------------------|------------------------|------------------------|---|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}^{(5)}$ |
| | $N_2 = 1$ | $0,1,\dots,O_1N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,2},i_{1,2},i_{1,2}}^{(5)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}^{(5)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}^{(5)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+8}^{(5)}$ |
| 4 | $N_1 \geq N_2, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}^{(5)}$ |
| | $N_2 = 1$ | $0,1,\dots,4N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}^{(5)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8}^{(5)}$ |

where

$$W_{l,l',l'',m,m',m''}^{(5)} = \frac{1}{\sqrt{5P}} \begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix} \text{ for Codebook-Config } = 2-4$$

$$W_{l,l',l'',m,m',m''}^{(5)} = \frac{1}{\sqrt{5P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} \end{bmatrix} \text{ for Codebook-Config } = 1$$

Table 7.2.4-15: Codebook for 6-layer CSI reporting using antenna ports 15 to 14+P

| 6 Layers, P=8, NI=N2 | | | | |
|---------------------------------|------------------------|------------------------|---|--|
| Value of Codebook-Config | $i_{1,1}$ | $i_{1,2}$ | | |
| 1 | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}^{(6)}$ | |
| 2-4 | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}^{(6)}$ | |

where

$$W_{l,l',l'',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix} \text{ for Codebook-Config } = 2-4$$

$$W_{l,l',l'',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix} \text{ for Codebook-Config } = 1$$

| 6 Layers, P=12 | | | | |
|---------------------------------|-----------------------|------------------------|------------------------|---|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 \geq 1$ | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}^{(6)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}^{(6)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}^{(6)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8}^{(6)}$ |
| 4 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}^{(6)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8}^{(6)}$ |

where

$$W_{l,l',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} \end{bmatrix} \text{ for Codebook-Config } 2-4$$

$$W_{l,l',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix} \text{ for Codebook-Config } 1$$

| 6 Layers, P ∈ {16,20,24,28,32} | | | | |
|---------------------------------------|-------------------------|------------------------|------------------------|---|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}^{(6)}$ |
| | $N_2 = 1$ | $0,1,\dots,O_1N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,2},i_{1,2},i_{1,2}}^{(6)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}^{(6)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}^{(6)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8}^{(6)}$ |
| 4 | $N_1 \geq N_2, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}^{(6)}$ |
| | $N_2 = 1$ | $0,1,\dots,4N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}^{(6)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8}^{(6)}$ |

where

$$W_{l,l',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l''}{4}, \frac{O_2 m''}{4}} \end{bmatrix} \text{ for Codebook-Config } 2-4$$

$$W_{l,l',m,m',m''}^{(6)} = \frac{1}{\sqrt{6P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix} \text{ and for Codebook-Config } 1$$

Table 7.2.4-16: Codebook for 7-layer CSI reporting using antenna ports 15 to 14+P

| 7 Layers $P=8, N_1=N_2$ | | | |
|--------------------------|----------------------|----------------------|---|
| Value of Codebook-Config | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $0,1,\dots,O_1N_1-1$ | $0,1,\dots,O_2N_2-1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}^{(7)}$ |
| 2-4 | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(7)}$ |

where

$$W_{l,l',l'',m,m',m'',m''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m'} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m'} \end{bmatrix} \text{ for Codebook-Config}$$

$$= 2-4$$

$$W_{l,l',l'',m,m',m'',m''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{l,m} & v_{l,m'} & v_{l',m} & v_{l',m'} & v_{l'',m} & v_{l'',m'} \\ v_{l,m} & -v_{l,m'} & v_{l',m} & -v_{l',m'} & v_{l'',m} & -v_{l'',m'} \end{bmatrix} \text{ for Codebook-Config} = 1$$

| 7 Layers, $P=12$ | | | | |
|--------------------------|-----------------------|----------------------|----------------------|---|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 \geq 1$ | $0,1,\dots,O_1N_1-1$ | $0,1,\dots,O_2N_2-1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}^{(7)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(7)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(7)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+4}^{(7)}$ |
| 4 | $N_1 \geq N_2$ | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4}^{(7)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1-1$ | $0,1,\dots,4N_2-1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}}^{(7)}$ |

where

$$W_{l,l',l'',m,m',m'',m''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$$

for Codebook-Config = 2-4

$$W_{l,l',l'',m,m',m'',m''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{l,m} & v_{l,m'} & v_{l',m} & v_{l',m'} & v_{l'',m} & v_{l'',m'} \\ v_{l,m} & -v_{l,m'} & v_{l',m} & -v_{l',m'} & v_{l'',m} & -v_{l'',m'} \end{bmatrix} \text{ for Codebook-Config} = 1$$

| 7 Layers, $P \in \{16, 20, 24, 28, 32\}$ | | | | |
|--|-------------------------|----------------------------|----------------------------|--|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 > 1$ | $0, 1, \dots, O_1 N_1 - 1$ | $0, 1, \dots, O_2 N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + O_1, i_{1,1} + O_1, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + O_2, i_{1,2} + O_2}^{(7)}$ |
| | $N_2 = 1$ | $0, 1, \dots, O_1 N_1 - 1$ | 0 | $W_{i_{1,1}, i_{1,1} + O_1, i_{1,1} + 2O_1, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + 4, i_{1,2}}^{(7)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + 4, i_{1,1} + 4, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + 4, i_{1,2} + 4}^{(7)}$ |
| 3 | $N_1 \geq N_2$ | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + 4, i_{1,1} + 8, i_{1,1} + 12, i_{1,2}, i_{1,2}, i_{1,2} + 4, i_{1,2} + 4}^{(7)}$ |
| | $N_1 < N_2$ | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1}, i_{1,1} + 4, i_{1,1} + 4, i_{1,2}, i_{1,2} + 4, i_{1,2} + 8, i_{1,2} + 12}^{(7)}$ |
| 4 | $N_1 \geq N_2, N_2 > 1$ | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + 4, i_{1,1} + 8, i_{1,1} + 12, i_{1,2}, i_{1,2}, i_{1,2}, i_{1,2}}^{(7)}$ |
| | $N_2 = 1$ | $0, 1, \dots, 4N_1 - 1$ | 0 | $W_{i_{1,1}, i_{1,1} + 4, i_{1,1} + 8, i_{1,1} + 12, i_{1,2}, i_{1,2}, i_{1,2}, i_{1,2}}^{(7)}$ |
| | $N_1 < N_2$ | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1}, i_{1,1}, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + 4, i_{1,2} + 8, i_{1,2} + 12}^{(7)}$ |

where

$$W_{l,l',l'',l''',m,m',m'',m'''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m''}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m''}{4}} \end{bmatrix} \text{ for Codebook-Config } 2-4$$

$$W_{l,l',l'',l''',m,m',m'',m'''}^{(7)} = \frac{1}{\sqrt{7P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m} & v_{l',m} & v_{l'',m} & v_{l'',m} & v_{l''',m} \\ v_{l,m} & -v_{l,m} & v_{l',m} & -v_{l',m} & v_{l'',m} & -v_{l'',m} & v_{l''',m} \end{bmatrix} \text{ and for Codebook-Config } 1$$

Table 7.2.4-17: Codebook for 8-layer CSI reporting using antenna ports 15 to 14+P

| 8 Layers, $P=8, N_1=N_2$ | | | | |
|--|--|----------------------------|--|--|
| Value of Codebook-Config | $i_{1,1}$ | $i_{1,2}$ | | |
| 1 | $0, 1, \dots, O_1 N_1 - 1$ | $0, 1, \dots, O_2 N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + O_1, i_{1,1} + O_1, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + O_2, i_{1,2} + O_2}^{(8)}$ | |
| 2-4 | $0, 1, \dots, 4N_1 - 1$ | $0, 1, \dots, 4N_2 - 1$ | $W_{i_{1,1}, i_{1,1} + 4, i_{1,1} + 4, i_{1,1}, i_{1,2}, i_{1,2}, i_{1,2} + 4, i_{1,2} + 4}^{(8)}$ | |
| where | $W_{l,l',l'',l''',m,m',m'',m'''}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m'''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m'''}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m'''}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4}, \frac{O_2 m''}{4}} & -v_{\frac{O_1 l'}{4}, \frac{O_2 m'''}{4}} \end{bmatrix}$ | for Codebook-Config = 2-4 | | |
| | $W_{l,l',l'',l''',m,m',m'',m'''}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m} & v_{l',m} & v_{l'',m} & v_{l'',m} & v_{l''',m} \\ v_{l,m} & -v_{l,m} & v_{l',m} & -v_{l',m} & v_{l'',m} & -v_{l'',m} & v_{l''',m} \end{bmatrix}$ | for Codebook-Config = 1 | | |

| 8 Layers, P=12 | | | | |
|--|-----------------------|------------------------|------------------------|---|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 \geq 1$ | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}^{(8)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(8)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(8)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+4}^{(8)}$ |
| 4 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4}^{(8)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}}^{(8)}$ |
| where $W_{l,l^-,l^+,m,m^-,m^+}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m^-}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^+}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^-}{4}} & -v_{\frac{O_1 l^-}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m^-}{4}} & -v_{\frac{O_1 l^+}{4}, \frac{O_2 m^+}{4}} \end{bmatrix}$ | | | | |
| for Codebook-Config = 2-4 | | | | |
| $W_{l,l^-,l^+,m,m^-,m^+}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{l,m} & v_{l,m^-} & v_{l,m^+} & v_{l^-,m} & v_{l^-,m^-} & v_{l^-,m^+} & v_{l^+,m} & v_{l^+,m^-} \\ v_{l,m} & -v_{l,m^-} & v_{l,m^+} & -v_{l^-,m} & v_{l^-,m^-} & -v_{l^-,m^+} & v_{l^+,m^-} & -v_{l^+,m^+} \end{bmatrix}$ for Codebook-Config = 1 | | | | |

| 8 Layers, $P \in \{16, 20, 24, 28, 32\}$ | | | | |
|--|-------------------------|------------------------|------------------------|--|
| Value of Codebook-Config | Configuration | $i_{1,1}$ | $i_{1,2}$ | |
| 1 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,O_1N_1 - 1$ | $0,1,\dots,O_2N_2 - 1$ | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}^{(8)}$ |
| | $N_2 = 1$ | $0,1,\dots,O_1N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,1}+3O_1,i_{1,2},i_{1,2},i_{1,2}}^{(8)}$ |
| 2 | $N_1 > 1, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(8)}$ |
| 3 | $N_1 \geq N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}^{(8)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+12}^{(8)}$ |
| 4 | $N_1 \geq N_2, N_2 > 1$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}^{(8)}$ |
| | $N_2 = 1$ | $0,1,\dots,4N_1 - 1$ | 0 | $W_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}^{(8)}$ |
| | $N_1 < N_2$ | $0,1,\dots,4N_1 - 1$ | $0,1,\dots,4N_2 - 1$ | $W_{i_{1,1},i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+12}^{(8)}$ |
| where $W_{l,l^-,l^+,m,m^-,m^+}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m^-}{4}} \\ v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m^-}{4}} & v_{\frac{O_1 l}{4}, \frac{O_2 m^+}{4}} & -v_{\frac{O_1 l}{4}, \frac{O_2 m}{4}} & v_{\frac{O_1 l^-}{4}, \frac{O_2 m^-}{4}} & -v_{\frac{O_1 l^-}{4}, \frac{O_2 m^+}{4}} & v_{\frac{O_1 l^+}{4}, \frac{O_2 m^-}{4}} & -v_{\frac{O_1 l^+}{4}, \frac{O_2 m^+}{4}} \end{bmatrix}$ | | | | |
| for Codebook-Config = 2-4 | | | | |
| $W_{l,l^-,l^+,m,m^-,m^+}^{(8)} = \frac{1}{\sqrt{8P}} \begin{bmatrix} v_{l,m} & v_{l,m^-} & v_{l,m^+} & v_{l^-,m} & v_{l^-,m^-} & v_{l^-,m^+} & v_{l^+,m} & v_{l^+,m^-} \\ v_{l,m} & -v_{l,m^-} & v_{l,m^+} & -v_{l^-,m} & v_{l^-,m^-} & -v_{l^-,m^+} & v_{l^+,m^-} & -v_{l^+,m^+} \end{bmatrix}$ Codebook-Config = 1 | | | | |

For 4 antenna ports $\{15,16,17,18\}$, 8 antenna ports $\{15,16,17,18,19,20,21,22\}$, 12 antenna ports $\{15,16,17,18,19,20,21,22,23,24,25,26\}$, 16 antenna ports $\{15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30\}$, 20 antenna ports $\{15,16,17,\dots,34\}$, 24 antenna ports $\{15,16,17,\dots,38\}$, 28 antenna ports $\{15,16,17,\dots,42\}$, 32 antenna ports $\{15,16,17,\dots,46\}$, and UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and $v \leq 2$ with v equal to the associated RI value, each PMI value corresponds to four codebook indices given in Table 7.2.4-17C, where the quantities φ_n , u_m and $v_{l,m}$ are given by

$$\begin{aligned}\varphi_n &= e^{j\pi n/2} \\ u_m &= \begin{bmatrix} 1 & e^{j\frac{2\pi m}{O_2 N_2}} & \dots & e^{j\frac{2\pi m(N_2-1)}{O_2 N_2}} \end{bmatrix} \\ v_{l,m} &= \begin{bmatrix} u_m & e^{j\frac{2\pi l}{O_1 N_1}} u_m & \dots & e^{j\frac{2\pi l(N_1-1)}{O_1 N_1}} u_m \end{bmatrix}^T\end{aligned}$$

- The values of N_1 , N_2 are configured with the higher-layer parameter *codebookConfig-N1*, and *codebookConfig-N2* respectively. The supported configurations of (N_1, N_2) for a given number of CSI-RS ports are given in Table 7.2.4-9. In addition, $(N_1, N_2) = (2,1)$ and $(N_1, N_2) = (4,1)$ are also supported configurations. The number of CSI-RS ports, P , is $2N_1N_2$. $O_1 = 4$; $O_2 = 1$ if $N_2 = 1$, $O_2 = 4$ otherwise.
- UE shall only use $i_{1,2} = 0$ and shall not report $i_{1,2}$ if the value of *codebookConfigN2* is set to 1.
- A first PMI value i_1 corresponds to the codebook indices combination $\{i_{1,1}, i_{1,2}, i_{1,3}\}$, and a second PMI value i_2 corresponds to the codebook index i_2 given in Table 7.2.4-17C for 1-layer and 2-layers. $i_2 = i_{2,1}$ for 1-layer, and $i_2 = 64 \cdot i_{2,2} + i_{2,1}$ for 2-layers where $i_{2,v}$ is the index for the v^{th} layer. The mapping of $i_{1,3}$ to d_1 and d_2 is given in Table 7.2.4-17A and relative power indicator (RPI), I_p , to p is given in Table 7.2.4-17B.
- In some cases codebook subsampling is supported. The sub-sampled codebook for PUCCH mode 1-1 for value of $RI = 2$ is defined in Table 7.2.2-1H for PUCCH Reporting Type 2b.

Table 7.2.4-17A: Mapping of $i_{1,3}$ field to d_1 and d_2

| Value of $i_{1,3}$ | $N_1 \geq N_2$, $N_1 \geq 4$, $N_2 \neq 1$ | | $N_1 = 3$, $N_2 = 2$ | | $N_1 = 2$, $N_2 = 2$ | | $N_2 > N_1$, $N_2 \geq 4$, $N_1 \neq 1$ | | $N_2 = 3$, $N_1 = 2$ | | $N_1 \geq 8$ | | $N_1 = 2$, $N_2 = 1$ | | $N_1 = 4$, $N_2 = 1$ | |
|--------------------|--|-------|-----------------------|-------|-----------------------|-------|---|-------|-----------------------|-------|--------------|-------|-----------------------|-------|-----------------------|-------|
| | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 | d_1 | d_2 |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 1 | 2 | 0 | 2 | 0 | 0 | 1 | 0 | 2 | 0 | 2 | 2 | 0 | | | 2 | 0 |
| 2 | 3 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 1 | 0 | 3 | 0 | | | 3 | 0 |
| 3 | 0 | 1 | 1 | 1 | | | 1 | 0 | 1 | 1 | 4 | 0 | | | | |
| 4 | 1 | 1 | 2 | 1 | | | 1 | 1 | 1 | 2 | 5 | 0 | | | | |
| 5 | 2 | 1 | | | | | 1 | 2 | | | 6 | 0 | | | | |
| 6 | 3 | 1 | | | | | 1 | 3 | | | 7 | 0 | | | | |

Table 7.2.1-17B: Mapping of I_p field to p

| Value of I_p field | p |
|----------------------|--------------|
| 0 | 0 |
| 1 | $\sqrt{1/4}$ |
| 2 | $\sqrt{1/2}$ |
| 3 | 1 |

Table 7.2.4-17C: Codebook for 1-layer and 2-layer CSI reporting using antenna ports 15 to 14+ P

| 1 and 2 Layers | | | | |
|---------------------------------|---|---|---|---|
| $\lfloor i_{2,v} / 4 \rfloor$ | | | | |
| $N_1 > 1, N_2 > 1$ | 0 | 1 | 2 | 3 |
| | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,3,i_{2,v}}^v$ |
| $0 \leq i_{1,1} \leq 4N_1 - 1,$ | 4 | 5 | 6 | 7 |
| $0 \leq i_{1,2} \leq 4N_2 - 1,$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,3,i_{2,v}}^v$ |
| $0 \leq i_{2,v} \leq 63$ | 8 | 9 | 10 | 11 |
| | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,3,i_{2,v}}^v$ |
| | 12 | 13 | 14 | 15 |
| | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,3,i_{2,v}}^v$ |
| $\lfloor i_{2,v} / 4 \rfloor$ | | | | |
| $N_2 = 1$ | 0 | 1 | 2 | 3 |
| | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,0,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,0,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,0,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,0,3,i_{2,v}}^v$ |
| $0 \leq i_{1,1} \leq 4N_1 - 1,$ | 4 | 5 | 6 | 7 |
| $i_{1,2} = 0,$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,1,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,1,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,1,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,1,3,i_{2,v}}^v$ |
| $0 \leq i_{2,v} \leq 63$ | 8 | 9 | 10 | 11 |
| | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,2,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,2,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,2,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,2,3,i_{2,v}}^v$ |
| | 12 | 13 | 14 | 15 |
| | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,3,0,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,3,1,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,3,2,i_{2,v}}^v$ | $W_{i_{1,1},i_{1,2},4d_1,d_2,p,3,3,i_{2,v}}^v$ |

| | |
|--|---|
| | $W_{k_1, k_2, m_1, m_2, p, q_1, q_2, q_3}^v = \frac{1}{\sqrt{P(1+p^2)}} \begin{bmatrix} v_{k_1, k_2} + p\varphi_{q_3} v_{k_1+m_1, k_2+m_2} \\ \varphi_{q_1} (v_{k_1, k_2} + p\varphi_{q_2} v_{k_1+m_1, k_2+m_2}) \end{bmatrix}, \quad v=1,2$ <p>For one layer:</p> $W_{k_1, k_2, m_1, m_2, p, q_1, q_2, q_3}^{(1)} = W_{k_1, k_2, m_1, m_2, p, q_1, q_2, q_3}^1,$ <p>and for two layers:</p> $W_{k_1, k_2, m_1, m_2, p, q_{1,1}, q_{2,1}, q_{3,1}, q_{1,2}, q_{2,2}, q_{3,2}}^{(2)} = \frac{1}{\sqrt{2}} [W_{k_1, k_2, m_1, m_2, p, q_{1,1}, q_{2,1}, q_{3,1}}^1 \quad W_{k_1, k_2, m_1, m_2, p, q_{1,2}, q_{2,2}, q_{3,2}}^2]$ |
| | |

For a UE configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_KI=TRUE* configured, or a UE configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', and one CSI-RS resource configured, and higher layer parameter *alternativeCodebookEnabledCLASSB_KI=TRUE* configured,

- For 2 antenna ports {15,16}, a PMI value corresponds to the codebook index *n* given in Table 7.2.4-18 with *v* equal to the associated RI value.
- For 2 antenna ports {15,16}, UE shall only use the precoding matrix corresponding to codebook index 0 in Table 6.3.4.2.3-1 of [3] with *v*=2 and shall not report PMI value if the UE is configured with higher layer parameter *semiOpenLoop=TRUE*.
- For 4 antenna ports {15,16,17,18}, a PMI corresponds to the codebook index *n* given in Table 7.2.4-19 with *v* equal to the associated RI value.
- For 4 antenna ports {15,16,17,18}, UE shall not report PMI value and shall use the precoding matrix for REs of *j*th PRB-pair according to $W(j) = C_k$, where *k* is the precoder index given by $k = (j \bmod 4) + 1 \in \{1,2,3,4\}$ and *C*₁, *C*₂, *C*₃, *C*₄ denote precoder matrices corresponding to precoder indices 12,13,14 and 15, respectively, in Table 6.3.4.2.3-2 of [3] with *v*=2 if the UE is configured with higher layer parameter *semiOpenLoop=TRUE*.
- For 8 antenna ports {15,16,17,18,19,20,21,22}, a PMI value corresponds to the codebook index *n* given in Table 7.2.4-20 with *v* equal to the associated RI value.

where $e_k^{(N)}$ is a length-*N* column-vector where its *l*-th element is 1 for $k=l$ ($k, l \in \{0,1,\dots,N-1\}$), and 0 otherwise.

Table 7.2.4-18: Codebook for *v* -layer CSI reporting using antenna ports {15,16}

| Codebook index, <i>n</i> | Number of layers <i>v</i> | |
|--------------------------|--|---|
| | 1 | 2 |
| 0 | $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$ |
| 1 | $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -1 \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} 1 & 1 \\ j & -j \end{bmatrix}$ |
| 2 | $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ j \end{bmatrix}$ | - |
| 3 | $\frac{1}{\sqrt{2}} \begin{bmatrix} 1 \\ -j \end{bmatrix}$ | - |

Table 7.2.4-19: Codebook for v -layer CSI reporting using antenna ports {15,16,17,18}

| Codebook index, n | Number of layers v | | | |
|---------------------|--|---|---|--|
| | 1 | 2 | 3 | 4 |
| 0 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(2)} \\ e_0^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(2)} & e_0^{(2)} \\ e_0^{(2)} & -e_0^{(2)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(2)} & e_0^{(2)} & e_1^{(2)} \\ e_0^{(2)} & -e_0^{(2)} & -e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_0^{(2)} & e_1^{(2)} & e_0^{(2)} & e_1^{(2)} \\ e_0^{(2)} & e_1^{(2)} & -e_0^{(2)} & -e_1^{(2)} \end{bmatrix}$ |
| 1 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(2)} \\ -e_0^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(2)} & e_0^{(2)} \\ je_0^{(2)} & -je_0^{(2)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(2)} & e_0^{(2)} & e_1^{(2)} \\ e_1^{(2)} & -e_0^{(2)} & -e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_0^{(2)} & e_1^{(2)} & e_0^{(2)} & e_1^{(2)} \\ je_0^{(2)} & je_1^{(2)} & -je_0^{(2)} & -je_1^{(2)} \end{bmatrix}$ |
| 2 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(2)} \\ j \cdot e_0^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(2)} & e_1^{(2)} \\ e_1^{(2)} & -e_1^{(2)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(2)} & e_1^{(2)} & e_1^{(2)} \\ e_0^{(2)} & e_1^{(2)} & -e_1^{(2)} \end{bmatrix}$ | - |
| 3 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(2)} \\ -j \cdot e_0^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(2)} & e_1^{(2)} \\ je_1^{(2)} & -je_1^{(2)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(2)} & e_0^{(2)} & e_0^{(2)} \\ e_1^{(2)} & e_0^{(2)} & -e_0^{(2)} \end{bmatrix}$ | - |
| 4 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(2)} \\ e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(2)} & e_1^{(2)} \\ e_0^{(2)} & -e_1^{(2)} \end{bmatrix}$ | - | - |
| 5 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(2)} \\ -e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(2)} & e_1^{(2)} \\ je_0^{(2)} & -je_1^{(2)} \end{bmatrix}$ | - | - |
| 6 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(2)} \\ j \cdot e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(2)} & e_0^{(2)} \\ e_1^{(2)} & -e_0^{(2)} \end{bmatrix}$ | - | - |
| 7 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(2)} \\ -j \cdot e_1^{(2)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(2)} & e_0^{(2)} \\ je_1^{(2)} & -je_0^{(2)} \end{bmatrix}$ | - | - |

Table 7.2.4-20: Codebook for v -layer CSI reporting using antenna ports {15,16,17,18,19,20,21,22}

| Codebook index, n | Number of layers v | | | |
|---------------------|--|---|---|--|
| | 1 | 2 | 3 | 4 |
| 0 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(4)} \\ e_0^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} \\ e_0^{(4)} & -e_0^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} & e_1^{(4)} \\ e_0^{(4)} & -e_0^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_0^{(4)} & e_1^{(4)} & e_0^{(4)} & e_1^{(4)} \\ e_0^{(4)} & e_1^{(4)} & -e_0^{(4)} & -e_1^{(4)} \end{bmatrix}$ |
| 1 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(4)} \\ -e_0^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} \\ je_0^{(4)} & -je_0^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(4)} & e_0^{(4)} & e_1^{(4)} \\ e_1^{(4)} & -e_0^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_0^{(4)} & e_1^{(4)} & e_0^{(4)} & e_1^{(4)} \\ je_0^{(4)} & je_1^{(4)} & -je_0^{(4)} & -je_1^{(4)} \end{bmatrix}$ |
| 2 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(4)} \\ j \cdot e_0^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_1^{(4)} \\ e_1^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(4)} & e_1^{(4)} & e_1^{(4)} \\ e_0^{(4)} & e_1^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_1^{(4)} & e_2^{(4)} & e_1^{(4)} & e_2^{(4)} \\ e_1^{(4)} & e_2^{(4)} & -e_1^{(4)} & -e_2^{(4)} \end{bmatrix}$ |
| 3 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_0^{(4)} \\ -j \cdot e_0^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_1^{(4)} \\ je_1^{(4)} & -je_1^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(4)} & e_0^{(4)} & e_0^{(4)} \\ e_1^{(4)} & e_0^{(4)} & -e_0^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_1^{(4)} & e_2^{(4)} & e_1^{(4)} & e_2^{(4)} \\ je_1^{(4)} & je_2^{(4)} & -je_1^{(4)} & -je_2^{(4)} \end{bmatrix}$ |
| 4 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(4)} \\ e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_2^{(4)} & e_2^{(4)} \\ e_2^{(4)} & -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(4)} & e_1^{(4)} & e_2^{(4)} \\ e_1^{(4)} & -e_1^{(4)} & -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_2^{(4)} & e_3^{(4)} & e_2^{(4)} & e_3^{(4)} \\ e_2^{(4)} & e_3^{(4)} & -e_2^{(4)} & -e_3^{(4)} \end{bmatrix}$ |
| 5 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(4)} \\ -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_2^{(4)} & e_2^{(4)} \\ je_2^{(4)} & -je_2^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_2^{(4)} & e_1^{(4)} & e_2^{(4)} \\ e_2^{(4)} & -e_1^{(4)} & -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_2^{(4)} & e_3^{(4)} & e_2^{(4)} & e_3^{(4)} \\ je_2^{(4)} & je_3^{(4)} & -je_2^{(4)} & -je_3^{(4)} \end{bmatrix}$ |
| 6 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(4)} \\ j \cdot e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_3^{(4)} & e_3^{(4)} \\ e_3^{(4)} & -e_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_1^{(4)} & e_2^{(4)} & e_2^{(4)} \\ e_1^{(4)} & e_2^{(4)} & -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_3^{(4)} & e_0^{(4)} & e_3^{(4)} & e_0^{(4)} \\ e_3^{(4)} & e_0^{(4)} & -e_3^{(4)} & -e_0^{(4)} \end{bmatrix}$ |
| 7 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_1^{(4)} \\ -j \cdot e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_3^{(4)} & e_3^{(4)} \\ je_3^{(4)} & -je_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_2^{(4)} & e_1^{(4)} & e_1^{(4)} \\ e_2^{(4)} & e_1^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{2}} \begin{bmatrix} e_3^{(4)} & e_0^{(4)} & e_3^{(4)} & e_0^{(4)} \\ je_3^{(4)} & je_0^{(4)} & -je_3^{(4)} & -je_0^{(4)} \end{bmatrix}$ |
| 8 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_2^{(4)} \\ e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_1^{(4)} \\ e_0^{(4)} & -e_1^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_2^{(4)} & e_2^{(4)} & e_3^{(4)} \\ e_2^{(4)} & -e_2^{(4)} & -e_3^{(4)} \end{bmatrix}$ | - |
| 9 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_2^{(4)} \\ -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_1^{(4)} \\ je_0^{(4)} & -je_1^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_3^{(4)} & e_2^{(4)} & e_3^{(4)} \\ e_3^{(4)} & -e_2^{(4)} & -e_3^{(4)} \end{bmatrix}$ | - |
| 10 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_2^{(4)} \\ j \cdot e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_2^{(4)} \\ e_1^{(4)} & -e_2^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_2^{(4)} & e_3^{(4)} & e_3^{(4)} \\ e_2^{(4)} & e_3^{(4)} & -e_3^{(4)} \end{bmatrix}$ | - |
| 11 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_2^{(4)} \\ -j \cdot e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_2^{(4)} \\ je_1^{(4)} & -je_2^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_3^{(4)} & e_2^{(4)} & e_2^{(4)} \\ e_3^{(4)} & e_2^{(4)} & -e_2^{(4)} \end{bmatrix}$ | - |
| 12 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_3^{(4)} \\ e_3^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_3^{(4)} \\ e_0^{(4)} & -e_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_3^{(4)} & e_3^{(4)} & e_0^{(4)} \\ e_3^{(4)} & -e_3^{(4)} & -e_0^{(4)} \end{bmatrix}$ | - |
| 13 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_3^{(4)} \\ -e_3^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_0^{(4)} & e_3^{(4)} \\ je_0^{(4)} & -je_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(4)} & e_3^{(4)} & e_0^{(4)} \\ e_0^{(4)} & -e_3^{(4)} & -e_0^{(4)} \end{bmatrix}$ | - |
| 14 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_3^{(4)} \\ j \cdot e_3^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_3^{(4)} \\ e_1^{(4)} & -e_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_3^{(4)} & e_0^{(4)} & e_0^{(4)} \\ e_3^{(4)} & e_0^{(4)} & -e_0^{(4)} \end{bmatrix}$ | - |
| 15 | $\frac{1}{\sqrt{2}} \begin{bmatrix} e_3^{(4)} \\ -j \cdot e_3^{(4)} \end{bmatrix}$ | $\frac{1}{2} \begin{bmatrix} e_1^{(4)} & e_3^{(4)} \\ je_1^{(4)} & -je_3^{(4)} \end{bmatrix}$ | $\frac{1}{\sqrt{6}} \begin{bmatrix} e_0^{(4)} & e_3^{(4)} & e_3^{(4)} \\ e_0^{(4)} & e_3^{(4)} & -e_3^{(4)} \end{bmatrix}$ | - |

| Codebook index, n | Number of layers ν | | | | |
|---------------------|--|---|---|---|---|
| | 5 | 6 | 7 | 8 | 9 |
| 0 | $\frac{1}{\sqrt{10}} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} & e_1^{(4)} & e_1^{(4)} & e_2^{(4)} \\ e_0^{(4)} & -e_0^{(4)} & e_1^{(4)} & -e_1^{(4)} & e_2^{(4)} \end{bmatrix}$ | $\frac{1}{2\sqrt{3}} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} & e_1^{(4)} & e_1^{(4)} & e_2^{(4)} & e_2^{(4)} \\ e_0^{(4)} & -e_0^{(4)} & e_1^{(4)} & -e_1^{(4)} & e_2^{(4)} & -e_2^{(4)} \end{bmatrix}$ | - | - | - |
| 1-15 | - | - | - | - | - |

| Codebook index, n | Number of layers ν | | | | | | |
|---------------------|---|--|---|----|----|----|----|
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 0 | $\frac{1}{\sqrt{14}} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} & e_1^{(4)} & e_1^{(4)} & e_2^{(4)} & e_2^{(4)} & e_3^{(4)} \\ e_0^{(4)} & -e_0^{(4)} & e_1^{(4)} & -e_1^{(4)} & e_2^{(4)} & -e_2^{(4)} & e_3^{(4)} \end{bmatrix}$ | $\frac{1}{4} \begin{bmatrix} e_0^{(4)} & e_0^{(4)} & e_1^{(4)} & e_1^{(4)} & e_2^{(4)} & e_2^{(4)} & e_3^{(4)} & e_3^{(4)} \\ e_0^{(4)} & -e_0^{(4)} & e_1^{(4)} & -e_1^{(4)} & e_2^{(4)} & -e_2^{(4)} & e_3^{(4)} & -e_3^{(4)} \end{bmatrix}$ | - | - | - | - | - |
| 1-15 | - | - | - | - | - | - | - |

7.2.5 Channel-State Information – Reference Signal (CSI-RS) definition

For a serving cell and UE configured in transmission mode 9 and not configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, the UE can be configured with one CSI-RS resource configuration.

For a serving cell and UE configured in transmission mode 9 and configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', the UE can be configured with one CSI-RS resource configuration.

For a serving cell and UE configured in transmission mode 9 and configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', the UE can be configured with one or more CSI-RS resource configuration(s).

For a serving cell and UE configured in transmission mode 9 and configured with higher layer parameter *eMIMO-Type2*, and *eMIMO-Type2* is set to 'CLASS B', the UE can be configured with one CSI-RS resource configuration.

For a serving cell and UE configured in transmission mode 10, the UE can be configured with one or more CSI-RS resource configuration(s).

The following parameters for which the UE shall assume non-zero transmission power for CSI-RS are configured via higher layer signaling for each CSI-RS resource configuration:

- CSI-RS resource configuration identity, if the UE is configured in transmission mode 9 and configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the UE is configured with more than one CSI-RS resource configurations, or if the UE is configured in transmission mode 10,
- Number of CSI-RS ports. The allowable values and port mapping are given in Subclause 6.10.5 of [3].
- CSI RS Configuration (see Table 6.10.5.2-1 and Table 6.10.5.2-2 in [3])
- CSI RS subframe configuration $I_{\text{CSI-RS}}$ except for aperiodic CSI-RS resource configuration. The allowable values are given in Subclause 6.10.5.3 of [3].
- UE assumption on reference PDSCH transmitted power for CSI feedback P_c , if the UE is configured in transmission mode 9.
- UE assumption on reference PDSCH transmitted power for CSI feedback P_c for each CSI process, if the UE is configured in transmission mode 10. If CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers for a CSI process, P_c is configured for each CSI subframe set of the CSI process.
- Pseudo-random sequence generator parameter, n_{ID} . The allowable values are given in [11].
- CDM type parameter, if the UE is configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A' for a CSI process. The allowable values are given in Subclause 6.10.5.2 of [3].
- *frequencyDensity*, if the UE is configured with higher layer parameter *eMIMO-Type* or *eMIMO-Type2* for a CSI process. The allowable values are given in Subclause 6.10.5.2 of [3].
- *transmissionComb*, if the UE is configured with higher layer parameter *eMIMO-Type* or *eMIMO-Type2* for a CSI process. The allowable values are given in Subclause 6.10.5.2 of [3].
- Higher layer parameter *qcl-CRS-Info-r11* for quasi co-location type B or type C UE assumption of CRS antenna ports and CSI-RS antenna ports with the following parameters, if the UE is configured in transmission mode 10:
 - *qcl-ScramblingIdentity-r11*.
 - *crs-PortsCount-r11*.
 - *mbsfn-SubframeConfigList-r11*.

P_c is the assumed ratio of PDSCH EPRE to CSI-RS EPRE when UE derives CSI feedback and takes values in the range of [-8, 15] dB with 1 dB step size, where the PDSCH EPRE corresponds to the symbols for which the ratio of the PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A , as specified in Table 5.2-2 and Table 5.2-3.

A UE should not expect the configuration of CSI-RS and PMCH in the same subframe of a serving cell.

For frame structure type 2 serving cell and 4 CRS ports, the UE is not expected to receive a CSI RS Configuration index (see Table 6.10.5.2-1 and Table 6.10.5.2-2 in [3]) belonging to the set [20-31] for the normal CP case or the set [16-27] for the extended CP case.

A UE may assume the CSI-RS antenna ports of a CSI-RS resource configuration are quasi co-located (as defined in [3]) with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

A UE configured in transmission mode 10 and with quasi co-location type B or type C, may assume the antenna ports 0 – 3 associated with *qcl-CRS-Info-r11* corresponding to a CSI-RS resource configuration and antenna ports 15 – 46 corresponding to the CSI-RS resource configuration are quasi co-located (as defined in [3]) with respect to Doppler shift, and Doppler spread.

A UE configured in transmission mode 10, and configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS B', and the number of configured CSI-RS resources is more than one for a CSI process, and with quasi co-location type B, is not expected to receive CSI-RS resource configurations for the CSI process that have different values of the higher layer parameter *qcl-CRS-Info-r11*.

A UE configured in transmission mode 10, and configured with higher layer parameter *eMIMO-Type* and *eMIMO-Type2*, and with quasi co-location type B, is not expected to receive CSI-RS resource configurations for *eMIMO-Type* and *eMIMO-Type2* of the CSI process that have different values of the higher layer parameter *qcl-CRS-Info-r11*.

A BL/CE UE configured with CEModeA or CEModeB is not expected to be configured with non-zero transmission power CSI-RS.

A UE configured in transmission mode 9 or 10, and configured with higher layer parameter *eMIMO-Type*, and *eMIMO-Type* is set to 'CLASS A', and more than one CSI-RS configurations for a CSI-RS resource, is not expected to receive CSI-RS configurations for the CSI-RS resource that have different values of *frequencyDensity*.

7.2.6 Channel-State Information – Interference Measurement (CSI-IM) Resource definition

For a serving cell and UE configured in transmission mode 10, the UE can be configured with one or more CSI-IM resource configuration(s). The following parameters are configured via higher layer signaling for each CSI-IM resource configuration:

- Zero-power CSI RS Configuration (see Table 6.10.5.2-1 and Table 6.10.5.2-2 in [3])
- Zero-power CSI RS subframe configuration $I_{\text{CSI-RS}}$. The allowable values are given in Subclause 6.10.5.3 of [3].

For a serving cell, if a UE is not configured with the higher layer parameter $\text{csi-SubframePatternConfig-r12}$, the UE is not expected to receive CSI-IM resource configuration(s) that are not all completely overlapping with one zero-power CSI-RS resource configuration which can be configured for the UE.

A UE is not expected to receive a CSI-IM resource configuration that is not completely overlapping with one of the zero-power CSI-RS resource configurations defined in Subclause 7.2.7.

For a serving cell, if a UE is not configured with CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ for any CSI process, and the UE is configured with four CSI-IM resources, then the UE is not expected to be configured with CSI processes that are associated with all of the four CSI-IM resources.

A UE should not expect the configuration of CSI-IM resource and PMCH in the same subframe of a serving cell.

7.2.7 Zero Power CSI-RS Resource definition

For a serving cell and UE configured in transmission mode 1-9 and UE not configured with $\text{csi-SubframePatternConfig-r12}$ for the serving cell, the UE can be configured with one zero-power CSI-RS resource configuration. For a serving cell and UE configured in transmission mode 1-9 and UE configured with $\text{csi-SubframePatternConfig-r12}$ for the serving cell, the UE can be configured with up to two zero-power CSI-RS resource configurations. For a serving cell and UE configured in transmission mode 10, the UE can be configured with one or more zero-power CSI-RS resource configuration(s).

For a serving cell, the UE can be configured with up to 5 additional zero-power CSI-RS resource configurations according to the higher layer parameter $ds\text{-ZeroTxPowerCSI-RS-r12}$.

The following parameters are configured via higher layer signaling for each zero-power CSI-RS resource configuration:

- Zero-power CSI RS Configuration list (16-bit bitmap ZeroPowerCSI-RS in [3])
- Zero-power CSI RS subframe configuration $I_{\text{CSI-RS}}$ except for aperiodic zero-power CSI-RS resource configuration. The allowable values are given in Subclause 6.10.5.3 of [3].

A UE should not expect the configuration of zero-power CSI-RS and PMCH in the same subframe of a serving cell.

For frame structure type 1 serving cell, the UE is not expected to receive the 16-bit bitmap ZeroPowerCSI-RS with any one of the 6 LSB bits set to 1 for the normal CP case, or with any one of the 8 LSB bits set to 1 for the extended CP case.

For frame structure type 2 serving cell and 4 CRS ports, the UE is not expected to receive the 16-bit bitmap ZeroPowerCSI-RS with any one of the 6 LSB bits set to 1 for the normal CP case, or with any one of the 8 LSB bits set to 1 for the extended CP case.

A BL/CE UE configured with CEModeA or CEModeB is not expected to be configured with zero-power CSI-RS.

7.2.8 CSI-RS Activation / Deactivation

For a serving cell and UE configured in transmission mode 9 or 10 and for a CSI process the UE configured with higher layer parameter $e\text{MIMO-Type}$ and $e\text{MIMO-Type}$ is set to 'CLASS B',

- if the UE is configured with higher layer parameter $\text{csi-RS-ConfigNZP-ApList}$, the higher layer parameter csi-RS-NZP-mode is set to aperiodic, and number of configured CSI-RS resources in $\text{csi-RS-ConfigNZP-ApList}$ is more

than 2 and more than the number of activated CSI-RS resources N given by the higher layer parameter *activatedResources* for the CSI process, or

- if the higher layer parameter *csi-RS-NZP-mode* is set to multiShot,
- when a UE receives an activation command [8] for CSI-RS resource(s) associated with the CSI process in subframe n , the corresponding actions in [8] and UE assumption on CSI-RS transmission corresponding to the $\min(4, N, N_{CSI-R})$ activated CSI-RS resource(s) shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe $n+8$, where N is the number of activated CSI-RS resources for the CSI process, and N_{CSI-R} is the maximum number of CSI-RS resources supported by the UE for a CSI process of the serving cell given by the higher layer parameter *nMaxResource-r14* included in the *MIMO-UE-ParametersPerTM-r14xy*,
- when a UE receives a deactivation command [8] for activated CSI-RS resource(s) associated with the CSI process in subframe n , the corresponding actions in [8] and UE assumption on cessation of CSI-RS transmission corresponding to the deactivated CSI-RS resource(s) shall apply no later than the minimum requirement defined in [10] and no later than subframe $n+8$.

7.3 UE procedure for reporting HARQ-ACK

If the UE is not configured with *shortTTI*, the term 'subframe/slot' refers to a subframe in this subclause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a slot, the term 'subframe/slot' refers to a slot, subframe otherwise, in this subclause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a subslot, the term 'slot/subslot' refers to a subslot, slot otherwise, in this subclause.

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

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', and 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell or serving cells belonging to the primary PUCCH group respectively unless stated otherwise.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell' and 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively unless stated otherwise. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

If each of the serving cell(s) configured for the UE has frame structure type 1, the UE procedure for HARQ-ACK reporting for frame structure type 1 is given in Subclause 7.3.1.

If each of the serving cell(s) configured for the UE has frame structure type 2, the UE procedure for HARQ-ACK reporting for frame structure type 2 is given in Subclause 7.3.2.

If the UE is configured with more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 1, UE procedure for HARQ-ACK reporting is given in Subclause 7.3.3.

If the UE is configured for more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 2, UE procedure for HARQ-ACK reporting is given in Subclause 7.3.4.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, UE procedure for HARQ-ACK reporting for the serving cell is given in Subclause 7.3.4 assuming primary cell frame structure type 2 with "UL/DL configuration" given by *subframeAssignment-r15*. The UE shall apply an offset value given by *harq-Offset-r15* to the subframe index in the UL/DL configuration for determining the HARQ-ACK reporting for the serving cell. The UE is not expected to transmit any uplink physical channel or signal in the serving cell on subframes other than the offset-UL subframes, where the offset-UL subframes are determined by applying the offset value to the subframes denoted as uplink in the UL/DL configuration. For a PDSCH data transmissions signalled via PDCCH in common search space for which HARQ-ACK response shall be provided, the UE shall assume the value of the DAI field in the corresponding DCI format is equal to '1'. If the UE transmits HARQ-ACK on PUSCH scheduled via PDCCH in common search space, the

UE shall assume the value of the DAI field in the DCI format for scheduling the PUSCH is equal to '1' and the UE is not expected to receive PDSCH scheduled via PDCCH/EPDCCH in UE-specific search space for which the HARQ-ACK response is multiplexed onto the PUSCH.

For a UE configured with EN-DC/NE-DC and more than one serving cells with primary cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the primary cell, UE procedure for HARQ-ACK reporting of each secondary cell follows the procedure of the primary cell.

Throughout this section,

- if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 3$ and $k_p = 4$ otherwise.
- if the UE is configured with higher layer parameter *shortTTI* and for PDSCH transmissions in a subslot, X_p is determined based on higher layer parameter *proc-Timeline-r15*, where
 - $X_p = 4$ if *proc-Timeline-r15* is set to 'nplus4set1'
 - $X_p = 6$ if *proc-Timeline-r15* is set to 'nplus6set1' or 'nplus6set2'
 - $X_p = 8$ if *proc-Timeline-r15* is set to 'nplus8set2'

If the UE is configured with higher layer parameter *shortTTI*, and the UE has received slot/subslot-PDSCH without an associated PDCCH/SPDCCH or with an associated PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G for which slot/subslot-PUCCH including HARQ-ACK and SR (if any) is to be transmitted on slot/subslot s of subframe n ,

- If the UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai*, the UE shall transmit the HARQ-ACK corresponding to subframe-PDSCH on the slot/subslot-PUCCH if the UE has received subframe-PDSCH without an associated PDCCH/SPDCCH or with an associated PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D on subframe $n - k$ of a serving cell and if the slot/subslot-PUCCH is the first occurrence of the slot/subslot-PUCCH/PUSCH in the subframe;
- If the UE is configured with no more than five serving cells or if the UE is configured with higher layer parameter *codebooksizeDetermination-r13 = cc*, the UE shall transmit the HARQ-ACK corresponding to subframe-PDSCH for all serving cells on the slot/subslot-PUCCH regardless whether the UE has received subframe-PDSCH without an associated PDCCH/SPDCCH or with an associated PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D associated with subframe-PDSCH for any of the serving cell(s) on subframe $n - k$. If the UE has not received subframe-PDSCH for a serving cell on subframe $n - k$, the corresponding HARQ-ACK bit(s) is NACK;

and

- $k = k_p$ for FDD, and $k \in K$ for TDD where K is defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH, and in Table 10.1.3.1-1 otherwise.
- spatial bundling of the HARQ-ACK corresponding to subframe-PDSCH is applied if the HARQ-ACK is to be transmitted on
 - subslot s or
 - slot s and *spatialBundlingPUCCH* is set *TRUE*.
- the sequence of HARQ-ACK bit(s) corresponding to subframe-PDSCH $\tilde{o}_0^{LACK} \tilde{o}_1^{LACK}, \dots, \tilde{o}_{O^{LACK}-1}^{LACK}$ is determined in Subclause 5.2.3.1A of [4]

If the UE is configured with higher layer parameter *shortTTI*, and the UE transmits slot/subslot-PUSCH on slot/subslot *s* of subframe *n* without associated PDCCH/SPDCCH or with associated PDCCH/SPDCCH with DCI format 7-0A/7-0B and if the UE is not configured with simultaneous PUSCH and PUCCH transmission,

- the UE shall transmit the HARQ-ACK corresponding to subframe-PDSCH on the slot/subslot-PUSCH if the UE has received subframe-PDSCH on subframe $n - k$ of a serving cell and if the slot/subslot-PUSCH is the first occurrence of the slot/subslot-PUCCH/PUSCH in the subframe;
- if the UE is configured with no more than five serving cells or if the UE is configured with higher layer parameter *codebooksizeDetermination-r13 = cc*, the UE shall transmit the HARQ-ACK corresponding to subframe-PDSCH for all serving cells on the slot/subslot-PUSCH if the UE has received slot/subslot-PDSCH without an associated PDCCH/SPDCCH or with an associated PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G for which HARQ-ACK response shall be provided on slot/subslot *s* of subframe *n*, and
 - if the UE has received subframe-PDSCH without an associated PDCCH/EPDCCH or with an associated PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D for at least one of the serving cell(s) on subframe $n - k$, or
 - if the UE has not received subframe-PDSCH without an associated PDCCH/EPDCCH or with an associated PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D for any of the serving cell(s) on subframe $n - k$, and if the slot/subslot-PUSCH is the first occurrence of the slot/subslot-PUCCH/PUSCH in the subframe;
 - the corresponding HARQ-ACK bit(s) is NACK, if the UE has not received subframe-PDSCH without an associated PDCCH/SPDCCH or with an associated PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D for a serving cell(s) on subframe $n - k$;

and

- $k = k_p$ for FDD, and $k \in K$ for TDD where K is defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH, and in Table 10.1.3.1-1 otherwise.
- spatial bundling of the HARQ-ACK corresponding to subframe-PDSCH is applied if the HARQ-ACK is to be transmitted on
 - subslot *s* or
 - slot *s* and *spatialBundlingPUCCH* is set *TRUE*
- the sequence of HARQ-ACK bit(s) corresponding to subframe-PDSCH $\tilde{o}_0^{LACK} \tilde{o}_1^{LACK}, \dots, \tilde{o}_{O^{LACK}-1}^{LACK}$ is determined in Subclause 5.2.2.6 of [4].

If the UE is configured with higher layer parameter *blindSubframePDSCH-Repetitions* for a given serving cell, UE procedure for HARQ-ACK reporting for the serving cell corresponding to a PDCCH/EPDCCH with DCI format 1A with CRC scrambled by C-RNTI in UE-specific search space is given in this clause assuming the subframe-PDSCH is received in the last subframe of the set of received *k* DL subframes according to the PDCCH/EPDCCH information as described in subclause 7.1.

If the UE is configured with higher layer parameter *blindSlotSubslotPDSCH-Repetitions* for a given serving cell, UE procedure for HARQ-ACK reporting for the serving cell corresponding to a PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI is given in this clause assuming the slot/subslot-PDSCH is received in the last slot/subslot of the set of received *k* DL slots/subslots according to the PDCCH/SPDCCH information as described in subclause 7.1.

7.3.1 FDD HARQ-ACK reporting procedure

For FDD with PUCCH format 1a/1b transmission, when both HARQ-ACK and SR are transmitted in the same subframe/slot, a UE shall transmit the HARQ-ACK on its assigned HARQ-ACK PUCCH format 1a/1b resource for a negative SR transmission and transmit the HARQ-ACK on its assigned SR PUCCH resource for a positive SR transmission.

For FDD with PUCCH format 1a transmission, when both HARQ-ACK and SR are transmitted in the same subslot, a UE shall transmit the HARQ-ACK bit according to Table 7.3.1-0A;

Table 7.3.1-0A: PUCCH format 1a resource for transmission of HARQ-ACK bit and SR

| HARQ-ACK | SR transmission | Resource for HARQ-ACK bits transmission |
|----------|-----------------|--|
| ACK/NACK | negative | HARQ-ACK PUCCH format 1a resource |
| NACK | positive | The first SR PUCCH resource value configured by the higher layers |
| ACK | positive | The second SR PUCCH resource value configured by the higher layers |

for FDD with PUCCH format 1b transmission, when both HARQ-ACK and SR are transmitted in the same subslot, a UE shall transmit the HARQ-ACK bits according to Table 7.3.1-0B;

Table 7.3.1-0B: PUCCH format 1b resource for transmission of HARQ-ACK bits

| HARQ-ACK(0) | HARQ-ACK(1) | SR transmission | Resource for HARQ-ACK bits transmission |
|-------------|-------------|-----------------|--|
| ACK/NACK | ACK/NACK | negative | HARQ-ACK PUCCH format 1b resource |
| NACK | NACK | positive | The first SR PUCCH resource value configured by the higher layers |
| ACK | NACK | positive | The second SR PUCCH resource value configured by the higher layers |
| NACK | ACK | positive | The third SR PUCCH resource value configured by the higher layers |
| ACK | ACK | positive | The fourth SR PUCCH resource value configured by the higher layers |

where SR PUCCH resources are configured by higher layer parameter *sr-SubslotSPUCCH-Resource*, and HARQ-ACK(j), $j=0, 1$ denotes the ACK/NACK response for a transport block or SPS release PDCCH/EPDCCH/SPDCCH associated with serving cell c .

For FDD with PUCCH format 1b with channel selection, when both HARQ-ACK and SR are transmitted in the same sub-frame a UE shall transmit the HARQ-ACK on its assigned HARQ-ACK PUCCH resource with channel selection as defined in Subclause 10.1.2.2.1 for a negative SR transmission and transmit one HARQ-ACK bit per serving cell on its assigned SR PUCCH resource for a positive SR transmission according to the following:

- if only one transport block or a PDCCH/EPDCCH indicating downlink SPS release is detected on a serving cell, the HARQ-ACK bit for the serving cell is the HARQ-ACK bit corresponding to the transport block or the PDCCH/EPDCCH indicating downlink SPS release;
- if two transport blocks are received on a serving cell, the HARQ-ACK bit for the serving cell is generated by spatially bundling the HARQ-ACK bits corresponding to the transport blocks;
- if neither PDSCH transmission for which HARQ-ACK response shall be provided nor PDCCH/EPDCCH indicating downlink SPS release is detected for a serving cell, the HARQ-ACK bit for the serving cell is set to NACK;

and the HARQ-ACK bits for the primary cell and the secondary cell are mapped to $b(0)$ and $b(1)$, respectively, where $b(0)$ and $b(1)$ are specified in Subclause 5.4.1 in [3].

For FDD, when a PUCCH format 3/4/5 transmission of HARQ-ACK coincides with a subframe/slot/subslot configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in Subclause 5.2.3.1 in [4], unless the HARQ-ACK corresponds to a subframe-PDSCH transmission on the primary cell only or a PDCCH/EPDCCH indicating downlink SPS release on the primary cell only, in which case the SR shall be transmitted as for FDD with PUCCH format 1a/1b.

For a non-BL/CE UE for FDD and for a PUSCH transmission, a UE shall not transmit HARQ-ACK on PUSCH in subframe/slot/subslot n if the UE does not receive PDSCH or PDCCH/SPDCCH indicating downlink SPS release in

- subframe $n - k_p$ for subframe-PDSCH or in subframe $n - 4$ for PDCCH indicating downlink SPS release
- slot $n-4$ for slot-PDSCH

- subslot $n - X_p$ for subslot-SPDSCH if the higher layer parameter *ul-TTI-Length* is set to 'subslot'
- any of the subslot numbers listed in Table 10.1-1 if the higher layer parameter *ul-TTI-Length* is set to 'slot' and slot-PUSCH is transmitted in subframe m

For a BL/CE UE, for FDD and for a PUSCH transmission scheduled by an MPDCCH where the last transmission of the MPDCCH is in subframe $n-4$, a UE shall not transmit HARQ-ACK on PUSCH in subframe n if there is no PDSCH or MPDCCH indicating downlink SPS release transmitted to the UE in subframe $n-4$ where the last transmission of the PDSCH or MPDCCH indicating downlink SPS release is in subframe $n-4$.

When only a positive SR is transmitted using subframe-PUCCH, a UE shall use PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 in [3].

When only a positive SR is transmitted using slot/subslot-PUCCH, a UE shall use PUCCH Format 1 for the first SR resource configured by higher layers as defined in Subclause 5.4.A.2 in [3].

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* and PDSCH is associated with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D, the following HARQ-ACK reporting procedure applies to subframe-PDSCH operation. If a UE is configured with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai* and PDSCH is associated with DCI format 7-1A/7-1B/7-1C/7-1D/7-1F/7-1G, the following HARQ-ACK reporting procedure applies to slot/subslot-PDSCH operation.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai*, for FDD and a subframe/subslot n , the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1F/7-1G denotes the accumulative number of {serving cell, subframe/slot/subslot}-pair(s) with PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH and serving cell with PDCCH/EPDCCH/SPDCCH indicating downlink SPS release, up to the present serving cell and present subframe/slot/subslot, first in increasing order of serving cell index and then in increasing order of subframe/slot/subslot index; the value of the total DAI in DCI format

1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the total number of {serving cell, subframe/slot/subslot}-pair(s) with PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH (s) and serving cell with PDCCH/EPDCCH/SPDCCH indicating downlink SPS release. Denote $V_{c-DAI,c,s}^{DL}$ as the value of the counter DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1F/7-1G scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe/slot/subslot s within the set of subframe(s)/slot(s)/subslot(s) for which HARQ-ACK response shall be provided in subframe/slot/subslot n , according to table 7.3.1-1. Denote $V_{T-DAI,s}^{DL}$ as the value of the total DAI, according to Table 7.3.1-1. The UE shall assume a same value of total DAI in all PDCCH/EPDCCH/SPDCCH scheduling PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in a subframe/slot/subslot.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe/slot/subslot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $s = 0$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_s = \emptyset$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set $S = 3$ for subslot PDSCH operation with higher layer parameter *dl-TTI-Length='subslot'* and *ul-TTI-Length='slot'*; $S = 2$ for subframe-PDSCH operation with the higher layer parameter *shortProcessingTime* configured; 1 otherwise

while $s < S$

while $c < N_{cells}^{DL}$

if there is a PDSCH on serving cell c associated with PDCCH/EPDCCH/SPDCCH or there is a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release on serving cell c for which HARQ-ACK is transmitted in subframe/slot/subslot n , or

if $V_{C-DAI,c,s}^{DL} = \emptyset$

$$V_{C-DAI,c,s}^{DL} = \text{mod}(V_{temp}, 4) + 1$$

end if

if $V_{C-DAI,c,s}^{DL} \leq V_{temp}$

$j = j + 1$

end if

$$V_{temp} = V_{C-DAI,c,s}^{DL}$$

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell and HARQ-ACK is not to be transmitted on subslot-PUCCH,

$$\tilde{o}_{8j+2(V_{C-DAI,c}^{DL}-1)}^{ACK} = \text{HARQ-ACK bit corresponding to the first codeword of this cell}$$

$$\tilde{o}_{8j+2(V_{C-DAI,c}^{DL}-1)+1}^{ACK} = \text{HARQ-ACK bit corresponding to the second codeword of this cell}$$

$$V_s = V_s \cup \{8j+2(V_{C-DAI,c}^{DL}-1), 8j+2(V_{C-DAI,c}^{DL}-1)+1\}$$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell or HARQ-ACK is to be transmitted on subslot-PUCCH,

$$\tilde{o}_{4j+V_{C-DAI,c}^{DL}-1}^{ACK} = \text{binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell}$$

$$V_s = V_s \cup \{4j+V_{C-DAI,c}^{DL}-1\}$$

else

$$\tilde{o}_{4j+V_{C-DAI,c}^{DL}-1}^{ACK} = \text{HARQ-ACK bit for subframe/slot/subslot } s \text{ of this cell.}$$

$$V_s = V_s \cup \{4j+V_{C-DAI,c}^{DL}-1\}$$

end if

end if

$$c = c + 1$$

end while

$$s = s + 1$$

end while

if $V_{T-DAI,s}^{DL} < V_{temp}$

j = j+1

end if

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell and HARQ-ACK is not to be transmitted on subslot-PUCCH,

$$O^{ACK} = 2 \cdot (4 \cdot j + V_{T-DAI,s}^{DL})$$

else

$$O^{ACK} = 4 \cdot j + V_{T-DAI,s}^{DL}$$

end if

$$\tilde{o}_i^{ACK} = \text{NACK} \text{ for any } i \in \{0, 1, \dots, O^{ACK} - 1\} \setminus V_s$$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in subframe/slot $n-4$ or in subslot $n-X_p$

$$O^{ACK} = O^{ACK} + 1$$

$$o_{O^{ACK}-1}^{ACK} = \text{HARQ-ACK bit associated with the SPS PDSCH transmission}$$

end if

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai*, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot/subslot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the above procedure as if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5, except that the higher layer parameter *spatialBundlingPUCCH* is replaced by *spatialBundlingPUSCH*.

Table 7.3.1-1: Value of counter DAI and total DAI

| DAI MSB, LSB | $V_{C-DAI,c,s}^{DL}$ or V_{T-DAI}^{DL} | Number of serving cells with PDSCH transmission associated with PDCCH/EPDCCH/SPDCCH and serving cell with PDCCH/EPDCCH/SPDCCH indicating DL SPS release |
|--------------------|---|---|
| 0,0 | 1 | 1 or 5 or 9 or 13 or 17 or 21 or 25 or 29 |
| 0,1 | 2 | 2 or 6 or 10 or 14 or 18 or 22 or 26 or 30 |
| 1,0 | 3 | 3 or 7 or 11 or 15 or 19 or 23 or 27 or 31 |
| 1,1 | 4 | 0 or 4 or 8 or 12 or 16 or 20 or 24 or 28 or 32 |

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = cc* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = cc* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe/slot/subslot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 for subframe-PUCCH transmission and Subclause 5.2.3.1A for slot/subslot-PUCCH transmission in [4].

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = cc* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = cc*, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot/subslot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.2.6 in [4].

For a BL/CE UE, for PDSCH transmission in subframe $n-k$, if the UE is in half-duplex FDD operation and is configured with CEModeA and higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, or if the UE is configured with higher layer parameter *ce-SchedulingEnhancement*,

- if the 'HARQ-ACK delay' field in the corresponding DCI indicates value k , the UE shall determine the subframe n as the HARQ-ACK transmission subframe.
- the HARQ-ACK delay value k is determined from the corresponding DCI based on the higher layer parameters according to Table 7.3.1-2.

For a BL/CE UE in half-duplex FDD operation, if the UE is configured with CEModeA, and if the UE is configured with higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1,

- for HARQ-ACK transmission in subframe n , the UE shall generate one HARQ-ACK bit by performing a logical AND operation of HARQ-ACKs across all $1 \leq M \leq 4$ BL/CE DL subframes for which subframe n is the 'HARQ-ACK transmission subframe'.
- if subframe $n-k_1$ is the most recent subframe for which subframe n is the 'HARQ-ACK transmission subframe', and if the 'Transport blocks in a bundle' field in the corresponding DCI for PDSCH transmission in subframe $n-k_1$ indicates a number of transport blocks in a bundle other than M , the UE shall generate a NACK for HARQ-ACK transmission in subframe n .
- if the UE has received W PDSCH transmissions before subframe n , and if the UE is expected to transmit HARQ-ACK for the W PDSCH transmissions in subframes $\{n_1 \dots n_L\}, n_i \geq n$, the UE is not expected to receive a new PDSCH transmission in subframe n , where $W=10$ if higher layer parameter *ce-pdsch-tenProcesses-config* is set to 'On', and $W=8$ otherwise.
- if the UE is expected to transmit HARQ-ACK for the PDSCH transmissions received before subframe n in subframes $\{n_1, n_2, n_3\}, n_i \geq n$, the UE is not expected to receive a new PDSCH transmission in subframe n for which the HARQ-ACK is to be transmitted in subframe $n_4 \notin \{n_1, n_2, n_3\}$.

Table 7.3.1-2: HARQ-ACK delay for BL/CE UE in CEModeA

| 'HARQ-ACK delay' field in DCI | HARQ-ACK delay value when 'ce-SchedulingEnhancement' set to 'range1' | HARQ-ACK delay value when 'ce-SchedulingEnhancement' set to 'range2', or 'ce-SchedulingEnhancement' is not configured and 'ce-HARQ-AckBundling' is set |
|-------------------------------|--|--|
| 000 | 4 | 4 |
| 001 | 5 | 5 |
| 010 | 7 | 6 |
| 011 | 9 | 7 |
| 100 | 11 | 8 |
| 101 | 13 | 9 |
| 110 | 15 | 10 |
| 111 | 17 | 11 |

7.3.2 TDD HARQ-ACK reporting procedure

For TDD and a UE not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell, if the UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, UE procedure for reporting HARQ-ACK is given in Subclause 7.3.2.1.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, UE procedure for reporting HARQ-ACK is given in Subclause 7.3.2.2.

When only a positive SR is transmitted, a UE shall use subframe-PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 in [3].

When only a positive SR is transmitted using slot-PUCCH, a UE shall use PUCCH Format 1 for the first SR resource configured by higher layers as defined in Subclause 5.4A.2 in [3].

7.3.2.1 TDD HARQ-ACK reporting procedure for same UL/DL configuration

Unless otherwise stated, the procedure in this subclause applies to non-BL/CE UEs.

For TDD, the UE shall upon detection of a PDSCH transmission or a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe/slot(s) $n - k$, where $k \in K$, intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe/slot n and K is defined in

- Table 10.1.3.1-1E if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH and special subframe configuration 0, 5, 9, and 10,
- Table 10.1.3.1-1D if the UE is configured with higher layer parameter *shortTTI* for special subframe configuration 3, 4, and 8,
- Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH and special subframe configuration 1, 2, 6, 7,
- Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-based PDSCH and
- Table 10.1.3.1-1 otherwise.

For TDD, when PUCCH format 3/4/5 is configured for transmission of HARQ-ACK,

- for special subframe configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or configurations 0 and 4 with extended downlink CP in a serving cell, shown in table 4.2-1 [3], the special subframe of the serving cell is excluded from the HARQ-ACK codebook size determination. In this case, if the serving cell is the primary cell, there is no PDCCH/EPDCCH indicating downlink SPS release in the special subframe.
- for special subframe configurations 1, 2, 6, and 7 and slot-PDSCH, the second slot of DwPTS of the serving cell is excluded from the HARQ-ACK codebook size determination. In this case, if the serving cell is the primary cell, there is no PDCCH/SPDCCH indicating downlink SPS release in the second slot of DwPTS.

For TDD UL/DL configurations 1-6 and one configured serving cell, if the UE is not configured with PUCCH format 3, the value of the Downlink Assignment Index (DAI) in DCI format 0/4/7-0A/7-0B, V_{DAI}^{UL} , detected by the UE according to Table 7.3-X in subframe/slot $n - k'$, where k' is defined in

- Table 7.3-Y4 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 3, 4, 8 for slot-PDSCH,
- Table 7.3-Y3 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 0, 5, 9, 10 for slot-PDSCH,
- Table 7.3-Y2 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 1,2,6,7 for slot-PDSCH,
- Table 7.3-Y1 if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH,
- Table 7.3-Y otherwise,

represents the total number of subframes/slots with PDSCH transmissions and with PDCCH/EPDCCH/SPDCCH indicating downlink SPS release to the corresponding UE within all the subframe(s) /slot(s) $n - k$, where $k \in K$. The value V_{DAI}^{UL} includes all PDSCH transmission with and without corresponding PDCCH/EPDCCH/SPDCCH within all the subframe(s) /slot(s) $n - k$. In case neither PDSCH transmission, nor PDCCH/EPDCCH/SPDCCH indicating the

downlink SPS resource release is intended to the UE, the UE can expect that the value of the DAI in DCI format 0/4/7-0A/7-0B, V_{DAI}^{UL} , if transmitted, is set to 4.

For TDD UL/DL configuration 1-6 and a UE configured with more than one serving cell, or for TDD UL/DL configuration 1-6 and a UE configured with one serving cell and PUCCH format 3, a value W_{DAI}^{UL} is determined by the Downlink Assignment Index (DAI) in DCI format 0/4/7-0A/7-0B according to Table 7.3-Z in subframe/slot $n - k'$, where k' is defined in

- Table 7.3-Y4 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 3, 4, 8 for slot-PDSCH,
- Table 7.3-Y3 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 0, 5, 9, 10 for slot-PDSCH,
- Table 7.3-Y2 if the UE is configured with higher layer parameter *shortTTI* and for special subframe configuration 1, 2, 6, 7 for slot-PDSCH,
- Table 7.3-Y1 if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH,
- Table 7.3-Y otherwise.

In case neither PDSCH transmission, nor PDCCH/EPDCCH/SPDCCH indicating the downlink SPS resource release is intended to the UE, the UE can expect that the value of W_{DAI}^{UL} is set to 4 by the DAI in DCI format 0/4/7-0A/7-0B if transmitted.

If a UE is not configured with higher layer parameter *shortTTI* and not configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or is configured with higher layer parameter *shortTTI* and not configured with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai*, for TDD UL/DL configurations 1-6, the value of the DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the accumulative number of PDCCH/EPDCCH/SPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release up to the present subframe/slot within subframe(s)/slot(s) $n - k$ of each configured serving cell, where $k \in K$, and shall be updated from subframe/slot to subframe/slot. Denote $V_{DAI,c}^{DL}$ as the value of the DAI in PDCCH/EPDCCH/SPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G detected by the UE according to Table 7.3-X in subframe/slot $n - k_m$ in serving cell c , where k_m is the smallest value in the set K (defined in Table 10.1.3.1-1D if the UE is configured with higher layer parameter *shortTTI* and special subframe configuration 3, 4, 8 for slot-PDSCH, in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* and special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10 for slot-PDSCH, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise) such that the UE detects a DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G. When configured with one serving cell, the subscript of c in $V_{DAI,c}^{DL}$ can be omitted.

For all TDD UL/DL configurations, denote $U_{DAI,c}$ as the total number of PDCCH/EPDCCH/SPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release detected by the UE within the subframe(s)/slot(s) $n - k$ in serving cell c , where $k \in K$. When configured with one serving cell, the subscript of c in $U_{DAI,c}$ can be omitted. Denote N_{SPS} , which can be zero or one, as the number of PDSCH transmissions without a corresponding PDCCH/EPDCCH/SPDCCH within the subframe(s)/slot(s) $n - k$, where $k \in K$.

For TDD HARQ-ACK bundling or HARQ-ACK multiplexing and a subframe/slot n with $M = 1$, the UE shall generate one or two HARQ-ACK bits by performing a logical AND operation per codeword across M subframe(s)/slot(s) downlink and special subframes associated with a single UL subframe/slot, of all the corresponding $U_{DAI} + N_{SPS}$ individual PDSCH transmission HARQ-ACKs and individual ACK in response to received PDCCH/EPDCCH/SPDCCH indicating downlink SPS release, where M is the number of elements in the set K defined in Table 10.1.3.1-1D if the UE is configured with higher layer parameter *shortTTI* and special subframe configuration 3, 4, 8 for slot-PDSCH, in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI*

and special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10 for slot-PDSCH, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise. The UE shall detect if at least one downlink assignment has been missed, and for the case that the UE is transmitting on PUSCH the UE shall also determine the parameter N_{bundled} .

- For TDD UL/DL configuration 0, N_{bundled} shall be 1 if the UE detects the PDSCH transmission with or without corresponding PDCCH/EPDCCH/SPDCCH, or detects PDCCH/SPDCCH indicating downlink SPS release within the subframe/slot $n - k$, where $k \in K$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/SPDCCH indicating downlink SPS release within the subframe(s)/slot(s) $n - k$, where $k \in K$.
- For the case that the UE is not transmitting on PUSCH in subframe/slot n and TDD UL/DL configurations 1-6, if $U_{\text{DAI}} > 0$ and $V_{\text{DAI}}^{DL} \neq (U_{\text{DAI}} - 1) \bmod 4 + 1$, the UE detects that at least one downlink assignment has been missed.
- For the case that the UE is transmitting on PUSCH and the PUSCH transmission is performed based on a detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B intended for the UE and TDD UL/DL configurations 1-6, if $V_{\text{DAI}}^{UL} \neq (U_{\text{DAI}} + N_{\text{SPS}} - 1) \bmod 4 + 1$ the UE detects that at least one downlink assignment has been missed and the UE shall generate NACK for all codewords where N_{bundled} is determined by the UE as $N_{\text{bundled}} = V_{\text{DAI}}^{UL} + 2$. If the UE does not detect any downlink assignment missing, N_{bundled} is determined by the UE as $N_{\text{bundled}} = V_{\text{DAI}}^{UL}$. UE shall not transmit HARQ-ACK if $U_{\text{DAI}} + N_{\text{SPS}} = 0$ and $V_{\text{DAI}}^{UL} = 4$.
- For the case that the UE is transmitting on PUSCH, and the PUSCH transmission is not based on a detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B intended for the UE and TDD UL/DL configurations 1-6, if $U_{\text{DAI}} > 0$ and $V_{\text{DAI}}^{DL} \neq (U_{\text{DAI}} - 1) \bmod 4 + 1$, the UE detects that at least one downlink assignment has been missed and the UE shall generate NACK for all codewords. The UE determines $N_{\text{bundled}} = (U_{\text{DAI}} + N_{\text{SPS}})$ as the number of assigned subframes/slots. The UE shall not transmit HARQ-ACK if $U_{\text{DAI}} + N_{\text{SPS}} = 0$.

For TDD, when PUCCH format 3 is configured for transmission of HARQ-ACK without PUCCH format 4 or PUCCH format 5 configured for transmission of HARQ-ACK, the HARQ-ACK feedback bits $o_{c,0}^{\text{ACK}}, o_{c,1}^{\text{ACK}}, \dots, o_{c,O_c^{\text{ACK}}-1}^{\text{ACK}}$ for the c -th serving cell configured by RRC are constructed as follows, where $c \geq 0$, $O_c^{\text{ACK}} = B_c^{DL}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied and $O_c^{\text{ACK}} = 2B_c^{DL}$ otherwise, where B_c^{DL} is the number of subframes/slots in downlink and special subframes for which the UE needs to feedback HARQ-ACK bits for the c -th serving cell.

- For subframe-PDSCH and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise; associated with subframe/slot n and the set K does not include a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.
- For slot-PDSCH, special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10, and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1C; associated with slot n and the set K does not include a slot in a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.

- For slot-PDSCH, special subframe configuration 3, 4, 8, and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1D; associated with slot n and the set K does not include a slot in a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.
- For subframe-PDSCH, and TDD UL/DL configuration 0 or for a PUSCH transmission not performed based on a detected PDCCH/EPDCCH with DCI format 0/4, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise; associated with subframe n and the set K does not include a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$, where $k \in K$.
- For slot-PDSCH, special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10, and TDD UL/DL configuration 0 or for a PUSCH transmission not performed based on a detected PDCCH/SPDCCH with DCI format 7-0A/7-0B, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1C associated with slot n and the set K does not include a slot in a special subframe of configurations 0 and 5 with normal downlink CP; otherwise $B_c^{DL} = M - 1$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH /SPDSCH indicating downlink SPS release in slot(s) $n - k$, where $k \in K$.
- For slot-PDSCH, special subframe configuration 3, 4, 8, and TDD UL/DL configuration 0 or for a PUSCH transmission not performed based on a detected PDCCH/SPDCCH with DCI format 7-0A/7-0B, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1D associated with slot n . The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/SPDSCH indicating downlink SPS release in slot(s) $n - k$, where $k \in K$.
- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission performed based on a detected PDCCH/EPDCCH with DCI format 0/4/7-0A/7-0B, the UE shall assume $B_c^{DL} = W_{DAI}^{UL}$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n - k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.
- For TDD UL/DL configurations 5 and a PUSCH transmission performed based on a detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B, the UE shall assume $B_c^{DL} = W_{DAI}^{UL} + 4 \lceil (U - W_{DAI}^{UL}) / 4 \rceil$, where U denotes the maximum value of U_c among all the configured serving cells, U_c is the total number of received PDSCHs and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n - k$ on the c -th serving cell, $k \in K$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n - k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

For TDD, when PUCCH format 4/5 is configured for transmission of HARQ-ACK and if the UE is configured with higher layer parameter *codebooksizeDetermination-r13* = cc or *codebooksizeDeterminationsSTTI-r15* = cc , the HARQ-ACK feedback bits $o_{c,0}^{ACK}, o_{c,1}^{ACK}, \dots, o_{c,O_c^{ACK}-1}^{ACK}$ for the c -th serving cell configured by RRC are constructed as follows,

where $c \geq 0$, $O_c^{ACK} = B_c^{DL}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied or for slot-PDSCH and $O_c^{ACK} = 2B_c^{DL}$ otherwise, where B_c^{DL} is the number of subframes/slots in downlink and special subframes for which the UE needs to feedback HARQ-ACK bits for the c -th serving cell.

- For subframe-PDSCH and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1B if the UE is configured with higher layer

parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise; associated with subframe n and the set K does not include a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.

- For slot-PDSCH, special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10 and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1C associated with slot n and the set K does not include a slot in a special subframe of configurations 0 and 5 with normal downlink CP; otherwise $B_c^{DL} = M - 1$.
- For slot-PDSCH, special subframe configuration 3, 4, 8, and the case that the UE is transmitting on PUCCH, $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1D associated with slot n .
- For subframe-PDSCH and the case that UE is transmitting on PUSCH not performed based on a detected PDCCH/EPDCCH with DCI format 0/4 or on PUSCH adjusted based on an associated detected DCI format 0/4, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1 associated with subframe n and the set K does not include a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$, where $k \in K$.
- For slot-PDSCH, special subframe configuration 0, 1, 2, 5, 6, 7, 9, 10, and the case that UE is transmitting on PUSCH not performed based on a detected PDCCH/SPDCCH with DCI format 7-0A/7-0B, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1C associated with slot n and the set K does not include a slot in a special subframe of configurations 0 and 5 with normal downlink CP; otherwise $B_c^{DL} = M - 1$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/SPDCCH indicating downlink SPS release in slot(s) $n - k$, where $k \in K$.
- For slot-PDSCH, special subframe configuration 3, 4, 8, and the case that UE is transmitting on PUSCH not performed based on a detected PDCCH/SPDCCH with DCI format 7-0A/7-0B, the UE shall assume $B_c^{DL} = M$ where M is the number of elements in the set K defined in Table 10.1.3.1-1D associated with slot n . The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/SPDCCH indicating downlink SPS release in slot(s) $n - k$, where $k \in K$.

For TDD, when PUCCH format 3/4/5 is configured for transmission of HARQ-ACK and if the UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = dai* for subframe-PDSCH or *codebooksizeDeterminationsSTTI-r15 = dai* for slot-PDSCH,

- for TDD UL/DL configurations 1-6, the HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH/SPDCCH or for a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe/slot $n - k$ is associated with $o_{c,DAI(k)-1}^{ACK}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied or for slot-PDSCH, or associated with $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ otherwise, where $DAI(k)$ is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G detected in subframe/slot $n - k$, $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH/SPDCCH is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH/SPDCCH indicating downlink SPS release are set to NACK;

- for TDD UL/DL configuration 0, the HARQ-ACK for a PDSCH transmission or for a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe/slot $n - k$ is associated with $o_{c,0}^{ACK}$ if transmission mode configured in the c -th serving cell supports one transport block or associated with $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ otherwise, where $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH/SPDCCH indicating downlink SPS release are set to NACK.

For TDD when format 1b with channel selection is configured for transmission of HARQ-ACK and for 2 configured serving cells, the HARQ-ACK feedback bits $o_0^{ACK}, o_1^{ACK}, \dots, o_{O^{ACK}-1}^{ACK}$ on PUSCH are constructed as follows.

- For TDD UL/DL configuration 0, $o_j^{ACK} = \text{HARQ-ACK}(j)$, $0 \leq j \leq A-1$ as defined in Subclause 10.1.3.2.1. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$.
- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission performed based on a detected PDCCH/EPDCCH with DCI format 0/4 with $W_{DAI}^{UL}=1$ or 2, o_j^{ACK} is determined as if PUCCH format 3 is configured for transmission of HARQ-ACK, except that spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for all serving cells configured with a downlink transmission mode that supports up to two transport blocks in case $W_{DAI}^{UL}=2$.
- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission performed based on a detected PDCCH/EPDCCH with DCI format 0/4 with $W_{DAI}^{UL}=3$ or 4, $o_j^{ACK} = o(j)$, $0 \leq j \leq 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the value of M is replaced by W_{DAI}^{UL} . The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.
- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission not performed based on a detected PDCCH/EPDCCH with DCI format 0/4 and a subframe n with $M=1$ or 2, $o_j^{ACK} = \text{HARQ-ACK}(j)$, $0 \leq j \leq A-1$ as defined in Subclause 10.1.3.2.1. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$.
- For TDD UL/DL configurations {1, 2, 3, 4, 6} and a PUSCH transmission not performed based on a detected PDCCH/EPDCCH with DCI format 0/4 and a subframe n with $M=3$ or 4, $o_j^{ACK} = o(j)$, $0 \leq j \leq 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$.

For TDD HARQ-ACK bundling, when the UE is configured by transmission mode 3, 4, 8, 9 or 10 defined in Subclause 7.1 and HARQ-ACK bits corresponding to a subframe-PDSCH are transmitted on PUSCH, the UE shall always generate 2 HARQ-ACK bits assuming both codeword 0 and 1 are enabled. For the case that the UE detects only the PDSCH transmission associated with codeword 0 within the bundled subframes, the UE shall generate NACK for codeword 1.

For TDD HARQ-ACK bundling, when HARQ-ACK response corresponds to a slot-PDSCH, the UE shall always generate 1 HARQ-ACK bit.

Table 7.3-X: Value of Downlink Assignment Index

| DAI MSB, LSB | V_{DAI}^{UL} or V_{DAI}^{DL} | Number of subframes/slots with PDSCH transmission and with PDCCH/EPDC/SPDCCCH CH indicating DL SPS release |
|-----------------|----------------------------------|---|
| 0,0 | 1 | 1 or 5 or 9 |
| 0,1 | 2 | 2 or 6 or 10 |
| 1,0 | 3 | 3 or 7 |
| 1,1 | 4 | 0 or 4 or 8 |

Table 7.3-Y: Uplink association index k' for TDD

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|----------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | | | 6 | 4 | | | | 6 | 4 | |
| 2 | | | 4 | | | | | 4 | | |
| 3 | | | 4 | 4 | 4 | | | | | |
| 4 | | | 4 | 4 | | | | | | |
| 5 | | | 4 | | | | | | | |
| 6 | | | 7 | 7 | 5 | | | 7 | 7 | |

Table 7.3-Y1: Uplink association index k' for TDD and UE configured with *shortProcessingTime*

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|----------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | | | 3 | 3 | | | | 3 | 3 | |
| 2 | | | 3 | | | | | 3 | | |
| 3 | | | 3 | 3 | 3 | | | | | |
| 4 | | | 3 | 3 | | | | | | |
| 5 | | | 3 | | | | | | | |
| 6 | | | 6 | 4 | 4 | | | 6 | 3 | |

**Table 7.3-Y2: Uplink association index k' for TDD with special subframe configuration 1, 2, 6, 7 and
UE configured with *ul-TTI-Length***

| TDD UL/DL Configuration | slot number n | | | | | | | | | | | | | | | | | | | |
|----------------------------|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1 | | | | 4 | 4 | 4 | | | | | | | | | 4 | 4 | 4 | | | |
| 2 | | | 4 | 4 | | | | | | | | | | | 4 | 4 | | | | |
| 3 | | | 6 | 6 | 6 | 6 | 6 | 6 | | | | | | | | | | | | |
| 4 | | | 4 | 4 | 4 | 4 | | | | | | | | | | | | | | |
| 5 | | | 4 | 4 | | | | | | | | | | | | | | | | |
| 6 | | | 6 | 6 | 6 | 6 | 6 | | | | | | | | 4 | 4 | 4 | | | |

**Table 7.3-Y3: Uplink association index k' for TDD with special subframe configuration 0, 5, 9, 10 and
UE configured with *ul-TTI-Length***

| TDD UL/DL Configuration | slot number n | | | | | | | | | | | | | | | | | | | |
|----------------------------|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1 | | | | 5 | 5 | 5 | 5 | | | | | | | | 5 | 5 | 5 | 5 | | |
| 2 | | | 4 | 4 | | | | | | | | | | | 4 | 4 | | | | |
| 3 | | | 7 | 7 | 7 | 7 | 7 | 7 | | | | | | | | | | | | |
| 4 | | | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | |
| 5 | | | 4 | 4 | | | | | | | | | | | | | | | | |
| 6 | | | 4 | | 5 | | 6 | | | | | | | | 4 | 4 | 4 | | | |

**Table 7.3-Y4: Uplink association index k' for TDD with special subframe configuration 3, 4, 8 and UE
configured with *ul-TTI-Length***

| TDD UL/DL Configuration | slot number n | | | | | | | | | | | | | | | | | | | |
|----------------------------|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1 | | | | 5 | 5 | 5 | 5 | | | | | | | | 5 | 5 | 5 | 5 | | |
| 2 | | | 4 | 4 | | | | | | | | | | | 4 | 4 | | | | |
| 3 | | | 7 | 7 | 7 | 7 | 7 | 7 | | | | | | | | | | | | |
| 4 | | | 5 | 5 | 5 | 5 | | | | | | | | | | | | | | |
| 5 | | | 4 | 4 | | | | | | | | | | | | | | | | |
| 6 | | | 4 | | 5 | | 6 | | | | | | | | 4 | 4 | 4 | | | |

| | | | | | | | | | | | | | | | | | | |
|---|--|--|--|---|---|---|---|---|---|--|--|--|---|---|---|---|--|--|
| 1 | | | | 4 | 4 | 4 | 4 | | | | | | 4 | 4 | 4 | 4 | | |
| 2 | | | | 4 | 4 | | | | | | | | 4 | 4 | | | | |
| 3 | | | | 6 | 6 | 6 | 6 | 6 | 6 | | | | | | | | | |
| 4 | | | | 4 | 4 | 4 | 4 | | | | | | | | | | | |
| 5 | | | | 4 | 4 | | | | | | | | | | | | | |
| 6 | | | | 6 | 6 | 6 | 6 | 6 | 6 | | | | 4 | 4 | 4 | 4 | | |

Table 7.3-Z: Value of W_{DAI}^{UL} determined by the DAI field in DCI format 0/4/7-0A/7-0B

| DAI MSB, LSB | W_{DAI}^{UL} |
|-----------------|----------------|
| 0,0 | 1 |
| 0,1 | 2 |
| 1,0 | 3 |
| 1,1 | 4 |

For subframe-PUSCH and TDD HARQ-ACK multiplexing and a subframe n with $M > 1$, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed by a logical AND operation of all the corresponding individual HARQ-ACKs. In case the UE is transmitting on PUSCH, the UE shall determine the number of HARQ-ACK feedback bits O^{ACK} and the HARQ-ACK feedback bits o_n^{ACK} , $n = 0, \dots, O^{ACK} - 1$ to be transmitted in subframe n .

- If the PUSCH transmission is performed based on a detected PDCCH/EPDCCH with DCI format 0/4 intended for the UE, then $O^{ACK} = V_{DAI}^{UL}$ unless $V_{DAI}^{UL} = 4$ and $U_{DAI} + N_{SPS} = 0$ in which case the UE shall not transmit HARQ-ACK. The spatially bundled HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH or for a PDCCH/EPDCCH indicating downlink SPS release in subframe $n - k$ is associated with $o_{DAI(k)-1}^{ACK}$ where $DAI(k)$ is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n - k$. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH is mapped to $o_{O^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK.
- If the PUSCH transmission is not performed based on a detected PDCCH/EPDCCH with DCI format 0/4 intended for the UE, $O^{ACK} = M$, and o_i^{ACK} is associated with the spatially bundled HARQ-ACK for downlink or special subframe $n - k_i$, where $k_i \in K$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH indicating downlink SPS release are set to NACK. The UE shall not transmit HARQ-ACK if $U_{DAI} + N_{SPS} = 0$.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* and PDSCH is associated with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D, the following HARQ-ACK reporting procedure applies to subframe-PDSCH operation. If a UE is configured with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai* and PDSCH is associated with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the following HARQ-ACK reporting procedure applies to slot-PDSCH operation.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or with higher layer parameter *codebooksizeDeterminationsSTTI-r15 = dai*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the accumulative number of {serving cell, subframe/slot}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe/slot, first in increasing order of serving cell index and then in increasing order of subframe/slot index within subframe(s)/slot(s) $n - k$ where $k \in K$; the value of the total DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the total number of {serving cell, subframe/slot }-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH(s) or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release is present, up to the present subframe/slot within subframe/slot (s) $n - k$ where $k \in K$, and shall be updated from subframe/slot to subframe/slot. Denote $V_{C-DAI,c,k}^{DL}$ as the value of the counter DAI in DCI format

1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe/slot $n - k$ where $k \in K$ according to table 7.3.2.1-1. Denote $V_{T-DAI,k}^{DL}$ as the value of the total DAI in subframe/slot $n - k$ where $k \in K$, according to Table 7.3.2.1-1. The UE shall assume a same value of total DAI in all PDCCH/EPDCCH/SPDCCH scheduling PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in a subframe/slot.

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$ and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe/slot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $m = 0$ – subframe/slot index: lower index corresponds to earlier subframe within subframe(s)/slot(s) $n - k$ where $k \in K$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

Set $V_s = \emptyset$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes/slots within subframe(s)/slot(s) $n - k$ where $k \in K$

while $m < M$

 while $c < N_{cells}^{DL}$

 if there is a PDSCH on serving cell c in subframe/slot m associated with PDCCH/EPDCCH/SPDCCH or there is a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release on serving cell c in subframe/slot m for which HARQ-ACK is transmitted in subframe/slot n ,

 if $V_{C-DAI,c,m}^{DL} \leq V_{temp}$

$j = j + 1$

 end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

 if $V_{T-DAI,m}^{DL} = \emptyset$

$V_{temp2} = V_{C-DAI,c,m}^{DL}$

 else

$V_{temp2} = V_{T-DAI,m}^{DL}$

 end if

 if the higher layer parameter $spatialBundlingPUCCH$ is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$\tilde{o}_{8j+2(V_{C-DAI,c,m}^{DL}-1)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$\tilde{o}_{8j+2(V_{C-DAI,c,m}^{DL}-1)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$$V_s = V_s \cup \{8j+2(V_{C-DAI,c,m}^{DL}-1), 8j+2(V_{C-DAI,c,m}^{DL}-1)+1\}$$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$$V_s = V_s \cup \{4j+V_{C-DAI,c,m}^{DL}-1\}$$

else

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$$V_s = V_s \cup \{4j+V_{C-DAI,c,m}^{DL}-1\}$$

end if

$c = c + 1$

end while

$m = m + 1$

end while

if $V_{temp2} < V_{temp}$

$j = j + 1$

end if

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$$O^{ACK} = 2 \cdot (4 \cdot j + V_{temp2})$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

\tilde{o}_i^{ACK} = NACK for any $i \in \{0, 1, \dots, O^{ACK} - 1\} \setminus V_s$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in a subframe/slot $n - k$ where $k \in K$

$$O^{ACK} = O^{ACK} + 1$$

$o_{O^{ACK}-1}^{ACK}$ = HARQ-ACK bit associated with the SPS PDSCH transmission

end if

For a UE configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the above procedure as if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5, except that the higher layer parameter $spatialBundlingPUCCH$ is replaced by $spatialBundlingPUSCH$.

Table 7.3.2.1-1: Value of counter DAI and total DAI

| DAI MSB, LSB | $V_{C-DAI,c,k}^{DL}$ or $V_{T-DAI,k}^{DL}$ | Number of {serving cell, subframe/slot }-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release is present, denoted as Y and $Y \geq 1$ |
|-----------------|---|--|
| 0,0 | 1 | $\text{mod}(Y-1,4)+1=1$ |
| 0,1 | 2 | $\text{mod}(Y-1,4)+1=2$ |
| 1,0 | 3 | $\text{mod}(Y-1,4)+1=3$ |
| 1,1 | 4 | $\text{mod}(Y-1,4)+1=4$ |

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$ and if the UE transmits HARQ-ACK using slot-PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe/slot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 for subframe-PUCCH transmission and Subclause 5.2.3.1A for slot-PUCCH transmission in [4].

For a UE configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.2.6 in [4].

For TDD when a PUCCH format 3 or a PUCCH format 4/5 configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or $codebooksizeDeterminationsSTTI-r15 = cc$ transmission of HARQ-ACK coincides with a subframe/slot configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in Subclause 5.2.3.1 for subframe-PUCCH transmission and Subclause 5.2.3.1A for slot-PUCCH transmission in [4], unless the HARQ-ACK corresponds to one of the following cases

- for subframe-PDSCH, a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCH is equal to '1', or
- for subframe-PDSCH, a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, or
- for subframe-PDSCH, a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in the subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH equal to '1',

in which case the UE shall transmit the HARQ-ACK and scheduling request according to the procedure for PUCCH format 1b with channel selection in TDD.

For TDD when a PUCCH format 4/5 configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or *codebooksizeDeterminationsSTI-r15 = dai* transmission of HARQ-ACK coincides with a subframe/slot configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in Subclause 5.2.3.1 and Subclause 5.2.3.1A for slot-PUCCH transmission in [4], unless the HARQ-ACK corresponds to one of the following cases

- for subframe-PDSCH, a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3.2.1-1), or a single PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3.2.1-1), or
- for subframe-PDSCH, a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, or
- for subframe-PDSCH, a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3.2.1-1) or an additional PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in the subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3.2.1-1),

in which case the UE shall transmit the HARQ-ACK and scheduling request according to the procedure for PUCCH format 1b with channel selection in TDD.

For TDD when the UE is configured with HARQ-ACK bundling, HARQ-ACK multiplexing or PUCCH format 1b with channel selection, and when both HARQ-ACK and SR are transmitted in the same subframe/slot, a UE shall transmit the bundled HARQ-ACK or the multiple HARQ-ACK responses (according to Subclause 10.1) on its assigned HARQ-ACK PUCCH resources for a negative SR transmission. For a positive SR, the UE shall transmit $b(0), b(1)$ on its assigned SR PUCCH resource using PUCCH format 1b according to Subclause 5.4.1 for subframe-PDSCH and Subclause 5.4A.2 for slot-PDSCH in [3]. For subframe-PDSCH, the value of $b(0), b(1)$ are generated according to

Table 7.3-1 from the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses including ACK in response to PDCCH/EPDCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for all serving cells N_{cells}^{DL} . For slot-PDSCH, the value of $b(0), b(1)$ are generated according to Table 7.3-

1 from the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses including ACK in response to SPDCCH indicating downlink SPS release. For TDD UL/DL configurations 1-6, if $\sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c} > 0$ and $V_{DAI,c}^{DL} \neq (U_{DAI,c} - 1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

Table 7.3-1: Mapping between multiple HARQ-ACK responses and $b(0), b(1)$

| Number of ACK among multiple ($N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$) HARQ-ACK responses | $b(0), b(1)$ |
|---|--------------|
| 0 or None (UE detect at least one DL assignment is missed) | 0, 0 |
| 1 | 1, 1 |
| 2 | 1, 0 |
| 3 | 0, 1 |
| 4 | 1, 1 |
| 5 | 1, 0 |
| 6 | 0, 1 |
| 7 | 1, 1 |
| 8 | 1, 0 |
| 9 | 0, 1 |

For TDD if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with HARQ-ACK bundling, HARQ-ACK multiplexing or PUCCH format 1b with channel selection, and if the UE receives PDSCH and/or PDCCH/EPDCCCH indicating downlink SPS release only on the primary cell within subframe(s) $n - k$, where $k \in K$, a UE shall transmit the CSI and $b(0), b(1)$ using PUCCH format 2b for normal CP or PUCCH format 2 for extended CP, according to Subclause 5.2.3.4 in [4] with a''_0, a''_1 replaced by $b(0), b(1)$. The

value of $b(0), b(1)$ are generated according to Table 7.3-1 from the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses

including ACK in response to PDCCH/EPDCCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for all serving cells N_{cells}^{DL} . For TDD UL/DL

configurations 1-6, if $\sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c} > 0$ and $V_{DAI,c}^{DL} \neq (U_{DAI,c} - 1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

For TDD if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection and receives at least one PDSCH on the secondary cell within subframe(s) $n - k$, where $k \in K$, the UE shall drop the CSI and transmit HARQ-ACK according to Subclause 10.1.3.

For TDD and a UE is configured with PUCCH format 3,

if the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives,

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCCH in subframe $n - k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for TDD UL/DL configurations 1-6 the DAI value in the PDCCH/EPDCCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$,

then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to Subclause 5.2.3.4 in [4];

else if

- the parameter *simultaneousAckNackAndCQI-Format3-r11* is set *TRUE* and if PUCCH format 3 resource is determined according to Subclause 10.1.3.1 or Subclause 10.1.3.2.2 and
 - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22, or

- if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

then the UE shall transmit the HARQ-ACKs, SR (if any) and the CSI using the determined PUCCH format 3 resource according to [4];

else,

- the UE shall drop the CSI and transmit the HARQ-ACK according to Subclause 10.1.3.

For TDD and a UE configured with PUCCH format 4 or PUCCH format 5, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe,

- if a PUCCH format 3 is determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.3 or 10.1.3.2.4, the UE shall use the determined PUCCH format 3 for transmission of the HARQ-ACK/SR and periodic CSI report(s) if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*; otherwise, the UE shall drop the periodic CSI report(s) and transmit only HARQ-ACK/SR;
- if a PUCCH format 4 is determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.3 or a PUCCH format 5 is determined to transmit the HARQ-ACK/SR according to 10.1.3.2.4, the UE shall use the determined PUCCH format 4 or PUCCH format 5 for transmission of the HARQ-ACK/SR and periodic CSI report(s) if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*; otherwise, the UE shall drop the periodic CSI report(s) and transmit only HARQ-ACK/SR;
- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.3 and there is no PUCCH format 3 or 5 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.4 and there are more than one periodic CSI report(s) in the subframe,
 - o if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with a single PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, the PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
 - o if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with a PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ according to higher layer parameter *format5-MultiCSI-resourceConfiguration*, the PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
 - o if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with two PUCCH format 4 resources $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, if $(O^{\text{ACK}} + O^{\text{SR}} + O_{\text{CSI}} + O_{\text{CRC}}) \leq \min(M_{\text{RB}_1}^{\text{PUCCH}4}, M_{\text{RB}_2}^{\text{PUCCH}4}) \cdot N_{\text{sc}}^{\text{RB}} \cdot N_{\text{symbol}}^{\text{PUCCH}4} \cdot 2 \cdot r$, the PUCCH format 4 resource with the smaller $M_{\text{RB},i}^{\text{PUCCH}4}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s); otherwise, the PUCCH format 4 resource with the larger $M_{\text{RB},i}^{\text{PUCCH}4}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the HARQ-ACK/SR periodic CSI report(s), where
 - O^{ACK} is the total number of HARQ-ACK bits in the subframe;
 - $O^{\text{SR}} = 0$ if there is no scheduling request bit in the subframe and $O^{\text{SR}} = 1$ otherwise
 - O_{CSI} is the total number of CSI report bits in the subframe;
 - O_{CRC} is the number of CRC bits;
 - $M_{\text{RB},i}^{\text{PUCCH}4}$, $i = 1, 2$, is the number of PRBs for $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ respectively, according to higher layer parameter *numberOfPRB-format4-r13* according to Table 10.1.1-2;

- $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1) - 1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1)$ otherwise; and
 - r is the code rate given by higher layer parameter *maximumPayloadCodeRate-r13* according to Table 10.1.1-1.
 - otherwise, the UE shall drop the periodic CSI reports and transmit only HARQ-ACK/SR.
 - if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.3 and there is no PUCCH format 3 or 5 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.3.2.4 and there is only one periodic CSI report in the subframe,
 - if there is no positive SR and the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives,
 - a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$, and the counter DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and the counter DAI value in the PDCCH/EPDCCH is equal to '1', or
 - a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$,
- then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to Subclause 5.2.3.4 in [4];
- else,
- the UE shall drop the CSI and transmit the HARQ-ACK according to Subclause 10.1.3.2.3 or 10.1.3.2.4 when UE shall transmit HARQ-ACK only or UE shall drop the CSI and transmit the HARQ-ACK and SR according to the procedure for PUCCH format 1b with channel selection in TDD when there is positive SR.
- If a UE transmits HARQ-ACK/SR and periodic CSI report(s) using either a PUCCH format 4 $n_{\text{PUCCH}}^{(4)}$ or PUCCH format 5 $n_{\text{PUCCH}}^{(5)}$ in a subframe
 - if $(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}}) \leq 2 \cdot N_{\text{RE}} \cdot r$, the UE shall transmit the HARQ-ACK/SR and periodic CSI bits using the PUCCH format 4 $n_{\text{PUCCH}}^{(4)}$ or the PUCCH format 5 $n_{\text{PUCCH}}^{(5)}$;
 - if $(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}}) > 2 \cdot N_{\text{RE}} \cdot r$, the UE shall select $N_{\text{CSI,reported}}$ CSI report(s) for transmission together with HARQ-ACK/SR in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$, where $\text{Pri}_{\text{CSI}}(y, s, c, t)$, N_{RE} and r are determined according to Subclause 7.2.2; the value of $N_{\text{CSI,reported}}$ satisfies $O^{ACK} + O^{SR} + \sum_{n=1}^{N_{\text{CSI,reported}}} O_{\text{P-CSI},n} + O_{\text{CRC}} \leq 2 \cdot N_{\text{RE}} \cdot r$ and $O_{\text{P-CSI},n}$ is the number of CSI report bits for the n th CSI report in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$.

For TDD and a BL/CE UE,

- if the UE is configured with *csi-NumRepetitionCE* equal to 1 and *mPDCCH-NumRepetition* equal to 1,

- the UE behaviour for HARQ-ACK reporting is the same as that of a non-BL/CE UE with TDD, except:
 - PDCCH/EPDCCH is replaced by MPDCCH; and
 - DCI format 1/1A/1B/1D/2/2A/2B/2C/2D is replaced by DCI format 6-1A; and
 - DCI format 0/4 is replaced by DCI format 6-0A; and
 - PUCCH is transmitted in a set of BL/CE UL subframe(s) according to Subclause 10.2 for TDD and BL/CE UEs;
- else
 - the UE is not expected to receive more than one PDSCH transmission, or more than one of PDSCH and MPDCCH indicating downlink SPS releases, with transmission ending within subframe(s) $n - k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE;
 - The UE behavior for HARQ-ACK reporting is the same as that of a BL/CE UE with FDD, except:
 - PUCCH resource is determined according to Subclause 10.1.3.1; and
 - PUCCH is transmitted in a set of BL/CE UL subframe(s) according to Subclause 10.2 for TDD and BL/CE UEs.

If the BL/CE UE is configured in CEModeA, and if the PDSCH is assigned by or semi-statically scheduled by a MPDCCH with DCI format 6-1A, the UE shall assume no PDSCH repetition if the higher layer parameter *csi-NumRepetitionCE-r13* indicates one subframe.

7.3.2.2 TDD HARQ-ACK reporting procedure for different UL/DL configurations

For a configured serving cell, the DL-reference UL/DL configuration as defined in Subclause 10.2 is referred to as the "DL-reference UL/DL configuration" in the rest of this Subclause.

For a configured serving cell, if a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or *codebooksizesSTTI-r15 = dai* and if the DL-reference UL/DL configuration is 0, then the DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is not used.

The UE shall upon detection of a PDSCH transmission or a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s)/slot(s) $n - k$ for serving cell c , where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe/slot n , wherein set K_c contains values of $k \in K$ such that subframe/slot $n-k$ corresponds to a downlink subframe/slot or a special subframe or a slot in a special subframe for serving cell c , where DL subframe or special subframe of serving cell c is according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for serving cell c , or to *harq-ReferenceConfig-r14* when the UE is configured with the parameter *harq-ReferenceConfig-r14*; K is defined in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise (where "UL/DL configuration" in Table 10.1.3.1-1, Table 10.1.3.1-1B, Table 10.1.3.1-1C refers to the DL-reference UL/DL configuration) is associated with subframe/slot n . M_c is the number of elements in set K_c associated with subframe/slot n for serving cell c .

For the remainder of this Subclause $K = K_c$.

If the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for the primary cell, "UL/DL configuration of the primary cell" in the rest of this Subclause refers to "DL-reference UL/DL configuration of the primary cell".

When PUCCH format 3/4/5 is configured for transmission of HARQ-ACK,

- for special subframe configurations 0 and 5 with normal downlink CP or configurations 0 and 4 with extended downlink CP in a serving cell, shown in table 4.2-1 [3], the special subframe of the serving cell is excluded from the HARQ-ACK codebook size determination. In this case, if the serving cell is the primary cell, there is no PDCCH/EPDCCH indicating downlink SPS release in the special subframe.

- for special subframe configurations 1, 2, 6, and 7 and slot-PDSCH, the second slot of DwPTS of the serving cell is excluded from the HARQ-ACK codebook size determination. In this case, if the serving cell is the primary cell, there is no PDCCH/EPDCCH indicating downlink SPS release in the second slot of DwPTS.

If the UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1,2,3,4,5,6} for a serving cell, a value W_{DAI}^{UL} is determined by the Downlink Assignment Index (DAI) in DCI format 0/4/7-0A/7-0B corresponding to a PUSCH on the serving cell according to Table 7.3-Z in subframe $n - k'$, where k' is defined in Table 7.3-Y2 if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH, Table 7.3-Y1 if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH, Table 7.3-Y otherwise and the "TDD UL/DL Configuration" in Table 7.3-Y/7.3-Y1/7.3-Y2 refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) for the serving cell. In case neither PDSCH transmission, nor PDCCH/EPDCCH/SPDCCH indicating the downlink SPS resource release is intended to the UE, the UE can expect that the value of W_{DAI}^{UL} is set to 4 by the DAI in DCI format 0/4/7-0A/7-0B if transmitted.

If a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = dai* or *codebooksizeDeterminationsSTTI-r15 = dai* and if the DL-reference UL/DL configuration belongs to {1,2,3,4,5,6}, the value of the DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the accumulative number of PDCCH/EPDCCH/SPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release up to the present subframe/slot within subframe(s)/slot(s) $n - k$ of each configured serving cell, where $k \in K$, and shall be updated from subframe/slot to subframe/slot. Denote $V_{DAI,c}^{DL}$ as the value of the DAI in PDCCH/EPDCCH/SPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G detected by the UE according to Table 7.3-X in subframe/slot $n - k_m$ in serving cell c , where k_m is the smallest value in the set K such that the UE detects a DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G.

For all TDD UL/DL configurations, denote $U_{DAI,c}$ as the total number of PDCCH/EPDCCH/SPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release detected by the UE within the subframe(s)/slot(s) $n - k$ in serving cell c , where $k \in K$. Denote N_{SPS} , which can be zero or one, as the number of PDSCH transmissions without a corresponding PDCCH/EPDCCH/SPDCCH within the subframe(s)/slot(s) $n - k$, where $k \in K$.

If PUCCH format 3 is configured for transmission of HARQ-ACK without PUCCH format 4/5 configured for transmission of HARQ-ACK, the HARQ-ACK feedback bits $o_{c,0}^{ACK}, o_{c,1}^{ACK}, \dots, o_{c,O_c^{ACK}-1}^{ACK}$ for the c -th serving cell configured by RRC are constructed as follows, where $c \geq 0$, $O_c^{ACK} = B_c^{DL}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied and $O_c^{ACK} = 2B_c^{DL}$ otherwise, where B_c^{DL} is the number of subframes/slots in downlink and special subframes for which the UE needs to feedback HARQ-ACK bits for the c -th serving cell.

- For the case that the UE is transmitting in subframe/slot n on PUCCH or a PUSCH transmission not performed based on a detected DCI format 0/4/7-0A/7-0B or a PUSCH transmission performed based on an associated detected DCI format 0/4/7-0A/7-0B with UL-reference UL/DL configuration 0 (defined in Sec 8.0), then $B_c^{DL} = M_c$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n - k$, where $k \in K$.
- If DL-reference UL/DL configuration of each of the configured serving cells belongs to {0, 1, 2, 3, 4, 6} and for a PUSCH transmission in a subframe/slot n performed based on a detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min(W_{DAI}^{UL}, M_c)$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n - k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.
- If DL-reference UL/DL configuration of at least one configured serving cell belongs to {5} and for a PUSCH transmission performed based on an associated detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-

0A/7-0B using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min(W_{DAI}^{UL} + 4 | (U - W_{DAI}^{UL}) / 4 |, M_c)$, where U denotes the maximum value of U_c among all the configured serving cells, U_c is the total number of received PDSCHs and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n-k$ for the c -th serving cell, $k \in K$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n-k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.

If PUCCH format 4/5 is configured for transmission of HARQ-ACK and higher layer parameter $codebooksizeDetermination-r13 = dai$ or $codebooksizeDeterminationsSTTI-r15 = dai$ is not configured, the HARQ-ACK feedback bits $o_{c,0}^{ACK}, o_{c,1}^{ACK}, \dots, o_{c,O_c^{ACK}-1}^{ACK}$ for the c -th serving cell configured by RRC are constructed as follows,

where $c \geq 0$, $O_c^{ACK} = B_c^{DL}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied and $O_c^{ACK} = 2B_c^{DL}$ otherwise, where B_c^{DL} is the number of subframes/slots in downlink and special subframes for which the UE needs to feedback HARQ-ACK bits for the c -th serving cell.

- For the case that the UE is transmitting in subframe/slot n on PUCCH or a PUSCH transmission not performed based on a detected DCI format 0/4/7-0A/7-0B or a PUSCH transmission performed based on an associated detected DCI format 0/4/7-0A/7-0B, then $B_c^{DL} = M_c$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe(s)/slot(s) $n-k$, where $k \in K$.

When PUCCH format 3/4/5 is configured for transmission of HARQ-ACK and if the UE is not configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or $codebooksizeDeterminationsSTTI-r15 = dai$,

- if DL-reference UL/DL configuration belongs to {1,2,3,4,5,6}, the HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH/SPDCCH or for a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe/slot $n-k$ is associated with $o_{c,DAI(k)-1}^{ACK}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ otherwise, where $DAI(k)$ is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n-k$, $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding PDCCH/EPDCCH/SPDCCH is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH/SPDCCH indicating downlink SPS release are set to NACK;
- if DL-reference UL/DL configuration is 0, the HARQ-ACK for a PDSCH transmission or for a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in subframe/slot $n-k$ is associated with $o_{c,0}^{ACK}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ otherwise, where $o_{c,0}^{ACK}$ and $o_{c,1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. The HARQ-ACK feedback bits without any detected PDSCH transmission or without detected PDCCH/EPDCCH/SPDCCH indicating downlink SPS release are set to NACK.

If DL-reference UL/DL configuration of each of the serving cells belongs to {0,1,2,3,4,6} and if PUCCH format 1b with channel selection is configured for transmission of HARQ-ACK and for two configured serving cells, the HARQ-ACK feedback bits $o_0^{ACK}, o_1^{ACK}, \dots, o_{O_0^{ACK}-1}^{ACK}$ on PUSCH are constructed as follows

- if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission performed based on a detected PDCCH/EPDCCH with DCI format 0/4 with $W_{DAI}^{UL} = 1$ or 2, o_j^{ACK} is determined as if PUCCH format 3 is configured for transmission of HARQ-ACK, except that spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for all serving cells configured with a downlink transmission mode that supports up to two transport blocks in case $W_{DAI}^{UL} = 2$, where the UL-

reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission.

- if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission performed based on a detected PDCCH/EPDCCH with DCI format 0/4 with $W_{DAI}^{UL} = 3$ or 4, $o_j^{ACK} = o(j)$, $0 \leq j \leq 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the value of M is replaced by W_{DAI}^{UL} where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$ and $W_{DAI}^{UL} = 4$.
- if UL-reference UL/DL configuration (defined in Sec 8.0) is 0, or if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6}, for a PUSCH transmission not performed based on a detected PDCCH/EPDCCH with DCI format 0/4, for a subframe n with $M = 1$ or 2 (M defined in Sec 10.1.3.2.1), $o_j^{ACK} = \text{HARQ-ACK}(j)$, $0 \leq j \leq A - 1$ as defined in Subclause 10.1.3.2.1, where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$.
- if UL-reference UL/DL configuration (defined in Sec 8.0) is 0, or if UL-reference UL/DL configuration (defined in Sec 8.0) belongs to {1, 2, 3, 4, 6} and, for a PUSCH transmission not performed based on a detected PDCCH/EPDCCH with DCI format 0/4, for a subframe n with $M = 3$ or 4 (M defined in Sec 10.1.3.2.1), $o_j^{ACK} = o(j)$, $0 \leq j \leq 3$ as defined in Table 10.1.3.2-5 or in Table 10.1.3.2-6 respectively, where the UL-reference UL/DL configuration is the UL-reference UL/DL configuration of the serving cell corresponding to the PUSCH transmission. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH/EPDCCH indicating downlink SPS release in subframe(s) $n - k$ where $k \in K$.

If a UE is configured with higher layer parameter $\text{codebooksizeDetermination-r13} = dai$ and PDSCH is associated with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D, the following HARQ-ACK reporting procedure applies to subframe-PDSCH operation. If a UE is configured with higher layer parameter $\text{codebooksizeDeterminationsSTTI-r15} = dai$ and PDSCH is associated with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the following HARQ-ACK reporting procedure applies to slot-PDSCH operation.

If a UE is configured with higher layer parameter $\text{codebooksizeDetermination-r13} = dai$ or with higher layer parameter $\text{codebooksizeDeterminationsSTTI-r15} = dai$, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the accumulative number of {serving cell, subframe/slot}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe/slot, first in increasing order of serving cell index and then in increasing order of subframe/slot index within subframe(s)/slot(s) $n - k$ where $k \in \bigcup_{i \in C} K_i$ and C is the set of configured serving cells; the value of the total DAI in

DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G denotes the total number of {serving cell, subframe/slot}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH/SPDCCH (s) or PDCCH/EPDCCH/SPDCCH indicating downlink SPS release is present, up to the present subframe/slot within subframe(s)/slot(s) $n - k$ where $k \in \bigcup_{i \in C} K_i$ and C is the set of configured serving cells, and shall be updated from

subframe/slot to subframe/slot. Denote $V_{C-DAI,c,k}^{DL}$ as the value of the counter DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe/slot $n - k$ where $k \in \bigcup_{i \in C} K_i$ according to table 7.3.2.1-1. Denote

$V_{T-DAI,k}^{DL}$ as the value of the total DAI in subframe/slot $n - k$ where $k \in \bigcup_{i \in C} K_i$, according to Table 7.3.2.1-1. The UE shall assume a same value of total DAI in all PDCCH/EPDCCH/SPDCCH scheduling PDSCH transmission(s) and PDCCH/EPDCCH/SPDCCH indicating downlink SPS release in a subframe/slot. For a serving cell c and a value $k \in \bigcup_{i \in C} K_i$ but $k \notin K_c$, the {serving cell, subframe/slot}-pair $\{c, n - k\}$ is excluded when determining the values of counter DAI and total DAI for HARQ-ACK transmission in subframe/slot n .

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$ and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe/slot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set $c = 0$ – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set $m = 0$ – subframe/slot index: lower index corresponds to earlier subframe/slot within subframe(s)/slot(s) $n - k$
where $k \in \bigcup_{i \in C} K_i$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

Set $V_s = \emptyset$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes/slots within subframe(s) /slot(s) $n - k$ where $k \in \bigcup_{i \in C} K_i$

while $m < M$

 while $c < N_{cells}^{DL}$

 if there is a PDSCH on serving cell c in subframe/slot m associated with PDCCH/EPDCCH/SPDCCH or
 there is a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release on serving cell c in subframe/slot m ,
 and if subframe/slot m belongs to the set of subframe(s)/slot(s) $n - k$ where $k \in K_c$,

 if $V_{C-DAI,c,m}^{DL} \leq V_{temp}$

$j = j + 1$

 end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

 if $V_{T-DAI,m}^{DL} = \emptyset$

$V_{temp2} = V_{C-DAI,c,m}^{DL}$

 else

$V_{temp2} = V_{T-DAI,m}^{DL}$

 end if

 if the higher layer parameter $spatialBundlingPUCCH$ is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$\tilde{o}_{8j+2(V_{C-DAI,c,m}^{DL}-1)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$\tilde{o}_{8j+2(V_{C-DAI,c,m}^{DL}-1)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$$V_s = V_s \cup \{8j+2(V_{C-DAI,c,m}^{DL}-1), 8j+2(V_{C-DAI,c,m}^{DL}-1)+1\}$$

elseif the higher layer parameter *spatialBundlingPUCCH* is set *TRUE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$$V_s = V_s \cup \{4j+V_{C-DAI,c,m}^{DL}-1\}$$

else

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$$V_s = V_s \cup \{4j+V_{C-DAI,c,m}^{DL}-1\}$$

end if

end if

$c = c + 1$

end while

$m = m + 1$

end while

if $V_{temp2} < V_{temp}$

$j = j + 1$

end if

if the higher layer parameter *spatialBundlingPUCCH* is set *FALSE* and the UE is configured with a transmission mode supporting two transport blocks in at least one configured serving cell,

$$O^{ACK} = 2 \cdot (4 \cdot j + V_{temp2})$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

end if

\tilde{o}_i^{ACK} = NACK for any $i \in \{0, 1, \dots, O^{ACK} - 1\} \setminus V_s$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in a subframe/slot $n - k$ where $k \in \bigcup_{i \in C} K_i$

$$O^{ACK} = O^{ACK} + 1$$

$o_{O^{ACK}-1}^{ACK}$ = HARQ-ACK bit associated with the SPS PDSCH transmission

end if

For a UE configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the above procedure as if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5, except that the higher layer parameter $spatialBundlingPUCCH$ is replaced by $spatialBundlingPUSCH$.

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$, if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe/slot n , the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 in [4].

For a UE configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$, if the UE transmits HARQ-ACK on PUSCH in a subframe/slot, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \dots, \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.2.6 in [4].

When a PUCCH format 3 transmission of HARQ-ACK coincides with a subframe/slot configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in Subclause 5.2.3.1 for subframe-PUCCH transmission and Subclause 5.2.3.1A for slot-PUCCH transmission in [4], unless the HARQ-ACK corresponds to one of the following cases

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH/SPDCCH in subframe/slot $n - k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6}, the DAI value in the PDCCH/EPDCCH/SPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe/slot $n - k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH/SPDCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH/SPDCCH detected within subframe(s)/slot(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH/SPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s)/slot(s) $n - k$, where $k \in K$, or
- a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH/SPDCCH detected within subframe(s)/slot(s) $n - k$, where $k \in K$ and an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH/SPDCCH in subframe/slot $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH/SPDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH/EPDCCH/SPDCCH indicating downlink SPS release (defined in Subclause 9.2) in the subframe/slot $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH/EPDCCH/SPDCCH equal to '1',

in which case the UE shall transmit the HARQ-ACK and scheduling request according to the procedure for PUCCH format 1b with channel selection in TDD for subframe-PDSCH and PUCCH format 1b for slot-PDSCH.

When a PUCCH format 4/5 transmission of HARQ-ACK coincides with a subframe/slot configured to the UE by higher layers for transmission of a scheduling request, the UE shall follow the same procedure described in Subclause 7.3.2.1.

If the parameter $simultaneousAckNackAndCQI$ provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection, and if the UE receives PDSCH and/or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell within subframe(s) $n - k$, where $k \in K$, a UE shall transmit the CSI and $b(0), b(1)$ using PUCCH format 2b for normal CP or PUCCH format 2 for extended CP, according to Subclause 5.2.3.4 in [4] with a_0'', a_1'' replaced by $b(0), b(1)$. The value of $b(0), b(1)$ are generated according to Table 7.3-1 from

the $N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$ HARQ-ACK responses including ACK in response to PDCCH/EPDCCH indicating downlink SPS release by spatial HARQ-ACK bundling across multiple codewords within each PDSCH transmission for

all serving cells N_{cells}^{DL} . If DL-reference UL/DL configuration belongs to {1,2,3,4,5,6} and, if $\sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c} > 0$ and $V_{DAI,c}^{DL} \neq (U_{DAI,c} - 1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

If the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, and if the UE is configured with PUCCH format 1b with channel selection and receives at least one PDSCH on the secondary cell within subframe(s) $n - k$, where $k \in K$, the UE shall drop the CSI and transmit HARQ-ACK according to Subclause 10.1.3.

When both HARQ-ACK and CSI are configured to be transmitted in the same sub-frame and if a UE is configured with PUCCH format 3 and not configured with PUCCH format 4/5,

if the parameter *simultaneousAckNackAndCQI* is set *TRUE* and if the UE receives

- a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH is equal to '1' (defined in Table 7.3-X), or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH/EPDCCH is equal to '1', or
- a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$,

then the UE shall transmit the CSI and HARQ-ACK using PUCCH format 2/2a/2b according to Subclause 5.2.3.4 in [4];

else if

- the parameter *simultaneousAckNackAndCQI-Format3-r11* is set *TRUE* and if PUCCH format 3 resource is determined according to Subclause 10.1.3.1 or Subclause 10.1.3.2.2 and
 - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22, or
 - if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

then the UE shall transmit the HARQ-ACKs, SR (if any) and the CSI using the determined PUCCH format 3 resource according to [4];

else,

- the UE shall drop the CSI and transmit the HARQ-ACK according to Subclause 10.1.3.

For TDD and a UE configured with PUCCH format 4 or PUCCH format 5, if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe, the UE HARQ-ACK/SR and periodic CSI reporting procedure follow the procedure described in Subclause 7.3.2.1 with the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*.

7.3.3 FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 1

For FDD-TDD and the primary cell is frame structure type 1, with PUCCH format 1b with channel selection,

- for a negative SR transmission,
- UE shall transmit the HARQ-ACK on its assigned HARQ-ACK PUCCH resource with channel selection as defined in Subclause 10.1.2A.

- for a positive SR transmission,
 - if one transport block or two transport blocks or a PDCCH/EPDCCH indicating downlink SPS release is detected on the primary cell in subframe i , and if subframe j is an uplink or a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP for the secondary cell according to the higher layer parameter *subframeAssignment* for UE not configured with either higher layer parameter *EIMTA-MainConfigServCell-r12* or *harq-ReferenceConfig-r14* and according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* for UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and to *harq-ReferenceConfig-r14* for the primary cell when the UE is configured with the parameter *harq-ReferenceConfig-r14*
 - UE shall transmit the HARQ-ACK and SR as for FDD with PUCCH format 1a/1b as described in Subclause 7.3.1.
 - otherwise
 - UE shall transmit the HARQ-ACK and SR as for FDD with PUCCH format 1b with channel selection as described in Subclause 7.3.1.

where the value of j is

- $i-1$ if UE is configured with higher layer parameter *shortProcessingTime* for primary cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space on primary cell, and UE is not configured with higher layer parameter *shortProcessingTime* for secondary cell,
- $i+1$ if UE is configured with higher layer parameter *shortProcessingTime* for both primary and secondary cells except when the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space on primary cell,
- i , otherwise.

For FDD-TDD and the primary cell is frame structure type 1, when PUCCH format 3/4/5 is configured for transmission of HARQ-ACK,

- for special subframe configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or configurations 0 and 4 with extended downlink CP in a serving cell, shown in table 4.2-1 [3], the special subframe of the serving cell is excluded from the HARQ-ACK codebook size determination.
- for special subframe configurations 1, 2, 6, and 7 and slot-PDSCH, the second slot of DwPTS of the serving cell is excluded from the HARQ-ACK codebook size determination.

For FDD-TDD and the primary cell is frame structure type 1, when a PUCCH format 3/4/5 transmission of HARQ-ACK coincides with a subframe/slot/subslot configured to the UE by higher layers for transmission of a scheduling request, the UE shall multiplex HARQ-ACK and SR bits on HARQ-ACK PUCCH resource as defined in Subclause 5.2.3.1 in [4], unless the HARQ-ACK corresponds to a subframe-PDSCH transmission on the primary cell only or a PDCCH/EPDCCH indicating downlink SPS release on the primary cell only, in which case the SR shall be transmitted as for FDD with PUCCH format 1a/1b as described in Subclause 7.3.1.

For FDD-TDD and for a PUSCH transmission, a UE shall not transmit HARQ-ACK on PUSCH in subframe/slot/subslot n if the UE does not receive PDSCH or PDCCH indicating downlink SPS release in

- subframe $n-k_p$ for subframe-PDSCH or in subframe $n-4$ for PDCCH indicating downlink SPS release,
- slot $n-4$ for slot-PDSCH,
- subslot $n-X_p$ for subslot- PDSCH if the higher layer parameter *ul-TTI-Length* is set to 'subslot',
- any of the subslot numbers listed in Table 10.1-1 if the higher layer parameter *ul-TTI-Length* is set to 'slot' and slot-PUSCH is transmitted in subframe m .

When only a positive SR is transmitted, a UE shall use PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 in [3].

When only a positive SR is transmitted using slot/subslot-PUCCH, a UE shall use PUCCH Format 1 for the first SR resource configured by higher layers as defined in Subclause 5.4A.2 in [3].

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$, the FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in Subclause 7.3.1 for a UE configured with higher layer parameter $codebooksizeDetermination-r13 = dai$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = dai$.

If a UE is configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$, the FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in Subclause 7.3.1 for a UE configured with higher layer parameter $codebooksizeDetermination-r13 = cc$ or with higher layer parameter $codebooksizeDeterminationsSTTI-r15 = cc$.

7.3.4 FDD-TDD HARQ-ACK reporting procedure for primary cell frame structure type 2

When only a positive SR is transmitted, a UE shall use PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 in [3].

When only a positive SR is transmitted using slot-PUCCH, a UE shall use PUCCH Format 1 for the first SR resource configured by higher layers as defined in Subclause 5.4A.2 in [3].

The FDD-TDD HARQ-ACK reporting procedure follows the HARQ-ACK procedure described in Subclause 7.3.2.2 with the following exceptions:

- for a serving cell with frame structure type 1, and a UE not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, K is defined in Table 10.1.3A-1, else K is defined in Table 10.1.3.1-1C if the UE is configured with higher layer parameter $shortTTI$ for slot-PDSCH, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise.
- for a serving cell with frame structure type 1 and a UE not configured to monitor PDCCH/EPDCCH/SPDCCH in another serving cell for scheduling the serving cell, if the DL-reference UL/DL configuration of the serving cell in Table 10.1.3A-1 belongs to {2,3,4}, B_c^{DL} is determined as in Subclause 7.3.2.2 for a serving cell with DL-reference UL/DL configuration {5}.
- for a serving cell with frame structure type 1, and if PUCCH format 3 is configured for transmission of HARQ-ACK, and for a PUSCH transmission in a subframe/slot n performed based on a detected PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B, the UE shall assume the UL-reference UL/DL configuration of the serving cell belongs to {1,2,3,4,5,6}.
- for a serving cell with frame structure type 1, and if DL-reference UL/DL configuration of each of the serving cells belongs to {0,1,2,3,4,6}, and if PUCCH format 1b with channel selection is configured for transmission of HARQ-ACK and for two configured serving cells, the UE shall assume the UL-reference UL/DL configuration of the serving cell belongs to {1,2,3,4,6}.
- for a serving cell with frame structure type 1, a value W_{DAI}^{UL} is determined by the Downlink Assignment Index (DAI) in DCI format 0/4/7-0A/7-0B corresponding to a PUSCH on the serving cell according to Table 7.3-Z in subframe/slot $n - k'$, where $k' = 4$.
- for a serving cell with frame structure type 1, when PUCCH format 3 is configured for transmission of HARQ-ACK, if the DL-reference UL/DL configuration of the serving cell is 0, the HARQ-ACK for a PDSCH transmission with a corresponding PDCCH/EPDCCH/SPDCCH in subframe/slot $n - k$ is associated with $o_{c,DAI(k)-1}^{ACK}$ if transmission mode configured in the c -th serving cell supports one transport block or spatial HARQ-ACK bundling is applied, or associated with $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ otherwise, where $DAI(k)$ is the value of DAI in DCI format 1A/1B/1D/1/2/2A/2B/2C/2D detected in subframe $n - k$, $o_{c,2DAI(k)-2}^{ACK}$ and $o_{c,2DAI(k)-1}^{ACK}$ are the HARQ-ACK feedback for codeword 0 and codeword 1, respectively. For the case with $N_{SPS} > 0$, the HARQ-ACK associated with a PDSCH transmission without a corresponding

PDCCH/EPDCCH/SPDCCH is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission are set to NACK.

8 Physical uplink shared channel related procedures

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

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

If a UE is configured with a LAA SCell for UL transmissions, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA SCell unless stated otherwise.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE is not expected to transmit any uplink physical channel or signal in the serving cell on subframes other than offset-UL subframes, where the offset-UL subframes are determined by applying an offset value given by *harq-Offset-r15* to the subframes denoted as uplink in the UL/DL configuration *subframeAssignment-r15*.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE is not expected to be configured with more than one serving cells in the uplink.

For a non-BL/CE UE, and for FDD and transmission mode 1 and a cell that is not a LAA SCell, there shall be 16 uplink HARQ processes per serving cell configured with higher layer parameter *ul-STTI-Length*, otherwise 8 uplink HARQ processes per serving cell for non-subframe bundling operation, i.e. normal HARQ operation, and 3 uplink HARQ processes for subframe bundling operation when parameter *e-HARQ-Pattern-r12* is set to *TRUE* and 4 uplink HARQ processes for subframe bundling operation otherwise. For a non-BL/CE UE, and for FDD and transmission mode 2 configured for subframe-PUSCH and a cell that is not a LAA SCell, there shall be 32 uplink HARQ processes per serving cell configured with higher layer parameters *ul-STTI-Length* and *shortProcessingTime*, otherwise 16 uplink HARQ processes per serving cell for non-subframe bundling operation and there are two HARQ processes associated with a given subframe for subframe-PUSCH as described in [8]. The subframe bundling operation is configured by the parameter *ttiBundling* provided by higher layers.

For FDD and a BL/CE UE configured with CEModeA, there shall be at most 8 uplink HARQ processes per serving cell.

For FDD and a BL/CE UE configured with CEModeB, there shall be at most 2 uplink HARQ processes per serving cell.

For a LAA SCell, and transmission mode 1, there shall be 16 uplink HARQ processes. For a LAA SCell, and transmission mode 2, there shall be 32 uplink HARQ processes.

There shall be 16 uplink HARQ processes per TDD serving cell configured with higher layer parameter *ul-STTI-Length*.

In case higher layers configure the use of subframe bundling for FDD and TDD, the subframe bundling operation is only applied to UL-SCH, such that four consecutive uplink subframes are used.

A BL/CE UE is not expected to be configured with simultaneous PUSCH and PUCCH transmission.

8.0 UE procedure for transmitting the physical uplink shared channel

The term "UL/DL configuration" in this Subclause refers to the higher layer parameter *subframeAssignment* unless specified otherwise.

Throughout this section, if the UE is configured with higher layer parameter *shortTTI* and the corresponding PDCCCH/SPDCCCH with DCI format 7-0A/7-0B is detected in a subslot, if the UE is configured for subslot uplink

transmissions, X_p is determined based on higher layer configuration from $\{4,6,8\}$, otherwise $X_p = 4$. If subslot number n is in subframe N , subslot $n + X_p$ refers to subslot number $(n + X_p) \bmod 6$ in subframe $N + \left\lfloor \frac{n + X_p}{6} \right\rfloor$.

For a given serving cell, if a UE is configured with higher layer parameter *shortProcessingTime*, the UE is not expected to receive

- more than one uplink scheduling grants for an uplink subframe.
- PDCCH in common search space with DCI format 0 in subframe n and PDCCH in User-specific search space with DCI format 0/4 in the same subframe n .

For a serving cell, and a UE configured with higher layer parameter *ul-STTI-Length*, the UE is not expected to transmit subframe-PUSCH

- in a given subframe corresponding to PDCCH with uplink DCI format other than 7-0A/7-0B or without a corresponding PDCCH if the UE detects PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B corresponding to a PUSCH transmission in the same subframe or if the UE transmits a slot/subslot-PUSCH without a corresponding PDCCH/SPDCCH. The UE shall transmit the HARQ-ACK response corresponding to the subframe-PUSCH using the slot/subslot-PUSCH (as defined in Subclause 7.3). The UE shall apply spatial HARQ-ACK bundling on the HARQ-ACK response
 - in case subslot-PUSCH is used
 - in case slot-PUSCH is used if the bundling is configured for the cell.
- in a given subframe corresponding to PDCCH/EPDCCH with uplink DCI format other than 7-0A/7-0B received in subframe n if the UE detects PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in any subframe from subframe $n+1$ to subframe $n+W_{UL}$ corresponding to a PUSCH transmission, and if $W_{UL} > 0$ is indicated by *skipSubframeProcessing* capability [12],
- in case of a collision between the subframe-PUSCH and slot/subslot-PUCCH. The UE shall transmit the HARQ-ACK response corresponding to the subframe-PUSCH using the slot/subslot-PUCCH (as defined in Subclause 7.3). The UE shall apply spatial HARQ-ACK bundling on the HARQ-ACK response
 - in case subslot-PUCCH is used
 - in case slot-PUCCH is used if the bundling is configured for the cell.
- in case of a collision between the subframe-PUSCH, subframe-PUCCH, and slot/subslot-PUSCH when simultaneous PUSCH and PUCCH transmission is configured for the UE. The UE is also not expected to transmit subframe-PUCCH. The UE shall transmit the HARQ-ACK response corresponding to the subframe-PUCCH using the slot/subslot-PUSCH.

For a serving cell, and a UE configured with higher layer parameter *shortTTI*, the UE is not expected to transmit PUSCH corresponding to PDCCH/SPDCCH with CRC scrambled by the C-RNTI/SPS C-RNTI and with uplink DCI format 7-0A/7-0B

- in UpPTS of the special subframe in frame structure type 2 with special subframe configuration 0-9 or,
- for a transport block corresponding to a HARQ process with NDI not toggled if the previous PUSCH transmission of the transport block was signalled via PDCCH in UE specific search space with CRC scrambled by the C-RNTI/SPS C-RNTI with DCI format other than DCI format 7-0A/7-0B when the number of codewords for the previous PUSCH transmission is two or the transport block size is larger than the maximum transport block size supported for slot/subslot-PUSCH transmission.

For a UE configured with more than one serving cell and not capable of simultaneous transmission of different uplink signal durations to different serving cells as indicated by UE capability *simultaneousTx-differentTx-duration*, in case of a collision between

- a slot-PUSCH of first serving cell and a subframe-PUSCH/PUCCH/SRS/PRACH of second serving cell or
- a subslot-PUSCH of first serving cell and a subframe/slot-PUSCH/PUCCH/SRS/PRACH of second serving cell

the uplink transmission(s) of the second serving cell are dropped.

For a serving cell, and a UE configured with higher layer parameter *shortTTI*, the UE shall discard PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B for subslot *n* if PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B for subslot *n*-1 indicates the DMRS transmission in the first symbol of subslot *n*

- if the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B for subslot *n* does not indicate DMRS transmission in the first symbol of subslot *n*, or
- if the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B for subslot *n* indicates the DMRS transmission in the first symbol of subslot *n*,
 - if the cyclic shift and/or IFDMA comb of subslot *n*-1 is not identical to that of subslot *n*, or
 - if the PUSCH RBs of subslot *n*-1 is not identical to those of subslot *n*, or
 - if precoding information and number of layers of subslot *n*-1 are not identical to those of subslot *n*, or
 - if TPC field for subslot *n* is not '1' and if the UE is configured with higher layer parameter *accumulationEnabledsTTI*, or
 - if TPC field for subslot *n*-1 is not identical to that of subslot *n* and if the UE is not configured with higher layer parameter *accumulationEnabledsTTI*.

For a serving cell, and a UE configured with higher layer parameter *totalNumberPUSCH-SPS-STTI-UL-Repetitions* or *totalNumberPUSCH-SPS-UL-Repetitions*,

- the UE is not expected to transmit PUSCH with a subframe/slot/subslot duration associated with a DCI scrambled by SPS C-RNTI colliding with ongoing PUSCH repetitions of the same subframe/slot/subslot duration associated with another DCI scrambled by SPS C-RNTI.
- for a FDD cell, the UE shall upon detection of a PDCCH/EPDCCH/SPDCCH with DCI format 0/7-0A/7-0B with CRC scrambled by SPS C-RNTI with NDI set to 0, intended for the UE, transmit the corresponding PUSCH in *k* consecutive UL subframes/slots/subslots.
- for a TDD cell not configured with higher layer parameter *symPUSCH-UpPts-r14*, the UE shall upon detection of a PDCCH/EPDCCH/SPDCCH with DCI format 0/7-0A/7-0B with CRC scrambled by SPS C-RNTI with NDI set to 0, intended for the UE, transmit the corresponding PUSCH in *k* consecutive UL subframes/slots according to the UL/DL configuration indicated by higher layer parameter *subframeAssignment* for the serving cell.
- for a TDD cell configured with higher layer parameter *symPUSCH-UpPts-r14*, the UE shall upon detection of a PDCCH/EPDCCH/SPDCCH with DCI format 0/7-0A/7-0B with CRC scrambled by SPS C-RNTI with NDI set to 0, intended for the UE, transmit the corresponding PUSCH in *k* consecutive UL subframes/slots or UpPTS according to the UL/DL configuration indicated by higher layer parameter *subframeAssignment* for the serving cell.
- for a TDD cell configured with UL/DL configuration 0 indicated by higher layer parameter *subframeAssignment*, the UE is not expected to receive a DCI of format 0 with CRC scrambled by SPS C-RNTI scheduling more than one PUSCH with a subframe duration by UL index.
- for a TDD cell configured with UL/DL configuration 6 indicated by higher layer parameter *subframeAssignment* and configured with higher layer parameters *symPUSCH-UpPts-r14*, the UE is not expected to receive a DCI of format 0 with CRC scrambled by SPS C-RNTI scheduling more than one PUSCH with a subframe duration by UL index.
- for a TDD cell configured with UL/DL configurations 0/6 indicated by higher layer parameter *subframeAssignment*, the UE is not expected to receive a DCI of format 7-0A/7-0B with CRC scrambled by SPS C-RNTI scheduling more than one PUSCH with a slot duration by UL index.

For a serving cell that is not a LAA SCell, and for FDD and normal HARQ operation, the UE shall upon detection on a given serving cell of a

- PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe *n* intended for the UE, perform a corresponding PUSCH transmission in subframe *n+k_p* according to the PDCCH/EPDCCH and PHICH information where $k_p = 3$ if the UE is configured with higher layer parameter *shortProcessingTime* and

the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 4$ otherwise.

- PDCCH/SPDCCH with DCI format 7-0A/7-0B intended for the UE in
 - slot n , perform a corresponding PUSCH transmission in slot $n + X_p$
 - subslot n , perform a corresponding PUSCH transmission
 - in subslot $n + X_p$ if the UE is configured with subslot-based uplink transmissions, or
 - in slot 0 of subframe N if the UE is configured with slot-based uplink transmissions, and subslot n (with n being subslot numbered from 0 to 5 within a subframe) is only one of
 - subframe $N-3$, and subslot number $n=4$ or 5, or
 - subframe $N-2$, and subslot number $n=0$
 - in slot 1 of subframe N if the UE is configured with slot-based uplink transmissions, and subslot n belongs to subframe $N-2$, and n is only one of subslot number {1, 2, 3}

if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

For FDD-TDD and normal HARQ operation and a PUSCH for serving cell c with frame structure type 1, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission for serving cell c in subframe $n + k_p$ according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], where $k_p = 3$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 4$ otherwise.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to Subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, the UE shall perform the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, and using the number of transmission layers and precoding matrix according to the most recent PDCCH/EPDCCH, if the number of negatively acknowledged transport blocks is equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to Subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, and if the number of negatively acknowledged transport blocks is not equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH then the UE shall perform the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, using the precoding matrix with codebook index 0 and the number of transmission layers equal to number of layers corresponding to the negatively acknowledged transport block from the most recent PDCCH/EPDCCH. In this case, the UL DMRS resources are calculated according to the cyclic shift field for DMRS [3] in the most recent PDCCH/EPDCCH with DCI format 4 associated with the corresponding PUSCH transmission and number of layers corresponding to the negatively acknowledged transport block.

If a UE is configured with the carrier indicator field for a given serving cell, the UE shall use the carrier indicator field value from the detected PDCCH/EPDCCH with uplink DCI format to determine the serving cell for the corresponding PUSCH transmission.

For FDD and normal HARQ operation, if a PDCCH/EPDCCH/SPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe/slot/subslot n , and simultaneous PUSCH and PUCCH transmission is not configured for the UE or is detected on slot/subslot n , then UCI is mapped on the corresponding PUSCH transmission on,

- slot $n+4$ for slot-PUSCH transmissions when the higher layer parameter *dl-STTI-Length* is set to 'slot'
- slot *0* of subframe $N+2$ for slot-PUSCH transmissions in case of subslot number $n=4$ or 5 in subframe $N-1$, or subslot number $n=0$ in subframe N when the higher layer parameter *dl-STTI-Length* is set to 'subslot'
- slot *1* of subframe $N+2$ for slot-PUSCH transmissions in case of subslot number $n=1$ or 2 or 3 in subframe N when the higher layer parameter *dl-STTI-Length* is set to 'subslot'
- subslot $n + X_p$ for subslot-PUSCH transmissions
- subframe $n + k_p$ where $k_p = 3$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 4$ otherwise for subframe-PUSCH transmissions.

For FDD and a BL/CE UE configured with CEModeA, if an MPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe n , then on subframe $n+4$ UCI is mapped on the corresponding PUSCH transmission, including all subframe repetitions of the PUSCH transmission.

For FDD-TDD and normal HARQ operation, for a serving cell with frame structure type 1, if a PDCCH/EPDCCH/SPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe n , and simultaneous PUSCH and PUCCH transmission is not configured for the UE or is detected on slot/subslot n , UCI is mapped on the corresponding PUSCH transmission on

- slot $n+4$ for slot-PUSCH transmissions when the higher layer parameter *dl-STTI-Length* is set to 'slot';
- slot *0* of subframe $N+2$ for slot-PUSCH transmissions in case of subslot number $n=4$ or 5 in subframe $N-1$, or subslot $n=0$ corresponding to subframe N when the higher layer parameter *dl-STTI-Length* is set to 'subslot';
- slot *1* of subframe $N+2$ for slot-PUSCH transmissions in case of subslot number $n=1$ or 2 or 3 in subframe N when the higher layer parameter *dl-STTI-Length* is set to 'subslot';
- subslot $n + X_p$ for subslot-PUSCH transmissions;
- subframe $n + k_p$ where $k_p = 3$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 4$ otherwise for subframe-PUSCH transmissions.

For TDD, if a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, then for a given serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different, if the serving cell is a primary cell or if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different and if the serving cell is a secondary cell and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling a secondary serving cell with frame structure type 2, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, and for secondary serving cell c with frame structure type 2, if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, if a UE is configured with more than one serving cell with frame structure type 2, and if the serving cell is a secondary cell with frame structure type 2 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

Table 8-0A: UL-reference UL/DL Configuration for serving cell based on the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration)

| Set # | (other serving cell UL/DL configuration, serving cell UL/DL configuration) | UL-reference UL/DL configuration |
|-------|--|----------------------------------|
| Set 1 | (1,1),(1,2),(1,4),(1,5) | 1 |
| | (2,2),(2,5) | 2 |
| | (3,3),(3,4),(3,5) | 3 |
| | (4,4),(4,5) | 4 |
| | (5,5) | 5 |
| Set 2 | (1,0),(2,0),(3,0),(4,0),(5,0) | 0 |
| | (2,1),(4,1),(5,1) | 1 |
| | (5,2) | 2 |
| | (4,3),(5,3) | 3 |
| | (5,4) | 4 |
| | (1,6),(2,6),(3,6),(4,6),(5,6) | 6 |
| Set 3 | (3,1) | 1 |
| | (3,2),(4,2) | 2 |
| | (1,3),(2,3) | 3 |
| | (2,4) | 4 |
| Set 4 | (0,0),(6,0) | 0 |
| | (0,1),(0,2),(0,4),(0,5),(6,1),(6,2),(6,5) | 1 |
| | (0,3),(6,3) | 3 |
| | (6,4) | 4 |
| | (0,6),(6,6) | 6 |

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for a serving cell, for a radio frame of the serving cell, PUSCH transmissions can occur only in subframes that are indicated by eIMTA-UL/DL-configuration as uplink subframe(s) for the serving cell unless specified otherwise.

For TDD and normal HARQ operation, if a PDCCH/EPDCCH/SPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe n and simultaneous PUSCH and PUCCH transmission is not configured for the UE or is detected by a UE on slot n , then on subframe/slot $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by

- Table 8-2m for special subframe configuration 1,2,3,4,6,7,8 if the UE is configured with higher layer parameter *ul-STTI-Length*, and the corresponding uplink DCI format is 7-0A/7-0B;
- Table 8-2n for special subframe configuration 0,5,9 if the UE is configured with higher layer parameter *ul-STTI-Length*, and the corresponding uplink DCI format is 7-0A/7-0B;
- Table 8-2p if the UE is configured with higher layer parameters *ul-STTI-Length* and *symPUSCH-UpPts-r14*, and the corresponding uplink DCI format is 7-0A/7-0B;
- Table 8-2i if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space;
- Table 8-2 otherwise.

For TDD and a BL/CE UE configured with CEModeA, if an MPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in Subclause 7.2.1, is detected by a UE on subframe n , then on subframe $n+k$ UCI is

mapped on the corresponding PUSCH transmission, including all subframe repetitions of the PUSCH transmission, where k is given by Table 8-2.

For FDD-TDD normal HARQ operation, for a serving cell with frame structure type 2, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report on the serving cell, as described in Subclause 7.2.1, is detected by a UE on subframe n , then on subframe $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by Table 8-2 and the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration for the serving cell, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

When a UE is configured with higher layer parameter $ttiBundling$ and configured with higher layer parameter $e\text{-HARQ-Pattern-}r12$ set to *FALSE* or not configured, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe $n-5$ intended for the UE, perform a corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

When a UE is configured with higher layer parameter $ttiBundling$ and configured with higher layer parameter $e\text{-HARQ-Pattern-}r12$ set to *TRUE*, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe $n-1$ intended for the UE, perform a corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

For both FDD and TDD serving cells, the NDI as signalled on PDCCH/EPDCCH/MPDCCH/SPDCCH, the RV as determined in Subclause 8.6.1, and the TBS as determined in Subclause 8.6.2, shall be delivered to higher layers.

If the UE is not configured with higher layer parameter $ul\text{-STTI-Length}$, for a non-BL/CE UE, for TDD and transmission mode 1, the number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in Table 8-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the serving cell, otherwise the number of HARQ processes per serving cell shall be determined as

- $\min\{8, Z\}$, where Z is indicated in Table 8-1a, if the UE is configured with $shortProcessingTime$ and the corresponding PDCCH is in the UE-specific search space,
- indicated in Table 8-1a.

For a non-BL/CE UE, for TDD and transmission mode 2 if the UE is not configured with higher layer parameter $ul\text{-STTI-Length}$, the number of HARQ processes per serving cell for non-subframe bundling operation shall be twice the number determined by the UL/DL configuration (Table 4.2-2 of [3]) for TDD and transmission mode 1 there are two HARQ processes associated with a given subframe as described in [8]. For TDD and both transmission mode 1 and transmission mode 2, the "TDD UL/DL configuration" in Table 8-1 and Table 8-1a refers to the UL-reference UL/DL configuration for the serving cell if UL-reference UL/DL configuration is defined for the serving cell and refers to the serving cell UL/DL configuration otherwise.

For a non-BL/CE UE configured higher layer parameter $ul\text{-STTI-Length}$, if the UE is configured with $shortProcessingTime$ and transmission mode 2 for subframe-PUSCH the number of HARQ processes per TDD serving cell for non-subframe bundling operation is 32, and 16 otherwise. There are two HARQ processes for transmission mode 2 of subframe-PUSCH associated with a given subframe as described in [8].

For a BL/CE UE configured with CEModeA and for TDD, the maximum number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]) according to the normal HARQ operation in Table 8-1. For TDD a BL/CE UE configured with CEModeB is not expected to support more than 2 uplink HARQ processes per serving cell.

Table 8-1: Number of synchronous UL HARQ processes for TDD

| TDD UL/DL configuration | Number of HARQ processes for normal HARQ operation | Number of HARQ processes for subframe bundling operation |
|-------------------------|--|--|
| 0 | 7 | 3 |
| 1 | 4 | 2 |
| 2 | 2 | N/A |
| 3 | 3 | N/A |
| 4 | 2 | N/A |
| 5 | 1 | N/A |
| 6 | 6 | 3 |

Table 8-1a: Number of synchronous UL HARQ processes for TDD and UE configured with *symPUSCH-UpPts-r14*

| TDD UL/DL configuration | Number of HARQ processes for normal HARQ operation | Number of HARQ processes for subframe bundling operation |
|-------------------------|--|--|
| 0 | 9 | N/A |
| 1 | 6 | N/A |
| 2 | 4 | 2 |
| 3 | 4 | 2 |
| 4 | 3 | N/A |
| 5 | 2 | N/A |
| 6 | 8 | N/A |

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, and if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For TDD UL/DL configurations 1-6 and normal HARQ operation and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH/SPDCCH with uplink DCI format in subframe/slot n and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe/slot $n+k$, with k given in
 - Table 8-2m for special subframe configuration 1, 2, 3, 4, 6, 7, 8 if the UE is configured with higher layer parameter *ul-STTI-Length*, and the corresponding uplink DCI format is 7-0A/7-0B
 - Table 8-2n for special subframe configuration 0, 5, 9 if the UE is configured with higher layer parameter *ul-STTI-Length*, and the corresponding uplink DCI format is 7-0A/7-0B
 - For TDD UL/DL configuration 6 and for $n=0, 1, 2, 10, 11, 12$
 - If only the MSB of the UL index in the uplink DCI is set in slot n , the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - If only the LSB of the UL index in the uplink DCI is set in slot n , the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$
 - If both the MSB and LSB of the UL index in the uplink DCI are set in slot n , the UE shall perform a corresponding PUSCH transmission in both slot $n+k$ and $n+k+1$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.
 - Table 8-2i if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with DCI format 0/4 and with CRC scrambled by C-RNTI is in the UE-specific search space,
 - Table 8-2 otherwise,

according to the PDCCH/EPDCCH/SPDCCH and PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

- For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe $n+k$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 is set to 1 or PHICH is received in subframe $n=0$ or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, or PHICH is received in subframe $n=1$ or 6 corresponding to PUSCH transmission in subframe $n-5$ for UE configured with higher layer parameter $symPUSCH-UpPts-r14$ for the serving cell. If, for TDD UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe n or a PHICH is received in subframe $n=0$ or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, or PHICH is received in subframe $n=1$ or 6 corresponding to PUSCH transmission in subframe $n-4$, the UE shall perform a corresponding PUSCH transmission in subframe $n+k_p$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for TDD UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 are set in subframe n , the UE shall perform a corresponding PUSCH transmission in both subframes $n+k$ and $n+k_p$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in
 - Table 8-2g if the UE is configured with higher layer parameter $symPUSCH-UpPts-r14$ and the UE is either not configured with higher layer parameter $shortProcessingTime$ for the serving cell or is configured with higher layer parameter $shortProcessingTime$ for the serving cell and the corresponding PDCCH is in the common search space,
 - Table 8-2i if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ and the UE is configured with higher layer parameter $shortProcessingTime$ for the serving cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
 - Table 8-2j if the UE is configured with higher layer parameters $symPUSCH-UpPts-r14$ and $shortProcessingTime$ for the serving cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
 - Table 8-2 otherwise.

$k_p = 6$ if the UE is configured with higher layer parameters $symPUSCH-UpPts-r14$ and $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, or if $n=1$ or 6 and the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ but is configured with $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 7$ otherwise.

In case the UE is configured with higher layer parameter $shortProcessingTime$ for the serving cell and both the MSB and LSB of the UL index in the PDCCH with uplink DCI format 0/4 with the UE's C-RNTI in the UE-specific search space are set to 1, the HARQ process number of the PUSCH in subframe $n+k$ is n_{HARQ_ID} and the HARQ process number of the PUSCH in subframe $n+k_p$ is $(n_{HARQ_ID} + 1) \bmod M_{UL_HARQ}$, where n_{HARQ_ID} is determined according to the *HARQ process number* field in the corresponding DCI format and M_{UL_HARQ} is the number of UL HARQ processes per cell for transmission mode 1 and half the number of UL HARQ processes per cell for transmission mode 2.

- For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot n intended for the UE, perform a corresponding PUSCH transmission in slot $n+k$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in
 - Table 8-2m for special subframe configuration 1, 2, 3, 4, 6, 7, 8, and in Table 8-2n for special subframe configuration 0, 5, 9
 - If only the MSB of the UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B is set in slot n , the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - If only the LSB of the UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B is set in slot n , the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$

- If both the MSB and LSB of the UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B are set in slot n , the UE shall perform a corresponding PUSCH transmission in both slot $n+k$ and $n+k+1$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.
- The UE is not expected to receive LSB of the UL index in PDCCH/SPDCCH with uplink DCI format set to 1 in slot $n=0, 1, 10$ and 11 for special subframe configuration 1, 2, 3, 4, 6, 7, 8
- Table 8-2p if the UE is configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell
 - If UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot $n=2$ or $n=12$ is set to
 - '10', the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - '01', the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$
 - '11', the UE shall perform a corresponding PUSCH transmission in slot $n+k+5$
 - '00', the UE shall perform a corresponding PUSCH transmission in slot $n+k$, $n+k+1$, and $n+k+5$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$, the HARQ process number of the PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$, and the HARQ process number of the PUSCH in $n+k+5$ is $(n_{\text{HARQ_ID}} + 2) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.
 - If UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot $n=0, 1, 10$ or 11 is set to
 - '10', the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - '01', the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$
 - '11', the UE shall perform a corresponding PUSCH transmission in slot $n+k$ and $n+k+1$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.
- For TDD UL/DL configurations 1-5 and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH/SPDCCH with uplink DCI format in subframe/slot n intended for the UE, and/or a PHICH transmission intended for the UE in subframe $n+l$ with l given in Table 8-2h, perform a corresponding PUSCH transmission in subframe/slot $n+k$, with k given in Table 8-2j if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI Format 0/4 and is in the UE-specific search space, Table 8-2p if the corresponding PDCCH/SPDCCH has DCI format 7-0A/7-0B, in Table 8-2g otherwise, according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].
- For TDD UL/DL configuration 6 and normal HARQ operation and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe $n+k$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 is set to 1 or PHICH is received in subframe $n=1$ or 6 or 9 , or PHICH is received in subframe $n=0$ corresponding to PUSCH transmission in subframe $n=6$, or PHICH is received in subframe $n=5$ corresponding to PUSCH transmission in subframe $n=7$, with k given in Table 8-2j if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format 0/4 and is in the UE-specific search space, in Table 8-2g otherwise. If, for TDD UL/DL configuration 6 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe n , or PHICH is received in subframe $n=0$ or 5 corresponding to PUSCH transmission in subframe $n=4$, the UE shall perform a corresponding PUSCH transmission in subframe $n+k$ if a transport block corresponding

to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for TDD UL/DL configuration 6, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 are set in subframe n , the UE shall perform a corresponding PUSCH transmission in both subframes $n+k$ and $n+k_p$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in Table 8-2j if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format 0/4 and is in the UE-specific search space, in Table 8-2g otherwise. In case the UE is configured with higher layer parameter *shortProcessingTime* for the serving cell and both the MSB and LSB of the UL index in the PDCCH with CRC scrambled by C-RNTI has DCI format 0/4 in the UE-specific search space are set to 1, the HARQ process number of the PUSCH in subframe $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH in subframe $n+k_p$ is

$(n_{\text{HARQ_ID}} + 1) \bmod M_{\text{UL_HARQ}}$, where $n_{\text{HARQ_ID}}$ is determined according to the *HARQ process number* field in the corresponding DCI format and $M_{\text{UL_HARQ}}$ is the number of UL HARQ processes per cell for transmission mode 1 and half the number of UL HARQ processes per cell for transmission mode 2. Note that k_p is given as,

- $k_p = 4$ if $n=0$ or 9 and the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
- $k_p = 6$ if $n=1, 5$, or 6 and the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
- $k_p = 6$ otherwise.

The UE is not expected to receive LSB of the UL index in PDCCH/EPDCCH with uplink DCI format 0/4 set to 1 in subframe $n=9$ unless the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format 0/4 in the UE-specific search space.

- For TDD UL/DL configuration 6 and normal HARQ operation and the UE is configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot n intended for the UE, perform a corresponding PUSCH transmission in slot $n+k$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in Table 8-2p
 - If UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot $n=2$ is set to
 - '10', the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - '01', the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$
 - '11', the UE shall perform a corresponding PUSCH transmission in slot $n+k+5$
 - '00', the UE shall perform a corresponding PUSCH transmission in slot $n+k$, $n+k+1$, and $n+k+5$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$, the HARQ process number of the PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$, and the HARQ process number of the PUSCH in $n+k+5$ is $(n_{\text{HARQ_ID}} + 2) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.
 - If UL index in the PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B in slot $n=0, 1, 10, 11, 12, 19$ is set to
 - '10', the UE shall perform a corresponding PUSCH transmission in slot $n+k$
 - '01', the UE shall perform a corresponding PUSCH transmission in slot $n+k+1$
 - '11', the UE shall perform a corresponding PUSCH transmission in slot $n+k$ and $n+k+1$, where the HARQ process number of the PUSCH in slot $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the

PUSCH in $n+k+1$ is $(n_{\text{HARQ_ID}} + 1) \bmod 16$ with $n_{\text{HARQ_ID}}$ from the HARQ process number field in the corresponding DCI format.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD,

- For a serving cell with an UL-reference UL/DL configurations belonging to {1,2,3,4,5,6} and normal HARQ operation and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe $n+k$ for the serving cell according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in Table 8-2i if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format 0/4 in the UE-specific search space, in Table 8-2 otherwise, where the "TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.
- For a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe $n+k$ for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 is set to 1 or PHICH is received in subframe $n=0$ or 5 in the resource corresponding to $I_{\text{PHICH}} = 0$, as defined in Subclause 9.1.2, or PHICH is received in subframe $n=1$ or 6 corresponding to PUSCH transmission in subframe $n-5$ for UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell. If, for a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe n or a PHICH is received in subframe $n=0$ or 5 in the resource corresponding to $I_{\text{PHICH}} = 1$, as defined in Subclause 9.1.2, or PHICH is received in subframe $n=1$ or 6 corresponding to PUSCH transmission in subframe $n-4$, the UE shall perform a corresponding PUSCH transmission in subframe $n+k_p$ for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for a serving cell with UL-reference UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format 0/4 are set in subframe n , the UE shall perform a corresponding PUSCH transmission in both subframes $n+k$ and $n+k_p$ for the serving cell if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. In case the UE is configured with higher layer parameter *shortProcessingTime* for the serving cell and both the MSB and LSB of the UL index in the PDCCH with uplink DCI format 0/4 with the UE's C-RNTI in the UE-specific search space are set to 1, the HARQ process number of the PUSCH in subframe $n+k$ is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH in subframe $n+k_p$ is $(n_{\text{HARQ_ID}} + 1) \bmod M_{\text{UL_HARQ}}$, where $n_{\text{HARQ_ID}}$ is determined according to the *HARQ process number* field in the corresponding DCI format and $M_{\text{UL_HARQ}}$ is the number of UL HARQ processes per cell for transmission mode 1 and half the number of UL HARQ processes per cell for transmission mode 2. Note that k is given in
 - Table 8-2g if the UE is configured with higher layer parameter *symPUSCH-UpPts-r14* and the UE is either not configured with higher layer parameter *shortProcessingTime* for the serving cell or is configured with higher layer parameter *shortProcessingTime* for the serving cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the common search space,
 - Table 8-2i if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* and the UE is configured with higher layer parameter *shortProcessingTime* for the serving cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
 - Table 8-2j if the UE is configured with higher layer parameters *symPUSCH-UpPts-r14* and *shortProcessingTime* for the serving cell and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
 - Table 8-2 otherwise,

where the "TDD UL/DL Configuration" given in Table 8-2, Table 8-2g, Table 8-2i, Table 8-2j refers to the UL-reference UL/DL configuration. Note that $k_p = 6$ if the UE is configured with higher layer parameters *symPUSCH-UpPts-r14* and *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-

RNTI is in the UE-specific search space, or if $n=1$ or 6 and the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ but is configured with $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 7$ otherwise.

- For a serving cell with an UL-reference UL/DL configurations belonging to $\{1,2,3,4,5\}$ and normal HARQ operation and UE configured with higher layer parameter $symPUSCH-UpPts-r14$ for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format $0/4$ in subframe n intended for the UE, and/or a PHICH transmission intended for the UE in subframe $n+l$ with l given in Table 8-2h, perform a corresponding PUSCH transmission in subframe $n+k$ for the serving cell according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in Table 8-2j if the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format $0/4$ in the UE-specific search space, in Table 8-2g otherwise, where the "TDD UL/DL Configuration" given in Table 8-2g, Table 8-2h and Table 8-2j refers to the UL-reference UL/DL configuration.
- For a serving cell with UL-reference UL/DL configuration configuration 6 and normal HARQ operation and UE configured with higher layer parameter $symPUSCH-UpPts-r14$ for the serving cell, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format $0/4$ and/or a PHICH transmission in subframe n intended for the UE, perform a corresponding PUSCH transmission in subframe $n+k$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format $0/4$ is set to 1 or PHICH is received in subframe $n=1$ or 6 or 9 , or PHICH is received in subframe $n=0$ corresponding to PUSCH transmission in subframe $n-6$, or PHICH is received in subframe $n=5$ corresponding to PUSCH transmission in subframe $n-7$, with k given in Table 8-2j if the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format $0/4$ in the UE-specific search space, in Table 8-2g otherwise. If, for a serving cell with UL-reference UL/DL configuration 6 and normal HARQ operation, the LSB of the UL index in the DCI format $0/4$ is set to 1 in subframe n , or PHICH is received in subframe $n=0$ or 5 corresponding to PUSCH transmission in subframe $n-4$, the UE shall perform a corresponding PUSCH transmission in subframe $n+k_p$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. If, for a serving cell with UL-reference UL/DL configuration 6, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format $0/4$ are set in subframe n , the UE shall perform a corresponding PUSCH transmission in both subframes $n+k$ and $n+k_p$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8], with k given in Table 8-2j if the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI has DCI format $0/4$ in the UE-specific search space, in Table 8-2g otherwise, where the "TDD UL/DL Configuration" given in Table 8-2g and Table 8-2j refers to the UL-reference UL/DL configuration. In case the UE is configured with higher layer parameter $shortProcessingTime$ for the serving cell and both the MSB and LSB of the UL index in the PDCCH with uplink DCI format $0/4$ with the UE's C-RNTI in the UE-specific search space are set to 1, the HARQ process number of the PUSCH in subframe $n+k$ is

n_{HARQ_ID} and the HARQ process number of the PUSCH in subframe $n+k_p$ is

$(n_{HARQ_ID} + 1) \bmod M_{UL_HARQ}$, where n_{HARQ_ID} is determined according to the *HARQ process number* field in the corresponding DCI format and M_{UL_HARQ} is the number of UL HARQ processes per cell for transmission mode 1 and half the number of UL HARQ processes per cell for transmission mode 2. Note that k_p is given as,

- $k_p = 4$ if $n = 0$ or 9 and the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
- $k_p = 6$ if $n=1, 5$, or 6 and the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
- $k_p = 6$ otherwise.

The UE is not expected to receive LSB of the UL index in PDCCH/EPDCCH with uplink DCI format set to 1 in subframe $n=9$ unless the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space.

For TDD UL/DL configurations 1, 2, 3 and 6 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission intended for the

UE in subframe $n-l$ with l given in Table 8-2a, perform a corresponding first PUSCH transmission in the bundle in subframe $n+k$ according to the PDCCH/EPDCCH and/or PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8], with k given in Table 8-2 if the UE is not configured with higher layer parameter $\text{symPUSCH-UpPts-r14}$ for the serving cell, otherwise k given in Table 8-2g.

For TDD UL/DL configuration 0 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission intended for the UE in subframe $n-l$ with l given in Table 8-2a, perform a corresponding first PUSCH transmission in the bundle in subframe $n+k$ according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8] and if the MSB of the UL index in the DCI format 0 is set to 1 or if $I_{\text{PHICH}} = 0$, as defined in Subclause 9.1.2, with k given in Table 8-2. If, for TDD UL/DL configuration 0 and subframe bundling operation, the LSB of the UL index in the PDCCH/EPDCCH with DCI format 0 is set to 1 in subframe n or if $I_{\text{PHICH}} = 1$, as defined in Subclause 9.1.2, the UE shall perform a corresponding first PUSCH transmission in the bundle in subframe $n+7$, according to the PDCCH/EPDCCH and PHICH information if a transport block corresponding to the HARQ process of the first PUSCH transmission is generated as described in [8].

Table 8-2: k for TDD configurations 0-6

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|-------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 4 | 6 | | | | 4 | 6 | | | |
| 1 | | 6 | | | 4 | | 6 | | | 4 |
| 2 | | | | 4 | | | | 4 | | |
| 3 | 4 | | | | | | | 4 | 4 | |
| 4 | | | | | | | | 4 | 4 | |
| 5 | | | | | | | | 4 | | |
| 6 | 7 | 7 | | | 7 | 7 | | | | 5 |

Table 8-2a: l for TDD configurations 0, 1, 2, 3 and 6

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|-------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 9 | 6 | | | | 9 | 6 | | | |
| 1 | | 2 | | | 3 | | 2 | | | 3 |
| 2 | | 3 | 0 | | | 3 | | 0 | | |
| 3 | 1 | | | | | | 7 | 0 | 1 | |
| 6 | 5 | 5 | | | 6 | 6 | | | | 8 |

Table 8-2g: k for TDD configurations 0-6 and UE configured with $\text{symPUSCH-UpPts-r14}$

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|-------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 4 | 5 | | | | 4 | 5 | | | |
| 1 | 6 | 6 | | | 4 | 6 | 6 | | | 4 |
| 2 | | 5 | 4 | | | 5 | | 4 | | |
| 3 | 4 | | | | | | 4 | 4 | 4 | |
| 4 | | | | | | | 4 | 4 | 4 | |
| 5 | | | | | | | 4 | 4 | | |
| 6 | 7 | 7 | | | 7 | 7 | | | | 5 |

Table 8-2h: *I* for TDD configurations 1-5 and UE configured with *symPUSCH-UpPts-r14*

| TDD UL/DL Configuration | subframe number <i>n</i> | | | | | | | | | |
|-------------------------|--------------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 1 | 1 | 0 | | | 0 | 1 | 0 | | | 0 |
| 2 | | 2 | 0 | | | 2 | | 0 | | |
| 3 | 0 | | | | | | 1 | 0 | 0 | |
| 4 | | | | | | | 1 | 0 | 0 | |
| 5 | | | | | | | 1 | 0 | | |

Table 8-2i: *k* for TDD configurations 0-6 and UE configured with *shortProcessingTime*

| TDD UL/DL Configuration | subframe number <i>n</i> | | | | | | | | | |
|-------------------------|--------------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 3 | 3 | | | | 3 | 3 | | | |
| 1 | 3 | | | | 3 | 3 | | | | 3 |
| 2 | | | | | 3 | | | | | 3 |
| 3 | 3 | 3 | | | | | | | | 3 |
| 4 | 3 | | | | | | | | | 3 |
| 5 | | | | | | | | | | 3 |
| 6 | 4 | 6 | | | | 3 | 6 | | | 4 |

Table 8-2j: *k* for TDD configurations 0-6 UE configured with *shortProcessingTime* and with *symPUSCH-UpPts-r14*

| TDD UL/DL Configuration | subframe number <i>n</i> | | | | | | | | | |
|-------------------------|--------------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 3 | 3 | | | | 3 | 3 | | | |
| 1 | 3 | 5 | | | 3 | 3 | 5 | | | 3 |
| 2 | | | | 3 | 3 | | | | 3 | 3 |
| 3 | 3 | 3 | | | | | | | 3 | 3 |
| 4 | 3 | | | | | | | | 3 | 3 |
| 5 | | | | | | | | | 3 | 3 |
| 6 | 3 | 5 | | | 3 | 5 | | | | 3 |

Table 8-2m: *k* for TDD configurations 0-6, special subframe configuration 1,2,3,4,6,7,8 and UE configured with *ul-STTI-Length*

| TDD UL/DL Configuration | slot number <i>n</i> | | | | | | | | | | | | | | | | | | | |
|-------------------------|----------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 0 | 4 | 4 | 4 | 5 | | | | | | | 4 | 4 | 4 | 5 | | | | | | |
| 1 | 4 | 4 | 4 | 4 | | | | | | | 4 | 4 | 4 | 4 | | | | | | |
| 2 | 4 | 4 | | | | | | | | | 4 | 4 | | | | | | | | |
| 3 | 6 | 6 | 6 | 6 | | | | | | | | | | | | | | 6 | 6 | |
| 4 | 4 | 4 | 4 | 4 | | | | | | | | | | | | | | | | |
| 5 | 4 | 4 | | | | | | | | | | | | | | | | | | |
| 6 | 6 | 6 | 6 | 6 | | | | | | | 4 | 4 | 4 | 4 | | | | | 6 | 6 |

Table 8-2n: k for TDD configurations 0-6, special subframe configuration 0,5,9 and UE configured with *ul-STTI-Length*

| TDD UL/DL Configuration | slot number n | | | | | | | | | | | | | | | | | | |
|-------------------------|---------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | 4 | 5 | 6 | | | | | | | 4 | 5 | 6 | | | | | | | |
| 1 | 5 | 5 | 5 | | | | | | 5 | 5 | 5 | 5 | | | | | | | 5 |
| 2 | 4 | 4 | | | | | | | | 4 | 4 | | | | | | | | |
| 3 | 7 | 7 | 7 | | | | | | | | | | | | | | 7 | 7 | 7 |
| 4 | 5 | 5 | 5 | | | | | | | | | | | | | | | | 5 |
| 5 | 4 | 4 | | | | | | | | | | | | | | | | | |
| 6 | 4 | 5 | 6 | | | | | | | 4 | 4 | 4 | | | | | | | |

Table 8-2p: k for TDD configurations 0-6, UE configured with *symPUSCH-UpPts-r14*, and *ul-STTI-Length*

| TDD UL/DL Configuration | slot number n | | | | | | | | | | | | | | | | | | |
|-------------------------|---------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | 4 | 5 | 6 | | | | | | | 4 | 5 | 6 | | | | | | | |
| 1 | 5 | 5 | 5 | | | | | | 5 | 5 | 5 | 5 | | | | | | 5 | 5 |
| 2 | 4 | 4 | | | | | | | 4 | 4 | 4 | | | | | | | | 4 |
| 3 | 7 | 7 | 7 | | | | | | | | | | | | | | 7 | 7 | 7 |
| 4 | 5 | 5 | 5 | | | | | | | | | | | | | | | 5 | 5 |
| 5 | 4 | 4 | | | | | | | | | | | | | | | | | 4 |
| 6 | 4 | 5 | 6 | | | | | | | 4 | 4 | 4 | | | | | | | 4 |

For BL/CE UEs, the higher layers indicate the set of BL/CE UL subframes according to *fdd-DownlinkOrTddSubframeBitmapBR* and *fdd-UplinkSubframeBitmapBR* [11].

A BL/CE UE shall upon detection on a given serving cell of an MPDCCH with DCI format 6-0A/6-0B scheduling PUSCH intended for the UE, perform a corresponding PUSCH transmission in subframe(s) $n+k_i$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] with $i = 0, 1, \dots, N-1$ according to the MPDCCH, where

- subframe n is the last subframe in which the MPDCCH is transmitted; and
- $x \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of $N' \in \{n1, n2, \dots, n_{\max}\}$ is determined by the *repetition number* field in the corresponding DCI, where
 - if the UE is configured with higher layer parameter *ce-pdsch-puschEnhancement-config* with value 'On' $n1, n2, \dots, n_{\max}$ are given by {1,2,4,8,12,16,24,32}
 - otherwise, $n1, n2, \dots, n_{\max}$ are given in Table 8-2b and Table 8-2c; and
 - if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment in the corresponding DCI is using uplink resource allocation type 5,
- $N = \left\lceil \frac{2N'}{M_{\text{slots}}^{\text{UL}} \cdot M_{\text{RU}}} \right\rceil \cdot \frac{M_{\text{slots}}^{\text{UL}}}{2} \cdot M_{\text{RU}}$ where $N \leq 32$ for CE Mode A and $N \leq 2048$ for CE Mode B, $M_{\text{slots}}^{\text{UL}}$ is defined in [3] and M_{RU} is determined according to procedure in subclause 8.1.6, $N = N'$ otherwise
- in case $N > 1$, subframe(s) $n+k_i$ with $i=0, 1, \dots, N-1$ are N consecutive BL/CE UL subframe(s) starting with subframe $n+x$, and in case $N=1$, $k_0=x$;
- for FDD, $x = 4$;
- for TDD UL/DL configurations 1-6, or for TDD UL/DL configuration 0 and a BL/CE UE in CE Mode B, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; If the value x is not given in Table 8-2 for subframe n , denote subframe n' as the first downlink/special subframe which has a

value in Table 8-2 after subframe n , and substitute n with n' in the above procedure for performing the PUSCH transmission.

- for TDD UL/DL configuration 0 and a BL/CE UE in CEModeA, if the MSB of the UL index in the MPDCCH with DCI format 6-0A is set to 1, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; if the LSB of the UL index in the MPDCCH with DCI format 6-0A is set to 1, $x = 7$. The UE is not expected to receive DCI format 6-0A with both the MSB and LSB of the UL index set to 1 when $N > 1$. In case both the MSB and LSB of the UL index are set to 1, the HARQ process number of the PUSCH corresponding the MSB of the UL index is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH corresponding the LSB of the UL index is $(n_{\text{HARQ_ID}} + 1) \bmod 7$, where $n_{\text{HARQ_ID}}$ is determined according to the *HARQ process number* field in DCI format 6-0A
- The higher layer parameter *ttiBundling* is not applicable to BL/CE UEs.
- For a BL/CE UE, in case a PUSCH transmission with a corresponding MPDCCH collides with a PUSCH transmission without a corresponding MPDCCH in a subframe n , the PUSCH transmission without a corresponding MPDCCH is dropped from subframe n .
- For a BL/CE UE, in case of collision between at least one physical resource block to be used for PUSCH transmission and physical resource blocks corresponding to configured PRACH resources for BL/CE UEs or non-BL/CE UEs (defined in [3]) in a same subframe, the PUSCH transmission is dropped in that subframe.
- For a BL/CE UE in half-duplex FDD operation, in case a PUSCH transmission including half-duplex guard subframe without a corresponding MPDCCH collides partially or fully with a PDSCH transmission with a corresponding MPDCCH, the PUSCH transmission without a corresponding MPDCCH is dropped.
- For a BL/CE UE in half-duplex FDD operation and configured with *ce-pdsch-puschEnhancement-config*, in case a PUSCH transmission including half-duplex guard subframe collides partially or fully with a PDSCH transmission without a corresponding MPDCCH, the PUSCH transmission is dropped.

For BL/CE UEs, and for a PUSCH transmission starting in subframe $n+k_0$ without a corresponding MPDCCH, the UE shall adjust the PUSCH transmission in subframe(s) $n+k_i$ with $i = 0, 1, \dots, N-1$, where

- $0 \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of $N' \in \{n_1, n_2, \dots, n_{\max}\}$ is determined by the *repetition number* field in the activation DCI, where $n_1, n_2, \dots, n_{\max}$ are given in Table 8-2b and Table 8-2c; and
- if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment in the activation DCI is using uplink resource allocation type 5, $N = \left\lceil \frac{2N'}{M_{\text{slots}}^{\text{UL}} \cdot M_{\text{RU}}} \right\rceil \cdot \frac{M_{\text{slots}}^{\text{UL}}}{2} \cdot M_{\text{RU}}$ where $M_{\text{slots}}^{\text{UL}}$ is defined in [3] and M_{RU} is determined according to procedure in subclause 8.1.6, $N = N'$ otherwise
- in case $N > 1$, subframe(s) $n+k_i$ with $i=0, 1, \dots, N-1$ are N consecutive BL/CE UL subframe(s), and in case $N=1$, $k_0=0$;

A BL/CE UE configured with *mpdcch-UL-HARQ-ACK-FeedbackConfig* shall upon detection on a given serving cell of an MPDCCH with DCI format 6-0A/6-0B intended for the UE in the UE-specific search space indicating HARQ-ACK corresponding to a transport block associated to a HARQ process in the most recent PUSCH transmission with $N > 1$, drop the remaining PUSCH transmission(s) (if any) corresponding to the transport block no later than subframe $n+k$, where

- subframe n is the last subframe in which the MPDCCH is transmitted; and
- for FDD, $k = 4$;
- for TDD the value of k is given in Table 8-2 for the corresponding TDD UL/DL configuration; If the value of k is not given in Table 8-2 for subframe n , denote subframe n' as the first downlink/special subframe which has a value in Table 8-2 after subframe n , and substitute n with n' in the above procedure;
- value of N' is determined by the *repetition number* field in the corresponding DCI associated with the most recent PUSCH transmission;

- if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment in the corresponding DCI associated with the most recent PUSCH transmission is using uplink resource allocation type 5, $N = \left\lceil \frac{2N'}{M_{\text{slots}}^{\text{UL}} \cdot M_{\text{RU}}} \right\rceil \cdot \frac{M_{\text{slots}}^{\text{UL}}}{2} \cdot M_{\text{RU}}$ where $M_{\text{slots}}^{\text{UL}}$ is defined in [3] and M_{RU} is determined according to procedure in subclause 8.1.6, $N = N'$ otherwise.

For a BL/CE UE configured with *mpdcch-UL-HARQ-ACK-FeedbackConfig*, if the UE detects a first MPDCCH with DCI format 6-0A/6-0B intended for the UE scheduling PUSCH in subframes $\{s_0, \dots, s_{N-1}\}$, and if the UE detects a second MPDCCH with DCI format 6-0A/6-0B intended for the UE scheduling PUSCH in subframes $\{q_0, \dots, q_{L-1}\}$ with $M \leq q_0 \leq s_{N-1}$, where

- the HARQ ID indicated in the second MPDCCH is different from the HARQ ID indicated in the first MPDCCH or the NDI indicated in the second MPDCCH is toggled with respect to the NDI indicated in the first MPDCCH, and
- the first subframe M in which the second MPDCCH is transmitted meets $M \geq s_0 + k$ and
 - for FDD, $k = 4$,
 - for TDD the value of k is given in Table 8-2 for the corresponding TDD UL/DL configuration; If the value of k is not given in Table 8-2 for subframe n , denote subframe n' as the first downlink/special subframe which has a value in Table 8-2 after subframe n , and substitute n with n' in the above procedure

the UE shall

- drop the remaining PUSCH transmission(s) of the transport block scheduled by the first MPDCCH starting from subframe K , where $M < K \leq q_0$, and
- deliver HARQ-ACK feedback corresponding to the transport block scheduled by the first MPDCCH to higher layers, and
- transmit the PUSCH scheduled by the second MPDCCH in subframes $\{q_0, \dots, q_{L-1}\}$

Table 8-2b: PUSCH repetition levels (DCI Format 6-0A)

| Higher layer parameter <i>'pusch-maxNumRepetitionCEmodeA'</i> | $\{n1, n2, n3, n4\}$ |
|--|----------------------|
| Not configured | $\{1, 2, 4, 8\}$ |
| 16 | $\{1, 4, 8, 16\}$ |
| 32 | $\{1, 4, 16, 32\}$ |

Table 8-2c: PUSCH repetition levels (DCI Format 6-0B)

| Higher layer parameter <i>'pusch-maxNumRepetitionCEmodeB'</i> | $\{n1, n2, \dots, n8\}$ |
|--|--|
| Not configured | $\{4, 8, 16, 32, 64, 128, 256, 512\}$ |
| 192 | $\{1, 4, 8, 16, 32, 64, 128, 192\}$ |
| 256 | $\{4, 8, 16, 32, 64, 128, 192, 256\}$ |
| 384 | $\{4, 16, 32, 64, 128, 192, 256, 384\}$ |
| 512 | $\{4, 16, 64, 128, 192, 256, 384, 512\}$ |
| 768 | $\{8, 32, 128, 192, 256, 384, 512, 768\}$ |
| 1024 | $\{4, 8, 16, 64, 128, 256, 512, 1024\}$ |
| 1536 | $\{4, 16, 64, 256, 512, 768, 1024, 1536\}$ |
| 2048 | $\{4, 16, 64, 128, 256, 512, 1024, 2048\}$ |

A UE configured with parameter *pusch-EnhancementsConfig* shall upon detection on a given serving cell of an PDCCHEPDCCH with DCI Format 0C intended for the UE, perform a corresponding PUSCH transmission in subframe(s) $n+k_i$ if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] with $i = 0, 1, \dots, N-1$ according to the PDCCH/EPDCCH, where

- subframe n is the subframe in which the PDCCH/EPDCCH is transmitted; and
- $x \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of N is given by Table 8-2k based on the *repetition number* field in the corresponding DCI Format 0C; and
- in case $N > 1$, subframe(s) $n+k_i$ with $i=0, 1, \dots, N-1$ are N consecutive UL subframe(s) starting with subframe $n+x$, and in case $N=1$, $k_0=x$;
- for FDD, $x = 4$;
- for TDD UL/DL configurations 1-5 or for TDD UL/DL configuration 6 and a UE not configured with higher layer parameter *symPUSCH-UpPts-r14*, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; If the value x is not given in Table 8-2 for subframe n , denote subframe n' as the first downlink/special subframe which has a value in Table 8-2 after subframe n , and substitute n with n' in the above procedure for performing the PUSCH transmission.
- for TDD UL/DL configuration 0, if the MSB of the UL index in the PDCCH with DCI format 0C is set to 1, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; if the LSB of the UL index in the PDCCH with DCI format 0C is set to 1, $x = 7$. The UE is not expected to receive DCI format 0C with both the MSB and LSB of the UL index set to 1 when $N > 1$. In case both the MSB and LSB of the UL index are set to 1, the HARQ process number of the PUSCH corresponding the MSB of the UL index is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH corresponding the LSB of the UL index is $(n_{\text{HARQ_ID}} + 1) \bmod 7$, where $n_{\text{HARQ_ID}}$ is determined according to the *HARQ process number* field in DCI format 0C
- for TDD UL/DL configuration 6 and a UE configured with higher layer parameter *symPUSCH-UpPTS-r14*, if the MSB of the UL index in the PDCCH with DCI format 0C is set to 1, the value of x is given as the value of k in Table 8-2 for the corresponding TDD UL/DL configuration; if the LSB of the UL index in the PDCCH with DCI format 0C is set to 1, $x = 6$. The UE is not expected to receive DCI format 0C with both the MSB and LSB of the UL index set to 1 when $N > 1$. In case both the MSB and LSB of the UL index are set to 1, the HARQ process number of the PUSCH corresponding the MSB of the UL index is $n_{\text{HARQ_ID}}$ and the HARQ process number of the PUSCH corresponding the LSB of the UL index is $(n_{\text{HARQ_ID}} + 1) \bmod 7$, where $n_{\text{HARQ_ID}}$ is determined according to the *HARQ process number* field in DCI format 0C

Table 8-2k: PUSCH repetition levels (DCI Format 0C)

| Repetition Number field in DCI Format 0C | Number of repetitions N |
|--|---------------------------|
| 000 | 1 |
| 001 | 2 |
| 010 | 4 |
| 011 | 8 |
| 100 | 12 |
| 101 | 16 |
| 110 | 24 |
| 111 | 32 |

For a serving cell that is a LAA SCell, a UE shall

- upon detection of an PDCCH/ EPDCCH with DCI format 0A/0B/4A/4B and with 'PUSCH trigger A' field set to '0' in subframe n intended for the UE, or
- upon detection of PDCCH/ EPDCCH with DCI format 0A/0B/4A/4B in subframe $n-p$ with 'PUSCH trigger A' field set to '1' intended for the UE for the serving cell and that has not been triggered by a 'PUSCH trigger B' field set to '1' received prior to subframe n on the serving cell, with $p \geq 1$ and $p \leq v$, and upon detection of PDCCH with DCI CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' in subframe n on the serving cell

perform a corresponding PUSCH transmission, conditioned on the channel access procedures described in subclause 4.2.1 of [13], in subframe(s) $n+l+k+i$ with $i = 0, 1, \dots, N-1$ according to the PDCCH/EPDCCCH and HARQ process ID $\text{mod}(n_{\text{HARQ_ID}} + i, N_{\text{HARQ}})$, where

- $N = 1$ for DCI format 0A/4A, and value of N is determined by the 'number of scheduled subframes' field in the corresponding DCI format 0B/4B.
- The UE is configured the maximum value of N by higher layer parameter *maxNumberOfSchedSubframes-Format0B* for DCI format 0B and higher layer parameter *maxNumberOfSchedSubframes-Format4B* for DCI format 4B;
- value of timing offset k is determined by the 'Timing offset' field in the corresponding DCI 0A/0B/4A/4B according to Table 8-2d if 'PUSCH trigger A' field set to '0' or Table 8-2e otherwise;
- value of $n_{\text{HARQ_ID}}$ is determined by the HARQ process number field in the corresponding DCI format 0A/0B/4A/4B and $N_{\text{HARQ}} = 16$;
- for 'PUSCH trigger A' field set to '0' in the corresponding DCI format 0A/0B/4A/4B,
 - $l = 3$ if the UE is configured with higher layer parameter *shortProcessingTime*, and 4 otherwise
- otherwise
 - value of l is the UL offset as determined by the 'UL duration and offset' field in the corresponding DCI with CRC scrambled by CC-RNTI according to the procedure in Subclause 13A, if 'PUSCH trigger B' field set to '1',
 - value of validation duration v is determined by the 'Timing offset' field in the corresponding PDCCH/EPDCCCH with DCI format 0A/0B/4A/4B according to Table 8-2f
 - the smallest value of $l+k$ supported by the UE is included in the *UE-EUTRA-Capability*
 - the value of $p+l+k$ is at least 3 if the UE is configured with higher layer parameter *shortProcessingTime*, and 4 otherwise.

Table 8-2d: Timing offset k for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '0'.

| Value of 'Timing offset' field | k |
|-----------------------------------|-----|
| 0000 | 0 |
| 0001 | 1 |
| 0010 | 2 |
| 0011 | 3 |
| 0100 | 4 |
| 0101 | 5 |
| 0110 | 6 |
| 0111 | 7 |
| 1000 | 8 |
| 1001 | 9 |
| 1010 | 10 |
| 1011 | 11 |
| 1100 | 12 |
| 1101 | 13 |
| 1110 | 14 |
| 1111 | 15 |

Table 8-2e: Timing offset k for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '1'.

| Value of the first two bits of 'Timing offset' field | k |
|--|-----|
| 00 | 0 |
| 01 | 1 |
| 10 | 2 |
| 11 | 3 |

Table 8-2f: Validation duration ν for DCI format 0A/0B/4A/4B with 'PUSCH trigger A' field set to '1'.

| Value of the last two bits of 'Timing offset' field | ν |
|---|-------|
| 00 | 8 |
| 01 | 12 |
| 10 | 16 |
| 11 | 20 |

For a serving cell that is an LAA SCell, a UE that is configured with autonomous uplink transmissions on the serving cell may perform a corresponding PUSCH transmission in subframe n , if the following conditions are met:

- subframe n is configured as usable for autonomous uplink transmission; and
- the UE has not received a grant according to DCI Format 0A/0B/4A/4B for transmission in subframe n ; and
- autonomous uplink transmissions on the serving cell have been activated and not released according to the procedure described in subclause 9.2A; and
- subframe n is not in the DMTC window of the serving cell; and
- channel access procedures described in subclause 4.2.1 of [13] are followed to obtain channel access on the serving cell for subframe n .
- Additionally, if subframe n is a subframe in which the UE is not required to receive any downlink physical channels and/or physical signals according to clause 13A, then in order to perform a corresponding PUSCH transmission the UE shall have detected a PDCCH with DCI CRC scrambled by CC-RNTI indicating that subframe n is shared with the UE.

For an LAA serving cell where a UE is performing an autonomous uplink transmission in one or more contiguous subframe(s) on all $N_{\text{RB}}^{\text{UL}}$ resource blocks, for the first such subframe the UE randomly determines a timing offset $N_{\text{start}}^{\text{FS3}}$ to be applied for transmission according to [3] from a set of values configured by higher layers according to the following rule:

- If the first such subframe is a subframe in which the UE is not required to receive any downlink physical channels and/or physical signals, the set of values is determined by $30.72 * \text{aul-startingFullBW-insideCOT}$;
- otherwise, the set of values is determined by $30.72 * \text{aul-startingFullBW-outsideCOT}$.
- $N_{\text{start}}^{\text{FS3}}$ is common for all carriers if more than one carrier is activated for autonomous uplink transmission.

For an LAA serving cell where a UE is performing an autonomous uplink transmission in one or more contiguous subframe(s) on fewer than $N_{\text{RB}}^{\text{UL}}$ resource blocks, for the first such subframe the UE determines a timing offset $N_{\text{start}}^{\text{FS3}}$ to be applied for transmission according to [3] according to the following rule:

- If the first such subframe is a subframe in which the UE is not required to receive any downlink physical channels and/or physical signals, $N_{\text{start}}^{\text{FS3}}$ is equal to $30.72 * \text{aul-startingPartialBW-insideCOT}$;
- otherwise, $N_{\text{start}}^{\text{FS3}}$ is equal to $30.72 * \text{aul-startingPartialBW-outsideCOT}$.

For a LAA SCell, a UE is not expected to receive more than one uplink scheduling grant for a subframe.

For a LAA SCell, the HARQ process ID shall be delivered to higher layers.

For a BL/CE UE, the HARQ process ID shall be delivered to higher layers.

If a UE is configured with higher layer parameter *shortTTI* or *shortProcessingTime*, the HARQ process ID shall be delivered to higher layers.

A UE is semi-statically configured via higher layer signalling to transmit PUSCH transmissions signalled via PDCCH/EPDCCH with DCI formats other than 7-0A/7-0B according to one of two uplink transmission modes, denoted mode 1 - 2. If a UE is configured with higher layer parameter *ul-STTI-Length*, the UE is semi-statically configured via higher layer signalling to transmit PUSCH transmissions signalled via PDCCH/SPDCCH with DCI formats 7-0A/7-0B according to one of two uplink transmission modes, denoted mode 1 - 2.

For a LAA SCell, the uplink transmission mode for autonomous uplink transmissions is configured independently from the uplink transmission mode for grant-based uplink transmissions. A UE is not expected to be configured with uplink transmission mode 2 for autonomous transmissions and uplink transmission mode 1 for grant-based uplink transmissions on the same LAA SCell.

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-3 and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these PDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-3A and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured with higher layer parameter *shortTTI* and the UE is configured by higher layers to decode SPDCCH with the CRC scrambled by the C-RNTI, the UE shall decode the SPDCCH according to the combination defined in Table 8-3C and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these SPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE shall decode PDCCH/EPDCCH DCI format 0C in UE specific search space. In this case the UE is not required to decode/monitor DCI format 0 in the UE specific search space.

If a UE is configured with a higher layer parameter *shortTTI*, the UE shall decode PDCCH DCI format 7-0A/7-0B in UE specific search space.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE may assume that PDCCH/EPDCCH for a PUSCH retransmission of a transport block will occur in the UE specific search space if the PDCCH/EPDCCH for the corresponding initial PUSCH transmission for the same transport block was decoded in the UE specific search space.

If a UE is configured with a higher layer parameter *pusch-EnhancementsConfig*, the UE may assume that PDCCH/EPDCCH for a PUSCH retransmission of a transport block will occur in the common search space if the PDCCH/EPDCCH for the corresponding initial PUSCH transmission for the same transport block was decoded in the common search space.

If a UE is configured with higher layer parameter *pusch-EnhancementsConfig*, and the UE decodes a DCI format 0 in the common search space, the UE shall calculate the HARQ ID n_{HARQ} for the corresponding PUSCH transmission in subframe $\left\lfloor \frac{n_s}{2} \right\rfloor$ and radio frame n_f as:

- For a transmission in a normal uplink subframe, $n_{HARQ} = \left(x_{HARQ} \left(\left\lfloor \frac{n_s}{2} \right\rfloor \right) + (x_{MAX} + 1) \times n_f \right) \bmod M_{HARQ}$, where
 - For FDD, $x_{HARQ}(n) = n$, and $x_{max} = 9$
 - For TDD, $x_{HARQ}(n)$ is given by Table 8-2q, and $x_{MAX} = \max\{x_{HARQ}(n)\}$.

- M_{HARQ} is the number of HARQ processes, which is $M_{HARQ} = 8$ for FDD, and given by the “Normal HARQ operation” column in table 8-1, in the case of TDD.
- For a transmission in a special subframe, $n_{HARQ} = M_{HARQ}$ if the transmission happens in the first special subframe of the radio frame, and $n_{HARQ} = M_{HARQ} + 1$ otherwise.

Table 8-2q: x_{HARQ} for TDD

| TDD UL/DL Configuration | subframe number n | | | | | | | | | |
|-------------------------|---------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | | | 0 | 1 | 2 | | | 3 | 4 | 5 |
| 1 | | | 0 | 1 | | | | 2 | 3 | |
| 2 | | | 0 | | | | | 1 | | |
| 3 | | | 0 | 1 | 2 | | | | | |
| 4 | | | 0 | 1 | | | | | | |
| 5 | | | 0 | | | | | | | |
| 6 | | | 0 | 1 | 2 | | | 3 | 4 | |

The UE may for handover purposes, and before acquiring the SFN at the target cell, assume an absolute value of the relative time difference between radio frame i in the current cell and the target cell of less than $153600 \cdot T_s$ when determining n_{HARQ} .

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the MPDCCH according to the combination defined in Table 8-3B and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these MPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

Transmission mode 1 is the default uplink transmission mode for a UE until the UE is assigned an uplink transmission mode by higher layer signalling.

When a UE configured in transmission mode 2 receives a DCI Format 0/0A/0B/0C uplink scheduling grant, it shall assume that the PUSCH transmission is associated with transport block 1 and that transport block 2 is disabled.

Table 8-3: PDCCH and PUSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to PDCCH |
|-------------------|-----------------------------------|----------------------------------|--|
| Mode 1 | DCI format 0 | Common and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 0A or 0B or 0C or 7-0A | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 0 | Common and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 0A or 0B or 0C | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 4 or 4A or 4B or 7-0B | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 8.0.2) |

Table 8-3A: EPDCCH and PUSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to EPDCCH |
|-------------------|--------------------------------|-----------------------|--|
| Mode 1 | DCI format 0 or 0A or 0B or 0C | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 0 or 0A or 0B or 0C | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 4 or 4A or 4B | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 8.0.2) |

Table 8-3B: MPDCCH and PUSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to MPDCCH |
|--------------------------|-------------------------|--|---|
| Mode 1 | DCI format 6-0A or 6-0B | Type0-common (only for 6-0A) and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |

Table 8-3C: SPDCCH and PUSCH configured by C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to SPDCCH |
|--------------------------|-------------------|-----------------------|---|
| Mode 1 | DCI format 7-0A | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 7-0B | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 8.0.2) |

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the PDCCH according to the combination defined in Table 8-4.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the EPDCCH according to the combination defined in Table 8-4A.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the MPDCCH according to the combination defined in Table 8-4B.

Table 8-4: PDCCH configured as "PDCCH order" to initiate random access procedure

| DCI format | Search Space |
|-------------------|----------------------------------|
| DCI format 1A | Common and UE specific by C-RNTI |

Table 8-4A: EPDCCH configured as "PDCCH order" to initiate random access procedure

| DCI format | Search Space |
|-------------------|-----------------------|
| DCI format 1A | UE specific by C-RNTI |

Table 8-4B: MPDCCH configured as "PDCCH order" to initiate random access procedure

| DCI format | Search Space |
|-------------------------|--|
| DCI format 6-1A or 6-1B | Type0-common (only for 6-1A) and UE specific by C-RNTI |

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the SPS C-RNTI or UL-SPS-V-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-5 and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8] except when the UE is configured with higher layer parameter *shortProcessingTime* and with DCI format 0 mapped onto the UE-specific search space.

The scrambling initialization of this PUSCH corresponding to these PDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding PDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the SPS C-RNTI or UL-SPS-V-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-5A and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8].

The scrambling initialization of this PUSCH corresponding to these EPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI. The scrambling initialization of initial transmission of this

PUSCH without a corresponding EPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI or UL-SPS-V-RNTI.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the MPDCCH according to the combination defined in Table 8-5B and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these MPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding MPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

If a UE is configured by higher layers to decode SPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the SPDCCH according to the combination defined in Table 8-5C and transmit the corresponding PUSCH if a transport block corresponding to the HARQ process of the PUSCH transmission is generated as described in [8]. The scrambling initialization of this PUSCH corresponding to these SPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding SPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

Table 8-5: PDCCH and PUSCH configured by SPS C-RNTI or UL-SPS-V-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to PDCCH |
|-------------------|-----------------|----------------------------------|---|
| Mode 1 | DCI format 0 | Common and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 7-0A | UE specific by C-RNTI | |
| Mode 2 | DCI format 0 | Common and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| | DCI format 7-0B | UE specific by C-RNTI | |

Table 8-5A: EPDCCH and PUSCH configured by SPS C-RNTI or UL-SPS-V-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to PDCCH |
|-------------------|--------------|-----------------------|---|
| Mode 1 | DCI format 0 | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 0 | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |

Table 8-5B: MPDCCH and PUSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to PDCCH |
|-------------------|-----------------|--|---|
| Mode 1 | DCI format 6-0A | Type0-common (only for 6-0A) and UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |

Table 8-5C: SPDCCH and PUSCH configured by SPS C-RNTI

| Transmission mode | DCI format | Search Space | Transmission scheme of PUSCH corresponding to SPDCCH |
|-------------------|-----------------|-----------------------|--|
| Mode 1 | DCI format 7-0A | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 7-0B | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-6 and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these PDCCH is by Temporary C-RNTI.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode MPDCCHs with the CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH according to the combination defined in

Table 8-6A and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these MPDCCH is by Temporary C-RNTI.

If a Temporary C-RNTI is set by higher layers, the scrambling of PUSCH corresponding to the Random Access Response Grant in Subclause 6.2 and the PUSCH retransmission for the same transport block is by Temporary C-RNTI. Else, the scrambling of PUSCH corresponding to the Random Access Response Grant in Subclause 6.2 and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is also configured by higher layers to decode MPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the MPDCCH according to the combination defined in Table 8-6A and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these MPDCCH is by C-RNTI.

Table 8-6: PDCCH configured by Temporary C-RNTI

| DCI format | Search Space |
|--------------|--------------|
| DCI format 0 | Common |

Table 8-6A: MPDCCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure

| DCI format | Search Space |
|-----------------------|--------------|
| DCI format 6-0A, 6-0B | Type2-Common |

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8-7. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 8-7A. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-7: PDCCH configured by TPC-PUCCH-RNTI

| DCI format | Search Space |
|-----------------|--------------|
| DCI format 3/3A | Common |

Table 8-7A: MPDCCH configured by TPC-PUCCH-RNTI

| DCI format | Search Space |
|-----------------|---------------------------------|
| DCI format 3/3A | Type0-Common (for CEModeA only) |

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8.8. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

If a UE is configured by higher layers to decode MPDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the MPDCCH according to the combination defined in table 8.8A. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-8: PDCCH configured by TPC-PUSCH-RNTI

| DCI format | Search Space |
|-----------------|--------------|
| DCI format 3/3A | Common |

Table 8-8A: MPDCCH configured by TPC-PUSCH-RNTI

| DCI format | Search Space |
|-----------------|---------------------------------|
| DCI format 3/3A | Type0-Common (for CEModeA only) |

If the UE is configured by higher layers to decode PDCCHs with the CRC scrambled by higher layer parameter *srs-TPC-RNTI-r14*, the UE shall decode the PDCCH according to the combination defined in Table 8-8B.

Table 8-8B: PDCCH configured by higher layer parameter *srs-TPC-RNTI-r14*

| DCI format | Search Space |
|---------------|--------------|
| DCI format 3B | Common |

If a UE is configured by higher layers to decode PDCCHs/EPDCCHs with the CRC scrambled by the AUL C-RNTI, the UE shall decode the PDCCH/EPDCCH according to the combination defined in Table 8-9.

Table 8-9: PDCCH/EPDCCH configured by AUL C-RNTI

| Autonomous uplink Transmission mode | DCI format | Search Space | Transmission scheme of corresponding autonomous PUSCH |
|-------------------------------------|---------------|-----------------------|--|
| Mode 1 | DCI format 0A | UE specific by C-RNTI | Single-antenna port, port 10 (see Subclause 8.0.1) |
| Mode 2 | DCI format 4A | UE specific by C-RNTI | Closed-loop spatial multiplexing (see Subclause 8.0.2) |

8.0.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 10) of the PUSCH, the UE transmission on the PUSCH is performed according to Subclause 5.3.2A.1 of [3].

8.0.2 Closed-loop spatial multiplexing scheme

For the closed-loop spatial multiplexing transmission scheme of the PUSCH, the UE transmission on the PUSCH is performed according to the applicable number of transmission layers as defined in Subclause 5.3.2A.2 of [3].

8.1 Resource allocation for PDCCH/EPDCCH/SPDCCH with uplink DCI format

Two resource allocation schemes Type 0 and Type 1 are supported for PDCCH/EPDCCH with uplink DCI format 0/4.

Resource allocation scheme Type 0 or Type 2 or Type 4 or Type 5 are supported for MPDCCH with uplink DCI format.

Resource allocation scheme Type 0 is supported for PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B.

Resource allocation scheme Type 3 is supported for a LAA SCell and PDCCH/EPDCCH with uplink DCI format 0A/0B/4A/4B.

If the resource allocation type bit is not present in the uplink DCI format, only resource allocation type 0 is supported.

If the resource allocation type bit is present in the uplink DCI format, the selected resource allocation type for a decoded PDCCH/EPDCCH is indicated by a resource allocation type bit where type 0 is indicated by 0 value and type 1 is indicated otherwise. The UE shall interpret the resource allocation field depending on the resource allocation type bit in the PDCCH/EPDCCH with uplink DCI format detected.

8.1.1 Uplink resource allocation type 0

The resource allocation information for uplink resource allocation type 0 indicates to a scheduled UE a set of contiguously allocated virtual resource block indices denoted by n_{VRB} . A resource allocation field in the scheduling grant consists of a resource indication value (*RIV*) corresponding to a starting resource block (RB_{START}) and a length in terms of contiguously allocated resource blocks ($L_{\text{CRBs}} \geq 1$).

For a BL/CE UE,

- uplink resource allocation type 0 is only applicable for UE configured with CEModeA, and
- $2 \leq L_{\text{CRBs}} \leq 6$, if the UE in TDD is configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*; otherwise $L_{\text{CRBs}} \leq 6$ and,
- if the UE is configured with higher layer parameters *ce-PUSCH-FlexibleStartPRB-AllocConfig*, L_{CRBs} shall not exceed $N_{\text{RB}}^{\text{UL}} - RB_{\text{START}} - l_e$ with $RB_{\text{START}} = \{l_e, \dots, (N_{\text{RB}}^{\text{UL}} - l_e - 1)\}$, where $l_e = \left\lfloor \frac{N_{\text{RB}}^{\text{UL}}}{2} \right\rfloor - \frac{6N_{\text{NB}}^{\text{UL}}}{2}$ is the number of edge RB(s) not belonging to any narrowband in one side of system bandwidth $N_{\text{RB}}^{\text{UL}}$, and $N_{\text{NB}}^{\text{UL}}$ is the number of narrowbands. PUSCH resource allocations shall not contain PRB(s) not belonging to any narrowband unless it is the center PRB in the uplink system bandwidth, and,
- if the UE is not configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*, $N_{\text{RB}}^{\text{UL}}$ is always set to 6 in this subclause regardless of the system bandwidth.

For PDCCH/SPDCCH DCI format 7-0A/7-0B and $N_{\text{RB}}^{\text{UL}} > 15$, VRB allocations for a UE vary from 4 VRB(s) up to $\lfloor N_{\text{RB}}^{\text{UL}} / 4 \rfloor \times 4$ VRBs with an increment step of 4 VRBs. A type 0 resource block assignment field consists of a resource indication value (*RIV*) corresponding to a starting resource block $RB_{\text{START}} = RB'_{\text{START}} \cdot 4 + \text{Offset}_{\text{START}}$ using $RB'_{\text{START}} = 0, 1, 2, \dots, (\lfloor N_{\text{RB}}^{\text{UL}} / 4 \rfloor - 1)$ and a length in terms of virtually contiguously allocated resource blocks ($L_{\text{CRBs}} = 4, 8, \dots, \lfloor N_{\text{RB}}^{\text{UL}} / 4 \rfloor \cdot 4$), where $\text{Offset}_{\text{START}}$ is defined if configured by higher layer parameter *resourceAllocationOffset*; otherwise set to 0. The resource indication value is defined by:

if $(L'_{\text{CRBs}} - 1) \leq \lfloor N'_{\text{RB}}^{\text{UL}} / 2 \rfloor$ then

$$RIV = N'_{\text{RB}}^{\text{UL}} (L'_{\text{CRBs}} - 1) + RB'_{\text{START}}$$

else

$$RIV = N_{RB}^{\prime UL} (N_{RB}^{\prime UL} - L'_{CRBs} + 1) + (N_{RB}^{\prime UL} - 1 - RB'_{START})$$

where $L'_{CRBs} = L_{CRBs} / 4$, and $N_{RB}^{\prime UL} = \lfloor N_{RB}^{UL} / 4 \rfloor$, and where,

$$L'_{CRBs} \geq 1 \text{ and shall not exceed } N_{RB}^{\prime UL} - RB'_{START}.$$

Otherwise, the resource indication value is defined by

if $(L_{CRBs} - 1) \leq \lfloor N_{RB}^{UL} / 2 \rfloor$ then

if a BL/CE UE in TDD is configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*,
then

$$RIV = N_{RB}^{UL} (L_{CRBs} - 2) + RB_{START}$$

else

$$RIV = N_{RB}^{UL} (L_{CRBs} - 1) + RB_{START}$$

else

$$RIV = N_{RB}^{UL} (N_{RB}^{UL} - L_{CRBs} + 1) + (N_{RB}^{UL} - 1 - RB_{START})$$

8.1.2 Uplink resource allocation type 1

The resource allocation information for uplink resource allocation type 1 indicates to a scheduled UE two sets of resource blocks with each set including one or more consecutive resource block groups of size P as given in table

7.1.6.1-1 assuming N_{RB}^{UL} as the system bandwidth. A combinatorial index r consists of $\left\lceil \log_2 \left(\binom{\lceil N_{RB}^{UL} / P + 1 \rceil}{4} \right) \right\rceil$ bits.

The bits from the resource allocation field in the scheduling grant represent r unless the number of bits in the resource allocation field in the scheduling grant is

- smaller than required to fully represent r , in which case the bits in the resource allocation field in the scheduling grant occupy the LSBs of r and the value of the remaining bits of r shall be assumed to be 0; or
- larger than required to fully represent r , in which case r occupies the LSBs of the resource allocation field in the scheduling grant.

The combinatorial index r corresponds to a starting and ending RBG index of resource block set 1, s_0 and $s_1 - 1$, and resource block set 2, s_2 and $s_3 - 1$ respectively, where r is given by equation $r = \sum_{i=0}^{M-1} \binom{N - s_i}{M - i}$ defined in Subclause 7.2.1 with $M=4$ and $N = \lceil N_{RB}^{UL} / P \rceil + 1$. Subclause 7.2.1 also defines ordering properties and range of values that s_i (RBG indices) map to. Only a single RBG is allocated for a set at the starting RBG index if the corresponding ending RBG index equals the starting RBG index.

8.1.3 Uplink resource allocation type 2

Uplink resource allocation type 2 is only applicable for BL/CE UE configured with CEModeB. The resource allocation information for uplink resource allocation type 2 indicates to a scheduled UE a set of contiguously allocated resource blocks within a narrowband as given in Table 8.1.3-1. If the UE is not configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocOffset*, $n_{RB} = 0$ else value of n_{RB} is given by the higher layer parameter, *offsetCeModeB*.

If the UE is configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocOffset* and the value of the resource allocation field is '110' or '111', the allocated resource blocks with indices less than 0 and greater than 5 correspond to resource-blocks outside the allocated narrowband relative to resource block 0. The physical resource-block numbers are $\{\max(l_e, n_{RB} + n_{NB,0} + 2i), \min(N_{RB}^{UL} - l_e - 1, n_{RB} + n_{NB,0} + 2i)\}$ with $i = 0$ or $i = 1$ for the resource allocation field of '110' or '111', respectively, where $l_e = \left\lfloor \frac{N_{RB}^{UL}}{2} \right\rfloor - \frac{6n_{NB}^{UL}}{2}$ is the number of edge RB(s) not belonging to any narrowband in one side of system bandwidth N_{RB}^{UL} , and n_{NB}^{UL} is the number of narrowbands, and $n_{NB,0}$ is the smallest physical resource-block number of the narrowband as defined in Subclause 6.2.7 of [3]. PUSCH resource allocations shall not contain PRB(s) not belonging to any narrowband unless it is the center PRB in the uplink system bandwidth.

Table 8.1.3-1: Resource block(s) allocation for BL/CE UE configured with CEModeB.

| Value of resource allocation field | Allocated resource blocks |
|------------------------------------|-------------------------------|
| '000' | 0 |
| '001' | 1 |
| '010' | 2 |
| '011' | 3 |
| '100' | 4 |
| '101' | 5 |
| '110' | n_{RB} and $n_{RB} + 1$ |
| '111' | $n_{RB} + 2$ and $n_{RB} + 3$ |

8.1.4 Uplink resource allocation type 3

Uplink resource allocation type 3 is only applicable for a LAA SCell. The resource allocation information for uplink resource allocation type 3 indicates to a scheduled UE a set of allocated resource blocks, $RB_{START} + l + i \cdot N$ where, $N = \left\lfloor N_{RB}^{UL} / 10 \right\rfloor$, $i = 0, 1, \dots, 9$.

For $N_{RB}^{UL} = 100$, a resource allocation field in the scheduling grant consists of a resource indication value (*RIV*). For $N_{RB}^{UL} = 100$ and $0 \leq RIV < N(N+1)/2$, $l = 0, 1, \dots, L-1$ and the resource indication value corresponds to the starting resource block (RB_{START}) and the value of L ($L \geq 1$). The resource indication value is defined by,

if $(L-1) \leq \lfloor N/2 \rfloor$ then

$$RIV = N(L-1) + RB_{START}$$

else

$$RIV = N(N-L+1) + (N-1-RB_{START})$$

For $N_{RB}^{UL} = 100$ and $RIV \geq N(N+1)/2$, the resource indication value corresponds to the starting resource block (RB_{START}) and the set of values l according to Table 8.1.4-1.

Table 8.1.4-1: RB_{START} and l for $RIV \geq N(N+1)/2$.

| $RIV - N(N+1)/2$ | RB_{START} | l |
|------------------|---------------------|--------------------------|
| 0 | 0 | {0, 5} |
| 1 | 0 | {0, 1, 5, 6} |
| 2 | 1 | {0, 5} |
| 3 | 1 | {0, 1, 2, 3, 5, 6, 7, 8} |
| 4 | 2 | {0, 5} |
| 5 | 2 | {0, 1, 2, 5, 6, 7} |
| 6 | 3 | {0, 5} |
| 7 | 4 | {0, 5} |

For $N_{\text{RB}}^{\text{UL}} = 50$, the resource allocation field indicates a bitmap of the allocated values of l where $l = 0, 1, 2, 3, 4$. The order of set of resource blocks to bitmap bit mapping is in such way that $l = 0$ to $l = 4$ are mapped to MSB to LSB of the bitmap respectively. The set of resource blocks is allocated to the UE if the corresponding bit value in the bitmap is 1, and the set of resource blocks are not allocated otherwise.

8.1.5 Uplink resource allocation type 4

Uplink resource allocation type 4 is only applicable for BL/CE UEs configured with CEModeA and configured with higher layer parameter *ce-pusch-maxBandwidth-config* with value 5MHz. The resource allocation information for uplink resource allocation type 4 indicates to a scheduled UE a set of contiguously allocated resource blocks as follows.

- the set of contiguously allocated resource blocks are indicated using resource block groups where each resource block group is a set of $P = 3$ consecutive resource blocks and resource block group indices are determined as described sub clause 8.1.5.1 where $N_{\text{RBG}}^{\text{UL}} = \left\lfloor \frac{N_{\text{RB}}^{\text{UL}}}{P} \right\rfloor$ and $N_{\text{RB}}^{\text{UL}} = 6 \cdot \left\lfloor \frac{N_{\text{RB}}^{\text{UL}}}{6} \right\rfloor$.
- the resource allocation field in the scheduling grant consists of a resource block group indication value (RBGIV') corresponding to a starting resource block group index ($\text{RBG}_{\text{start}}$) and a length in terms of contiguously allocated resource block groups ($L_{\text{CRBGs}} > 2$). The resource block group indication value is determined from RBGIV' by $\text{RBGIV}' = \lfloor \text{RBGIV}'/11 \rfloor \cdot 32 + \text{RBGIV}' \bmod 11 + 21$ and RBGIV' is defined by

$$\text{if } (L_{\text{CRBGs}} - 1) \leq (M / 2)$$

$$\text{RBGIV}' = (2N_{\text{RBG}}^{\text{UL}} - K)(L_{\text{CRBGs}} - 3) + \text{RBG}_{\text{start}}$$

Else

$$\text{RBGIV}' = (2N_{\text{RBG}}^{\text{UL}} - K)(M - L_{\text{CRBGs}} + 1) - \text{RBG}_{\text{start}} - 1$$

where, for $N_{\text{RB}}^{\text{UL}} > 15$, $K = 9$, $M = 8$, and for $N_{\text{RB}}^{\text{UL}} = 15$, $K = 5$, $M = 4$.

- For odd $N_{\text{RB}}^{\text{UL}}$, if the resource allocation computed using the RBGIV' includes PRBs on both sides of the centre PRB, the resource allocation is updated by removing the PRB with the largest PRB index and including the centre PRB.

8.1.5.1 UL Resource Block Groups

The uplink resource block groups of size P are numbered $n_{\text{RBG}} = 0, \dots, N_{\text{RBG}}^{\text{UL}} - 1$ in order of increasing physical resource-block number where uplink resource block group n_{RBG} is composed of physical resource-block indices

$$\begin{cases} P \cdot n_{\text{RBG}} + i_0 + i & \text{if } N_{\text{RB}}^{\text{UL}} \bmod 2 = 0 \\ P \cdot n_{\text{RBG}} + i_0 + i & \text{if } N_{\text{RB}}^{\text{UL}} \bmod 2 = 1 \text{ and } n_{\text{RBG}} < N_{\text{RBG}}^{\text{UL}} / 2 \\ P \cdot n_{\text{RBG}} + i_0 + i + 1 & \text{if } N_{\text{RB}}^{\text{UL}} \bmod 2 = 1 \text{ and } n_{\text{RBG}} \geq N_{\text{RBG}}^{\text{UL}} / 2 \end{cases}$$

where

$$i = 0, 1, \dots, P - 1$$

$$i_0 = \left\lfloor \frac{N_{\text{RB}}^{\text{UL}}}{2} \right\rfloor - \frac{6 \cdot \lfloor N_{\text{RB}}^{\text{UL}} / 6 \rfloor}{2}$$

8.1.6 Uplink resource allocation type 5

Uplink resource allocation type 5 is only applicable for BL/CE UEs configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*.

The resource allocation information for uplink resource allocation type 5 indicates to a scheduled UE

- a set of contiguously allocated subcarriers within an allocated resource block of a narrowband,
- a number of resource units (M_{RU}) determined by the 'number of resource units' field in the corresponding DCI according to Table 8.1.6-2 for UE configured with CEModeA, and Table 8.1.6-3 for UE configured with CEModeB.

For a UE configured with CEModeA and the value of the 'number of resource units' field in the scheduling grant set to

other than '00', the allocated resource block within a narrowband is given by $\left\lfloor \frac{n_{\text{RA}}^{\text{UL}}}{10} \right\rfloor$ where $n_{\text{RA}}^{\text{UL}}$ is the value of the

'resource allocation' field in the scheduling grant, and the allocated subcarriers within the allocated resource block is given in Table 8.1.6-1. For PUSCH sub-PRB allocation in CE Mode A, the UE shall consider the DCI valid even if the number of transmitted subframes is greater than *pusch-maxNumRepetitionCEmodeA*.

For a UE configured with CEModeB and the value of the 'sub-PRB allocation flag' field in the scheduling grant set to '1', the allocated resource block within a narrowband is given by the higher layer parameter *locationCE-ModeB*, and the allocated subcarriers within the allocated resource block is given in Table 8.1.6-1.

In Table 8.1.6-1, $N_{\text{ID}}^{\text{cell}}$ is the physical-layer cell identity as given in subclause 6.11 of [3].

Table 8.1.6-1: Subcarriers allocation for BL/CE UE.

| $n_{\text{RA}}^{\text{UL}} \bmod 10$ $n_{\text{RA}}^{\text{UL}} = \text{value of resource allocation field}$ | Modulation | Set of Allocated subcarriers |
|---|---------------------|---|
| 0 | $\pi/2\text{-BPSK}$ | $N_{\text{ID}}^{\text{cell}} \bmod 2 + (0, 1)$ |
| 1 | $\pi/2\text{-BPSK}$ | $N_{\text{ID}}^{\text{cell}} \bmod 2 + (3, 4)$ |
| 2 | $\pi/2\text{-BPSK}$ | $N_{\text{ID}}^{\text{cell}} \bmod 2 + (6, 7)$ |
| 3 | $\pi/2\text{-BPSK}$ | $N_{\text{ID}}^{\text{cell}} \bmod 2 + (9, 10)$ |
| 4 | QPSK | 0, 1, 2 |
| 5 | QPSK | 3, 4, 5 |
| 6 | QPSK | 6, 7, 8 |
| 7 | QPSK | 9, 10, 11 |
| 8 | QPSK | 0, 1, 2, 3, 4, 5 |
| 9 | QPSK | 6, 7, 8, 9, 10, 11 |

Table 8.1.6-2: Number of resource units for CEModeA.

| Value of 'number of resource units' field | Number of resource units M_{RU} |
|---|--------------------------------------|
| '01' | 1 |
| '10' | 2 |
| '11' | 4 |

Table 8.1.6-3: Number of resource units for CEModeB.

| Value of 'number of resource units' field | Number of resource units M_{RU} |
|---|--------------------------------------|
| '0' | 2 |
| '1' | 4 |

8.2 UE sounding procedure

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

- When the procedures are applied for the primary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', and 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell or serving cells belonging to the primary PUCCH group respectively unless stated otherwise.
- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell' and 'serving cells' in this clause refer to secondary cell, secondary cells (not including the PUCCH-SCell), serving cell, serving cells belonging to the secondary PUCCH group respectively unless stated otherwise. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

A UE shall transmit Sounding Reference Symbol (SRS) on per serving cell SRS resources based on two trigger types:

- trigger type 0: higher layer signalling
- trigger type 1: DCI formats 0/0A/0B/4/4A/4B/1A/6-0A/6-1A for FDD, TDD, and frame structure type 3 and DCI formats 2B/2C/2D/3B for TDD, and frame structure type 3, and DCI format 7-0A/7-0B/7-1E/7-1F/7-1G for TDD if the UE is configured by higher layers for SRS triggering via DCI format 7-0A and has indicated the capability *srs-DCI7-Triggering-FS2-r15* and the UE is configured for SRS triggering with *srs-DCI7-TriggeringConfig-r15*.

A UE is not expected to be configured with SRS trigger type 0 on a LAA SCell.

In case both trigger type 0 and trigger type 1 SRS transmissions would occur in the same subframe in the same serving cell, the UE shall only transmit the trigger type 1 SRS transmission. This prioritization rule shall be applied before other prioritization rules defined in this subclause.

If higher layer parameter *specialSubframePatterns-v1430* indicates *ssp10*, or if higher layer parameter *specialSubframePatterns-v1450* indicates *ssp10-CRS-LessDwPTS*, the UE shall assume for the purpose of determining k_{SRS} that the special subframe configuration is that signalled by *specialSubframePatterns* (without suffix).

A UE may be configured with SRS parameters for trigger type 0 and trigger type 1 on each serving cell. A BL/CE UE configured with CEModeB is not expected to be configured with SRS parameters for trigger type 0 and trigger type 1. The following SRS parameters are serving cell specific and semi-statically configurable by higher layers for trigger type 0 and for trigger type 1.

- Number of combs K_{TC} as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1, if configured
- *srs-UpPtsAdd*: two or four additional SC-FDMA symbols in UpPTS as defined in [11] for trigger type 0 and trigger type 1, if configured
- Transmission comb \bar{k}_{TC} , as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Starting physical resource block assignment n_{RRC} , as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1 for a serving cell that is not a LAA SCell. For a serving cell that is a LAA SCell, $n_{RRC} = 0$.
- *duration*: single or indefinite (until disabled), as defined in [11] for trigger type 0
- *srs-ConfigIndex* I_{SRS} for SRS periodicity T_{SRS} and SRS subframe offset T_{offset} , as defined in Table 8.2-1 and Table 8.2-2 for trigger type 0 and SRS periodicity $T_{SRS,1}$ and SRS subframe offset $T_{offset,1}$, as defined in Table 8.2-4 and Table 8.2-5 trigger type 1 for a serving cell that is not a LAA SCell
- SRS bandwidth B_{SRS} , as defined in Subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1 for a serving cell that is not a LAA SCell. For a serving cell that is a LAA SCell, $B_{SRS} = 0$.

- Frequency hopping bandwidth, b_{hop} , as defined in Subclause 5.5.3.2 of [3] for trigger type 0
- Cyclic shift n_{SRS}^{cs} , as defined in Subclause 5.5.3.1 of [3] for trigger type 0 and each configuration of trigger type 1
- Number of antenna ports N_p for trigger type 0 and each configuration of trigger type 1
- SRS subframe for each configuration of trigger type 1 for a serving cell that is a LAA SCell and DCI format 4B

For a TDD serving cell,

- If the serving cell not configured for PUSCH/PUCCH transmission, or if the UE supports *ce-srsEnhancement-r14*
 - For trigger type 0, the UE can be configured with more than one configuration of *SoundingRS-UL-ConfigDedicatedUpPTsExt* and/or *SoundingRS-UL-ConfigDedicated*, and the SRS parameters in each of the configurations shall be used. The UE is not expected to receive more than one SRS configuration indicating SRS transmission on multiple symbols in different subframes within a half frame.
 - For trigger type 1, the UE can be configured with more than one configuration of *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* and/or *SoundingRS-UL-ConfigDedicatedAperiodic*, and the SRS parameters in each of the configurations shall be used. The UE is not expected to receive more than one SRS configuration indicating SRS transmission on multiple symbols in different subframes within a half frame.
- Otherwise
 - For trigger type 0, if *SoundingRS-UL-ConfigDedicatedUpPTsExt* is configured, the SRS parameters in *SoundingRS-UL-ConfigDedicatedUpPTsExt* shall be used; otherwise, *SoundingRS-UL-ConfigDedicated* shall be used.
 - For trigger type 1, if *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* is configured, the SRS parameters in *SoundingRS-UL-ConfigDedicatedAperiodicUpPTsExt* shall be used; otherwise, *SoundingRS-UL-ConfigDedicatedAperiodic* shall be used.

For trigger type 1 and DCI format 4/4A/4B/7-0B three sets of SRS parameters, *srs-ConfigApDCI-Format4*, are configured by higher layer signalling. The 2-bit SRS request field [4] in DCI format 4/4A/4B/7-0B indicates the SRS parameter set given in Table 8.1-1. For trigger type 1 and DCI format 0/0A/0B /6-0A/7-0A, a single set of SRS parameters, *srs-ConfigApDCI-Format0*, is configured by higher layer signalling. For trigger type 1 and DCI formats 1A/2B/2C/2D/6-1A/7-1E/7-1F/7-1G, a single common set of SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, is configured by higher layer signalling. For a serving cell that is not a LAA SCell, the SRS request field is 1 bit [4] for DCI formats 0/1A/2B/2C/2D/6-0A/6-1A/7-0A/7-1E/7-1F/7-1G, with a type 1 SRS triggered if the value of the SRS request field is set to '1'. For a serving cell that is a LAA SCell, the SRS timing offset field is 3 bits [4] for DCI formats 1A/2B/2C/2D, with a type 1 SRS triggered if the value of the SRS timing offset field is not set to '000'. The SRS request field is 1 bit [4] for DCI formats 0A, with a type 1 SRS triggered if the value of the SRS request field is set to '1'. The 2-bit SRS request field [4] in DCI format 0B indicates the type 1 SRS triggering and PUSCH subframe (as determined in Subclause 8.0) with SRS as given in Table 8.2-0A.

For a serving cell that is not a LAA SCell, a 1-bit SRS request field shall be included in DCI formats 0/1A for frame structure type 1 and 0/1A/2B/2C/2D for frame structure type 2 if the UE is configured with SRS parameters for DCI formats 0/1A/2B/2C/2D by higher-layer signalling. A 1-bit SRS request field shall be included in DCI format 7-0A for frame structure type 2 if the UE is configured with SRS parameters *srs-ConfigApDCI-Format0* and *srs-DCI7-TriggeringConfig-r15* by higher-layer signalling. A 1-bit SRS request field shall be included in DCI formats 7-1E/7-1F/7-1G for frame structure type 2 if the UE is configured with SRS parameters *srs-ConfigApDCI-Format1a2b2c* and *srs-DCI7-TriggeringConfig-r15* by higher-layer signalling. A 1-bit SRS request field shall be included in DCI formats 6-0A/6-1A, the value of which is reserved if the UE is not configured with SRS parameters for DCI formats 6-0A/6-1A by higher layer signalling.

For a TDD serving cell not configured for PUSCH/PUCCH transmission, and trigger type 1, a SRS request field [4] shall be included in DCI format 3B if the value of the higher layer parameter *fieldTypeFormat3B* is set to 3 or 4. If the UE is configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, a single SRS request field is included in DCI format 3B for a set of the TDD serving cells without PUSCH/PUCCH transmission as given in Table 8.2-0C; otherwise one or more SRS request fields is included in DCI format 3B each corresponding to a TDD serving cell without PUSCH/PUCCH transmission as configured by higher layers. If the UE is configured with no more than 5

TDD serving cells without PUSCH/PUCCH transmission, and the UE is not configured with *srs-ConfigApDCI-Format4*, the SRS request field [4] in DCI format 3B is 1-bit, 2-bits otherwise. For the 1-bit SRS request field [4] in DCI format 3B, a type 1 SRS is triggered if the value of the SRS request field is set to '1' with SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, configured by higher layer signalling. For the 2-bit SRS request field [4] in DCI format 3B, and UE configured with no more than 5 TDD serving cells without PUSCH/PUCCH transmission, the SRS request field indicates the SRS parameter set given in Table 8.1-1 with the three sets of SRS parameters, *srs-ConfigApDCI-Format4*, configured by higher layer signalling. For the 2-bit SRS request field [4] in Table 8.2-0C and DCI format 3B, and UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, configured by higher layer signalling for the associated serving cell, is used if a type 1 SRS is triggered. For the 2-bit SRS request field [4] in Table 8.2-0C and DCI format 3B, and UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, if the UE receives an SRS request field with value '00', the DCI does not indicate a type 1 SRS trigger, but the UE shall apply the power control commands received in the DCI format 3B according to Clause 5.1.3.1.

Table 8.1-1: SRS request value for trigger type 1 in DCI format 4/4A/4B/7-0B

| Value of SRS request field | Description |
|----------------------------|---|
| '00' | No type 1 SRS trigger |
| '01' | The 1 st SRS parameter set configured by higher layers |
| '10' | The 2 nd SRS parameter set configured by higher layers |
| '11' | The 3 rd SRS parameter set configured by higher layers |

Table 8.2-0A: SRS request value for trigger type 1 in DCI format 0B

| Value of SRS request field | Description |
|----------------------------|--|
| '00' | No type 1 SRS trigger |
| '01' | Type 1 SRS trigger and first scheduled PUSCH subframe |
| '10' | Type 1 SRS trigger and second scheduled PUSCH subframe |
| '11' | Type 1 SRS trigger and last scheduled PUSCH subframe |

Table 8.2-0C: SRS request value for trigger type 1 in DCI format 3B and for UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission

| Value of SRS request field | Description |
|----------------------------|--|
| '00' | No type 1 SRS trigger for a 1 st set of serving cells configured by higher layers |
| '01' | Type 1 SRS trigger for a 2 nd set of serving cells configured by higher layers |
| '10' | Type 1 SRS trigger for a 3 rd set of serving cells configured by higher layers |
| '11' | Type 1 SRS trigger for a 4 th set of serving cells configured by higher layers |

For a serving cell that is not a LAA SCell, the serving cell specific SRS transmission bandwidths C_{SRS} are configured by higher layers. The allowable values are given in Subclause 5.5.3.2 of [3].

For a serving cell that is not a LAA SCell, the serving cell specific SRS transmission sub-frames are configured by higher layers. The allowable values are given in Subclause 5.5.3.3 of [3].

For a TDD serving cell, SRS transmissions can occur in UpPTS and uplink subframes of the UL/DL configuration indicated by the higher layer parameter *subframeAssignment* for the serving cell.

When closed-loop or open-loop UE transmit antenna selection is enabled for a given serving cell for a UE that supports transmit antenna selection, or for a UE that can be configured with *ue-TxAntennaSelection-SRS-1T4R-Config* or *ue-TxAntennaSelection-SRS-2T4R-NrOfPairs*,

- when higher layer parameter '*ue-TxAntennaSelection-SRS-1T4R-Config*' is configured for a given serving cell, the index $a(n_{SRS})$, of the UE antenna that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod 4$, for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} \left(n_{SRS} + \left\lfloor \frac{n_{SRS}}{\max(4, K)} \right\rfloor + \beta \left(\left\lfloor \frac{n_{SRS}}{4} \right\rfloor \bmod \left\lfloor \frac{\max(4, K)}{4} \right\rfloor \right) \right) \bmod 4, & \text{when } K \text{ is even} \\ n_{SRS} \bmod 4, & \text{otherwise} \end{cases}$$

with $\beta = \begin{cases} 1, & \text{if } N_1 = 2, N_2 = 2 \\ 0, & \text{otherwise} \end{cases}$, when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$).

- when higher layer parameter '*ue-TxAntennaSelection-SRS-2T4R-NrOfPairs*' is configured for a given serving cell for a UE configured with Λ UE antenna pairs, where $\Lambda = \{2 \text{ or } 3\}$ is given by higher layer parameter '*ue-TxAntennaSelection-SRS-2T4R-NrOfPairs*', the index $a(n_{SRS})$ for the UE antenna pair as $\{2a(n_{SRS}), 2a(n_{SRS}) + 1\}$ when $\Lambda = 2$, or $\{0, a(n_{SRS}) + 1\}$ when $\Lambda = 3$ that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod \Lambda$ for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} \left(n_{SRS} + \left\lfloor \frac{n_{SRS}}{\Lambda} \right\rfloor + \beta \left(\left\lfloor \frac{n_{SRS}}{K} \right\rfloor \right) \right) \bmod \Lambda, & \text{when } K \bmod \Lambda = 0 \\ n_{SRS} \bmod \Lambda, & \text{otherwise} \end{cases}$$

with $\beta = \begin{cases} 1, & \text{if } K \bmod \Lambda^2 = 0 \\ 0, & \text{otherwise} \end{cases}$, when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$).

- otherwise, the index $a(n_{SRS})$, of the UE antenna that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod 2$, for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} \left(n_{SRS} + \left\lfloor \frac{n_{SRS}}{2} \right\rfloor + \beta \cdot \left\lfloor \frac{n_{SRS}}{K} \right\rfloor \right) \bmod 2 & \text{when } K \text{ is even} \\ n_{SRS} \bmod 2 & \text{when } K \text{ is odd} \end{cases}, \quad \beta = \begin{cases} 1 & \text{where } K \bmod 4 = 0 \\ 0 & \text{otherwise} \end{cases}$$

when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$),

where values B_{SRS} , b_{hop} , N_b , and n_{SRS} are given in Subclause 5.5.3.2 of [3], and $K = \prod_{b'=b_{hop}}^{B_{SRS}} N_{b'}$ (where $N_{b_{hop}} = 1$

regardless of the N_b value), except when a single SRS transmission is configured for the UE. If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE is not expected to transmit SRS on different antenna ports simultaneously. If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE is not expected to transmit SRS and PUSCH on different antenna ports simultaneously.

When higher layer parameter '*ue-TxAntennaSelection-SRS-IT4R-Config*' is configured or '*ue-TxAntennaSelection-SRS-2T4R-NrOfPairs*' is configured for a serving cell, a UE is not expected to be configured with more than two antenna ports for any uplink physical channel or signal on that serving cell.

A UE may be configured to transmit SRS on N_p antenna ports of a serving cell where N_p may be configured by higher layer signalling. For PUSCH transmission mode 1 $N_p \in \{0, 1, 2, 4\}$ and for PUSCH transmission mode 2 $N_p \in \{0, 1, 2\}$ with two antenna ports configured for PUSCH and $N_p \in \{0, 1, 4\}$ with 4 antenna ports configured for PUSCH. A UE configured for SRS transmission on multiple antenna ports of a serving cell shall transmit SRS for all the configured transmit antenna ports within one SC-FDMA symbol of the same subframe of the serving cell. The SRS transmission bandwidth and starting physical resource block assignment are the same for all the configured

antenna ports of a given serving cell. The UE does not support a value of K_{TC} set to '4', if the UE is configured for SRS transmission on 4 antenna ports of a serving cell.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured for PUSCH transmission in UpPTS and a SRS transmission overlaps with a PUSCH transmission on the same symbol in UpPTS within a TDD serving cell, the UE shall not transmit SRS in a symbol whenever SRS and PUSCH transmissions happen to overlap in the same symbol, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission. For the case when an SRS transmission in a first serving cell happens to overlap in the same symbol as a PUSCH transmission in a second serving cell, and the first and second serving cells are in the same TAG, same band, and use the same cyclic prefix, the UE may drop the SRS transmission.

For TDD serving cell, and UE not configured with additional SC-FDMA symbols in UpPTS, when one SC-FDMA symbol exists in UpPTS of the given serving cell, it can be used for SRS transmission, when two SC-FDMA symbols exist in UpPTS of the given serving cell, both can be used for SRS transmission and for trigger type 0 SRS both can be assigned to the same UE. For TDD serving cell, and if the UE is configured with two or four additional SC-FDMA symbols in UpPTS of the given serving cell, all can be used for SRS transmission and for trigger type 0 SRS at most two SC-FDMA symbols out of the configured additional SC-FDMA symbols in UpPTS can be assigned to the same UE, except for UE not configured for PUSCH/PUCCH transmission or for UE supporting *ce-srsEnhancement-r14*, where all can be assigned to the same UE.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured with multiple TAGs and SRS and PUCCH format 2/2a/2b happen to coincide in the same subframe in the same serving cell, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission,

- The UE shall not transmit type 0 triggered SRS whenever type 0 triggered SRS and PUCCH format 2/2a/2b transmissions happen to coincide in the same subframe;
- The UE shall not transmit type 1 triggered SRS whenever type 1 triggered SRS and PUCCH format 2a/2b or format 2 with HARQ-ACK transmissions happen to coincide in the same subframe;
- The UE shall not transmit PUCCH format 2 without HARQ-ACK whenever type 1 triggered SRS and PUCCH format 2 without HARQ-ACK transmissions happen to coincide in the same subframe.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, or if a UE is configured with multiple TAGs and SRS and PUCCH happen to coincide in the same subframe/slot/subslot in the same serving cell, except when the SRS is on a TDD serving cell not configured for PUSCH/PUCCH transmission,

- The UE shall not transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR happen to coincide in the same subframe/slot/subslot if the parameter *ackNackSRS-SimultaneousTransmission* is *FALSE*;
- For FDD-TDD and primary cell frame structure 1, the UE shall not transmit SRS in a symbol whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in Subclauses 5.4.1, 5.4.2A, 5.4.2B, 5.4.2C, and 5.4A of [3] happen to overlap in the same symbol if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.
- Unless otherwise prohibited, the UE shall transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in Subclauses 5.4.1, 5.4.2A, and 5.4A of [3] happen to coincide in the same subframe/slot/subslot if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.

If a UE is not configured with multiple TAGs and the UE is not configured with the parameter *srs-UpPtsAdd* for trigger type 1, or if a UE is not configured with multiple TAGs and the UE is not configured with more than one serving cell of different CPs, the UE shall not transmit SRS whenever SRS transmission on any serving cells and PUCCH transmission carrying HARQ-ACK and/or positive SR using normal PUCCH format as defined in Subclauses 5.4.1, 5.4.2A, and 5.4A of [3] happen to coincide in the same subframe/slot/subslot.

In UpPTS, whenever SRS transmission instance overlaps with the PRACH region for preamble format 4 or exceeds the range of uplink system bandwidth configured in the serving cell, the UE shall not transmit SRS.

For a TDD serving cell d not configured for PUSCH/PUCCH transmission, denote as $s_0(d)$ the corresponding serving cell whose UL transmissions may be interrupted as signalled by *srs-SwitchFromServCellIndex*. Define the set $S(d) = \{s_0(d), \dots, s_{N-1}(d)\}$ as the set of serving cells that meet all the following conditions:

- $\{s_0(d), \dots, s_{N-1}(d)\}$ are in the same band as $s_0(d)$.
- $\{s_0(d), \dots, s_{N-1}(d)\}$ have the same CP as $s_0(d)$.
- $\{s_0(d), \dots, s_{N-1}(d)\}$ are in the same TAG as $s_0(d)$.

The following prioritization rules shall be applied in case of collision between a transmission of SRS over serving cell d and transmission of a physical signal/channel over a serving cell in set $S(d)$:

- If PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/PTI/CRI/wideband PMI only (PUCCH reporting type 2a in Subclause 7.2.2) and/or PRACH on a serving cell in set $S(d)$ overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell d , then the UE shall not transmit SRS. Otherwise,
- if PUSCH transmission carrying aperiodic CSI on a serving cell in set $S(d)$ overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in serving cell d , and if the SRS transmission is a type 0 SRS transmission, then the UE shall not transmit the type 0 SRS. Otherwise,
- if PUSCH transmission on a serving cell in set $S(d)$ overlaps in more than one symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in serving cell d , then the UE shall drop the PUSCH transmission. If PUCCH/SRS transmission on a serving cell in set $S(d)$ overlaps in the same symbol with the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell d , the UE shall drop the PUCCH/SRS transmission.

In case an SRS transmission in subframe N on serving cell d is dropped due to a collision with a higher priority transmission (as defined above) in subframe N+1, and there is a lower priority transmission (as defined above) in subframe N that would have been dropped had the transmission in subframe N+1 not occurred, the UE is not required to transmit the lower priority transmission in subframe N.

The parameter *ackNackSRS-SimultaneousTransmission* provided by higher layers determines if a UE is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe/slot/subslot. If it is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe/slot/subslot, then in the cell specific SRS subframes of the primary cell in case of subframe-PUCCH or in the last slot/subslot of the cell specific SRS subframes of the primary cell in case of slot/subslot-PUCCH,

- if the UE transmits PUCCH format 1/1a/1b/3, the UE shall transmit HARQ-ACK and SR using the shortened PUCCH format as defined in Subclauses 5.4.1, 5.4.2A, and 5.4A.3 of [3], where the HARQ-ACK or the SR symbol corresponding to the SRS location is punctured.
- If the UE transmits PUCCH format 4/5 partly or fully overlapping with the cell specific SRS bandwidth in the cell specific SRS subframes of the primary cell, then UE shall transmit UCI using the shortened PUCCH format as defined in Subclauses 5.4.2B, 5.4.2C, and 5.4A.4 of [3].

For PUCCH format 1/1a/1b/3, this shortened PUCCH format shall be used in a cell specific SRS subframe or the last slot/subslot of the cell specific SRS subframe of the primary cell even if the UE does not transmit SRS in that subframe. For PUCCH format 4/5, this shortened PUCCH format shall be used if the PUCCH transmission partly or fully overlaps with the cell-specific SRS bandwidth in the cell specific SRS subframes or the last slot/subslot of the cell specific SRS subframes of the primary cell even if the UE does not transmit SRS in that subframe, or if the UE transmits SRS in that subframe even if the PUCCH format 4/5 does not partly or fully overlap with the cell-specific SRS. The cell specific SRS subframes are defined in Subclause 5.5.3.3 of [3]. Otherwise, the UE shall use the normal PUCCH format 1/1a/1b as defined in Subclause 5.4.1, and 5.4A.2 of [3] or normal PUCCH format 3 as defined in Subclause 5.4.2A, and 5.4A.3 or normal PUCCH format 4 as defined in Subclause 5.4.2B, and 5.4A.4 or normal PUCCH format 5 as defined in Subclause 5.4.2C of [3].

For a BL/CE UE not configured with the higher layer parameter *srs-UpPtsAdd*, for a SRS transmission in subframe n and if the UE transmits PUSCH/PUCCH in subframe n and/or $n+1$, the UE shall not transmit the SRS in subframe n if

the SRS transmission bandwidth in subframe n is not completely within the narrowband of PUSCH/PUCCH in subframe n and/or $n+1$

A BL/CE UE not configured with the higher layer parameter $srs-UpPtsAdd$ shall not transmit SRS in UpPTS if SRS frequency location is different from DwPTS reception narrowband in the same special subframe.

For a TDD serving cell, c_1 , not configured for PUSCH/PUCCH transmission, the UE is not expected to be configured with SRS resource(s) such that the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) may overlap in time with PDCCH monitoring in subframes 0 or 5 on serving cell c_2 , if the UE is not capable of simultaneous transmission and reception on serving cell c_1 and serving cell c_2 .

Trigger type 0 SRS configuration of a UE in a serving cell for SRS periodicity, T_{SRS} , and SRS subframe offset, T_{offset} , is defined in Table 8.2-1 and Table 8.2-2, for FDD and TDD serving cell, respectively. The periodicity T_{SRS} of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10, 20, 40, 80, 160, 320} ms or subframes. For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell configured for PUSCH and/or PUCCH transmission, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell. For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell not configured for PUSCH/PUCCH transmission, two or more SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

Type 0 triggered SRS transmission instances in a given serving cell for TDD serving cell with $T_{SRS} > 2$ and for FDD serving cell are the subframes satisfying $(10 \cdot n_f + k_{SRS} - T_{offset}) \bmod T_{SRS} = 0$, where for FDD $k_{SRS} = \{0, 1, \dots, 9\}$ is the subframe index within the frame, for TDD serving cell, if the UE is configured with the parameter $srs-UpPtsAdd$ for trigger type 0, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3. The SRS transmission instances for TDD serving cell with $T_{SRS} = 2$ are the subframes satisfying $(k_{SRS} - T_{offset}) \bmod 5 = 0$.

For TDD serving cell, and a UE configured for type 0 triggered SRS transmission in serving cell c , and the UE configured with the parameter $EIMTA-MainConfigServCell-r12$ for serving cell c , if the UE does not detect an UL/DL configuration indication for radio frame m (as described in Subclause 13.1), the UE shall not transmit trigger type 0 SRS in a subframe of radio frame m that is indicated by the parameter $eimta-HARQ-ReferenceConfig-r12$ as a downlink subframe unless the UE transmits PUSCH in the same subframe.

For a serving cell that is not a LAA SCell, trigger type 1 SRS configuration of a UE in a serving cell for SRS periodicity, $T_{SRS,1}$, and SRS subframe offset, $T_{offset,1}$, is defined in Table 8.2-4 and Table 8.2-5, for FDD and TDD serving cell, respectively. The periodicity $T_{SRS,1}$ of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10} ms or subframes.

For the SRS periodicity $T_{SRS,1}$ of 2 ms in TDD serving cell configured for PUSCH and/or PUCCH transmission, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell. For the SRS periodicity $T_{SRS,1}$ of 2 ms in TDD serving cell not configured for PUSCH/PUCCH transmission, two or more SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

For TDD serving cell configured for PUSCH and/or PUCCH transmission, and a UE configured for type 1 triggered SRS transmission in serving cell c and configured with the parameter $srs-UpPtsAdd$, the UE is not expected to receive trigger type 1 SRS configurations with SRS periodicity $T_{SRS,1}$ of 2 ms.

A UE configured for type 1 triggered SRS transmission in serving cell c and not configured with a carrier indicator field shall transmit SRS on serving cell c upon detection of a positive SRS request in PDCCH/EPDCCH/MPDCCH/SPDCCH scheduling PUSCH/PDSCH on serving cell c .

A UE configured for type 1 triggered SRS transmission in serving cell c and configured with a carrier indicator field shall transmit SRS on serving cell c upon detection of a positive SRS request in PDCCH/EPDCCH/SPDCCH scheduling PUSCH/PDSCH with the value of carrier indicator field corresponding to serving cell c .

For a serving cell that is not a LAA SCell, a non-BL/CE UE configured for type 1 triggered SRS transmission on serving cell c upon detection of a positive SRS request in subframe n , slot $2n$ or slot $2n+1$ of serving cell c shall commence SRS transmission in the first subframe satisfying $n + k, k \geq k_p$, and

- $k_p = 2$ if the positive SRS request in PDCCH/SPDCCCH with DCI format 7-0A/7-1A is detected in slot $2n$ or slot $2n+1$, for TDD
- $k_p = 3$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI with DCI format other than DCI format 7-0A/7-0B/7-1E/7-1F/7-1G is in the UE-specific search space,
- $k_p = 4$ otherwise, and

$(10 \cdot n_f + k_{\text{SRS}} - T_{\text{offset},1}) \bmod T_{\text{SRS},1} = 0$ for TDD serving cell c with $T_{\text{SRS},1} > 2$ and for FDD serving cell c ,

$(k_{\text{SRS}} - T_{\text{offset},1}) \bmod 5 = 0$ for TDD serving cell c with $T_{\text{SRS},1} = 2$

where for FDD serving cell c $k_{\text{SRS}} = \{0,1,\dots,9\}$ is the subframe index within the frame n_f , for TDD serving cell c , if the UE is configured with the parameter *srs-UpPtsAdd* for trigger type 1, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3. For a TDD serving cell not configured for PUSCH/PUCCH transmission and the positive SRS request detected in PDCCH/EPDCCCH scheduling PDSCH and the UE configured with *soundingRS-FlexibleTiming-r14* by higher layer signalling, if the SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) in the first subframe $n+k, k \geq 4$ happens to overlap with a HARQ-ACK transmission for any serving cell, the UE shall commence SRS transmission in subframe $n+k+l$, where $l = \max(5, T_{\text{SRS},1})$.

For a type 1 SRS triggered for more than one TDD serving cell in DCI format 3B and UE configured with more than 5 TDD serving cells without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells in the indicated set of serving cells configured by higher layers. For a type 1 SRS triggered for more than one TDD serving cell in DCI format 3B and UE configured with no more than 5 TDD serving cells without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells with type 1 SRS triggered in the DCI. The SRS resource for the n -th ($n \geq 2$) SRS transmission is determined such that it is the first SRS resource on or after the SRS resource for the $(n-1)$ -th SRS transmission provided it does not collide with any previous SRS transmission triggered in the DCI format 3B, or interruption due to UL or DL RF retuning time [10].

For a serving cell c that is a LAA SCell, a UE configured for type 1 triggered SRS transmission on serving cell c upon detection of a positive SRS request in subframe n of serving cell c shall commence SRS transmission, conditioned on the channel access procedures described in subclause 4.2.1 of [13], in subframe $n+k$, where

- k corresponds to the scheduled PUSCH subframe determined in Subclause 8.0 if SRS is triggered in DCI format 0A/4A,
- k is determined from Table 8.2-0A and the corresponding scheduled PUSCH subframe determined in Subclause 8.0 if SRS is triggered in DCI format 0B,
- $k = m + \text{mod}(l, N)$ where the value of l is determined from SRS subframe parameter for the indicated SRS parameter set in Table 8.1, m is determined from the first scheduled PUSCH subframe determined in Subclause 8.0 and N is determined by the procedure in Subclause 8.0 if SRS is triggered in DCI format 4B,
- $k = 3+l$ where the value of l is determined by the SRS timing offset field in the corresponding DCI if SRS is triggered in DCI format 1A/2B/2C/2D according to Table 8.2-0B.

Table 8.2-0B: l for SRS trigger type 1 in DCI format 1A/2B/2C/2D

| Value of SRS timing offset field | l |
|----------------------------------|-----------------------|
| '000' | No type 1 SRS trigger |
| '001' | 1 |
| '010' | 2 |
| '011' | 3 |
| '100' | 4 |
| '101' | 5 |
| '110' | 6 |
| '111' | 7 |

A BL/CE UE configured for type 1 triggered SRS transmission on serving cell c upon detection of a positive SRS request of serving cell c shall commence SRS transmission in the first subframe satisfying $n + k, k \geq 4$, where subframe n is the last subframe in which the DCI format 6-0A/6-1A with the positive SRS request is transmitted, and

$(10 \cdot n_f + k_{\text{SRS}} - T_{\text{offset},1}) \bmod T_{\text{SRS},1} = 0$ for TDD serving cell c with $T_{\text{SRS},1} > 2$ and for FDD serving cell c ,

$(k_{\text{SRS}} - T_{\text{offset},1}) \bmod 5 = 0$ for TDD serving cell c with $T_{\text{SRS},1} = 2$ where for FDD serving cell c $k_{\text{SRS}} = \{0,1,\dots,9\}$ is the subframe index within the frame n_f , for TDD serving cell c , if the UE is configured with the parameter *srs-UpPtsAdd* for trigger type 1, k_{SRS} is defined in Table 8.2-6; otherwise k_{SRS} is defined in Table 8.2-3.

A UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering events associated with different values of trigger type 1 SRS transmission parameters, as configured by higher layer signalling, for the same subframe and the same serving cell.

For a serving cell that is a LAA SCell, a UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering event in DCI format 0B associated with a subframe that is not scheduled for PUSCH transmission for the same serving cell.

For a serving cell that is an LAA SCell, if the uplink transmission in a subframe is ending in the end of symbol #3 or in the end of symbol #6, the UE shall not transmit SRS in that subframe.

A UE configured for type 1 or type 0 triggered SRS transmission and more than one TDD serving cell without PUSCH/PUCCH transmission is not expected to receive type 1 or type 0 SRS triggering events that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in the *UE-EUTRA-Capability* [12].

For TDD serving cell c , and a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell c , the UE shall not transmit SRS in a subframe of a radio frame that is indicated by the corresponding eIMTA-UL/DL-configuration as a downlink subframe.

A UE shall not transmit SRS whenever SRS and a PUSCH transmission corresponding to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure coincide in the same subframe.

Table 8.2-1: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, FDD

| SRS Configuration Index I_{SRS} | SRS Periodicity T_{SRS} (ms) | SRS Subframe Offset T_{offset} |
|-----------------------------------|--------------------------------|----------------------------------|
| 0 – 1 | 2 | I_{SRS} |
| 2 – 6 | 5 | $I_{SRS} - 2$ |
| 7 – 16 | 10 | $I_{SRS} - 7$ |
| 17 – 36 | 20 | $I_{SRS} - 17$ |
| 37 – 76 | 40 | $I_{SRS} - 37$ |
| 77 – 156 | 80 | $I_{SRS} - 77$ |
| 157 – 316 | 160 | $I_{SRS} - 157$ |
| 317 – 636 | 320 | $I_{SRS} - 317$ |
| 637 – 1023 | reserved | reserved |

Table 8.2-2: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, TDD

| SRS Configuration Index I_{SRS} | SRS Periodicity T_{SRS} (ms) | SRS Subframe Offset T_{offset} |
|-----------------------------------|--------------------------------|----------------------------------|
| 0 | 2 | 0, 1 |
| 1 | 2 | 0, 2 |
| 2 | 2 | 1, 2 |
| 3 | 2 | 0, 3 |
| 4 | 2 | 1, 3 |
| 5 | 2 | 0, 4 |
| 6 | 2 | 1, 4 |
| 7 | 2 | 2, 3 |
| 8 | 2 | 2, 4 |
| 9 | 2 | 3, 4 |
| 10 – 14 | 5 | $I_{SRS} - 10$ |
| 15 – 24 | 10 | $I_{SRS} - 15$ |
| 25 – 44 | 20 | $I_{SRS} - 25$ |
| 45 – 84 | 40 | $I_{SRS} - 45$ |
| 85 – 164 | 80 | $I_{SRS} - 85$ |
| 165 – 324 | 160 | $I_{SRS} - 165$ |
| 325 – 644 | 320 | $I_{SRS} - 325$ |
| 645 – 1023 | reserved | reserved |

Table 8.2-3: k_{SRS} for TDD

| | subframe index n | | | | | | | | | | | |
|---|--------------------|------------------------|------------------------|---|---|---|---|------------------------|------------------------|---|---|---|
| | 0 | 1 | | 2 | 3 | 4 | 5 | 6 | | 7 | 8 | 9 |
| | | 1st symbol of UpPTS | 2nd symbol of UpPTS | | | | | 1st symbol of UpPTS | 2nd symbol of UpPTS | | | |
| k_{SRS} in case UpPTS length of 2 symbols | | 0 | 1 | 2 | 3 | 4 | | 5 | 6 | 7 | 8 | 9 |
| k_{SRS} in case UpPTS length of 1 symbol | | 1 | | 2 | 3 | 4 | | 6 | | 7 | 8 | 9 |

Table 8.2-4: UE Specific SRS Periodicity $T_{SRS,1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, FDD

| SRS Configuration Index l_{SRS} | SRS Periodicity $T_{SRS,1}$ (ms) | SRS Subframe Offset $T_{offset,1}$ |
|--------------------------------------|-------------------------------------|---------------------------------------|
| 0 – 1 | 2 | l_{SRS} |
| 2 – 6 | 5 | $l_{SRS} - 2$ |
| 7 – 16 | 10 | $l_{SRS} - 7$ |
| 17 – 31 | reserved | reserved |

Table 8.2-5: UE Specific SRS Periodicity $T_{SRS,1}$ and Subframe Offset Configuration $T_{offset,1}$ for trigger type 1, TDD

| SRS Configuration Index l_{SRS} | SRS Periodicity $T_{SRS,1}$ (ms) | SRS Subframe Offset $T_{offset,1}$ |
|--------------------------------------|-------------------------------------|---------------------------------------|
| 0 | reserved | reserved |
| 1 | 2 | 0, 2 |
| 2 | 2 | 1, 2 |
| 3 | 2 | 0, 3 |
| 4 | 2 | 1, 3 |
| 5 | 2 | 0, 4 |
| 6 | 2 | 1, 4 |
| 7 | 2 | 2, 3 |
| 8 | 2 | 2, 4 |
| 9 | 2 | 3, 4 |
| 10 – 14 | 5 | $l_{SRS} - 10$ |
| 15 – 24 | 10 | $l_{SRS} - 15$ |
| 25 – 31 | reserved | reserved |

Table 8.2-6: k_{SRS} for TDD and UE configured with two or four additional SC-FDMA symbols in UpPTS

| | subframe index n | | | | | | | | | | | | | | | |
|--|--------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---|---|---|---|--------------------------------|--------------------------------|--------------------------------|--------------------------------|---|---|---|
| | 0 | 1 | | | | 2 | 3 | 4 | 5 | 6 | | | | 7 | 8 | 9 |
| | | 1st symb ol of UpPT S | 2nd symb ol of UpPT S | 3rd symb ol of UpPT S | 4th symb ol of UpPT S | | | | | 1st symb ol of UpPT S | 2nd symb ol of UpPT S | 3rd symb ol of UpPT S | 4th symb ol of UpPT S | | | |
| k_{SRS} in case UpPTS length of 4 symbol s | | 0 | 1 | 2 | 3 | | | | | 5 | 6 | 7 | 8 | | | |
| k_{SRS} in case UpPTS length of 2 symbol s | | 2 | 3 | | | | | | | 7 | 8 | | | | | |

8.3 UE HARQ-ACK procedure

For FDD, and serving cell with frame structure type 1, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in subframe $i-4$.

For FDD-TDD, and serving cell with frame structure type 1, and UE not configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in subframe $i-4$.

For FDD-TDD, if a serving cell is a secondary cell with frame structure type 1 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with PUSCH transmission on the serving cell in subframe $i-6$.

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For frame structure type 2 UL/DL configuration 1-6, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-k$ as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2.
- For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-k$ as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2. For frame structure type 2 UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-6$.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell is frame structure type 2,

- For serving cell with an UL-reference UL/DL configuration (defined in Subclause 8.0) belonging to {1,2,3,4,5,6}, an HARQ-ACK received on the PHICH assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-k$ for the serving cell as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2, where "TDD UL/DL Configuration" in Table 8.3-1 and Table 8.3-2 refers to the UL-reference UL/DL Configuration.
- For a serving cell with UL-reference UL/DL configuration 0 (defined in Subclause 8.0), an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 0$, as defined in Subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-k$ for the serving cell as indicated by the following Table 8.3-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise as indicated by the following Table 8.3-2, where "TDD UL/DL Configuration" in Table 8.3-1 and Table 8.3-2 refers to the UL-reference UL/DL configuration. For a serving cell with UL-reference UL/DL configuration 0, an HARQ-ACK received on the PHICH in the resource corresponding to $I_{PHICH} = 1$, as defined in Subclause 9.1.2, assigned to a UE in subframe i is associated with the PUSCH transmission in the subframe $i-6$ for the serving cell.
- For FDD-TDD, if a serving cell is a secondary cell with UL-reference UL/DL configuration 0 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, for downlink subframe i , if a transport block was transmitted in the associated PUSCH subframe $i-6$ for the serving cell then PHICH resource corresponding to that transport block is not present in subframe i .

For a BL/CE UE, the UE is not expected to receive PHICH corresponding to a transport block.

If a UE is configured with a LAA SCell for UL transmissions, the UE is not expected to receive PHICH corresponding to a transport block on the LAA SCell.

For a serving cell, if a UE is configured with a higher layer parameter *shortProcessingTime*, the UE is not expected to receive PHICH corresponding to a transport block scheduled by an uplink scheduling grant via PDCCH in the UE-specific search space on the serving cell.

For a serving cell, if a UE is configured with a higher layer parameter *shortTTI*, the UE is not expected to receive PHICH corresponding to a transport block scheduled by an uplink scheduling grant via PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B on the serving cell.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE is not expected to receive PHICH corresponding to a transport block on the serving cell and ACK for that transport block shall be delivered to the higher layers.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, UL grant in subframe *n* schedules the same UL HARQ process as that in subframe *n-6*.

Table 8.3-1: *k* for TDD configurations 0-6

| TDD UL/DL Configuration | subframe number <i>i</i> | | | | | | | | | |
|-------------------------|--------------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 7 | 4 | | | | 7 | 4 | | | |
| 1 | | 4 | | | 6 | | 4 | | | 6 |
| 2 | | | | 6 | | | | | 6 | |
| 3 | 6 | | | | | | | | 6 | 6 |
| 4 | | | | | | | | | 6 | 6 |
| 5 | | | | | | | | 6 | | |
| 6 | 6 | 4 | | | 7 | 4 | | | 6 | |

Table 8.3-2: *k* for TDD configurations 0-6 and UE configured with *symPUSCH-UpPts-r14*

| TDD UL/DL Configuration | subframe number <i>i</i> | | | | | | | | | |
|-------------------------|--------------------------|-----|---|-----|-----|---|-----|-----|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | 7 | 5,4 | | | | 7 | 5,4 | | | |
| 1 | | 5,4 | | | 6 | | 5,4 | | | 6 |
| 2 | | | | 7,6 | | | | 7,6 | | |
| 3 | 6 | | | | | | | 7,6 | 6 | |
| 4 | | | | | | | | 7,6 | 6 | |
| 5 | | | | | | | | 7,6 | | |
| 6 | 6,4 | 4 | | | 7,4 | 4 | | | 6 | |

For a non-BL/CE UE, the physical layer in the UE shall deliver indications to the higher layers as follows:

For FDD with a UE not configured with *subframeAssignment-r15*, and for TDD with a UE configured with one serving cell, and for TDD with a UE configured with more than one serving cell and with TDD UL/DL configuration of all configured serving cells the same, and UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; else NACK for that transport block shall be delivered to the higher layers.

For TDD, if the UE is configured with more than one serving cell, and if at least two serving cells have different UL/DL configurations, or the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD, for downlink or special subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

if ACK is decoded on the PHICH corresponding to that transport block in subframe *i*, or if that transport block is disabled by PDCCH/EPDCCH received in downlink or special subframe *i*, ACK for that transport block shall be delivered to the higher layers; or

if a PHICH resource corresponding to that transport block is not present in subframe *i* or if UE is not expected to receive PHICH corresponding to that transport block in subframe *i*, ACK for that transport block shall be delivered to the higher layers.

else NACK for that transport block shall be delivered to the higher layers.

8.3A Autonomous uplink feedback procedure

If the UE detects on the scheduling cell for an UL transmissions on an LAA SCell a transmission of DCI Format 0A/4A with the CRC scrambled by AUL C-RNTI carrying AUL-DFI, the UE shall use the autonomous uplink feedback information according to the following procedures:

- For each HARQ process configured for autonomous uplink transmission, the corresponding HARQ-ACK feedback is delivered to higher layers. For the HARQ processes not configured for autonomous uplink transmission, the corresponding HARQ-ACK feedback is not delivered to higher layers;
- For an uplink transmission in subframe n , the UE expects HARQ-ACK feedback in the AUL-DFI at earliest in subframe $n+4$;
- If the UE receives AUL-DFI in a subframe indicating ACK for a HARQ process, the UE is not expected to receive AUL-DFI indicating ACK for the same HARQ process prior to 4ms after the UE transmits another uplink transmission associated with that HARQ process;
- The “TPC for PUSCH” information is applied according to the procedures in subclause 5.1;
- If present, the UE applies the TPMI field received in subframe n for autonomous uplink transmissions starting from subframe $n+4$. The UE is not expected to receive a TPMI that changes the number of transmission layers.

8.4 UE PUSCH hopping procedure

The UE shall perform PUSCH frequency hopping if the single bit Frequency Hopping (FH) field in a corresponding PDCCH/EPDCCH with DCI format 0 is set to 1 and the uplink resource block assignment is type 0 otherwise no PUSCH frequency hopping is performed.

A UE performing PUSCH frequency hopping shall determine its PUSCH Resource Allocation (RA) for the first slot of a subframe ($S1$) including the lowest index PRB ($n_{PRB}^{S1}(n)$) in subframe n from the resource allocation field in the latest PDCCH/EPDCCH with DCI format 0 for the same transport block. If there is no PDCCH/EPDCCH for the same transport block, the UE shall determine its hopping type based on

- the hopping information in the most recent semi-persistent scheduling assignment PDCCH/EPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled or
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

The resource allocation field in DCI format 0 excludes either 1 or 2 bits used for hopping information as indicated by Table 8.4-1 below where the number of PUSCH resource blocks is defined as

$$N_{RB}^{PUSCH} = \begin{cases} N_{RB}^{UL} - \tilde{N}_{RB}^{HO} - (N_{RB}^{UL} \bmod 2) & \text{Type 1 PUSCH hopping} \\ N_{RB}^{UL} & \text{Type 2 } N_{sb} = 1 \text{ PUSCH hopping} \\ N_{RB}^{UL} - \tilde{N}_{RB}^{HO} & \text{Type 2 } N_{sb} > 1 \text{ PUSCH hopping} \end{cases}$$

For type 1 and type 2 PUSCH hopping, $\tilde{N}_{RB}^{HO} = N_{RB}^{HO} + 1$ if N_{RB}^{HO} is an odd number where N_{RB}^{HO} defined in [3].

$\tilde{N}_{RB}^{HO} = N_{RB}^{HO}$ in other cases. The size of the resource allocation field in DCI format 0 after excluding either 1 or 2 bits shall be $y = \lceil \log_2(N_{RB}^{UL}(N_{RB}^{UL} + 1)/2) \rceil - N_{UL_hop}$, where $N_{UL_hop} = 1$ or 2 bits. The number of contiguous RBs that can be assigned to a type-1 hopping user is limited to $\lfloor 2^y / N_{RB}^{UL} \rfloor$. The number of contiguous RBs that can be

assigned to a type-2 hopping user is limited to $\min(\lfloor 2^y / N_{\text{RB}}^{\text{UL}} \rfloor, \lfloor N_{\text{RB}}^{\text{PUSCH}} / N_{\text{sb}} \rfloor)$, where the number of sub-bands N_{sb} is given by higher layers.

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in Subclause 8.4.1 and type 2 is described in Subclause 8.4.2.

Table 8.4-1: Number of Hopping Bits $N_{\text{UL_hop}}$ vs. System Bandwidth

| System BW $N_{\text{RB}}^{\text{UL}}$ | #Hopping bits for 2nd slot RA ($N_{\text{UL_hop}}$) |
|--|---|
| 6-49 | 1 |
| 50-110 | 2 |

The parameter *Hopping-mode* provided by higher layers determines if PUSCH frequency hopping is "inter-subframe" or "intra and inter-subframe".

8.4.1 Type 1 PUSCH hopping

For PUSCH hopping type 1 the hopping bit or bits indicated in Table 8.4-1 determine $\tilde{n}_{\text{PRB}}(i)$ as defined in Table 8.4-2. The lowest index PRB ($n_{\text{PRB}}^{S1}(i)$) of the 1st slot RA in subframe i is defined as $n_{\text{PRB}}^{S1}(i) = \tilde{n}_{\text{PRB}}(i) + \tilde{N}_{\text{RB}}^{\text{HO}} / 2$, where $n_{\text{PRB}}^{S1}(i) = RB_{\text{START}}$, and RB_{START} is obtained from the uplink scheduling grant as in Subclause 8.4 and Subclause 8.1.

The lowest index PRB ($n_{\text{PRB}}(i)$) of the 2nd slot RA in subframe i is defined as $n_{\text{PRB}}(i) = \tilde{n}_{\text{PRB}}(i) + \tilde{N}_{\text{RB}}^{\text{HO}} / 2$.

The set of physical resource blocks to be used for PUSCH transmission are L_{CRBs} contiguously allocated resource blocks from PRB index $n_{\text{PRB}}^{S1}(i)$ for the 1st slot, and from PRB index $n_{\text{PRB}}(i)$ for the 2nd slot, respectively, where L_{CRBs} is obtained from the uplink scheduling grant as in Subclause 8.4 and Subclause 8.1.

If the *Hopping-mode* is "inter-subframe", the 1st slot RA is applied to even CURRENT_TX_NB, and the 2nd slot RA is applied to odd CURRENT_TX_NB, where CURRENT_TX_NB is defined in [8].

8.4.2 Type 2 PUSCH hopping

In PUSCH hopping type 2 the set of physical resource blocks to be used for transmission in slot n_s is given by the scheduling grant together with a predefined pattern according to [3] Subclause 5.3.4.

If the system frame number is not acquired by the UE yet, the UE shall not transmit PUSCH with type-2 hopping and $N_{\text{sb}} > 1$ for TDD, where N_{sb} is defined in [3].

Table 8.4-2: PDCCH/EPDCCH DCI format 0 hopping bit definition

| System BW N_{RB}^{UL} | Number of Hopping bits | Information in hopping bits | $\tilde{n}_{PRB}(i)$ |
|----------------------------|------------------------|-----------------------------|--|
| 6 – 49 | 1 | 0 | $\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH},$ |
| | | 1 | Type 2 PUSCH Hopping |
| 50 – 110 | 2 | 00 | $\left(\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ |
| | | 01 | $\left(-\left\lfloor N_{RB}^{PUSCH} / 4 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ |
| | | 10 | $\left(\left\lfloor N_{RB}^{PUSCH} / 2 \right\rfloor + \tilde{n}_{PRB}^{S1}(i)\right) \bmod N_{RB}^{PUSCH}$ |
| | | 11 | Type 2 PUSCH Hopping |

8.5 UE Reference Symbol (RS) procedure

If UL sequence-group hopping or sequence hopping is configured in a serving cell, it applies to all Reference Symbols (SRS, PUSCH and PUCCH RS). If disabling of the sequence-group hopping and sequence hopping is configured for the UE in the serving cell through the higher-layer parameter *Disable-sequence-group-hopping*, the sequence-group hopping and sequence hopping for PUSCH RS are disabled.

8.6 Modulation order, redundancy version and transport block size determination

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

- for a cell that is
 - a LAA SCell or,
 - configured with higher layer parameter *shortProcessingTime* and the PDCCH with CRC scrambled by C-RNTI corresponding to the PUSCH is in the UE-specific search space, or
 - configured with higher layer parameter *shortTTI* and the associated DCI is of format 7-0A/7-0B,

read the "modulation and coding scheme" field (I_{MCS}) and "redundancy version" field (rv), otherwise read the "modulation and coding scheme and redundancy version" field (I_{MCS}) if the UE is a non-BL/CE UEs and read the "modulation and coding scheme" field (I_{MCS}) if the UE is a BL/CE UE, and

- check the "CSI request" bit field, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in Subclause 8.1, and
- compute the number of coded symbols for control information.

8.6.1 Modulation order and redundancy version determination

For a non-BL/CE UE and for $0 \leq I_{MCS} \leq 28$, the modulation order (Q_m) is determined as follows, where $Q_m = Q'_m$ unless specified otherwise:

- If the UE is capable of supporting 64QAM in PUSCH and is not capable of supporting 256QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by Q'_m in Table 8.6.1-1.
- If the UE is capable of supporting 256QAM in PUSCH, and has not been configured by higher layers to transmit only QPSK and 16QAM and has not been configured with higher layer parameter *Enable256QAM*, the modulation order is given by Q'_m in Table 8.6.1-1.
- If the UE is capable of supporting 256QAM in subframe-PUSCH and configured with higher layer parameter *Enable256QAM*, the modulation order is given by Q'_m in Table 8.6.1-3 for subframe-PUSCH,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe/slot/subslot of the PUSCH belongs to uplink power control subframe set 2, or,

- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, or,
 - if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI,
 - otherwise, the modulation order is given by Q_m' in Table 8.6.1-1 for subframe-PUSCH.
- If the UE is capable of supporting 256QAM in slot/subslot PUSCH and configured with higher layer parameter *Enable256QAMSTTI*, the modulation order is given by Q_m' in Table 8.6.1-3 for slot/subslot-PUSCH,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-256QAM-STTI=TRUE*, the associated DCI is of format 7-0A/7-0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the slot/subslot-PUSCH belongs to uplink power control subframe set 1, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-256QAM-STTI=TRUE*, the associated DCI is of format 7-0A/7-0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI, and the subframe of the slot/subslot PUSCH belongs to uplink power control subframe set 2, or,
 - if higher layer parameter *tpc-SubframeSet* is not configured, the associated DCI is of format 7-0A/7-0B mapped onto the UE specific search space and with CRC scrambled by the C-RNTI,;
 - otherwise, the modulation order is given by Q_m' in Table 8.6.1-1 for slot/subslot PUSCH.
- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, Q_m' is first read from Table 8.6.1-1. The modulation order is set to $Q_m' = \min(4, Q_m')$.
- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the modulation order is set to $Q_m = 2$. Resource allocation size is restricted to $N_{\text{PRB}} \leq 3$ applies in this case if the UE does not indicate support by higher layers to operate without it.
 - If the UE is configured with higher layer parameter *pusch-EnhancementsConfig*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space, then Q_m' is first obtained according to the procedure above. The modulation order (Q_m) is determined as follows.
 - If the uplink DCI modulation override bit is set to zero, or if $Q_m' = 2$
 - then $Q_m = Q_m'$
 - otherwise
 - if $Q_m' = 8$ then $Q_m = 6$,
 - if $Q_m' = 6$ then $Q_m = 4$,
 - if $Q_m' = 4$ then $Q_m = 2$.

For a non-BL/CE UE and for $29 \leq I_{\text{MCS}} \leq 31$ the modulation order (Q_m) is determined as follows:

- if DCI format 0/0A/0B/7-0A is used and $I_{\text{MCS}} = 29$ and $N = 1$ (determined by the procedure in Subclause 8.0) or, if DCI format 4/7-0B is used and only 1 TB is enabled and $I_{\text{MCS}} = 29$ for the enabled TB and the signalled number of transmission layers is 1 or if DCI format 4A/4B is used and $I_{\text{MCS}} = 29$ for both TBs and $N = 1$ (determined by the procedure in Subclause 8.0), and if

- the "CSI request" bit field is 1 bit and the bit is set to trigger an aperiodic report and, $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and, $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{\text{PRB}} \leq 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and $N_{\text{PRB}} \leq 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G, or
- the "CSI request" bit field in DCI format 0A/0B/4A/4B/7-0A/7-0B is set to trigger an aperiodic CSI report, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K, or
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *advancedCodebookEnabled*,
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *FeCoMPCSIEnabled*,

then the modulation order is set to $Q_m = 2$.

- Otherwise,
 - For a cell that is not a LAA SCell, the modulation order shall be determined from the DCI transported in the latest PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B for the same transport block using $0 \leq I_{MCS} \leq 28$. If there is no PDCCH/EPDCCH/SPDCCH with DCI format 0/4/7-0A/7-0B for the same transport block using $0 \leq I_{MCS} \leq 28$, the modulation order shall be determined from
 - the most recent semi-persistent scheduling assignment PDCCH/EPDCCH/SPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
 - the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.
 - For a cell that is an LAA SCell and a UE that is configured with Partial PUSCH Mode 2 or 3, if $I_{MCS} = 30$, the modulation order shall be determined from the DCI transported in the latest PDCCH/EPDCCH with DCI format 0A/0B/4A/4B for the same transport block using $0 \leq I_{MCS} \leq 28$.

For a cell that is not a LAA SCell, and a non-BL/CE UE,

- for subframe-PUSCH, if the UE is configured with higher layer parameter *enable256QAM-r14*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space with CRC scrambled by the C-RNTI, the UE shall use I_{MCS} and Table 8.6.1-3 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
 - if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
 - if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B, or,
 - if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B;
- otherwise, the UE shall use I_{MCS} and Table 8.6.1-1 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel.

For a LAA SCell and DCI format 0A/4A, the redundancy version (rv_{idx}) to use in the physical uplink shared channel is given by $rv_{idx} = rv$.

For a LAA SCell and DCI format 0B/4B, the redundancy version (rv_{idx}) to use in the physical uplink shared channel is given by $rv_{idx} = 2 \cdot rv$.

For a serving cell, if the UE is configured with higher layer parameter

- *shortProcessingTime* if the PDCCH with CRC scrambled by C-RNTI corresponding to the PUSCH transmission is located in UE specific search space or
- *shortTTI* and if the associated DCI is of format 7-0A/7-0B,

the redundancy version (rv_{idx}) to use in the physical uplink shared channel is given by $rv_{idx} = rv$.

For a serving cell, for semi-persistently scheduled slot/subslot-PUSCH transmissions of a transport block spanning K consecutive PUSCH transmissions corresponding to an SPS configuration with higher layer parameters $rv\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$ and $totalNumberPUSCH\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$, the redundancy version (rv_{idx}) is determined according to Table 8.6.1-0 for the k th PUSCH transmission, using $rv = (k - 1) \bmod 4$ where $k=1,\dots, K$, and $K=totalNumberPUSCH\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$.

For a serving cell, for semi-persistently scheduled subframe-PUSCH transmissions of a transport block spanning K consecutive PUSCH transmissions corresponding to an SPS configuration with higher layer parameters $rv\text{-}SPS\text{-}UL\text{-}Repetitions$ and $totalNumberPUSCH\text{-}SPS\text{-}UL\text{-}Repetitions$, the redundancy version (rv_{idx}) is determined according to Table 8.6.1-0 for the k th PUSCH transmission, using $rv = (k - 1) \bmod 4$ where $k=1,\dots, K$, and $K=totalNumberPUSCH\text{-}SPS\text{-}UL\text{-}Repetitions$.

Table 8.6.1-0: Redundancy Version corresponding to different values of higher layer parameter $rv\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$ or $rv\text{-}SPS\text{-}UL\text{-}Repetitions$

| Redundancy version Index rv | rv_{idx} for $rv\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$ or $rv\text{-}SPS\text{-}UL\text{-}Repetitions = \{0,0,0,0,0,0\}$ | rv_{idx} for $rv\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$ or $rv\text{-}SPS\text{-}UL\text{-}Repetitions = \{0,2,3,1,0,2\}$ | rv_{idx} for $rv\text{-}SPS\text{-}STTI\text{-}UL\text{-}Repetitions$ or $rv\text{-}SPS\text{-}UL\text{-}Repetitions = \{0,3,0,3,0,3\}$ |
|----------------------------------|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 0 | 2 | 3 |
| 2 | 0 | 3 | 0 |
| 3 | 0 | 1 | 3 |

Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH

| MCS Index I_{MCS} | Modulation Order Q'_m | TBS Index I_{TBS} | Redundancy Version rv_{idx} |
|--------------------------------------|-----------------------------------|--------------------------------------|---|
| 0 | 2 | 0 | 0 |
| 1 | 2 | 1 | 0 |
| 2 | 2 | 2 | 0 |
| 3 | 2 | 3 | 0 |
| 4 | 2 | 4 | 0 |
| 5 | 2 | 5 | 0 |
| 6 | 2 | 6 | 0 |
| 7 | 2 | 7 | 0 |
| 8 | 2 | 8 | 0 |
| 9 | 2 | 9 | 0 |
| 10 | 2 | 10 | 0 |
| 11 | 4 | 10 | 0 |
| 12 | 4 | 11 | 0 |
| 13 | 4 | 12 | 0 |
| 14 | 4 | 13 | 0 |
| 15 | 4 | 14 | 0 |
| 16 | 4 | 15 | 0 |
| 17 | 4 | 16 | 0 |
| 18 | 4 | 17 | 0 |
| 19 | 4 | 18 | 0 |
| 20 | 4 | 19 | 0 |
| 21 | 6 | 19 | 0 |
| 22 | 6 | 20 | 0 |
| 23 | 6 | 21 | 0 |
| 24 | 6 | 22 | 0 |
| 25 | 6 | 23 | 0 |
| 26 | 6 | 24 | 0 |
| 27 | 6 | 25 | 0 |
| 28 | 6 | 26 | 0 |
| 29 | reserved | | 1 |
| 30 | | | 2 |
| 31 | | | 3 |

For a BL/CE UE

- if the UE is configured with CEModeA, and higher layer parameter *ce-pusch-nb-maxTbs-config* configured with value 'On', and if the MPDCCH corresponding to the PUSCH transmission is located in UE-specific search space, the modulation order is determined according to table 8.6.1-2A.
- if the UE is configured with higher layer parameter *ce-pdsch-puschEnhancement-config* with value 'On', and if the *Modulation order override* field in the DCI is set to 1, the modulation order is set to $Q_m = 2$
- if the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the PUSCH transmission is scheduled by the Random Access Response Grant, and the higher layers indicate EDT to the physical layer as defined in [8], or the PUSCH retransmission of the same transport block including EDT as part of the contention based random access procedure with $I_{\text{MCS}} = 15$ in the uplink scheduling grant, the modulation order is set to $Q_m = 2$.
- if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment is using uplink resource allocation type 5, the modulation order is set to $Q_m = 1$ for $\pi/2$ -BPSK, $Q_m = 2$ otherwise.
- otherwise, the modulation order is determined according to table 8.6.1-2.

A BL/CE UE configured with CEModeB is not expected to receive a DCI format 6-0B indicating $I_{\text{MCS}} > 10$.

For a BL/CE UE or for UEs configured with higher layer parameter *PUSCH-EnhancementsConfig*,

- if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment is using uplink resource allocation type 5, the redundancy version (rv_{idx}) to use for the i-th BL/CE UL subframe in the physical uplink shared channel is determined according to Table 7.1.7.1-2 using

$$rv = \left(\left\lfloor \frac{i}{M_{RU} \cdot M_{slots}^{\text{UL}} / 2} \right\rfloor + rv_{DCI} \right) \bmod 4 \quad \text{where } i = 0, 1, \dots, N - 1, \text{ and } N \text{ is the number of BL/CE UL}$$

subframes for the PUSCH transmission as determined in subclause 8.0. For a BL/CE UE configured in CEModeA, rv_{DCI} is determined by the 'Redundancy version' field in DCI format 6-0A. For a BL/CE UE configured with CEModeB, $rv_{DCI} = 0$.

- otherwise, the same redundancy version is applied to PUSCH transmitted in a given block of N_{acc} consecutive subframes. The subframe number of the first subframe in each block of N_{acc} consecutive subframes, denoted as $n_{abs,1}$, satisfies $n_{abs,1} \bmod N_{acc} = 0$. Denote i_0 as the subframe number of the first uplink subframe intended for PUSCH. For BL/CE UEs, the PUSCH transmission spans N_{abs}^{PUSCH} consecutive subframes including subframes that are not BL/CE UL subframes where the PUSCH transmission is postponed. For the j^{th} block of N_{acc} consecutive subframes within the set of N_{abs}^{PUSCH} subframes, the redundancy version (rv_{idx}) is determined according to Table 7.1.7.1-2 using $rv = (j + rv_{DCI}) \bmod 4$, where $j = 0, 1, \dots, J^{\text{PUSCH}} - 1$,

and $J^{\text{PUSCH}} = \left\lceil \frac{N_{abs}^{\text{PUSCH}} + (i_0 \bmod N_{acc})}{N_{acc}} \right\rceil$. The J^{PUSCH} blocks of subframes are sequential in time, starting

with $j = 0$ to which subframe i_0 belongs. For a BL/CE UE configured in CEModeA, $N_{acc} = 1$ and rv_{DCI} is determined by the 'Redundancy version' field in DCI format 6-0A. For a BL/CE UE configured with CEModeB, $N_{acc} = 4$ for FDD and $N_{acc} = 5$ for TDD, and $rv_{DCI} = 0$. For a UE configured with higher layer parameter *PUSCH-EnhancementsConfig*, $N_{acc} = 1$ and rv_{DCI} is determined by the 'Redundancy version' field in DCI format 0C. For UEs configured with higher layer parameter *PUSCH-EnhancementsConfig*, $N_{abs}^{\text{PUSCH}} = N_{rep}^{\text{PUSCH}}$.

Table 8.6.1-2: Modulation and TBS index table for PUSCH

| MCS Index I_{MCS} | Modulation Order Q_m | TBS Index I_{TBS} |
|-------------------------------|----------------------------------|-------------------------------|
| 0 | 2 | 0 |
| 1 | 2 | 1 |
| 2 | 2 | 2 |
| 3 | 2 | 3 |
| 4 | 2 | 4 |
| 5 | 2 | 5 |
| 6 | 2 | 6 |
| 7 | 2 | 7 |
| 8 | 2 | 8 |
| 9 | 2 | 9 |
| 10 | 2 | 10 |
| 11 | 4 | 10 |
| 12 | 4 | 11 |
| 13 | 4 | 12 |
| 14 | 4 | 13 |
| 15 | 4 | 14 |

Table 8.6.1-2A: Modulation and TBS index table for PUSCH

| MCS Index I_{MCS} | Modulation Order Q_m | TBS Index I_{TBS} |
|-------------------------------|----------------------------------|-------------------------------|
| 0 | 2 | 0 |
| 1 | 2 | 2 |
| 2 | 2 | 4 |
| 3 | 2 | 5 |
| 4 | 2 | 6 |
| 5 | 2 | 8 |
| 6 | 2 | 10 |
| 7 | 4 | 10 |
| 8 | 4 | 12 |
| 9 | 4 | 14 |
| 10 | 4 | 16 |
| 11 | 4 | 17 |
| 12 | 4 | 18 |
| 13 | 4 | 19 |
| 14 | 4 | 20 |
| 15 | 4 | 21 |

Table 8.6.1-3: Modulation, TBS index and redundancy version table for PUSCH

| MCS Index I_{MCS} | Modulation Order Q'_m | TBS Index I_{TBS} | Redundancy Version rV_{idx} |
|-------------------------------|-----------------------------------|-------------------------------|---|
| 0 | 2 | 0 | 0 |
| 1 | 2 | 2 | 0 |
| 2 | 2 | 4 | 0 |
| 3 | 2 | 6 | 0 |
| 4 | 2 | 8 | 0 |
| 5 | 2 | 10 | 0 |
| 6 | 4 | 11 | 0 |
| 7 | 4 | 12 | 0 |
| 8 | 4 | 13 | 0 |
| 9 | 4 | 14 | 0 |
| 10 | 4 | 16 | 0 |
| 11 | 4 | 17 | 0 |
| 12 | 4 | 18 | 0 |
| 13 | 4 | 19 | 0 |
| 14 | 6 | 20 | 0 |
| 15 | 6 | 21 | 0 |
| 16 | 6 | 22 | 0 |
| 17 | 6 | 23 | 0 |
| 18 | 6 | 24 | 0 |
| 19 | 6 | 25 | 0 |
| 20 | 6 | 27 | 0 |
| 21 | 6 | 28 | 0 |
| 22 | 6 | 29 | 0 |
| 23 | 8 | 30 | 0 |
| 24 | 8 | 31 | 0 |
| 25 | 8 | 32 | 0 |
| 26 | 8 | 32A | 0 |
| 27 | 8 | 33 | 0 |
| 28 | 8 | 34 | 0 |
| 29 | reserved | | 1 |
| 30 | | | 2 |
| 31 | | | 3 |

Table 8.6.1-4: Void

8.6.2 Transport block size determination

For a non-BL/CE UE and for $0 \leq I_{\text{MCS}} \leq 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} except if the transport block is disabled in DCI format 4/4A/4B as specified below. For a transport block that is not mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.1. For a transport block that is mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Subclause 7.1.7.2.2.

For, DCI format 7-0A/7-0B, the derived transport block size as described in section 7.1.7.2.1 when the transport block is mapped to one spatial layer and the derived transport block size after TBS translation as described in sections 7.1.7.2.2, 7.1.7.2.4, 7.1.7.2.5 when the transport block is mapped to more than one spatial layer is scaled by α , then rounded to the closest valid transport block size

- in Table 7.1.7.2.1-1 when the transport block is mapped to one spatial layer,
- the union of Table 7.1.7.2.1-1 and Table 7.1.7.2.2-1 when the transport block is mapped to two spatial layers,
- the union of Table 7.1.7.2.1-1 and Table 7.1.7.2.4-1 when the transport block is mapped to three spatial layers,
- the union of Table 7.1.7.2.1-1 and Table 7.1.7.2.5-1 when the transport block is mapped to four spatial layers,

where

- α is given by higher layer parameter *tbs-scalingFactorSubslotSPS-UL-Repetitions* for subslot-PUSCH if the UE is configured with higher layer parameter *totalNumberPUSCH-SPS-STTI-UL-Repetitions* when the PDCCH/SPDCCH CRC is scrambled by SPS C-RNTI.
- $\alpha = 0.5$ for slot-PUSCH except if the UE is configured with a higher layer parameter *symPUSCH-UpPts-r14* and the TB is transmitted in UpPTS of the special subframe in frame structure type 2, $\alpha = 0.125$ for slot-PUSCH in special subframe configuration with up to 3 UpPTS SC-FDMA data symbols, $\alpha = 0.375$ for slot-PUSCH in special subframe configuration with more than 3 UpPTS SC-FDMA data symbols, $\alpha = \frac{1}{12}$ for subslot-PUSCH with one data symbol in the subslot, and $\alpha = \frac{1}{6}$ for subslot-PUSCH with two or three data symbols in the subslot.

If the scaled TBS is closest to two valid transport block sizes, it is rounded to the larger transport block size.

For subframe-PUSCH, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-3, if the UE is configured with higher layer parameter *enable256QAM*, and if the PDCCH corresponding to the PUSCH transmission is located in UE specific search space with CRC scrambled by the C-RNTI, and

- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format0=TRUE*, the associated DCI is of format 0/0A/0B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-DCI-Format4=TRUE*, the associated DCI is of format 4/4A/4B, and the subframe of the PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format0=TRUE*, and the associated DCI is of format 0/0A/0B, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, higher layer parameter *dci-Format4=TRUE*, and the associated DCI is of format 4/4A/4B;

otherwise, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-1.

For subslot/slot-PUSCH, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-3, if the UE is configured with higher layer parameter *Enable256QAMSTTI*, and if the PDCCH/SPDCCH corresponding to the PUSCH transmission is located in UE specific search space with CRC scrambled by the C-RNTI, and

- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet1-256QAM-STTI=TRUE*, the associated DCI is of format 7-0A/7-0B, and the subframe of the slot/subslot-PUSCH belongs to uplink power control subframe set 1, or,
- if higher layer parameter *tpc-SubframeSet* is configured, higher layer parameter *subframeSet2-256QAM-STTI=TRUE*, the associated DCI is of format 7-0A/7-0B, and the subframe of the slot/subslot-PUSCH belongs to uplink power control subframe set 2, or,
- if higher layer parameter *tpc-SubframeSet* is not configured, and the associated DCI is of format 7-0A/7-0B;

otherwise, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-1.

If the UE is configured with higher layer parameter *symPUSCH-UpPts-r14*, *ttiBundling=FALSE*, and the transport block is transmitted in UpPTS of the special subframe in frame structure type 2, then

- for special subframe configuration with up to 3 UpPTS SC-FDMA data symbols:
 - set the Table 7.1.7.2.1-1 column indicator to $\max\{N_{PRB} \times 0.125 \downarrow 1\}$ instead of N_{PRB}
- otherwise:
 - set the Table 7.1.7.2.1-1 column indicator to $\max\{N_{PRB} \times 0.375 \downarrow 1\}$ instead of N_{PRB} .

If the transport block is transmitted on an LAA SCell,

- If $0 \leq I_{MCS} \leq 28$, then
 - if the UE is transmitting a Partial PUSCH Mode 2, or if the UE is transmitting a Partial PUSCH Mode 3 ending at symbol #6
 - set the Table 7.1.7.2.1-1 column indicator to $\max\{N_{PRB} \times 0.5 \downarrow 1\}$ instead of N_{PRB}
 - if the UE is transmitting a Partial PUSCH Mode 3 ending at symbol #3
 - set the Table 7.1.7.2.1-1 column indicator to $\max\{N_{PRB} \times 0.125 \downarrow 1\}$ instead of N_{PRB}
- If the UE is configured with Partial PUSCH Mode 2 or 3 on the LAA SCell and $I_{MCS} = 30$, the transport block size shall be determined from the latest PDCCH/EPDCCH with DCI format 0A/0B/4A/4B for the same transport block using $0 \leq I_{MCS} \leq 28$.

For a non-BL/CE UE and for $29 \leq I_{MCS} \leq 31$,

- if DCI format 0/0A/0B/7-0A/7-0B is used and $I_{MCS} = 29$ and $N=1$ (determined by the procedure in Subclause 8.0) or, if DCI format 4 is used and only 1 TB is enabled and $I_{MCS} = 29$ for the enabled TB and the number of transmission layers is 1 or if DCI format 4A/4B is used and $I_{MCS} = 29$ for both TBs and $N=1$ (determined by the procedure in Subclause 8.0), and if
 - the "CSI request" bit field is 1 bit and is set to trigger an aperiodic CSI report and $N_{PRB} \leq 4$ or,
 - the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one serving cell according to Table 7.2.1-1A, and, $N_{PRB} \leq 4$ or,

- the "CSI request" bit field is 2 bits and is triggering aperiodic CSI report for more than one serving cell according to Table 7.2.1-1A and, $N_{\text{PRB}} \leq 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1B and $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process according to Table 7.2.1-1B and, $N_{\text{PRB}} \leq 20$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for one CSI process or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\text{PRB}} \leq 4$ or,
- the "CSI request" bit field is 2 bits and is triggering an aperiodic CSI report for more than one CSI process and/or {CSI process, CSI subframe set}-pair according to Table 7.2.1-1C and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 3 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1D or Table 7.2.1-1E or Table 7.2.1-1F or Table 7.2.1-1G, or
- the "CSI request" bit field in DCI format 0A/0B/4A/4B/7-0A/7-0B is set to trigger an aperiodic CSI report, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 4 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1H or Table 7.2.1-1I, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for one CSI process according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\text{PRB}} \leq 4$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for 2 to 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K and $N_{\text{PRB}} \leq 20$, or
- the "CSI request" bit field is 5 bits and is triggering an aperiodic CSI report for more than 5 CSI processes according to Table 7.2.1-1J or Table 7.2.1-1K, or
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *advancedCodebookEnabled*,
- the "CSI request" bit field in DCI is set to trigger an aperiodic CSI report and UE is configured with higher layer parameter *FeCoMPCSIEnabled*,

then there is no transport block for the UL-SCH and only the control information feedback for the current PUSCH reporting mode is transmitted by the UE.

- Otherwise, the transport block size shall be determined from the initial PDCCH/EPDCCH/SPDCCH for the same transport block using $0 \leq I_{\text{MCS}} \leq 28$. If there is no initial PDCCH/EPDCCH/SPDCCH with an uplink DCI format for the same transport block using $0 \leq I_{\text{MCS}} \leq 28$, the transport block size shall be determined from

- the most recent semi-persistent scheduling assignment PDCCH/EPDCCH/SPDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

In DCI format 4 a transport block is disabled if either the combination of $I_{MCS} = 0$ and $N_{PRB} > 1$ or the combination of $I_{MCS} = 28$ and $N_{PRB} = 1$ is signalled, otherwise the transport block is enabled.

In DCI formats 4A/4B a transport block is disabled if $I_{MCS} = 29$ and otherwise the transport block is enabled.

If DCI format 4B is used and $I_{MCS} = 29$ for both TBs, UE is not expected to receive the value of $N > 1$ as determined by the procedure in Subclause 8.0.

If DCI format 0B is used and $I_{MCS} = 29$, UE is not expected to receive the value of $N > 1$ as determined by the procedure in Subclause 8.0.

For a BL/CE UE configured with CEModeA and a PUSCH transmission not scheduled by the Random Access Response Grant,

- if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*,
 - if the value of the 'number of resource units' field in the scheduling grant is set to '01', the TBS is determined according to the procedure in Subclause 7.1.7.2.1 with $I_{TBS} = I_{MCS}$ and $N_{PRB} = 2$ for $0 \leq I_{TBS} \leq 7$,
 - elseif the value of the 'number of resource units' field in the scheduling grant is set to '10', the TBS is determined according to the procedure in Subclause 7.1.7.2.1 with $I_{TBS} = I_{MCS} + 1$ and $N_{PRB} = 3$ for $1 \leq I_{TBS} \leq 8$,
 - elseif the value of the 'number of resource units' field in the scheduling grant is set to '11', $TBS = \min\{TBS', 1000\}$ where TBS' is the TBS determined according to the procedure in Subclause 7.1.7.2.1 with $I_{TBS} = I_{MCS} + 3$ and $N_{PRB} = 6$ for $3 \leq I_{TBS} \leq 10$,
- elseif the UE is configured with higher layer parameter *ce-pusch-nb-maxTbs-config* with value 'On', and if the MPDCCH corresponding to the PUSCH transmission is located in UE-specific search space, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2A;
- otherwise, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2.

For a BL/CE UE configured with CEModeA and a PUSCH transmission not scheduled by the Random Access Response Grant,

- if the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the uplink scheduling grant corresponding to the PUSCH transmission indicates a retransmission as part of the contention based random access procedure with $0 \leq I_{MCS} \leq 7$ and the most recent PUSCH transmission including a transport block with EDT, the TBS is determined by the procedure in Subclause 7.1.7.2.1, for $0 \leq I_{TBS} \leq 7$ and the transport block does not include EDT;
- elseif the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the uplink scheduling grant corresponding to the PUSCH transmission indicates a retransmission of the same transport block including EDT as part of the contention based random access procedure with $I_{MCS} = 15$,
 - if the UE is configured with higher layer parameter *edt-SmallTBS-Enabled-r15*, the repetition number for the transmission of Msg3 PUSCH is the smallest integer multiple of M that is equal to or larger than $TBS_{Msg3}/TBS_{Msg3,max} \cdot N_{Msg3}$ where TBS_{Msg3} is the TBS corresponding to the PUSCH transmission

scheduled by the Random Access Response Grant, and $TBS_{Msg3,max}$ is the value of the higher layer parameter *edt-TBS-r15*. $M = 4$ if $N_{Msg3} > 4$, $M = 1$ otherwise.

- otherwise, the TBS is given by higher layer parameter *edt-TBS-r15*.
- elseif the UE is not configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, or if the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15* and the value of the 'number of resource units' field in the scheduling grant is set to '00'
 - if the UE is configured with higher layer parameter *ce-pusch-maxBandwidth-config* with value 5MHz, the TBS is determined by the procedure in Subclause 7.1.7.2.1, for $0 \leq I_{TBS} \leq 14$
 - otherwise, the TBS is determined by the procedure in Subclause 7.1.7.2.1.

For a BL/CE UE configured with CEModeA and a PUSCH transmission scheduled by the Random Access Response Grant,

- if the UE is configured with higher layer parameter *edt-Parameters-r15*, and the higher layers indicate EDT to the physical layer as defined in [8],
- if the UE is not configured with higher layer parameter *edt-SmallTBS-Enabled-r15*, the TBS is given by higher layer parameter *edt-TBS-r15*, the UE selects a TBS from the allowed TBS values in Table 8.6.2-1 otherwise.
- otherwise, the UE shall determine the TBS index by the procedure in Subclause 6.2.

Table 8.6.2-1: EDT TBS for CEModeA with *edt-SmallTBS-Enabled-r15* set to “true”.

| <i>edt-TBS-r15</i> | <i>edt-SmallTBS-Subset-r15</i> | Allowable TBS values |
|---------------------------|---------------------------------------|-----------------------------|
| 408 | not configured | 328, 408 |
| 504 | not configured | 328, 408, 456, 504 |
| 504 | enabled | 408, 504 |
| 600 | not configured | 328, 408, 504, 600 |
| 600 | enabled | 408, 600 |
| 712 | not configured | 328, 456, 600, 712 |
| 712 | enabled | 456, 712 |
| 808 | not configured | 328, 504, 712, 808 |
| 808 | enabled | 504, 808 |
| 936 | not configured | 328, 504, 712, 936 |
| 936 | enabled | 504, 936 |
| 1000 | not configured | 328, 536, 776, 1000 |
| 1000 | enabled | 536, 1000 |

For a BL/CE UE configured with CEModeB,

- if the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the PUSCH transmission is scheduled by the Random Access Response Grant, and the higher layers indicate EDT to the physical layer as defined in [8],
- if the UE is not configured with higher layer parameter *edt-SmallTBS-Enabled-r15*, the TBS is given by higher layer parameter *edt-TBS-r15*, the UE selects a TBS from the allowed TBS values in Table 8.6.2-2 otherwise.
- elseif the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the uplink scheduling grant corresponding to the PUSCH transmission indicates a retransmission as part of the contention based random access procedure with $0 \leq I_{MCS} \leq 3$ and the most recent PUSCH transmission including a transport block with EDT, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2, and the TBS is determined by the procedure in Subclause 7.1.7.2.1, for $0 \leq I_{TBS} \leq 3$ and the transport block does not include EDT

- elseif the UE is configured with higher layer parameter *edt-Parameters-r15*, and if the uplink scheduling grant corresponding to the PUSCH transmission indicates a retransmission of the same transport block including EDT as part of the contention based random access procedure with $I_{MCS} = 15$,
 - if the UE is configured with higher layer parameter *edt-SmallTBS-Enabled-r15*, the repetition number for the transmission of Msg3 PUSCH is the smallest integer multiple of M that is equal to or larger than $TBS_{Msg3}/TBS_{Msg3,\max} \cdot N_{Msg3}$ where TBS_{Msg3} is the TBS corresponding to the PUSCH transmission scheduled by the Random Access Response Grant, and $TBS_{Msg3,\max}$ is the value of the higher layer parameter *edt-TBS-r15*. $M = 4$ if $N_{Msg3} > 4$, $M = 1$ otherwise.
 - otherwise, the TBS is given by higher layer parameter *edt-TBS-r15*.
- elseif the UE is configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the value of the 'sub-PRB allocation flag' field in the scheduling grant is set to '1',
 - if the value of the 'number of resource units' field in the scheduling grant is set to '0', the TBS is determined according to the procedure in Subclause 7.1.7.2.1 with $I_{TBS} = I_{MCS} + 1$ and $N_{PRB} = 3$ for $1 \leq I_{TBS} \leq 8$,
 - elseif the value of the 'number of resource units' field in the scheduling grant is set to '1', the TBS is determined according to the procedure in Subclause 7.1.7.2.1 with $I_{TBS} = I_{MCS} + 3$ and $N_{PRB} = 6$ for $3 \leq I_{TBS} \leq 9$,
 - otherwise, the UE shall determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-2, and the TBS is determined according to the procedure in Subclause 7.1.7.2.1 for $0 \leq I_{TBS} \leq 10$, and $N_{PRB} = 6$ when resource allocation field is '110' or '111' otherwise $N_{PRB} = 3$.

Table 8.6.2-2: EDT TBS for CEModeB with *edt-SmallTBS-Enabled-r15* set to “true”.

| <i>edt-TBS-r15</i> | <i>edt-SmallTBS-Subset-r15</i> | Allowable TBS values |
|---------------------------|---------------------------------------|-----------------------------|
| 408 | not configured | 328, 408 |
| 456 | not configured | 328, 408, 456 |
| 456 | enabled | 408, 456 |
| 504 | not configured | 328, 408, 456, 504 |
| 504 | enabled | 408, 504 |
| 600 | not configured | 328, 408, 504, 600 |
| 600 | enabled | 408, 600 |
| 712 | not configured | 328, 456, 600, 712 |
| 712 | enabled | 456, 712 |
| 808 | not configured | 328, 504, 712, 808 |
| 808 | enabled | 504, 808 |
| 936 | not configured | 328, 504, 712, 936 |
| 936 | enabled | 504, 936 |

8.6.3 Control information MCS offset determination

Offset values are defined for single codeword PUSCH transmission and multiple codeword PUSCH transmission. Single codeword subframe-PUSCH transmission offsets $\beta_{\text{offset}}^{\text{HARQ-ACK}}$, $\beta_{\text{offset}}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{\text{offset}}^{\text{HARQ-ACK}}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH or if $I_{\text{offset},X}^{\text{HARQ-ACK}}$ is not configured, $I_{\text{offset}}^{\text{RI}}$, and $I_{\text{offset}}^{\text{CQI}}$, respectively. Single codeword PUSCH transmission offset $\beta_{\text{offset}}^{\text{HARQ-ACK}}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{\text{offset},X}^{\text{HARQ-ACK}}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH and $I_{\text{offset},X}^{\text{HARQ-ACK}}$ is configured.

AUL PUSCH transmission offset for AUL-UCI $\beta_{\text{offset}}^{\text{AUL-UCI}}$ shall be configured to values according to Table 8.6.3-1 with the higher layer signalled index $I_{\text{offset}}^{\text{AUL-UCI}}$.

If the UE is configured with higher layer parameter *ul-STTI-Length*,

- slot-PUSCH transmission offsets, $\beta_{\text{offset}}^{\text{HARQ-ACK}}$, $\beta_{\text{offset}}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ shall be configured via higher layer parameters *betaOffsetSlot-ACK-Index*, *betaOffsetSlot-RI-Index*, and *betaOffsetSlot-CQI-Index* to values according to Table 8.6.3-1, Table 8.6.3-2, and Table 8.6.3-3 with the higher layer signalled indexes $I_{\text{offset}}^{\text{HARQ-ACK}}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH, and $I_{\text{offset}}^{\text{RI}}$, and $I_{\text{offset}}^{\text{CQI}}$ respectively. Slot-PUSCH transmission offset $\beta_{\text{offset}}^{\text{HARQ-ACK}}$ shall be configured to values according to Table 8.6.3-1 with the higher layer signalled index $I_{\text{offset},X}^{\text{HARQ-ACK}}$ if the UE transmits more than 22 HARQ-ACK bits on a slot-PUSCH.
- subslot-PUSCH transmission offsets, $\beta_{\text{offset},1}^{\text{HARQ-ACK}}$, $\beta_{\text{offset},2}^{\text{HARQ-ACK}}$, $\beta_{\text{offset},1}^{\text{RI}}$, $\beta_{\text{offset},2}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ shall be configured via higher layer parameters *betaOffsetSubslot-ACK-Index*, *betaOffset2Subslot-ACK-Index*, *betaOffsetSubslot-RI-Index*, *betaOffset2Subslot-RI-Index*, and *betaOffsetSubslot-CQI-Index* to values according to Table 8.6.3-1, Table 8.6.3-2, and Table 8.6.3-3 with the higher layer signalled indexes $I_{\text{offset},1}^{\text{HARQ-ACK}}$, $I_{\text{offset},2}^{\text{HARQ-ACK}}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH, and $I_{\text{offset},1}^{\text{RI}}$, $I_{\text{offset},2}^{\text{RI}}$ and $I_{\text{offset}}^{\text{CQI}}$ respectively. Subslot-PUSCH transmission offset $\beta_{\text{offset},1}^{\text{HARQ-ACK}}$ and $\beta_{\text{offset},2}^{\text{HARQ-ACK}}$ shall be configured to values according to Table 8.6.3-1 with the higher layer signalled index $I_{\text{offset},1,X}^{\text{HARQ-ACK}}$, and $I_{\text{offset},2,X}^{\text{HARQ-ACK}}$ if the UE transmits more than 22 HARQ-ACK bits on a subslot-PUSCH. If the *Beta offset indicator* field in PDCCH/SPDCCH with DCI format 7-0A/7-0B is set to 0, $\beta_{\text{offset}}^{\text{HARQ-ACK}} = \beta_{\text{offset},1}^{\text{HARQ-ACK}}$, and $\beta_{\text{offset}}^{\text{RI}} = \beta_{\text{offset},1}^{\text{RI}}$, otherwise $\beta_{\text{offset}}^{\text{HARQ-ACK}} = \beta_{\text{offset},2}^{\text{HARQ-ACK}}$, and $\beta_{\text{offset}}^{\text{RI}} = \beta_{\text{offset},2}^{\text{RI}}$.

Multiple codeword PUSCH transmission offsets $\beta_{\text{offset}}^{\text{HARQ-ACK}}$, $\beta_{\text{offset}}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{\text{offset},MC}^{\text{HARQ-ACK}}$ if the UE transmits no more than 22 HARQ-ACK bits on a PUSCH or if $I_{\text{offset},MC,X}^{\text{HARQ-ACK}}$ is not configured, $I_{\text{offset},MC}^{\text{RI}}$ and $I_{\text{offset},MC}^{\text{CQI}}$, respectively. Multiple codeword PUSCH transmission offset $\beta_{\text{offset}}^{\text{HARQ-ACK}}$ shall be configured to values according to [Table 8.6.3-1] with the higher layer signalled index $I_{\text{offset},MC,X}^{\text{HARQ-ACK}}$ if the UE transmits more than 22 HARQ-ACK bits on a PUSCH and $I_{\text{offset},MC,X}^{\text{HARQ-ACK}}$ is configured.

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c , and if a subframe belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*, then for that subframe, the UE shall use

- the higher layer indexes $I_{\text{offset},\text{set}2}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{set}2,\text{X}}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{set}2}^{\text{RI}}$ and $I_{\text{offset},\text{set}2}^{\text{CQI}}$ in place of $I_{\text{offset}}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{X}}^{\text{HARQ-ACK}}$, $I_{\text{offset}}^{\text{RI}}$, and $I_{\text{offset}}^{\text{CQI}}$ respectively in Tables 8.6.3-1,2,3, to determine $\beta_{\text{offset}}^{\text{HARQ-ACK}}$, $\beta_{\text{offset}}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ respectively for single codeword PUSCH transmissions, and
- the higher layer indexes $I_{\text{offset},\text{MC},\text{set}2}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{MC},\text{set}2,\text{X}}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{MC},\text{set}2}^{\text{RI}}$ and $I_{\text{offset},\text{MC},\text{set}2}^{\text{CQI}}$ in place of $I_{\text{offset}}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{MC},\text{X}}^{\text{HARQ-ACK}}$, $I_{\text{offset},\text{MC}}^{\text{RI}}$ and $I_{\text{offset},\text{MC}}^{\text{CQI}}$ respectively in Tables 8.6.3-1,2,3, to determine $\beta_{\text{offset}}^{\text{HARQ-ACK}}$, $\beta_{\text{offset}}^{\text{RI}}$ and $\beta_{\text{offset}}^{\text{CQI}}$ respectively for multiple codeword PUSCH transmissions.

Table 8.6.3-1: Mapping of HARQ-ACK offset or AUL-UCI offset values and the index signalled by higher layers

| $I_{\text{offset}}^{\text{HARQ-ACK}}$ or $I_{\text{offset},\text{MC}}^{\text{HARQ-ACK}}$ or $I_{\text{offset}}^{\text{AUL-UCI}}$ | $\beta_{\text{offset}}^{\text{HARQ-ACK}}$ or $\beta_{\text{offset}}^{\text{AUL-UCI}}$ |
|--|---|
| 0 | 2.000 |
| 1 | 2.500 |
| 2 | 3.125 |
| 3 | 4.000 |
| 4 | 5.000 |
| 5 | 6.250 |
| 6 | 8.000 |
| 7 | 10.000 |
| 8 | 12.625 |
| 9 | 15.875 |
| 10 | 20.000 |
| 11 | 31.000 |
| 12 | 50.000 |
| 13 | 80.000 |
| 14 | 126.000 |
| 15 | 1.0 |

Table 8.6.3-2: Mapping of RI offset values and the index signalled by higher layers

| I_{offset}^{RI} or $I_{offset,MC}^{RI}$ | β_{offset}^{RI} |
|---|-----------------------|
| 0 | 1.250 |
| 1 | 1.625 |
| 2 | 2.000 |
| 3 | 2.500 |
| 4 | 3.125 |
| 5 | 4.000 |
| 6 | 5.000 |
| 7 | 6.250 |
| 8 | 8.000 |
| 9 | 10.000 |
| 10 | 12.625 |
| 11 | 15.875 |
| 12 | 20.000 |
| 13 | reserved |
| 14 | reserved |
| 15 | reserved |

Table 8.6.3-3: Mapping of CQI offset values and the index signalled by higher layers

| I_{offset}^{CQI} or $I_{offset,MC}^{CQI}$ | β_{offset}^{CQI} |
|---|------------------------|
| 0 | reserved |
| 1 | reserved |
| 2 | 1.125 |
| 3 | 1.250 |
| 4 | 1.375 |
| 5 | 1.625 |
| 6 | 1.750 |
| 7 | 2.000 |
| 8 | 2.250 |
| 9 | 2.500 |
| 10 | 2.875 |
| 11 | 3.125 |
| 12 | 3.500 |
| 13 | 4.000 |
| 14 | 5.000 |
| 15 | 6.250 |

8.7 UE transmit antenna selection

UE transmit antenna selection is configured by higher layers via parameter *ue-TransmitAntennaSelection*. The UE is not expected to be simultaneously configured with *SRS-Antenna-Switching-2T4R* and *ue-TransmitAntennaSelection*.

A UE configured with transmit antenna selection for a serving cell is not expected to

- be configured with more than one antenna port for any uplink physical channel or signal for any configured serving cell, or
- be configured with trigger type 1 SRS transmission on any configured serving cell, or
- be configured with simultaneous PUCCH and PUSCH transmission, or
- receive DCI Format 0 indicating uplink resource allocation type 1 for any serving cell, or
- be configured with a SCG.

If UE transmit antenna selection is disabled or not supported by the UE, the UE shall transmit from UE port 0.

If closed-loop UE transmit antenna selection is enabled by higher layers the UE shall perform transmit antenna selection for PUSCH in subframe n in response to the most recent command received via DCI Format 0 in subframe $n-4$ or earlier (see Subclause 5.3.3.2 of [4]).

If a UE is configured with more than one serving cell, and for a group of cells belonging to bands that are signalled to be switched together in *txAntennaSwitchUL* the UE may assume the same transmit antenna port value is indicated in each PDCCH/EPDCCH with DCI format 0 in a given subframe.

If open-loop UE transmit antenna selection is enabled by higher layers, the transmit antenna for PUSCH to be selected by the UE is not specified.

8.8 Transmission timing adjustments

The higher layers indicate the 16-bit UL Grant to the physical layer, as defined in [11]. This is referred to the UL Grant in the physical layer. The content of these 16 bits starting with the MSB and ending with the LSB are as follows:

- Hopping flag – 1 bit, as described in Subclause 6.2
- Fixed size resource block assignment – 10 bits, as described in Subclause 6.2
- Truncated modulation and coding scheme – 4 bits, as described in Subclause 6.2
- CQI request – 1 bit, as described in Subclause 6.2

9 Physical downlink control channel procedures

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

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

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

For a UE configured with EN-DC/NE-DC and more than one serving cells with primary cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the primary cell, the UE is not expected to be configured with carrier indicator field in any of the serving cells.

9.1 UE procedure for determining physical downlink control channel assignment

9.1.1 PDCCH assignment procedure

The control region of each serving cell consists of a set of CCEs, numbered from 0 to $N_{\text{CCE},k} - 1$ according to Subclause 6.8.1 in [3], where $N_{\text{CCE},k}$ is the total number of CCEs in the control region of subframe k .

The UE shall monitor a set of PDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the PDCCHs in the set according to all the monitored DCI formats.

A BL/CE UE is not required to monitor PDCCH.

A UE is not required to monitor PDCCH in an MBSFN subframe with zero-size non-MBSFN region.

The set of PDCCH candidates to monitor are defined in terms of search spaces, where a search space $S_k^{(L)}$ at aggregation level $L \in \{1, 2, 4, 8\}$ is defined by a set of PDCCH candidates. For each serving cell on which PDCCH is monitored, the CCEs corresponding to PDCCH candidate m of the search space $S_k^{(L)}$ are given by

$$L \cdot \left\{ (Y_k + m') \bmod \left\lfloor N_{\text{CCE},k} / L \right\rfloor \right\} + i$$

where Y_k is defined below, $i = 0, \dots, L-1$. For the common search space $m' = m$. For the PDCCH UE specific search space, for the serving cell on which PDCCH is monitored, if the monitoring UE is configured with carrier indicator field then $m' = m$ for $n_{CI} = 0$ and $m' = m + \sum_{x=0}^{n_{CI}-1} M_x^{(L)}$ for $n_{CI} > 0$ where n_{CI} is the carrier indicator field value and

$M_x^{(L)}$ is the reference number of PDCCH candidates for a carrier indicator field value "x", else if the monitoring UE is not configured with carrier indicator field then $m' = m$, where $m = 0, \dots, M^{(L)} - 1$. $M^{(L)}$ is the number of PDCCH candidates to monitor in the given search space for the scheduled serving cell. If the monitoring UE is configured with higher layer parameter *shortTTI*, for monitoring DCI format 7-0A/7-0B/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, $M^{(L)}$ is replaced by the corresponding element of higher layer parameter *dci7-CandidatesPerAL-PDCCH*. If a carrier indicator field value "x" corresponds to a LAA SCell and the monitoring UE is configured with uplink transmission on the LAA SCell, $M_x^{(L)}$ is the maximum number of $M^{(L)}$ over all configured DCI formats for the LAA SCell. Otherwise, $M_x^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_x^{(L)}$.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

If a UE is configured with a LAA SCell for UL transmissions, and if the UE is configured with higher layer parameter *cif-InSchedulingCell-r14* for the LAA SCell, the carrier indicator field value in PDCCH scheduling PUSCH corresponds to *cif-InSchedulingCell-r14*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

The UE shall monitor one common search space in every non-DRX subframe at each of the aggregation levels 4 and 8 on the primary cell.

A UE shall monitor common search space on a cell to decode the PDCCHs necessary to receive MBMS on that cell when configured by higher layers.

If a UE is not configured for EPDCCH monitoring, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on each activated serving cell in every non-DRX subframe.

If a UE is not configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on one or more activated serving cells as configured by higher layer signalling in every non-DRX subframe.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is not configured with a carrier indicator field, then the UE shall monitor one PDCCH UE-specific search space at each of the aggregation levels 1, 2, 4, 8 on that serving cell in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

If a UE is configured for EPDCCH monitoring on a serving cell, and if that serving cell is activated, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more PDCCH UE-specific search spaces at each of the aggregation levels 1, 2, 4, 8 on that serving cell as configured by higher layer signalling in all non-DRX subframes where EPDCCH is not monitored on that serving cell.

A UE is not expected to monitor PDCCH candidates with DCI format 0/1/1A/2/2A/2B/2C/2D mapped onto the UE-specific search space, and with the CRC scrambled by the SPS C-RNTI, when the UE is configured with higher layer parameter *shortProcessingTime*.

A UE is not expected to monitor PDCCH candidates with DCI format 7-0A/7-0B/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G over more than

- 28 CCEs on a serving cell if the higher layer parameter *dl-STTI-Length* is set to 'subslot'.
- 32 CCEs on a serving cell if the higher layer parameter *dl-STTI-Length* is set to 'slot'.

A UE is not expected to be configured to monitor more than

- 6 PDCCH candidates with DCI format 7-0A/7-0B/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G on a service cell in a subslot if the higher layer parameter *dl-STTI-Length* is set to 'subslot'
- 12 PDCCH candidates with DCI format 7-0A/7-0B/7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G on a serving cell in a slot if the higher layer parameter *dl-STTI-Length* is set to 'slot'.

The UE is not expected to be configured to monitor PDCCH corresponding to DCI format 7-0A/7-0B /7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with carrier indicator field in a given serving cell.

A UE configured with higher layer parameter *shortTTI* for a serving cell is not required to monitor PDCCH for the serving cell on any other serving cell.

The UE is not expected to be configured to monitor PDCCH corresponding to DCI format 7-0A/7-0B /7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G when CFI value is 3 and $N_{RB}^{DL} \leq 10$.

The common and PDCCH UE-specific search spaces on the primary cell may overlap. If the UE is configured with higher layer parameter *shortProcessingTime*, a PDCCH with DCI format 0/1A detected in the overlap shall be considered by the UE as having been received in the PDCCH common search space.

A UE configured with the carrier indicator field associated with monitoring PDCCH on serving cell *c* shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the PDCCH UE specific search space of serving cell *c*.

A UE configured with the carrier indicator field associated with monitoring PDCCH on the primary cell shall monitor PDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI or UL-SPS-V-RNTI in the PDCCH UE specific search space of the primary cell.

The UE shall monitor the common search space for PDCCH without carrier indicator field.

For the serving cell on which PDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the PDCCH UE specific search space for PDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the PDCCH UE specific search space for PDCCH with carrier indicator field.

If the UE is not configured with a LAA Scell, the UE is not expected to monitor the PDCCH of a secondary cell if it is configured to monitor PDCCH with carrier indicator field corresponding to that secondary cell in another serving cell.

If the UE is configured with a LAA Scell, the UE is not expected to monitor the PDCCH UE specific space of the LAA Scell if it is configured to monitor PDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell,

- where the UE is not expected to be configured to monitor PDCCH with carrier indicator field in an LAA Scell;
- where the UE is not expected to be scheduled with PDSCH starting in the second slot in a subframe in an LAA Scell if the UE is configured to monitor PDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell.

For the serving cell on which PDCCH is monitored, the UE shall monitor PDCCH candidates at least for the same serving cell.

A UE configured to monitor PDCCH candidates with CRC scrambled by C-RNTI, SPS C-RNTI or UL-SPS-V-RNTI with a common payload size and with the same first CCE index n_{CCE} (as described in Subclause 10.1) but with different sets of DCI information fields as defined in [4] in the

- common search space
- PDCCH UE specific search space

on the primary cell shall assume that for the PDCCH candidates with CRC scrambled by C-RNTI, SPS C-RNTI or UL-SPS-V-RNTI,

if the UE is configured with the carrier indicator field associated with monitoring the PDCCH on the primary cell,
only the PDCCH in the common search space is transmitted by the primary cell;

otherwise, only the PDCCH in the UE specific search space is transmitted by the primary cell.

A UE configured to monitor PDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the PDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that a PDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any PDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07',

- The UE monitors PDCCH UE-specific search space candidates on the Scell in both the first and second slots of a subframe, and the aggregation levels defining the search spaces are listed in Table 9.1.1-1A;

otherwise,

- The aggregation levels defining the search spaces are listed in Table 9.1.1-1.

If a serving cell is a LAA Scell, the UE may receive PDCCH with DCI CRC scrambled by CC-RNTI as described in Subclause 13A on the LAA Scell.

The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in Subclause 7.1.

If a UE is configured with higher layer parameter *skipMonitoringDCI-format0-1A* for a serving cell, the UE is not required to monitor the PDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *skipMonitoringDCI-format0A* for the LAA SCell, the UE is not required to monitor the PDCCH with DCI Format 0A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *skipMonitoringDCI-format4A* for the LAA SCell, the UE is not required to monitor the PDCCH with DCI Format 4A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *enableMonitoringDCI-format0B* for the LAA SCell, the UE is required to monitor the PDCCH with DCI Format 0B in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *enableMonitoringDCI-format4B* for the LAA SCell, the UE is required to monitor the PDCCH with DCI Format 4B in the UE specific search space for the LAA SCell.

If a UE is not configured for PUSCH/PUCCH transmission for at least one TDD serving cell, the UE is not expected to monitor PDCCH on serving cell c_1 if the PDCCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on TDD serving cell c_2 not configured for PUSCH/PUCCH transmission, and if the UE is not capable of simultaneous reception and transmission on serving cell c_1 and serving cell c_2 .

If a UE is configured with higher layer parameter $pdcch-candidateReductions$ for a UE specific search space at aggregation level L for a serving cell, the corresponding number of PDCCH candidates is given by

$M^{(L)} = \text{round}(a \times M_{\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{\text{full}}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter $pdcch-candidateReductions-Format0A$ for a UE specific search space at aggregation level L for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0A is given by $M^{(L)} = \text{round}(a \times M_{\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{\text{full}}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter $pdcch-candidateReductions-Format0B-4A-4B-AL1-2$ for a UE specific search space of the first and second aggregation level for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0B/4A/4B is given by

$M^{(L)} = \text{round}(a \times M_{\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{\text{full}}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter $pdcch-candidateReductions-Format0B-4A-4B-AL3-4$ for a UE specific search space of the third and fourth aggregation level for the LAA SCell, the corresponding number of PDCCH candidates for DCI format 0B/4A/4B is given by

$M^{(L)} = \text{round}(a \times M_{\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-3 and $M_{\text{full}}^{(L)}$ is determined according to Table 9.1.1-1 by replacing $M^{(L)}$ with $M_{\text{full}}^{(L)}$.

Table 9.1.1-1: PDCCH candidates monitored by a UE

| Search space $S_k^{(L)}$ | | | Number of PDCCH candidates $M^{(L)}$ |
|--------------------------|-----------------------|----------------|--------------------------------------|
| Type | Aggregation level L | Size [in CCEs] | |
| UE-specific | 1 | 6 | 6 |
| | 2 | 12 | 6 |
| | 4 | 8 | 2 |
| | 8 | 16 | 2 |
| Common | 4 | 16 | 4 |
| | 8 | 16 | 2 |

Note: the Size [in CCEs] is given assuming $a = 1$

Table 9.1.1-1A: PDCCH UE-specific search space candidates monitored by a UE on LAA Scell

| Search space $S_k^{(L)}$ | | | Number of PDCCH candidates $M^{(L)}$ in first slot | Number of PDCCH candidates $M^{(L)}$ in second slot |
|--------------------------|-----------------------|----------------|--|---|
| Type | Aggregation level L | Size [in CCEs] | | |
| UE-specific | 1 | 6 | 6 | 6 |
| | 2 | 12 | 6 | 6 |
| | 4 | 8 | 2 | 2 |
| | 8 | 16 | 2 | 2 |

Note: the Size [in CCEs] is given assuming $a = 1$

Table 9.1.1-2: Scaling factor for PDCCH candidates reduction

| pdcch-candidateReductions | Value of a |
|---------------------------|--------------|
| 0 | 0 |
| 1 | 0.33 |
| 2 | 0.66 |
| 3 | 1 |

Table 9.1.1-3: Scaling factor for PDCCH candidates reduction

| pdcch-candidateReductions | Value of a |
|---------------------------|--------------|
| 0 | 0 |
| 1 | 0.5 |
| 2 | 1 |
| 3 | 1.5 |

For the common search spaces, Y_k is set to 0 for the two aggregation levels $L=4$ and $L=8$.

For the UE-specific search space $S_k^{(L)}$ at aggregation level L , the variable Y_k is defined by

$$Y_k = (A \cdot Y_{k-1}) \bmod D$$

where $Y_{-1} = n_{\text{RNTI}} \neq 0$, $A = 39827$, $D = 65537$ and $k = \lfloor n_s / 2 \rfloor$, n_s is the slot number within a radio frame.

The RNTI value used for n_{RNTI} is defined in Subclause 7.1 in downlink and Subclause 8 in uplink.

9.1.2 PHICH assignment procedure

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and PUSCH transmissions scheduled from serving cell c in subframe n are not scheduled by a Random Access Response Grant corresponding to a random access preamble transmission for a secondary cell

- For PUSCH transmissions scheduled from serving cell c in subframe n , the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n+k_{\text{PHICH}}$, where
 - k_{PHICH} is always 4 for FDD.
 - k_{PHICH} is 6 for FDD-TDD and serving cell c frame structure type 2 and the PUSCH transmission is for another serving cell with frame structure type 1.
 - k_{PHICH} is 4 for FDD-TDD and serving cell c frame structure type 1 and the PUSCH transmission is for a serving cell with frame structure type 1.
 - k_{PHICH} is given in table 9.1.2-1 for FDD-TDD and serving cell c frame structure type 1 and the PUSCH transmission is for another serving cell with frame structure type 2.
- For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell and, if the UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, for PUSCH transmissions scheduled from serving cell c in subframe n , the UE shall determine the corresponding PHICH resource of serving cell c in subframe $n+k_{\text{PHICH}}$, where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell, otherwise k_{PHICH} is given in Table 9.1.2-3.
- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell c frame structure type 2, for PUSCH transmissions scheduled from serving cell c in subframe n , the UE shall determine the corresponding PHICH resource of

serving cell c in subframe $n+k_{PHICH}$, where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the serving cell, otherwise k_{PHICH} is given in Table 9.1.2-3, where the "TDD UL/DL Configuration" in the rest of this Subclause refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) of the serving cell corresponding to the PUSCH transmission.

If a UE is configured with multiple TAGs, for PUSCH transmissions on subframe n for a secondary cell c scheduled by a Random Access Response grant corresponding to a random access preamble transmission for the secondary cell c ,

- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with $EIMTA-MainConfigServCell-r12$ for at least one serving cell, or for FDD-TDD and serving cell c frame structure type 2, the "TDD UL/DL Configuration" in the rest of this Subclause refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) of secondary cell c .
- If the UE is not configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell, the UE shall determine the corresponding PHICH resource on the secondary cell c in subframe $n+k_{PHICH}$, where
 - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the secondary cell c , otherwise k_{PHICH} is given in Table 9.1.2-3 for TDD.
 - k_{PHICH} is 4 for FDD-TDD and secondary cell c frame structure type 1.
 - k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the secondary cell c , otherwise k_{PHICH} is given in Table 9.1.2-3 for FDD-TDD and secondary cell c frame structure type 2
- If the UE is configured to monitor PDCCH/EPDCCH with carrier indicator field corresponding to secondary cell c in another serving cell $c1$, the UE configured with multiple TAGs shall determine the corresponding PHICH resource on the serving cell $c1$ in subframe $n+k_{PHICH}$, where
 - k_{PHICH} is always 4 for FDD and where k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the secondary cell c , otherwise k_{PHICH} is given in Table 9.1.2-3 for TDD.
 - k_{PHICH} is 4 for FDD-TDD and primary cell frame structure type 1 and frame structure type 1 for secondary cell c and serving cell $c1$
 - k_{PHICH} is given in table 9.1.2-1 if the UE is not configured with higher layer parameter $symPUSCH-UpPts-r14$ for the secondary cell c , otherwise k_{PHICH} is given in Table 9.1.2-3 for FDD-TDD and serving cell c frame structure type 2
 - k_{PHICH} is 6 for FDD-TDD and serving cell c frame structure type 1 and serving cell $c1$ frame structure type 2

For subframe bundling operation, the corresponding PHICH resource is associated with the last subframe in the bundle.

Table 9.1.2-1: k_{PHICH} for TDD

| TDD UL/DL Configuration | subframe index n | | | | | | | | | |
|-------------------------|--------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | | | 4 | 7 | 6 | | | 4 | 7 | 6 |
| 1 | | | 4 | 6 | | | | 4 | 6 | |
| 2 | | | 6 | | | | | 6 | | |
| 3 | | | 6 | 6 | 6 | | | | | |
| 4 | | | 6 | 6 | | | | | | |
| 5 | | | 6 | | | | | | | |
| 6 | | | 4 | 6 | 6 | | | 4 | 7 | |

Table 9.1.2-3: k_{PHICH} for TDD and UE configured with symPUSCH-UpPts-r14

| TDD UL/DL Configuration | subframe index n | | | | | | | | | |
|-------------------------|--------------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | | 5 | 4 | 7 | 6 | | 5 | 4 | 7 | 6 |
| 1 | | 5 | 4 | 6 | | | 5 | 4 | 6 | |
| 2 | | 7 | 6 | | | | 7 | 6 | | |
| 3 | | 7 | 6 | 6 | 6 | | | | | |
| 4 | | 7 | 6 | 6 | | | | | | |
| 5 | | 7 | 6 | | | | | | | |
| 6 | | 4 | 4 | 6 | 6 | | 4 | 4 | 7 | |

The PHICH resource is identified by the index pair $(n_{PHICH}^{group}, n_{PHICH}^{seq})$ where n_{PHICH}^{group} is the PHICH group number and n_{PHICH}^{seq} is the orthogonal sequence index within the group as defined by:

$$\begin{aligned} n_{PHICH}^{group} &= (I_{PRB_RA} + n_{DMRS}) \bmod N_{PHICH}^{group} + I_{PHICH} N_{PHICH}^{group} \\ n_{PHICH}^{seq} &= (\lfloor I_{PRB_RA} / N_{PHICH}^{group} \rfloor + n_{DMRS}) \bmod 2N_{SF}^{PHICH} \end{aligned}$$

where

- n_{DMRS} is mapped from the cyclic shift for DMRS field (according to Table 9.1.2-2) in the most recent PDCCH/EPDCCH with uplink DCI format [4] for the transport block(s) associated with the corresponding PUSCH transmission. n_{DMRS} shall be set to zero, if there is no PDCCH/EPDCCH with uplink DCI format for the same transport block, and
 - if the initial PUSCH for the same transport block is semi-persistently scheduled, or
 - if the initial PUSCH for the same transport block is scheduled by the random access response grant .
- N_{SF}^{PHICH} is the spreading factor size used for PHICH modulation as described in Subclause 6.9.1 in [3].
- $I_{PRB_RA} = \begin{cases} I_{PRB_RA}^{lowest_index} & \text{for the first TB of a PUSCH with associated PDCCH/EPDC CH or for the case of no associated PDCCH/EPDC CH when the number of negatively acknowledged TBs is not equal to the number of TBs indicated in the most recent PDCCH/EPDC CH associated with the corresponding PUSCH} \\ I_{PRB_RA}^{lowest_index} + 1 & \text{for a second TB of a PUSCH with associated PDCCH/EPDC CH} \end{cases}$ where $I_{PRB_RA}^{lowest_index}$ is the lowest PRB index in the first slot of the corresponding PUSCH transmission
- N_{PHICH}^{group} is the number of PHICH groups configured by higher layers as described in Subclause 6.9 of [3],

- $I_{PHICH} = \begin{cases} 1 & \text{for TDD UL/DL configuration 0 with PUSCH transmission in subframe } n = 4 \text{ or } 9 \\ 0 & \text{otherwise} \end{cases}$

Table 9.1.2-2: Mapping between n_{DMRS} and the cyclic shift for DMRS field in PDCCH/EPDCCH with uplink DCI format in [4]

| Cyclic Shift for DMRS Field in PDCCH/EPDCCH with uplink DCI format in [4] | n_{DMRS} |
|---|------------|
| 000 | 0 |
| 001 | 1 |
| 010 | 2 |
| 011 | 3 |
| 100 | 4 |
| 101 | 5 |
| 110 | 6 |
| 111 | 7 |

9.1.3 Control Format Indicator (CFI) assignment procedure

For a serving cell, if a UE is configured with higher layer parameter *semiStaticCFI-SlotSubslotNonMBSFN*, the UE shall assume the CFI is equal to the value of the higher layer parameter *semiStaticCFI-SlotSubslotNonMBSFN* for non-MBSFN subframes for receiving physical downlink shared channel with slot/subslot duration.

For a serving cell, if a UE is configured with higher layer parameter *semiStaticCFI-SlotSubslotMBSFN*, the UE shall assume the CFI is equal to the value of the higher layer parameter *semiStaticCFI-SlotSubslotMBSFN* for MBSFN subframes for receiving physical downlink shared channel with slot/subslot duration.

For a serving cell using frame structure 2, if a UE is configured with higher layer parameter *cfi-Radioframe-patternSlot*, the UE shall assume the CFI is equal to the value of the higher layer parameter *cfi-Radioframe-patternSlot* for the subframes for receiving physical downlink shared channel with slot duration.

For a serving cell, if a UE is configured with higher layer parameter *semiStaticCFI-SubframeNonMBSFN*, the UE shall assume the CFI is equal to the value of the higher layer parameter *semiStaticCFI-SubframeNonMBSFN* for non-MBSFN subframes for receiving physical downlink shared channel with subframe duration.

For a serving cell using frame structure 2, if a UE is configured with higher layer parameter *cfi-Radioframe-patternSubframe*, the UE shall assume the CFI is equal to the value of the higher layer parameter *cfi-Radioframe-patternSubframe* for the subframes for receiving physical downlink shared channel with subframe duration.

For a serving cell, if a UE is configured with higher layer parameters *semiStaticCFI-SubframeNonMBSFN* and *semiStaticCFI-SlotSubslotNonMBSFN*, the UE is not expected the values of *semiStaticCFI-SlotSubslotNonMBSFN* and *semiStaticCFI-SubframeNonMBSFN* are different.

For a serving cell, if a UE is configured with higher layer parameters *semiStaticCFI-SubframeMBSFN* and *semiStaticCFI-SlotSubslotMBSFN*, the UE is not expected the values of *semiStaticCFI-SlotSubslotMBSFN* and *semiStaticCFI-SubframeMBSFN* are different.

For a serving cell using frame structure 2, if a UE is configured with higher layer parameters *cfi-Radioframe-patternSlot* and *cfi-Radioframe-patternSubframe*, the UE is not expected the values of *cfi-Radioframe-patternSlot* and *cfi-Radioframe-patternSubframe* are different.

PHICH duration is signalled by higher layers according to Table 6.9.3-1 in [3]. The duration signalled puts a lower limit on the size of the control region determined from the control format indicator (CFI). When $N_{RB}^{DL} > 10$, if extended PHICH duration is indicated by higher layers then the UE shall assume that CFI is equal to PHICH duration.

In subframes indicated by higher layers to decode PMCH, when $N_{\text{RB}}^{\text{DL}} > 10$, a UE may assume that CFI is equal to the value of the higher layer parameter *non-MBSFNregionLength* [11].

9.1.4 EPDCCH assignment procedure

For each serving cell, higher layer signalling can configure a UE with one or two EPDCCH-PRB-sets for EPDCCH monitoring. The PRB-pairs corresponding to an EPDCCH-PRB-set are indicated by higher layers as described in Subclause 9.1.4.4. Each EPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N_{\text{ECCE},p,k} - 1$ where

$N_{\text{ECCE},p,k}$ is the number of ECCEs in EPDCCH-PRB-set p of subframe k . Each EPDCCH-PRB-set can be configured for either localized EPDCCH transmission or distributed EPDCCH transmission.

The UE shall monitor a set of EPDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the EPDCCHs in the set according to the monitored DCI formats.

A BL/CE UE is not required to monitor EPDCCH.

A UE configured with higher layer parameter *shortProcessingTime* or *shortTTI* for a serving cell is not required to monitor EPDCCH for the serving cell or on that serving cell.

If a UE is configured with higher layer parameter *shortTTI* for a serving cell, and if the UE does not support *epdcch-STTI-differentCells-r15* (3GPP TS 36.331 [11]), the UE is not expected to monitor EPDCCH for any serving cell.

If a UE is configured with higher layer parameter *shortProcessingTime* for a serving cell, and if the UE does not support *epdcch-SPT-differentCells-r15* (3GPP TS 36.331 [11]), the UE is not expected to monitor EPDCCH for any serving cell.

A UE is not required to monitor EPDCCH in an MBSFN subframe with zero-size non-MBSFN region.

The set of EPDCCH candidates to monitor are defined in terms of EPDCCH UE-specific search spaces.

For each serving cell, the subframes in which the UE monitors EPDCCH UE-specific search spaces are configured by higher layers.

The UE shall not monitor EPDCCH

- For TDD and normal downlink CP, in special subframes for the special subframe configurations 0 and 5, or for frame structure type 3, in the subframe with the same duration as the DwPTS duration of the special subframe configurations 0 and 5, shown in Table 4.2-1 of [3], or for the special subframe configuration 10 configured by the higher layer signalling *ssp10-CRS-LessDwPTS*.
- For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3].
- In subframes indicated by higher layers to decode PMCH.
- For TDD and if the UE is configured with different UL/DL configurations for the primary and a secondary cell, in a downlink subframe on the secondary cell when the same subframe on the primary cell is a special subframe and the UE is not capable of simultaneous reception and transmission on the primary and secondary cells.

An EPDCCH UE-specific search space $ES_k^{(L)}$ at aggregation level $L \in \{1, 2, 4, 8, 16, 32\}$ is defined by a set of EPDCCH candidates.

For an EPDCCH-PRB-set p , the ECCEs corresponding to EPDCCH candidate m of the search space $ES_k^{(L)}$ are given by

$$L \left\{ \left(Y_{p,k} + \left\lceil \frac{m \cdot N_{\text{ECCE},p,k}}{L \cdot M_{p,\text{full}}^{(L)}} \right\rceil + b \right) \bmod \left\lfloor N_{\text{ECCE},p,k} / L \right\rfloor \right\} + i$$

where

$Y_{p,k}$ is defined below,

$$i = 0, \dots, L-1$$

$b = n_{CI}$ if the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored,
otherwise $b = 0$

n_{CI} is the carrier indicator field value,

$M_{p,\text{full}}^{(L)}$ is the maximum number of EPDCCH candidates among all the configured DCI formats over all the configured carrier indicator field values for an aggregation level L in EPDCCH-PRB-set p if the UE is configured with uplink transmission on a LAA SCell, otherwise, $M_{p,\text{full}}^{(L)}$ is the nominal number of EPDCCH candidates at aggregation level L in EPDCCH-PRB-set p determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,\text{full}}^{(L)}$,

$$m = 0, 1, \dots, M_p^{(L)} - 1.$$

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell on which EPDCCH is monitored, as given in Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.1.4-4b, 9.1.4-5a, 9.1.4-5b below; otherwise, $M_p^{(L)}$ is the number of EPDCCH candidates to monitor at aggregation level L in EPDCCH-PRB-set p for the serving cell indicated by n_{CI} .

If a UE is configured with higher layer parameter *pdcch-candidateReductions* for a specific search space at aggregation level L in EPDCCH-PRB-set p for a serving cell, the corresponding number of EPDCCH candidates is given by $M_p^{(L)} = \text{round}(a \times M_{p,\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,\text{full}}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0A* for a UE specific search space at aggregation level L in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0A is given by $M_p^{(L)} = \text{round}(a \times M_{p,\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,\text{full}}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL1-2* for a UE specific search space of the first and second aggregation level in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0B/4A/4B is given by $M_p^{(L)} = \text{round}(a \times M_{p,\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-2 and $M_{p,\text{full}}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,\text{full}}^{(L)}$.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *pdcch-candidateReductions-Format0B-4A-4B-AL3-5* for a UE specific search space of the third, fourth, and fifth aggregation level in EPDCCH-PRB-set p for the LAA SCell, the corresponding number of EPDCCH candidates for DCI format 0B/4A/4B is given by $M_p^{(L)} = \text{round}(a \times M_{p,\text{full}}^{(L)})$, where the value of a is determined according to Table 9.1.1-3 and $M_{p,\text{full}}^{(L)}$ is determined according to Tables 9.1.4-1a to 9.1.4-5b by replacing $M_p^{(L)}$ with $M_{p,\text{full}}^{(L)}$.

If a UE is configured with higher layer parameter *cif-InSchedulingCell-r13*, the carrier indicator field value corresponds to *cif-InSchedulingCell-r13*, otherwise the carrier indicator field value is the same as *ServCellIndex* given in [11].

If a UE is configured with a LAA SCell for UL transmissions, and if the UE is configured with higher layer parameter *cif-InSchedulingCell-r14* for the LAS SCell, the carrier indicator field value in EPDCCH scheduling PUSCH

corresponds to *cif-InSchedulingCell-r14*, otherwise, the carrier indicator field value is the same as *ServCellIndex* given in [11].

A UE is not expected to monitor an EPDCCH candidate, if an ECCE corresponding to that EPDCCH candidate is mapped to a PRB pair that overlaps in frequency with a transmission of either PBCH or primary or secondary synchronization signals in the same subframe.

If a UE is configured with two EPDCCH-PRB-sets with the same $n_{ID,i}^{\text{EPDCCH}}$ value (where $n_{ID,i}^{\text{EPDCCH}}$ is defined in Subclause 6.10.3A.1 in [3]), if the UE receives an EPDCCH candidate with a given DCI payload size corresponding to one of the EPDCCH-PRB-sets and mapped only to a given set of REs (as described in Subclause 6.8A.5 in [3]), and if the UE is also configured to monitor an EPDCCH candidate with the same DCI payload size and corresponding to the other EPDCCH-PRB-set and which is mapped only to the same set of REs, and if the number of the first ECCE of the received EPDCCH candidate is used for determining PUCCH resource for HARQ-ACK transmission (as described in Subclause 10.1.2 and Subclause 10.1.3), the number of the first ECCE shall be determined based on EPDCCH-PRB-set $p = 0$.

The variable $Y_{p,k}$ is defined by

$$Y_{p,k} = (A_p \cdot Y_{p,k-1}) \bmod D$$

where $Y_{p,-1} = n_{\text{RNTI}} \neq 0$, $A_0 = 39827$, $A_1 = 39829$, $D = 65537$ and $k = \lfloor n_s / 2 \rfloor$, n_s is the slot number within a radio frame. The RNTI value used for n_{RNTI} is defined in Subclause 7.1 in downlink and Subclause 8 in uplink. The DCI formats that the UE shall monitor depend on the configured transmission mode per each serving cell as defined in Subclause 7.1.

If a UE is configured with higher layer parameter *skipMonitoringDCI-format0-1A* for a serving cell, the UE is not required to monitor the EPDCCH with DCI Format 0/1A in the UE specific search space for that serving cell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *skipMonitoringDCI-format0A* for the LAA SCell, the UE is not required to monitor the EPDCCH with DCI Format 0A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *skipMonitoringDCI-format4A* for the LAA SCell, the UE is not required to monitor the EPDCCH with DCI Format 4A in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured with higher layer parameter *enableMonitoringDCI-format0B* for the LAA SCell, the UE is required to monitor the EPDCCH with DCI Format 0B in the UE specific search space for the LAA SCell.

If a UE is configured with a LAA SCell for UL transmissions and if the UE is configured in transmission mode 2 and if the UE is configured with higher layer parameter *enableMonitoringDCI-format4B* for the LAA SCell, the UE is required to monitor the EPDCCH with DCI Format 4B in the UE specific search space for the LAA SCell.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- the UE monitors EPDCCH UE-specific search space candidates on the Scell assuming they start in both the first slot and the second slot of a subframe.

The aggregation levels defining the search spaces and the number of monitored EPDCCH candidates is given as follows

- For a UE configured with only one EPDCCH-PRB-set for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-1a, Table 9.1.4-1b.
- For a UE configured with only one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-2a, Table 9.1.4-2b.
- For a UE configured with two EPDCCH-PRB-sets for distributed transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-3a, 9.1.4-3b.

- For a UE configured with two EPDCCH-PRB-sets for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-4a, 9.4.4-4b.
- For a UE configured with one EPDCCH-PRB-set for distributed transmission, and one EPDCCH-PRB-set for localized transmission, the aggregation levels defining the search spaces and the number of monitored EPDCCH candidates are listed in Table 9.1.4-5a, 9.1.4-5b.

If the UE is not configured with a carrier indicator field for the serving cell on which EPDCCH is monitored,

$\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell on which EPDCCH is monitored. If the UE is configured with a carrier indicator field for the serving cell on which EPDCCH is monitored, $\hat{N}_{\text{RB}}^{\text{DL}} = N_{\text{RB}}^{\text{DL}}$ of the serving cell indicated by n_{CI} .

For Tables 9.1.4-1a, 9.1.4-1b, 9.1.4-2a, 9.1.4-2b, 9.1.4-3a, 9.1.4-3b, 9.1.4-4a, 9.4.4-4b, 9.1.4-5a, 9.1.4-5b

- Case 1 applies
 - for normal subframes and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\text{RB}}^{\text{DL}} \geq 25$, or
 - for frame structure type 3, for downlink subframes with PDSCH transmissions starting in the second slot,
 - for special subframes with special subframe configuration 3,4,8 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 3,4,8 for frame structure type 3, and normal downlink CP when DCI formats 2/2A/2B/2C/2D are monitored and $\hat{N}_{\text{RB}}^{\text{DL}} \geq 25$, or
 - for normal subframes and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, and when $n_{\text{EPDCCH}} < 104$ (n_{EPDCCH} defined in Subclause 6.8A.1 in [3]), or
 - for special subframes with special subframe configuration 3, 4, 8 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 3,4,8 for frame structure type 3, and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, and when $n_{\text{EPDCCH}} < 104$ (n_{EPDCCH} defined in Subclause 6.8A.1 in [3]);
- Case 2 applies
 - for normal subframes and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored or,
 - for special subframes with special subframe configuration 1, 2, 6, 7, 9, 10 for frame structure type 2 or the subframes with the same duration as the DwPTS duration of a special subframe configuration 1, 2, 6, 7, 9, 10 for frame structure type 3, and normal downlink CP when DCI formats 1A/1B/1D/1/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored, or
 - for special subframes with special subframe configuration 1,2,3,5,6 and extended downlink CP when DCI formats 1A/1B/1D/1/2A/2B/2C/2D/0/0A/0B/4/4A/4B/5/6-0A/6-0B/6-1A/6-1B are monitored;
- otherwise
 - Case 3 is applied.

$N_{\text{RB}}^{X_p}$ is the number of PRB-pairs constituting EPDCCH-PRB-set p .

**Table 9.1.4-1a: EPDCCH candidates monitored by a UE
(One Distributed EPDCCH-PRB-set - Case1, Case 2)**

| $N_{\text{RB}}^{X_p}$ | Number of EPDCCH candidates $M_p^{(L)}$ for Case 1 | | | | | Number of EPDCCH candidates $M_p^{(L)}$ for Case 2 | | | | |
|-----------------------|---|-----|-----|------|------|---|-----|-----|-----|------|
| | L=2 | L=4 | L=8 | L=16 | L=32 | L=1 | L=2 | L=4 | L=8 | L=16 |
| | 2 | 4 | 2 | 1 | 0 | 0 | 4 | 2 | 1 | 0 |
| 4 | 8 | 4 | 2 | 1 | 0 | 8 | 4 | 2 | 1 | 0 |
| 8 | 6 | 4 | 3 | 2 | 1 | 6 | 4 | 3 | 2 | 1 |

**Table 9.1.4-1b: EPDCCH candidates monitored by a UE
(One Distributed EPDCCH-PRB-set – Case 3)**

| $N_{\text{RB}}^{X_p}$ | Number of EPDCCH candidates $M_p^{(L)}$ for Case 3 | | | | |
|-----------------------|---|-----|-----|-----|------|
| | L=1 | L=2 | L=4 | L=8 | L=16 |
| | 2 | 8 | 4 | 2 | 1 |
| 4 | 4 | 5 | 4 | 2 | 1 |
| 8 | 4 | 4 | 4 | 2 | 2 |

**Table 9.1.4-2a: EPDCCH candidates monitored by a UE
(One Localized EPDCCH-PRB-set - Case1, Case 2)**

| $N_{\text{RB}}^{X_p}$ | Number of EPDCCH candidates $M_p^{(L)}$ for Case 1 | | | | | Number of EPDCCH candidates $M_p^{(L)}$ for Case 2 | | | |
|-----------------------|---|-----|-----|------|------|---|-----|-----|-----|
| | L=2 | L=4 | L=8 | L=16 | L=32 | L=1 | L=2 | L=4 | L=8 |
| | 2 | 4 | 2 | 1 | 0 | 4 | 2 | 1 | 0 |
| 4 | 8 | 4 | 2 | 1 | 0 | 8 | 4 | 2 | 1 |
| 8 | 6 | 6 | 2 | 2 | 0 | 6 | 6 | 2 | 2 |

**Table 9.1.4-2b: EPDCCH candidates monitored by a UE
(One Localized EPDCCH-PRB-set – Case 3)**

| $N_{\text{RB}}^{X_p}$ | Number of EPDCCH candidates $M_p^{(L)}$ for Case 3 | | | |
|-----------------------|---|-----|-----|-----|
| | L=1 | L=2 | L=4 | L=8 |
| | 2 | 8 | 4 | 2 |
| 4 | 6 | 6 | 2 | 2 |
| 8 | 6 | 6 | 2 | 2 |

**Table 9.1.4-3a: EPDCCH candidates monitored by a UE
(Two Distributed EPDCCH-PRB-sets - Case1, Case 2)**

| $N_{\text{RB}}^{X_{p_1}}$ | $N_{\text{RB}}^{X_{p_2}}$ | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 1 | | | | | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 2 | | | | |
|---------------------------|---------------------------|--|-----|-----|------|------|--|-----|-----|-----|------|
| | | L=2 | L=4 | L=8 | L=16 | L=32 | L=1 | L=2 | L=4 | L=8 | L=16 |
| | | 2 | 4,4 | 2,2 | 1,1 | 0,0 | 0,0 | 4,4 | 2,2 | 1,1 | 0,0 |
| 4 | 4 | 3,3 | 3,3 | 1,1 | 1,1 | 0,0 | 3,3 | 3,3 | 1,1 | 1,1 | 0,0 |
| 8 | 8 | 3,3 | 2,2 | 1,1 | 1,1 | 1,1 | 3,3 | 2,2 | 1,1 | 1,1 | 1,1 |
| 4 | 2 | 5,3 | 3,2 | 1,1 | 1,0 | 0,0 | 5,3 | 3,2 | 1,1 | 1,0 | 0,0 |
| 8 | 2 | 4,2 | 4,2 | 1,1 | 1,0 | 1,0 | 4,2 | 4,2 | 1,1 | 1,0 | 1,0 |
| 8 | 4 | 3,3 | 2,2 | 2,1 | 1,1 | 1,0 | 3,3 | 2,2 | 2,1 | 1,1 | 1,0 |

**Table 9.1.4-3b: EPDCCH candidates monitored by a UE
(Two Distributed EPDCCH-PRB-sets – Case 3)**

| $N_{\text{RB}}^{Xp_1}$ | $N_{\text{RB}}^{Xp_2}$ | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 3 | | | | |
|------------------------|------------------------|--|-----|-----|-----|------|
| | | L=1 | L=2 | L=4 | L=8 | L=16 |
| 2 | 2 | 2,2 | 3,3 | 2,2 | 1,1 | 0,0 |
| 4 | 4 | 2,2 | 2,2 | 2,2 | 1,1 | 1,1 |
| 8 | 8 | 2,2 | 2,2 | 2,2 | 1,1 | 1,1 |
| 4 | 2 | 3,1 | 3,2 | 3,1 | 1,1 | 1,0 |
| 8 | 2 | 3,1 | 4,1 | 3,1 | 1,1 | 1,0 |
| 8 | 4 | 2,2 | 2,2 | 2,2 | 1,1 | 1,1 |

**Table 9.1.4-4a: EPDCCH candidates monitored by a UE
(Two Localized EPDCCH-PRB-sets - Case1, Case 2)**

| $N_{\text{RB}}^{Xp_1}$ | $N_{\text{RB}}^{Xp_2}$ | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 1 | | | | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 2 | | | |
|------------------------|------------------------|--|-----|-----|------|--|-----|-----|-----|
| | | L=2 | L=4 | L=8 | L=16 | L=1 | L=2 | L=4 | L=8 |
| 2 | 2 | 4,4 | 2,2 | 1,1 | 0,0 | 4,4 | 2,2 | 1,1 | 0,0 |
| 4 | 4 | 3,3 | 3,3 | 1,1 | 1,1 | 3,3 | 3,3 | 1,1 | 1,1 |
| 8 | 8 | 3,3 | 3,3 | 1,1 | 1,1 | 3,3 | 3,3 | 1,1 | 1,1 |
| 4 | 2 | 4,3 | 4,2 | 1,1 | 1,0 | 4,3 | 4,2 | 1,1 | 1,0 |
| 8 | 2 | 5,2 | 4,2 | 1,1 | 1,0 | 5,2 | 4,2 | 1,1 | 1,0 |
| 8 | 4 | 3,3 | 3,3 | 1,1 | 1,1 | 3,3 | 3,3 | 1,1 | 1,1 |

**Table 9.1.4-4b: EPDCCH candidates monitored by a UE
(Two Localized EPDCCH-PRB-sets – Case 3)**

| $N_{\text{RB}}^{Xp_1}$ | $N_{\text{RB}}^{Xp_2}$ | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 3 | | | |
|------------------------|------------------------|--|-----|-----|-----|
| | | L=1 | L=2 | L=4 | L=8 |
| 2 | 2 | 3,3 | 3,3 | 1,1 | 1,1 |
| 4 | 4 | 3,3 | 3,3 | 1,1 | 1,1 |
| 8 | 8 | 3,3 | 3,3 | 1,1 | 1,1 |
| 4 | 2 | 4,2 | 4,2 | 1,1 | 1,1 |
| 8 | 2 | 4,2 | 4,2 | 1,1 | 1,1 |
| 8 | 4 | 3,3 | 3,3 | 1,1 | 1,1 |

Table 9.1.4-5a: EPDCCH candidates monitored by a UE (NOTE)

| $N_{\text{RB}}^{Xp_1}$ | $N_{\text{RB}}^{Xp_2}$ | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 1 | | | | | Number of EPDCCH candidates $[M_{p_1}^{(L)}, M_{p_2}^{(L)}]$ for Case 2 | | | | |
|------------------------|------------------------|--|-----|-----|------|------|--|-----|-----|-----|------|
| | | L=2 | L=4 | L=8 | L=16 | L=32 | L=1 | L=2 | L=4 | L=8 | L=16 |
| 2 | 2 | 4,4 | 2,2 | 1,1 | 0,0 | 0,0 | 4,4 | 2,2 | 1,1 | 0,0 | 0,0 |
| 4 | 4 | 4,2 | 4,3 | 0,2 | 0,1 | 0,0 | 4,2 | 4,3 | 0,2 | 0,1 | 0,0 |
| 8 | 8 | 4,1 | 4,2 | 0,2 | 0,2 | 0,1 | 4,1 | 4,2 | 0,2 | 0,2 | 0,1 |
| 2 | 4 | 4,3 | 2,4 | 0,2 | 0,1 | 0,0 | 4,3 | 2,4 | 0,2 | 0,1 | 0,0 |
| 2 | 8 | 4,1 | 2,2 | 0,4 | 0,2 | 0,1 | 4,1 | 2,2 | 0,4 | 0,2 | 0,1 |
| 4 | 2 | 5,2 | 4,2 | 1,1 | 1,0 | 0,0 | 5,2 | 4,2 | 1,1 | 1,0 | 0,0 |
| 4 | 8 | 4,1 | 4,2 | 0,2 | 0,2 | 0,1 | 4,1 | 4,2 | 0,2 | 0,2 | 0,1 |
| 8 | 2 | 5,1 | 4,2 | 2,1 | 1,0 | 0,0 | 5,1 | 4,2 | 2,1 | 1,0 | 0,0 |
| 8 | 4 | 6,1 | 4,2 | 0,2 | 0,1 | 0,0 | 6,1 | 4,2 | 0,2 | 0,1 | 0,0 |

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set, - Case1, Case 2;
 p_1 is the identity of the localized EPDCCH-PRB-set,
 p_2 is the identity of the distributed EPDCCH-PRB-set

Table 9.1.4-5b: EPDCCH candidates monitored by a UE (NOTE)

| $N_{\text{RB}}^{Xp_1}$ | $N_{\text{RB}}^{Xp_2}$ | Number of EPDCCH candidates $[M_{p1}^{(L)}, M_{p2}^{(L)}]$ for Case 3 | | | | |
|------------------------|------------------------|--|-----|-----|-----|------|
| | | L=1 | L=2 | L=4 | L=8 | L=16 |
| 2 | 2 | 4,1 | 4,2 | 2,2 | 0,1 | 0,0 |
| 4 | 4 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |
| 8 | 8 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |
| 2 | 4 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |
| 2 | 8 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |
| 4 | 2 | 4,1 | 4,1 | 2,2 | 1,1 | 0,0 |
| 4 | 8 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |
| 8 | 2 | 4,1 | 4,1 | 4,1 | 0,1 | 0,0 |
| 8 | 4 | 4,1 | 4,1 | 2,2 | 0,1 | 0,1 |

NOTE: One localized EPDCCH-PRB-set and one distributed EPDCCH-PRB-set - Case 3);
 p_1 is the identity of the localized EPDCCH-PRB-set,
 p_2 is the identity of the distributed EPDCCH-PRB-set)

If the UE is not configured with a carrier indicator field, then the UE shall monitor one EPDCCH UE-specific search space at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on each activated serving cell for which it is configured to monitor EPDCCH.

If a UE is configured for EPDCCH monitoring, and if the UE is configured with a carrier indicator field, then the UE shall monitor one or more EPDCCH UE-specific search spaces at each of the aggregation levels given by Tables 9.1.4-1a to 9.1.4-5b on one or more activated serving cells as configured by higher layer signalling.

A UE configured with the carrier indicator field associated with monitoring EPDCCH on serving cell c shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by C-RNTI in the EPDCCH UE specific search space of serving cell c .

A UE configured with the carrier indicator field associated with monitoring EPDCCH on the primary cell shall monitor EPDCCH configured with carrier indicator field and with CRC scrambled by SPS C-RNTI or UL-SPS-V-RNTI in the EPDCCH UE specific search space of the primary cell.

A UE is not expected to be configured to monitor EPDCCH with carrier indicator field in an LAA Scell

A UE is not expected to be scheduled with PDSCH starting in the second slot in a subframe in an LAA Scell if the UE is configured to monitor EPDCCH with carrier indicator field corresponding to that LAA Scell in another serving cell

For the serving cell on which EPDCCH is monitored, if the UE is not configured with a carrier indicator field, it shall monitor the EPDCCH UE specific search space for EPDCCH without carrier indicator field, if the UE is configured with a carrier indicator field it shall monitor the EPDCCH UE specific search space for EPDCCH with carrier indicator field.

A UE is not expected to monitor the EPDCCH of a secondary cell if it is configured to monitor EPDCCH with carrier indicator field corresponding to that secondary cell in another serving cell. For the serving cell on which EPDCCH is monitored, the UE shall monitor EPDCCH candidates at least for the same serving cell.

A UE configured to monitor EPDCCH candidates in a given serving cell with a given DCI format size with CIF, and CRC scrambled by C- RNTI, where the EPDCCH candidates may have one or more possible values of CIF for the given DCI format size, shall assume that an EPDCCH candidate with the given DCI format size may be transmitted in the given serving cell in any EPDCCH UE specific search space corresponding to any of the possible values of CIF for the given DCI format size.

For the serving cell on which EPDCCH is monitored, a UE is not required to monitor the EPDCCH in a subframe which is configured by higher layers to be part of a positioning reference signal occasion if the positioning reference signal occasion is only configured within MBSFN subframes and the cyclic prefix length used in subframe #0 is normal cyclic prefix.

A UE may assume the same c_{init} value (described in Subclause 6.10.3A.1 of [3]) is used for antenna ports 107,108 while monitoring an EPDCCH candidate associated with either antenna port 107 or antenna port 108.

A UE may assume the same c_{init} value (described in Subclause 6.10.3A.1 of [3]) is used for antenna ports 109,110 while monitoring an EPDCCH candidate associated with either antenna port 109 or antenna port 110.

9.1.4.1 EPDCCH starting position

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9,

- if the UE is configured with a higher layer parameter *epdcch-StartSymbol-r11*,
 - o the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStat}}$ is determined from the higher layer parameter,
- otherwise
 - o the starting OFDM symbol for EPDCCH given by index $l_{\text{EPDCCHStat}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{EPDCCHStat}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, for each EPDCCH-PRB-set, the starting OFDM symbol for monitoring EPDCCH in subframe k is determined from the higher layer parameter *pdsch-Start-r11* (defined in Subclause 9.1.4.3) as follows

- if the value of the parameter *pdsch-Start-r11* belongs to {1,2,3,4},
 - o $l'_{\text{EPDCCHStat}}$ is given by the higher layer parameter *pdsch-Start-r11*
- otherwise
 - o $l'_{\text{EPDCCHStat}}$ is given by the CFI value in subframe k of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l'_{\text{EPDCCHStat}}$ is given by the CFI value+1 in subframe k of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$
- if subframe k is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* (defined in Subclause 9.1.4.3), or if subframe k is subframe 1 or 6 for frame structure type 2,
 - o $l_{\text{EPDCCHStat}} = \min(2, l'_{\text{EPDCCHStat}})$,
- otherwise
 - o $l_{\text{EPDCCHStat}} = l'_{\text{EPDCCHStat}}$.

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07'

- for monitoring EPDCCH candidates starting in the first slot of the subframe, the starting OFDM symbol for EPDCCH is given by index $l_{\text{EPDCCHStat}}$ in the first slot in a subframe;
- for monitoring EPDCCH candidates starting in the second slot of the subframe, the starting OFDM symbol for EPDCCH is given by index $l_{\text{EPDCCHStat}}$ in the second slot in a subframe;

otherwise

- the starting OFDM symbol for EPDCCH is given by index $l_{\text{EPDCCHStat}}$ in the first slot in a subframe.

9.1.4.2 Antenna ports quasi co-location for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission modes 1-9, and if the UE is configured to monitor EPDCCH,

- the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set,

- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-A as described in Subclause 7.1.10
 - the UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.
- if the UE is configured by higher layers to decode PDSCH according to quasi co-location Type-B or type C as described in Subclause 7.1.10
 - the UE may assume antenna ports 15 – 22 corresponding to the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* (defined in Subclause 9.1.4.3) and antenna ports 107-110 are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.1.4.3 Resource mapping parameters for EPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to receive PDSCH data transmissions according to transmission mode 10, and if the UE is configured to monitor EPDCCH, for each EPDCCH-PRB-set, the UE shall use the parameter set indicated by the higher layer parameter *re-MappingQCL-ConfigId-r11* for determining the EPDCCH RE mapping (defined in Subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location. The following parameters for determining EPDCCH RE mapping (as described in Subclause 6.8A.5 of [3]) and EPDCCH antenna port quasi co-location are included in the parameter set:

- *crs-PortsCount-r11*.
- *crs-FreqShift-r11*.
- *mbsfn-SubframeConfigList-r11*.
- *csi-RS-ConfigZPId-r11*.
- *pdsch-Start-r11*.
- *qcl-CSI-RS-ConfigNZPId-r11*.
- *csi-RS-ConfigZPId2-r12* if the UE is configured with CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ by the higher layer parameter *csi-SubframePatternConfig-r12* for the serving cell or the UE is configured with higher layer parameter *eMIMO-Type* for TDD serving cell.

9.1.4.4 PRB-pair indication for EPDCCH

For BL/CE UEs and USS, following is applied in the rest of this Subclause.

- $N_{\text{RB}}^{X_p}$ is used in place of N_{RB}^X .
- If $N_{\text{RB}}^{X_p} = 2+4$, PRB-pairs of the 2 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause. PRB-pairs of the 4 PRB set is the remaining 4 PRB-pairs in PRB-pairs in MPDCCH-PRB-set p . If $N_{\text{RB}}^{X_p} = 2$, PRB-pairs of the 2 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause. If $N_{\text{RB}}^{X_p} = 4$, PRB-pairs of the 4 PRB set is obtained using *resourceBlockAssignment-r11* and the procedure described in the rest of this Subclause.
- N_{RB}^{DL} is set to 6.

For a given serving cell, for each EPDCCH-PRB-pair set/MPDCCH-PRB-pair set p , the UE is configured with a higher layer parameter *resourceBlockAssignment-r11* indicating a combinatorial index r corresponding to the PRB

index $\{k_i\}_{i=0}^{N_{RB}^{X_p}-1}$, ($1 \leq k_i \leq N_{RB}^{DL}$, $k_i < k_{i+1}$) and given by equation $r = \sum_{i=0}^{N_{RB}^{X_p}-1} \binom{N_{RB}^{DL} - k_i}{N_{RB}^{X_p} - i}$, where N_{RB}^{DL} is the number of

PRB pairs associated with the downlink bandwidth, $N_{RB}^{X_p}$ is the number of PRB-pairs constituting EPDCCH-PRB-set/MPDCCH-PRB-pair set p , and is configured by the higher layer parameter *numberPRBPairs-r11*, and

$$\binom{x}{y} = \begin{cases} \binom{x}{y} & x \geq y \\ 0 & x < y \end{cases} \text{ is the extended binomial coefficient, resulting in unique label } r \in \left\{ 0, \dots, \binom{N_{RB}^{DL}}{N_{RB}^{X_p}} - 1 \right\}.$$

9.1.5 MPDCCH assignment procedure

A BL/CE UE shall monitor a set of MPDCCH candidates on one or more Narrowbands (described in Subclause 6.2.7 of [3]) as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the MPDCCHs in the set according to all the monitored DCI formats. The Narrowband in a subframe used for MPDCCH monitoring is determined as described in [3].

A UE that is not a BL/CE UE is not required to monitor MPDCCH.

A BL/CE UE can derive the configuration of one or two MPDCCH-PRB-sets for MPDCCH monitoring from higher layer signalling. The PRB-pairs corresponding to MPDCCH-PRB-set $p = 0$ are indicated by higher layers. Each MPDCCH-PRB-set consists of set of ECCEs numbered from 0 to $N'_{ECCE,p,k} - 1$ where $N'_{ECCE,p,k}$ is the number of ECCEs in MPDCCH-PRB-set p of subframe k .

The MPDCCH-PRB-set(s) can be configured by higher layers for either localized MPDCCH transmission or distributed MPDCCH transmission.

The set of MPDCCH candidates to monitor are defined in terms of MPDCCH search spaces.

The BL/CE UE shall monitor one or more of the following search spaces

- a Type0-MPDCCH common search space if configured with CEmodeA,
- a Type1-MPDCCH common search space,
- a Type1A-MPDCCH common search space,
- a Type2-MPDCCH common search space,
- a Type2A-MPDCCH common search space, and
- a MPDCCH UE-specific search space.

A BL/CE UE configured with CEModeB is not required to monitor Type0-MPDCCH common search space.

The BL/CE UE is not required to simultaneously monitor MPDCCH UE-specific search space and Type1-MPDCCH common search space.

The BL/CE UE is not required to simultaneously monitor MPDCCH UE-specific search space and Type2-MPDCCH common search space.

The BL/CE UE is not required to monitor Type1A-MPDCCH common search space or Type2A-MPDCCH common search space if the set of subframes comprising the search space include any subframes in which it monitors Type1-MPDCCH common search space or any subframes in which the UE receives PDSCH assigned by PDCCH with DCI CRC scrambled by P-RNTI.

The BL/CE UE is not required to monitor Type2A-MPDCCH common search space if the set of subframes comprising the search space include any subframes in which it monitors Type1A-MPDCCH common search space or any subframes in which the UE receives PDSCH assigned by MPDCCH with DCI CRC scrambled by SC-RNTI.

A BL/CE UE is not expected to monitor an MPDCCH candidate, if an ECCE corresponding to that MPDCCH candidate is mapped to a PRB pair that overlaps with a transmission of PDSCH scheduled previously in the same subframe.

For aggregation level $L' = 24$ or $L' = 12$ ECCEs, the number of ECCEs refers to the MPDCCH mapping to the REs of the 2+4 PRB set as defined in [3]. An MPDCCH search space $MS_k^{(L',R)}$ at aggregation level $L' \in \{1, 2, 4, 8, 16, 12, 24\}$ and repetition level $R \in \{1, 2, 4, 8, 16, 32, 64, 128, 256\}$ is defined by a set of MPDCCH candidates where each candidate is repeated in a set of R consecutive BL/CE downlink subframes starting with subframe k . For an MPDCCH-PRB-set p , the ECCEs corresponding to MPDCCH candidate m of the search space $MS_k^{(L',R)}$ are given by

$$L' \left\{ (Y_{p,k} + \left\lfloor \frac{m \cdot N'_{ECCE,p,k}}{L' \cdot M_p^{(L')}} \right\rfloor) \bmod \left\lfloor N'_{ECCE,p,k} / L' \right\rfloor \right\} + i$$

where

$$i = 0, \dots, L' - 1$$

$$m = 0, 1, \dots, M_p^{(L')} - 1,$$

$M_p^{(L')}$ is the number of MPDCCH candidates to monitor at aggregation level L' in MPDCCH-PRB-set p in each subframe in the set of R consecutive subframes.

$Y_{p,k}$ for MPDCCH UE-specific search space is determined as described in Subclause 9.1.4, and $Y_{p,k} = 0$ for Type0-MPDCCH common search space, Type1-MPDCCH common search space and Type2-MPDCCH common search space.

For $R > 1$, if subframe k is a special subframe that does not support MPDCCH according to table 6.8B.1-1 in [3], the UE shall calculate $N'_{ECCE,p,k}$ by assuming $N'_{ECCE}^{REG} = 4$ for normal cyclic prefix and $N'_{ECCE}^{REG} = 8$ for extended cyclic prefix.

A BL/CE UE is not expected to monitor MPDCCH in subframes that are not BL/CE DL subframes.

Until BL/CE UE receives higher layer configuration of MPDCCH UE-specific search space, the BL/CE UE monitors MPDCCH according to the same configuration of MPDCCH search space and Narrowband as that for MPDCCH scheduling Msg4.

The aggregation and repetition levels defining the MPDCCH search spaces and the number of monitored MPDCCH candidates are given as follows:

For MPDCCH UE-specific search space

- if the BL/CE UE is configured with $N'_{RB}^{X_p} = 2$ or $N'_{RB}^{X_p} = 4$ PRB-pairs, and $mPDCCH-NumRepetition = 1$, and
 - if the MPDCCH-PRB-set is configured for distributed transmission, the aggregation levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.4-1a and Table 9.1.4-1b, where L is substituted with L' for $L \leq 24$, and $N'_{RB}^{X_p}$ is substituted with $N'_{RB}^{X_p}$.
 - if the MPDCCH-PRB-set is configured for localized transmission, the aggregation levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.4-2a and Table 9.1.4-2b, where L is substituted with L' and $N'_{RB}^{X_p}$ is substituted with $N'_{RB}^{X_p}$.
- otherwise
 - if the UE is configured with CEModeA, and $N'_{RB}^{X_p} = 2$ or $N'_{RB}^{X_p} = 4$, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-1a

- if the UE is configured with CEModeA, and $N_{\text{RB}}^{X_p} = 2+4$, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-1b
- if the UE is configured with CEModeB, and $N_{\text{RB}}^{X_p} = 2$ or $N_{\text{RB}}^{X_p} = 4$, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-2a
- if the UE is configured with CEModeB, and $N_{\text{RB}}^{X_p} = 2+4$, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are listed in Table 9.1.5-2b

$N_{\text{RB}}^{X_p}$ is the number of PRB-pairs configured for MPDCCH UE-specific search space. When $N_{\text{RB}}^{X_p} = 2+4$, it is given by the higher layer parameter *numberPRB-Pairs-r13*, and when $N_{\text{RB}}^{X_p} = 2$ or $N_{\text{RB}}^{X_p} = 4$, it is given by the higher layer parameter *numberPRB-Pairs-r11*.

$r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{\max} with the value of higher layer parameter *mPDCH-NumRepetition*.

The PRB-pairs within a Narrowband corresponding to an MPDCCH-PRB-set are indicated by higher layers and are determined using the description given in Subclause 9.1.4.4.

If higher layer configuration *numberPRB-Pairs-r13* for MPDCCH-PRB-set p is 6, $N_{\text{RB}}^{X_p} = 2+4$, and the number of PRB-pairs in an MPDCCH-PRB-set $p = 2+4$.

If Type2-MPDCCH common search space or Type2A-MPDCCH common search space,

- PRB-pairs of the 2 PRB set in the 2+4 PRB set correspond to PRB-pairs with the largest two PRB indices in MPDCCH-PRB-set p .
- PRB-pairs of the 4 PRB set in the 2+4 PRB set correspond to PRB-pairs with the smallest 4 PRB indices in MPDCCH-PRB-set p .
- PRB-pairs of the 2+4 PRB set in the 2+4 PRB set correspond to all PRB-pairs in MPDCCH-PRB-set p

**Table 9.1.5-1a: MPDCCH candidates monitored by a BL/CE UE
(CEModeA, MPDCCH-PRB-set size – 2PRBs or 4PRBs)**

| $N_{\text{RB}}^{X_p}$ | \mathbf{R} | $M_p^{(L')}$ | | | | |
|-----------------------|--------------|--------------|--------|--------|---------|---------|
| | | $L'=2$ | $L'=4$ | $L'=8$ | $L'=16$ | $L'=24$ |
| 2 | $r1$ | 2 | 1 | 1 | 0 | 0 |
| 4 | | 1 | 1 | 1 | 1 | 0 |
| 2 | $r2$ | 2 | 1 | 1 | 0 | 0 |
| 4 | | 1 | 1 | 1 | 1 | 0 |
| 2 | $r3$ | 2 | 1 | 1 | 0 | 0 |
| 4 | | 1 | 1 | 1 | 1 | 0 |
| 2 | $r4$ | 2 | 1 | 1 | 0 | 0 |
| 4 | | 1 | 1 | 1 | 1 | 0 |

**Table 9.1.5-1b: MPDCCH candidates monitored by a BL/CE UE
(CEModeA, MPDCCH-PRB-set size – 2+4PRBs)**

| MPDCCH PRB set | R | $M_p^{(L')}$ | | | | |
|------------------------------|----|--------------|------|------|-------|-------|
| | | L'=2 | L'=4 | L'=8 | L'=16 | L'=24 |
| 2 PRB set in 2+4 PRB set | r1 | 1 | 1 | 0 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 2 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r2 | 0 | 1 | 1 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 2 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r3 | 0 | 0 | 0 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 1 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r4 | 0 | 0 | 0 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 0 | 0 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |

**Table 9.1.5-2a: MPDCCH candidates monitored by a BL/CE UE
(CEModeB, MPDCCH-PRB-set size – 2PRBs or 4PRBs)**

| $N_{\text{RB}}^{X_p}$ | R | $M_p^{(L')}$ | | | | |
|-----------------------|----|--------------|------|------|-------|-------|
| | | L'=2 | L'=4 | L'=8 | L'=16 | L'=24 |
| 2 | r1 | 0 | 0 | 1 | 0 | 0 |
| 4 | | 0 | 0 | 1 | 1 | 0 |
| 2 | r2 | 0 | 0 | 1 | 0 | 0 |
| 4 | | 0 | 0 | 1 | 1 | 0 |
| 2 | r3 | 0 | 0 | 1 | 0 | 0 |
| 4 | | 0 | 0 | 1 | 1 | 0 |
| 2 | r4 | 0 | 0 | 1 | 0 | 0 |
| 4 | | 0 | 0 | 1 | 1 | 0 |

**Table 9.1.5-2b: MPDCCH candidates monitored by a BL/CE UE
(CEModeB, MPDCCH-PRB-set size – 2+4PRBs)**

| MPDCCH PRB set | R | $M_p^{(L')}$ | | | | |
|------------------------------|----|--------------|------|------|-------|-------|
| | | L'=2 | L'=4 | L'=8 | L'=16 | L'=24 |
| 2 PRB set in 2+4 PRB set | r1 | 0 | 0 | 1 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 0 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r2 | 0 | 0 | 1 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 0 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r3 | 0 | 0 | 1 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 0 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |
| 2 PRB set in 2+4 PRB set | r4 | 0 | 0 | 1 | 0 | 0 |
| 4 PRB set in 2+4 PRB set | | 0 | 0 | 0 | 1 | 0 |
| Both PRB sets in 2+4 PRB set | | 0 | 0 | 0 | 0 | 1 |

Table 9.1.5-3: Determination of repetition levels

| r_{\max} | $r1$ | $r2$ | $r3$ | $r4$ |
|------------|----------------|----------------|----------------|------------|
| 1 | 1 | - | - | - |
| 2 | 1 | 2 | - | - |
| 4 | 1 | 2 | 4 | - |
| ≥ 8 | $r_{\max} / 8$ | $r_{\max} / 4$ | $r_{\max} / 2$ | r_{\max} |

Table 9.1.5-4: Repetition levels for Type1/1A-MPDCCH common search space

| r_{\max} | $r1$ | $r2$ | $r3$ | $r4$ |
|------------|------|------|------|------|
| 256 | 2 | 16 | 64 | 256 |
| 128 | 2 | 16 | 64 | 128 |
| 64 | 2 | 8 | 32 | 64 |
| 32 | 1 | 4 | 16 | 32 |
| 16 | 1 | 4 | 8 | 16 |
| 8 | 1 | 2 | 4 | 8 |
| 4 | 1 | 2 | 4 | - |
| 2 | 1 | 2 | - | - |
| 1 | 1 | - | - | - |

For Type0-MPDCCH common search space, the narrowband location and the MPDCCH-PRB-set p are the same as for MPDCCH UE-specific search space, and

- if $N_{\text{RB}}^{X_p} = 2$,
- $M_p^{(L)} = 1$ for $L' = 8$ and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5-3. For all other cases,
 $M_p^{(L)} = 0$
- if $N_{\text{RB}}^{X_p} = 4$,
- $M_p^{(L)} = 1$ for $L' = 16$ and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5-3. For all other cases,
 $M_p^{(L)} = 0$
- if $N_{\text{RB}}^{X_p} = 2+4$,
- $M_p^{(L)} = 1$ for $L' = 24$ and repetition levels $r1, r2, r3, r4$ given in Table 9.1.5-3. For all other cases,
 $M_p^{(L)} = 0$

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{\max} with the value of higher layer parameter *mPDCCH-NumRepetition*.

For Type1-MPDCCH common search space and Type1A-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- $M_p^{(L)} = 1$ for $L' = 24$ and repetition levels $r1, r2, r3, r4$ where the repetition levels are determined from Table 9.1.5-4 by substituting the value of r_{\max}
 - with higher layer parameter *mPDCCH-NumRepetition-Paging* for Type1-MPDCCH common search space, and
 - with higher layer parameter *mpdcch-NumRepetitions-SC-MCCH* for Type1A-MPDCCH common search space.
- For all other cases, $M_p^{(L)} = 0$

For Type2-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- If the most recent coverage enhancement level used for PRACH is coverage enhancement level 0 and 1, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-1b, by assuming that the number of candidates for $L' < 8$ as zero.

- If the most recent coverage enhancement level used for PRACH is coverage enhancement level 2 and 3, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-2b.

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{max} with the value of higher layer parameter $mPDCCH-NumRepetition-RA$.

For Type2A-MPDCCH common search space, the number of PRB-pairs in MPDCCH-PRB-set p is 2+4 PRB-pairs, and

- for CEModeA, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-1b, by assuming that the number of candidates for $L' < 8$ as zero,
- for CEModeB, the aggregation and repetition levels defining the search spaces and the number of monitored MPDCCH candidates are determined from Table 9.1.5-2b,

where $r1, r2, r3, r4$ are determined from Table 9.1.5-3 by substituting the value of r_{max} with the value of higher layer parameter $mpdcch-NumRepetitions-SC-MTCH$.

In tables 9.1.5-1a, 9.1.5-1b, 9.1.5-2a, 9.1.5-2b, and for MPDCCH UE-specific search space when BL/CE UE is configured with $N_{RB}^{X_p} = 2+4$ or $mPDCCH-NumRepetition > 1$, Type0, Type1, Type1A, Type2, Type2A MPDCCH common search space, L' is applied for $N_{EREG}^{ECCE} = 4$, and L'' is applied for $N_{EREG}^{ECCE} = 8$ wherein $L'' = L'/2$ substituting the values of L' .

For Type1-MPDCCH common search space, Type1A-MPDCCH common search space, Type2-MPDCCH common search space and Type2A-MPDCCH common search space, distributed MPDCCH transmission is used.

For MPDCCH UE-specific search space, Type0-MPDCCH common search space, Type1A-MPDCCH common search space, Type2-MPDCCH common search space and Type2A-MPDCCH common search space locations of starting subframe k are given by $k = k_b$ where k_b is the b^{th} consecutive BL/CE DL subframe from subframe $k0$, and

$$b = u \cdot rj, \text{ and } u = 0, 1, \dots, \frac{r_{max}}{rj} - 1, \text{ and } j \in \{1, 2, 3, 4\}, \text{ where}$$

- subframe $k0$ is a subframe satisfying the condition $(10n_f + \lfloor n_s/2 \rfloor) \bmod T = \lfloor \alpha_{offset} \cdot T \rfloor$, where $T = r_{max} \cdot G$
 - For MPDCCH UE-specific search space, and Type0-MPDCCH common search space, G is given by the higher layer parameter $mPDCCH-startSF-UESS$,
 - For Type1A-MPDCCH common search space, G is given by the higher layer parameter $mpdcch-startSF-SC-MCCH$
 - For Type2-MPDCCH common search space, G is given by the higher layer parameter $mPDCCH-startSF-CSS-RA-r13$
 - For Type2A-MPDCCH common search space, G is given by the higher layer parameter $mpdcch-startSF-SC-MTCH$
- α_{offset} is given by higher layer parameter $mpdcch-Offset-SC-MTCH$ for Type2A-MPDCCH common search space, and $\alpha_{offset} = 0$ otherwise; and
- r_{max} is given by higher layer parameter $mPDCCH-NumRepetition$ for MPDCCH UE-specific search space and Type0-MPDCCH common search space, and $mPDCCH-NumRepetition-RA$ for Type2-MPDCCH common search space, and $mpdcch-NumRepetitions-SC-MCCH$ for Type1A-MPDCCH common search space, and $mpdcch-NumRepetitions-SC-MTCH$ for Type2A-MPDCCH common search space and
- $r1, r2, r3, r4$ are given in Table 9.1.5-3.

A BL/CE UE is not expected to be configured with values of r_{\max} and G that result in non-integer values of T .

For Type1-MPDCCH common search space, $k=k0$ and is determined from locations of paging opportunity subframes,

If *SystemInformationBlockType1-BR* or SI message is transmitted in one narrowband in subframe k , a BL/CE UE shall assume MPDCCH in the same narrowband in the subframe k is dropped.

The BL/CE UE is not required to monitor an MPDCCH search space if any ECCEs corresponding to any of its MPDCCH candidates occur within a frame before $n_f = 0$ and also occur within frame $n_f \geq 0$.

The BL/CE UE is not required to monitor an MPDCCH search space during the PUSCH transmission gap as defined in clause 5.3.4 of [3].

The BL/CE UE is not expected to be configured with overlapping MPDCCH search spaces of the same type.

A BL/CE UE configured to monitor MPDCCH candidates with CRC scrambled by C-RNTI or SPS C-RNTI with the same payload size and with the same aggregation level in the Type0-MPDCCH common search space and the MPDCCH UE-specific search space shall assume that for the MPDCCH candidates with CRC scrambled by C-RNTI or SPS C-RNTI, only the MPDCCH in the UE specific search space is transmitted.

For MPDCCH UE-specific search space or for Type0-MPDCCH common search space if the higher layer parameter *mPDCCH-NumRepetition* is set to 1; or for Type2-MPDCCH common search space if the higher layer parameter *mPDCCH-NumRepetition-RA* is set to 1; or for Type2A-MPDCCH common search space if the higher layer parameter *mpdcch-NumRepetitions-SC-MTCH* is set to 1;

- The BL/CE UE is not required to monitor MPDCCH
 - For TDD and normal downlink CP, in special subframes for the special subframe configurations 0 and 5 shown in Table 4.2-1 of [3], or for the special subframe configuration 10 configured by the higher layer signalling *ssp10-CRS-LessDwPTS*
 - For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3];

otherwise

- The BL/CE UE is not required to monitor MPDCCH
 - For TDD, in special subframes, if the BL/CE UE is configured with CEModeB
 - For TDD and normal downlink CP, in special subframes for the special subframe configurations 0, 1, 2, 5, 6, 7, 9, and 10 shown in Table 4.2-1 of [3], if the BL/CE UE is configured with CEModeA
 - For TDD and extended downlink CP, in special subframes for the special subframe configurations 0, 4 and 7 shown in Table 4.2-1 of [3], if the BL/CE UE is configured with CEModeA.
 - For TDD, in special subframes, for MPDCCH in Type1/1A-MPDCCH common search space.

The number of MPDCCH repetitions is indicated in the 'DCI subframe repetition number' field in the DCI according to the mapping in Table 9.1.5-5. For a BL/CE UE in half-duplex FDD operation, if the UE is configured with CEModeA, and configured with higher layer parameter *ce-HARQ-AckBundling*, and 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, the UE shall assume the number of MPDCCH repetitions as 1.

Table 9.1.5-5: Mapping for DCI subframe repetition number

| R | DCI subframe repetition number |
|----|--------------------------------|
| r1 | 00 |
| r2 | 01 |
| r3 | 10 |
| r4 | 11 |

9.1.5.1 MPDCCH starting position

The starting OFDM symbol for MPDCCH given by index $l_{MPDCCHStart}$ in the first slot in a subframe k and is determined as follows

- $l'_{MPDCCHStart}$ is given by the higher layer parameter *startSymbolBR*
- if subframe k is a special subframe or configured as an MBSFN subframe, and if the BL/CE UE is configured in CEModeA
- $l_{MPDCCHStart} = \min(2, l'_{MPDCCHStart})$
- else
 - $l_{MPDCCHStart} = l'_{MPDCCHStart}$.

9.1.5.2 Antenna ports quasi co-location for MPDCCH

Regardless of transmission modes configuration of PDSCH data transmissions, the BL/CE UE may assume the antenna ports 0 – 3, 107 – 110 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.1.6 SPDCCH assignment procedure

If the UE is configured with *shortTTI*, and SPDCCH is monitored in a slot, the term 'slot/subslot' refers to a slot in this clause.

If the UE is configured with *shortTTI*, and SPDCCH is monitored in a subslot, the term 'slot/subslot' refers to a subslot in this clause.

For each serving cell, higher layer signalling can configure a UE with

- one or two SPDCCH-PRB-sets for SPDCCH monitoring in a slot/subslot of a non-MBSFN subframe, and
- one or two SPDCCH-PRB-sets for SPDCCH monitoring in a slot/subslot of an MBSFN subframe.

The PRBs corresponding to a SPDCCH-PRB-set are indicated by higher layers as described in Subclause 9.1.6.2. Each SPDCCH-PRB-set consists of a set of SCCEs numbered from 0 to $N_{SCCE,p} - 1$ where $N_{SCCE,p}$ is the number of SCCEs in SPDCCH-PRB-set p in a subframe. Each SPDCCH-PRB-set can be configured for either localized SPDCCH transmission or distributed SPDCCH transmission.

The UE shall monitor a set of SPDCCH candidates on one or more activated serving cells as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the SPDCCHs in the set according to the monitored DCI formats.

A UE is not required to monitor CRS-based SPDCCH in an MBSFN subframe.

A UE is not required to monitor CRS-based SPDCCH and DMRS-based SPDCCH in a slot/subslot if the UE does not support *differentRSType*.

A UE is not expected to receive DMRS-based SPDCCH scheduling PDSCH in slots/subslots where the UE is configured with DL transmission modes 1-4, 6.

The UE is not expected to be configured to monitor SPDCCH with carrier indicator field in a given serving cell.

The UE is not expected to monitor

- SPDCCH in the first subslot of a subframe
- SPDCCH in the first slot of a subframe if higher layer parameters *dl-STTI-Length* is set to 'slot'.

For 4 port CRS-based SPDCCH, a UE is not required to receive an SREG belonging to multiple PDCCH candidates if any resource element in that SREG corresponds to different antenna ports for those multiple PDCCH candidates, where the precoding sub-matrix is described in the precoding operation from clause 6.3.4.3 of 3GPP TS 36.211 [3].

The set of SPDCCH candidates to monitor are defined in terms of SPDCCH UE-specific search spaces. An SPDCCH UE-specific search space $sS_k^{(L)}$ or slot/subslot number k at aggregation level $L \in \{1, 2, 4, 8\}$ is defined by a set of SPDCCH candidates.

For a CRS-based SPDCCH-PRB-set P or a DMRS-based SPDCCH-PRB-set P configured with localized SPDCCH transmission in slot/subslot number k , the SCCEs corresponding to SPDCCH candidate m of the search space $sS_k^{(L)}$ at aggregation level L are given by

$$\left\{ \left(Y_p^L + L \cdot \left\{ \left\lfloor \frac{m \cdot N_{SCCE,p}}{L \cdot M_{p,k}^{(L)}} \right\rfloor \bmod \left\lfloor \frac{N_{SCCE,p}}{L} \right\rfloor \right\} + i \right) \bmod N_{SCCE,p} \right\}$$

For a DMRS-based SPDCCH-PRB-set P configured with distributed SPDCCH transmission in slot/subslot number k , the SCCEs corresponding to SPDCCH candidate m of the search space $sS_{k,l}^{(L)}$ are given by

$$\left(Y_p^L + \left\lfloor \frac{m \cdot N_{SCCE,p}}{L \cdot M_{p,k}^{(L)}} \right\rfloor \right) \bmod \left\lfloor \frac{N_{SCCE,p}}{L} \right\rfloor + i \cdot \left\lfloor \frac{N_{SCCE,p}}{L} \right\rfloor$$

where

Y_p^L is determined by higher layer parameter *al-StartingPointSPDCCH*,

$i = 0, \dots, L-1$

$M_{p,k}^{(L)}$ is the number of SPDCCH candidates, determined by higher layer parameter *dci7-CandidateSetsPerAL-SPDCCH-r15*, to monitor among all the configured DCI formats for an aggregation level L in SPDCCH-PRB-set P in slot/subslot number k , $m = 0, \dots, M_{p,k}^{(L)} - 1$.

For SPDCCH-PRB-set P , and k belonging to the set of subslots indicated by higher layer parameter

subslotApplicability-r15, $M_{p,k}^{(L)}$ is given by the first value of higher layer parameter *dci7-CandidateSetsPerAL-SPDCCH-r15* corresponding to aggregation level L , otherwise, $M_{p,k}^{(L)}$ is given by the second value of higher layer parameter *dci7-CandidateSetsPerAL-SPDCCH-r15* corresponding to aggregation level L .

The UE is not required to receive DMRS-based SPDCCH on resource blocks of a PRG overlapping with PBCH or primary or secondary synchronization signals in a slot/subslot.

A UE is not expected to be configured to monitor more than

- 6 SPDCCH candidates on a service cell in a subslot if the higher layer parameter *dl-STTI-Length* is set to 'subslot'
- 12 SPDCCH candidates on a serving cell in a slot if the higher layer parameter *dl-STTI-Length* is set to 'slot'.

A UE is not expected to monitor SPDCCH candidates over more than

- 16 SCCEs on a serving cell in a subslot if the higher layer parameter *dl-STTI-Length* is set to 'subslot'
- 32 SCCEs on a serving cell in a slot if the higher layer parameter *dl-STTI-Length* is set to 'slot'

A UE is not expected to monitor more than $68 \times \text{numberOfBlindeDecodesUSS}$ DCI blind decodes on PDCCH/EPDCCH and SPDCCH UE-specific search space(s) in a subframe if the UE indicated capability *numberOfBlindeDecodesUSS*.

9.1.6.1 Resource mapping parameters for SPDCCH

For a given serving cell, if the UE is configured via higher layer signalling to monitor SPDCCH, for each SPDCCH-PRB-set, for

- CRS-based SPDCCH, the UE shall use the parameter set indicated by the higher layer parameter *sPDCCH-NoOfSymbols* to determine the SPDCCH symbols starting from the first OFDM symbol of the slot/subslot.

9.1.6.2 PRB-pair indication for SPDCCH

For a given serving cell, for each CRS-based SPDCCH-PRB set p , the UE is configured with a higher layer parameter *resourceBlockAssignment* indicating a combinatorial index r corresponding to the PRB index $\{k_i\}_{i=0}^{N_{RB}^{X_p}-1}$, ($1 \leq k_i \leq N_{RB}^{DL}, k_i < k_{i+1}$) and given by equation

$$r = \sum_{i=0}^{N_{RB}^{X_p}-1} \binom{N_{RB}^{DL} - k_i}{N_{RB}^{X_p} - i}, \text{ where } N_{RB}^{DL} \text{ is the number of PRB-pairs}$$

associated with the downlink bandwidth, $N_{RB}^{X_p}$ is the number of PRB-pairs constituting SPDCCH-PRB-set p , and is

configured by the higher layer parameter *numberRB-InFreq-domain* and $\binom{x}{y} = \begin{cases} \binom{x}{y} & x \geq y \\ 0 & x < y \end{cases}$ is the extended binomial

coefficient, resulting in unique label $r \in \left\{ 0, \dots, \binom{N_{RB}^{DL}}{N_{RB}^{X_p}} - 1 \right\}$.

For a given serving cell, for each DMRS-based SPDCCH-PRB set p , the UE is configured with a higher layer parameter *resourceBlockAssignment* indicating a combinatorial index r corresponding to the PRB indices

$2 \times \{k_i\}_{i=0}^{\frac{N_{RB}^{X_p}}{2}-1} - 1$, and $2 \times \{k_i\}_{i=0}^{\frac{N_{RB}^{X_p}}{2}-1}, (1 \leq k_i \leq \lfloor N_{RB}^{DL} / 2 \rfloor, k_i < k_{i+1})$ and given by equation

$$r = \sum_{i=0}^{\frac{N_{RB}^{X_p}}{2}} \binom{\lfloor N_{RB}^{DL} / 2 \rfloor - k_i}{N_{RB}^{X_p} / 2 - i}, \text{ where } N_{RB}^{DL} \text{ is the number of PRB-pairs associated with the downlink bandwidth, } N_{RB}^{X_p}$$

is the number of PRB-pairs constituting SPDCCH-PRB-set p , and is configured by the higher layer parameter

numberRB-InFreq-domain and $\binom{x}{y} = \begin{cases} \binom{x}{y} & x \geq y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label

$r \in \left\{ 0, \dots, \binom{\lfloor N_{RB}^{DL} / 2 \rfloor}{N_{RB}^{X_p} / 2} - 1 \right\}$.

9.1.6.3 Physical Resource Block (PRB) bundling for DMRS-based SPDCCH

For an SPDCCH-PRB-set with DMRS-based SPDCCH candidates, precoding granularity is 2 resource blocks in frequency domain. Precoding Resource block Groups (PRGs) of size 2 partition the system bandwidth and each PRG consists of consecutive PRBs. The UE is expected to receive UE-specific reference signal corresponding to a DMRS-based SPDCCH candidate over both resource blocks of a PRG. If $N_{\text{RB}}^{\text{DL}} \bmod 2 > 0$ then, no DMRS-based SPDCCH candidate is mapped to the last resource block. The UE may assume that the same precoder applies on the two PRBs within a PRG.

9.1.6.4 Antenna ports quasi co-location for DMRS-based SPDCCH

For a given serving cell, if the UE is configured to monitor DMRS-based SPDCCH in slots/subslots where the UE is configured via higher layer signalling to receive slot/subslot-PDSCH data transmissions according to transmission modes 8 and 9,

- the UE may assume the antenna ports 0 – 3, 107 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

For a given serving cell, if the UE is configured to monitor DMRS-based SPDCCH in slots/subslots where the UE is configured via higher layer signalling to receive slot/subslot-PDSCH data transmissions according to transmission modes 10, for each DMRS-based SPDCCH-PRB-set,

- if the UE is configured by higher layers to decode slot/subslot-PDSCH according to quasi co-location Type-A as described in Subclause 7.1.10
 - the UE may assume the antenna ports 0 – 3, 107 of the serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.
- if the UE is configured by higher layers to decode slot/subslot-PDSCH according to quasi co-location Type-B as described in Subclause 7.1.10
 - the UE may assume antenna ports 15 – 22 corresponding to the higher layer parameter *qcl-CSI-RS-ConfigNZPId-r11* (defined in Subclause 9.1.4.3) and antenna port 107 are quasi co-located (as defined in [3]) with respect to Doppler shift, Doppler spread, average delay, and delay spread.

9.2 PDCCH/EPDCCH/MPDCCH/SPDCCH validation for semi-persistent scheduling

A UE shall validate a Semi-Persistent Scheduling assignment PDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the PDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI or UL-SPS-V-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

A UE shall validate a Semi-Persistent Scheduling assignment EPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the EPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI or UL-SPS-V-RNTI
- the new data indicator field is set to '0'. In case of DCI formats 2, 2A, 2B, 2C and 2D, the new data indicator field refers to the one for the enabled transport block.

A UE shall validate a Semi-Persistent Scheduling assignment MPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the MPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'.

A UE shall validate a Semi-Persistent Scheduling assignment SPDCCH/PDCCH with DCI format 7-0A/7-0B /7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G only if all the following conditions are met:

- the CRC parity bits obtained for the SPDCCH/PDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'.
- the DMRS position indicator field for DCI formats 7-1F/7-1G is set to 0 in case of subslot-PDSCH.
- in case of subslot-PUSCH, the DMRS pattern field for DCI formats 7-0A/7-0B is set to,
 - '0' for the LSB if the higher layer parameter *semiPersistSchedIntervalUL* is set to 1 subslot or if the UE is configured with higher layer parameter *totalNumberPUSCH-SPS-STI-UL-Repetitions*, '00' otherwise for semi-persistent scheduling activation PDCCH /SPDCCH validation,
 - '11' for semi-persistent scheduling release PDCCH /SPDCCH validation,

If the UE is not configured with more than one uplink SPS configuration on a given serving cell, validation is achieved if all the fields for the respective used DCI format are set according to Table 9.2-1 or Table 9.2-1A, 9.2-1B, 9.2-1C; otherwise, if the UE is configured with more than one uplink SPS configurations on a given serving cell, validation is achieved if all the fields excluding the 3 least significant bits of HARQ process number field for the respective used DCI format are set according to Table 9.2-1 or Table 9.2-1A.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid semi-persistent activation or release.

- If the valid DCI format 0 is scrambled with UL-SPS-V-RNTI, the UE shall consider the received DCI information as a valid semi-persistent activation or release only for the SPS configuration indicated by the UL SPS configuration index field.
- On a given serving cell, if the UE is configured with more than one uplink SPS configurations, and if the valid DCI format 0/7-0A/7-0B is scrambled with SPS C-RNTI, the UE shall consider the received DCI information as a valid semi-persistent activation or release only for the SPS configuration indicated by the 3 least significant bits of the HARQ process number field in the DCI.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 9.2-1: Special fields for Semi-Persistent Scheduling Activation PDCCH/EPDCCH/SPDCCH Validation

| | DCI format 0 | DCI format 1/1A | DCI format 2/2A/2B/2C/2D | DCI format 7-0A/7-0B | DCI format 7-1A/1B/1C/1D/1E/1F/1G |
|--|-------------------------|--|--|----------------------|-----------------------------------|
| TPC command for scheduled PUSCH | set to '00' | N/A | N/A | set to '00' | N/A |
| Cyclic shift DM RS | set to '000' if present | N/A | N/A | set to '0' | N/A |
| Modulation and coding scheme and redundancy version | MSB is set to '0' | N/A | N/A | N/A | N/A |
| HARQ process number | N/A | FDD: set to '000' TDD: set to '0000' | FDD: set to '000' TDD: set to '0000' | set to '0000' | set to '0000' |
| Modulation and coding scheme | N/A | MSB is set to '0' for 5-bit MCS field, otherwise two MSBs are set to '0' | For the enabled transport block: MSB is set to '0' for 5-bit MCS field, otherwise two MSBs are set to '0' | - | - |
| Redundancy version | N/A | set to '00' | For the enabled transport block: set to '00' | set to '00' | set to '00' |
| TPC command for slot/subslot-PUCCH | N/A | N/A | N/A | N/A | set to '00' |
| Cyclic Shift Field mapping table for DMRS | - | N/A | N/A | set to '0' | N/A |

Table 9.2-1A: Special fields for Semi-Persistent Scheduling Release PDCCH/EPDCCH/SPDCCH Validation

| | DCI format 0 | DCI format 1A | DCI format 7-0A/7-0B | DCI format 7-1A/1B/1C/1D/1E/1F/1G |
|--|-------------------------|---|----------------------|-----------------------------------|
| TPC command for scheduled PUSCH | set to '00' | N/A | set to '00' | N/A |
| Cyclic shift DM RS | set to '000' if present | N/A | set to '0' | N/A |
| Modulation and coding scheme and redundancy version | set to '11111' | N/A | N/A | N/A |
| Resource block assignment and hopping resource allocation | Set to all '1's | N/A | N/A | N/A |
| HARQ process number | N/A | FDD: set to '000' TDD: set to '0000' | set to '0000' | set to '0000' |
| Modulation and coding scheme | N/A | set to '11111' for 5-bit MCS field, otherwise set to '111111' | set to '11111' | set to '11111' |
| Redundancy version | N/A | set to '00' | set to '00' | set to '00' |
| Resource block assignment | N/A | Set to all '1's | set to all '1's | set to all '1's |
| TPC command for slot/subslot-PUCCH | N/A | N/A | N/A | set to '00' |
| Cyclic Shift Field mapping table for DMRS | - | N/A | set to '0' | N/A |

Table 9.2-1B: Special fields for Semi-Persistent Scheduling Activation MPDCCH Validation

| | DCI format 6-0A | DCI format 6-1A |
|--|------------------------|---|
| HARQ process number | set to '000' | FDD: set to '000' TDD: set to '0000' |
| Redundancy version | set to '00' | set to '00' |
| TPC command for scheduled PUSCH | set to '00' | N/A |
| TPC command for scheduled PUCCH | N/A | set to '00' |

Table 9.2-1C: Special fields for Semi-Persistent Scheduling Release MPDCCH Validation

| | DCI format 6-0A | DCI format 6-1A |
|--|------------------------|---|
| HARQ process number | set to '000' | FDD: set to '000' TDD: set to '0000' |
| Redundancy version | set to '00' | set to '00' |
| Repetition number | set to '00' | set to '00' |
| Modulation and coding scheme | set to '1111' | set to '1111' |
| TPC command for scheduled PUSCH | set to '00' | N/A |
| Resource block assignment | Set to all '1's | Set to all '1's |

For the case that the DCI format indicates a semi-persistent downlink scheduling activation, the TPC command for PUCCH field shall be used as an index to one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 9.2-2

Table 9.2-2: PUCCH resource value for downlink semi-persistent scheduling

| Value of 'TPC command for PUCCH' | $n_{\text{PUCCH}}^{(1,p)}$ |
|---|---|
| '00' | The first PUCCH resource value configured by the higher layers |
| '01' | The second PUCCH resource value configured by the higher layers |
| '10' | The third PUCCH resource value configured by the higher layers |
| '11' | The fourth PUCCH resource value configured by the higher layers |

9.2A PDCCH/EPDCCCH validation for autonomous uplink transmissions

A UE shall validate a autonomous uplink assignment PDCCH/EPDCCCH only if all the following conditions are met:

- the CRC parity bits obtained for the PDCCH/EPDCCCH payload are scrambled with the AUL C-RNTI; and
- the 'Flag for AUL differentiation' indicates activating/releasing AUL transmission.

Validation is achieved if all the fields for the respective used DCI format are set according to Table 9.2A-1 or Table 9.2A-2.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid autonomous uplink transmission activation or release.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 9.2A-1: Special fields for Autonomous Uplink Activation PDCCH/EPDCCH Validation

| | DCI Format 0A | DCI Format 4A |
|--------------------------------------|----------------------|-------------------------|
| PUSCH trigger A | Set to '0' | N/A |
| Timing offset | Set to '0000' | Set to '0000' |
| HARQ process number | Set to '0000' | Set to '0000' |
| New data indicator | Set to '0' | Set to '0' for both CWs |
| Redundancy version | Set to '00' | Set to '00' |
| TPC for scheduled PUSCH | Set to '00' | Set to '00' |
| CSI request | All bits set to '0' | All bits set to '0' |
| SRS request | Set to '0' | Set to '00' |
| PUSCH starting position | Set to '00' | Set to '00' |
| PUSCH ending position | Set to '0' | Set to '0' |
| Channel Access type | Set to '0' | Set to '0' |
| Channel Access Priority Class | Set to '00' | Set to '00' |

Table 9.2A-2: Special fields for Autonomous Uplink Release PDCCH/EPDCCH Validation

| | DCI Format 0A | DCI Format 4A |
|---|----------------------|-----------------------------|
| PUSCH trigger A | Set to '0' | N/A |
| Timing offset | Set to '1111' | Set to '1111' |
| Resource block assignment | All bits set to '1' | All bits set to '1' |
| Modulation and coding scheme | Set to '11111' | Set to '11111' for both CWs |
| HARQ process number | Set to '0000' | Set to '0000' |
| New data indicator | Set to '0' | Set to '0' for both CWs |
| Redundancy version | Set to '00' | Set to '00' |
| TPC for scheduled PUSCH | Set to '00' | Set to '00' |
| Cyclic shift for DM RS and OCC index | Set to '000' | Set to '000' |
| CSI request | All bits set to '0' | All bits set to '0' |
| SRS request | Set to '0' | Set to '00' |
| PUSCH starting position | Set to '00' | Set to '00' |
| PUSCH ending position | Set to '0' | Set to '0' |
| Channel Access type | Set to '0' | Set to '0' |
| Channel Access Priority Class | Set to '00' | Set to '00' |

9.3 PDCCH/EPDCCH/MPDCCH/SPDCCH control information procedure

A UE shall discard the PDCCH/EPDCCH/MPDCCH/SPDCCH if consistent control information is not detected.

For a serving cell, if the UE is configured with higher layer parameter *blindSubframePDSCH-Repetitions*, the UE shall discard any PDCCH/EPDCCH for PDSCH data transmissions in subframes in which the UE is receiving PDSCH assigned by PDCCH/EPDCCH with DCI format 1A with CRC scrambled by C-RNTI in UE-specific search space.

For a serving cell, if the UE is configured with higher layer parameter *blindSlotSubslotPDSCH-Repetitions*, the UE shall discard any PDCCH/SPDCCH for PDSCH data transmissions in slots/subslots in which the UE is receiving PDSCH assigned by PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G with CRC scrambled by C-RNTI.

10 Physical uplink control channel procedures

If the UE is configured with *shortTTI*, PUCCH in this clause refers to SPUCC defined in [3] if the HARQ-ACK is sent in response to PDSCH scheduled by DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or scheduling request is sent on resources configured by higher layer parameter *sr-slotSPUCCH-IndexFH* or *sr-slotSPUCCH-IndexNoFH* or *sr-subslotSPUCCH-Resource* for slot/subslot-based transmissions, unless otherwise noted.

If the UE is not configured with *shortTTI* or the UE is configured with *shortTTI*, and UCI is to be transmitted in a subframe, the term 'subframe/slot/subslot' or 'subframe/slot' refers to a subframe in this clause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a slot, the term 'subframe/slot/subslot' or 'slot/subslot' or 'subframe/slot' refers to a slot in this clause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a subslot, the term 'subframe/slot/subslot' or 'slot/subslot' refers to a subslot in this clause.

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

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

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

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

If a UE is configured with a LAA Scell, the UE shall apply the procedures described in this clause assuming frame structure type 1 for the LAA Scell unless stated otherwise.

A UE is not expected to be configured with PUCCH on a LAA SCell.

Throughout this section,

- if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, $k_p = 3$ and $k_p = 4$ otherwise,
- if the UE is configured with higher layer parameter *shortTTI* and the corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is detected in a subslot, X_p is determined based on higher layer parameter *min-proc-TimelineSubslot* from $\{4,6,8\}$.

For a UE configured with EN-DC/NE-DC and serving cell frame structure type 1, if the UE is configured with *subframeAssignment-r15* for the serving cell, the UE shall apply the procedures described in this clause assuming FDD-TDD and primary cell frame structure type 2 with "UL/DL configuration" given by *subframeAssignment-r15*. The UE shall apply an offset value given by *harq-Offset-r15* to the subframe index in the UL/DL configuration when applying the procedures in this clause. The UE is not expected to transmit any uplink physical channel or signal in the serving cell on subframes other than the offset-UL subframes, where the offset-UL subframes are determined by applying the offset value to the subframes denoted as uplink in the UL/DL configuration. The UE is configured by higher layers to use PUCCH format 3/4/5 for transmission of HARQ-ACK. The UE shall use $N_c = 0, \forall c$ and

$N_{ECCE,q,n-k_i} = 0, \forall i 1$ (defined in Subclause 10.1.3.2.2/10.1.3.2.3/10.2.3.2.4) when applying the procedures described in Subclause 10.1.3.2.2/10.1.3.2.3/10.2.3.2.4.

10.1 UE procedure for determining physical uplink control channel assignment

If a non-BL/CE UE is configured for a single serving cell and is not configured for simultaneous PUSCH and PUCCH transmissions, then in subframe/slot/subslot n uplink control information (UCI) shall be transmitted

- on subframe-PUCCH using format 1/1a/1b/3 or 2/2a/2b if the UE is not transmitting PUSCH
- on slot-PUCCH using format 1/1a/1b/3/4 if the UE is not transmitting PUSCH and the UE is configured with higher-layer parameter *ul-STTI-Length='slot'*
- on subslot-PUCCH using format 1/1a/1b/4 if the UE is not transmitting PUSCH and the UE is configured with higher-layer parameter *ul-STTI-Length='subslot'*
- on PUSCH if the UE is transmitting PUSCH in subframe/slot/subslot n unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted
 - if the UE is semi-persistently scheduled for subframe-PUSCH transmissions of a transport block spanning consecutive PUSCH transmissions (including subframe n) corresponding to an SPS configuration with higher layer parameter *totalNumberPUSCH-SPS-UL-Repetitions*, in which case periodic CSI is not transmitted

If the UE is configured for a single serving cell and simultaneous PUSCH and PUCCH transmission, then in subframe/slot n UCI shall be transmitted

- on subframe-PUCCH using format 1/1a/1b/3 if the UCI consists only of HARQ-ACK and/or SR
- on slot-PUCCH using format 1/1a/1b/3/4 if the UCI consists only of HARQ-ACK and/or SR and the UE is configured with higher-layer parameter *ul-STTI-Length='slot'*
- on subslot-PUCCH using format 1/1a/1b/4 if the UCI consists only of HARQ-ACK and/or SR and the UE is configured with higher-layer parameter *ul-STTI-Length='subslot'*
- on PUCCH using format 2 if the UCI consists only of periodic CSI
- on PUCCH using format 2/2a/2b/3 if the UCI consists of periodic CSI and HARQ-ACK and if the UE is not transmitting PUSCH
- on PUCCH and PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and periodic/aperiodic CSI and if the UE is transmitting PUSCH in subframe/slot/subslot n , in which case the HARQ-ACK/HARQ-ACK+SR/positive SR is transmitted on subframe-PUCCH using format 1/1a/1b/3 or format 1/1a/1b/3/4 if the UE is configured with higher-layer parameter *ul-STTI-Length='slot'*, or format 1/1a/1b/4 if the UE is configured with higher-layer parameter *ul-STTI-Length='subslot'*, and the periodic/aperiodic CSI transmitted on PUSCH unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case periodic/aperiodic CSI is not transmitted
- on PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and if the UE is configured with higher-layer parameter *ul-STTI-Length='subslot'*, and if the PUSCH transmission corresponds to semi-persistent scheduling of subslot-PUSCH (i.e. higher layer parameter *sps-ConfigUL-sTTI-r15* is configured, see 3GPP TS 36.331 [9]) and with a configured periodicity of 1 subslot (i.e. *semiPersistSchedIntervalUL-STTI-r15* set to *sTTI*) and with *DMRS-pattern* field in the related DCI format equal to '10' (i.e., see Table 5.5.2.1.2-2 of 3GPP TS 36.211 [3]), in which case PUCCH is not transmitted

If the UE is configured with more than one serving cell and is not configured for simultaneous PUSCH and PUCCH transmission, then in subframe/slot/subslot n UCI shall be transmitted

- on subframe-PUCCH using format 1/1a/1b/3/4/5 or 2/2a/2b if the UE is not transmitting PUSCH
- on slot-PUCCH using format 1/1a/1b/3/4 if the UE is not transmitting PUSCH

- on subslot-PUCCH using format 1/1a/1b/4 if the UE is not transmitting PUSCH
- on PUSCH of the serving cell given in Subclause 7.2.1 if the UCI consists of aperiodic CSI or aperiodic CSI and HARQ-ACK
- on primary cell PUSCH if the UCI consists of periodic CSI and/or HARQ-ACK and if the UE is transmitting on the primary cell PUSCH in subframe n unless the primary cell PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted
- on primary cell subframe-PUSCH if the UCI consists of periodic CSI and/or HARQ-ACK and if the PUSCH in subframe n is semi-persistently scheduled as part of consecutive PUSCH transmissions of a transport block associated with an SPS configuration with higher layer parameter *totalNumberPUSCH-SPS-UL-Repetitions*, in which case periodic CSI is not transmitted.
- on PUSCH of the secondary cell (other than an LAA SCell) with smallest *SCellIndex* if the UCI consists of periodic CSI and/or HARQ-ACK and if the UE is not transmitting PUSCH on primary cell but is transmitting PUSCH on at least one secondary cell (other than an LAA SCell)

If the UE is configured with more than one serving cell and simultaneous PUSCH and PUCCH transmission, then in subframe/slot/subslot n UCI shall be transmitted

- on subframe-PUCCH using format 1/1a/1b/3 if the UCI consists only of HARQ-ACK and/or SR
- on slot-PUCCH using format 1/1a/1b/3/4 if the UCI consists only of HARQ-ACK and/or SR
- on subslot-PUCCH using format 1/1a/1b/4 if the UCI consists only of HARQ-ACK and/or SR
- on subframe-PUCCH using format 4/5 if the UCI consists only of HARQ-ACK and/or SR and/or periodic CSI
- on PUCCH using format 2 if the UCI consists only of periodic CSI corresponding to one serving cell
- as described in Subclause 10.1.1, if the UCI consists of periodic CSI and HARQ-ACK and if the UE is not transmitting on PUSCH
- on PUCCH and primary cell PUSCH if the UCI consists of HARQ-ACK and periodic CSI and the UE is transmitting PUSCH on the primary cell, in which case the HARQ-ACK is transmitted on PUCCH using format 1a/1b/3 and the periodic CSI is transmitted on PUSCH unless the primary cell PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case periodic CSI is not transmitted
- on PUCCH and PUSCH of the secondary cell (other than a LAA SCell) with the smallest *SCellIndex* if the UCI consists of HARQ-ACK and periodic CSI and if the UE is not transmitting PUSCH on primary cell but is transmitting PUSCH on at least one secondary cell, in which case, the HARQ-ACK is transmitted on subframe-PUCCH using format 1a/1b/3 and the periodic CSI is transmitted on PUSCH
- on PUCCH and PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and aperiodic CSI in which case the HARQ-ACK/HARQ-ACK+SR/positive SR is transmitted on subframe/slot-PUCCH using format 1/1a/1b/3 or on slot-PUCCH using format 1/1a/1b/3/4 or on subslot-PUCCH using format 1/1a/1b/4 and the aperiodic CSI is transmitted on PUSCH of the serving cell given in Subclause 7.2.1
- on PUSCH if the UCI consists of HARQ-ACK/HARQ-ACK+SR/positive SR and if the UE is configured with higher-layer parameter *ul-STTI-Length*=‘subslot’, and if the PUSCH transmission corresponds to semi-persistent scheduling of subslot-PUSCH (i.e. higher layer parameter *sps-ConfigUL-sTTI-r15* is configured, see 3GPP TS 36.331 [9]) and with a configured periodicity of 1 subslot (i.e. *semiPersistSchedIntervalUL-STTI-r15* set to *STTI1*) and with *DMRS-pattern* field in the related DCI format equal to ‘10’ (i.e., see Table 5.5.2.1.2-2 of 3GPP TS 36.211 [3]), in which case PUCCH is not transmitted

For a BL/CE UE, uplink control information (UCI) shall be transmitted in subframe n

- on PUCCH using PUCCH formats 1, 1a, 2, 2a for FDD and a UE configured or assumed in CEModeA if the UE is not transmitting PUSCH in subframe n , or if the UE is transmitting PUSCH in subframe n and the number of PUCCH repetitions defined for the UCI in [3] is larger than 1, or if the UE is transmitting PUSCH in subframe n and the indicated PUSCH repetition number in DCI format 6-0A/6-0B is larger than 1, or if the UE

is transmitting PUSCH in subframe n and the PUSCH resource assignment is using uplink resource allocation type 5

- on PUCCH using PUCCH formats 1, 1a, 1b, 2, 2a, 2b for TDD and a UE configured or assumed in CEModeA if the UE is not transmitting PUSCH in subframe n , or if the UE is transmitting PUSCH in subframe n and the number of PUCCH repetitions defined for the UCI in [3] is larger than 1, or if the UE is transmitting PUSCH in subframe n and the indicated PUSCH repetition number in DCI format 6-0A/6-0B is larger than 1, or if the UE is transmitting PUSCH in subframe n and the PUSCH resource assignment is using uplink resource allocation type 5
- on PUCCH formats 1, 1a for a UE configured or assumed in CEModeB
- on PUSCH if the UE is transmitting PUSCH in subframe n and the number of PUCCH repetitions defined for the UCI in [3] is equal to 1, the indicated PUSCH repetition number in DCI format 6-0A/6-0B is equal to 1 and the PUSCH resource assignment is not using uplink resource allocation type 5 unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted.

If the UE is configured with more than one serving cell, then reporting prioritization and collision handling of periodic CSI reports of a certain PUCCH reporting type is given in Subclause 7.2.2.

If a UE is not configured with simultaneous transmission of PUSCH and PUCCH, and if a subframe-PUSCH and at least two slot/subslot-PUCCHs or two slot/subslot-PUSCHs are collided within the same subframe on a given carrier, prioritization and collision handling between PUSCH and PUCCH spanning the same number of symbols (given in this clause) is first applied, followed by prioritization and collision handling of PUSCH and PUCCH spanning different number of symbols (given in this clause).

A UE transmits PUCCH only on the primary cell.

A UE is configured by higher layers to transmit PUCCH on one antenna port ($p = p_0$) or two antenna ports ($p \in [p_0, p_1]$). PUCCH format 4 and PUCCH format 5 can only be transmitted on one antenna port ($p = p_0$).

For a serving cell, and a UE configured with higher layer parameter *shortTTI*, in case of a collision between a subframe-PUCCH and slot/subslot-PUCCH in a subframe, the subframe-PUCCH transmission is dropped. If the slot/subslot-PUCCH coincides with a SR transmission instance, SR that was prepared as part of the subframe-PUCCH transmission is transmitted on the slot/subslot-PUCCH in case SR is not already prepared for the slot/subslot-PUCCH. Otherwise, the SR that was prepared as part of the subframe-PUCCH transmission is not transmitted on that slot/subslot-PUCCH. The UE shall transmit the HARQ-ACK response associated with the subframe-PUCCH using the slot/subslot-PUCCH (as defined in Subclause 7.3). The UE shall apply spatial HARQ-ACK bundling on the HARQ-ACK response associated with the subframe-PUCCH

- in case subslot-PUCCH is used
- in case slot-PUCCH is used if bundling is configured for the cell (see *spatialBundlingPUCCH* in 3GPP TS 36.331 [11]).

For a serving cell, and a UE configured with higher layer parameter *shortTTI*, the UE is not expected to transmit subframe-PUCCH in a given subframe if the UE detects PDCCH/SPDCCH with uplink DCI format 7-0A/7-0B corresponding to a slot/subslot-PUSCH transmission in the same subframe. In this case, the UE shall transmit the HARQ-ACK response associated with the subframe-PUCCH on slot/subslot-PUSCH (as defined in Subclause 7.3). The UE shall apply spatial HARQ-ACK bundling on the HARQ-ACK response associated with the subframe-PUCCH

- in case subslot-PUSCH is used
- in case slot-PUSCH is used if bundling is configured for the cell (see *spatialBundlingPUCCH* in 3GPP TS 36.331 [11]).

For a UE configured with more than one serving cell and not capable of simultaneous transmission of different uplink signal durations to different serving cells as indicated by UE capability *simultaneousTx-differentTx-duration*, in case of a collision between

- a slot-PUCCH of first serving cell and a subframe-PUSCH/PUCCH/SRS/PRACH of second serving cell or
- a subslot-PUCCH of first serving cell and a subframe/slot-PUSCH/PUCCH/SRS/PRACH of second serving cell

the uplink transmission(s) of the second serving cell are dropped.

For a UE configured with higher layer parameter *ul-STTI-Length*, and not configured with simultaneous PUSCH and PUCCH transmissions, the UE is not expected to transmit PUCCH and demodulation reference signal for PUSCH in a slot/subslot in which the UE does not transmit PUSCH.

For a serving cell, and a UE configured with higher layer parameter *ul-STTI-Length*, if the UE is configured with simultaneous PUSCH and PUCCH transmission, in case subframe-PUSCH and/or subframe-PUCCH collide(s) with slot/subslot-PUCCH, the UE is not expected to transmit either of subframe-PUSCH or subframe-PUCCH. The UE shall transmit the HARQ-ACK response corresponding to the subframe-PUSCH/PUCCH using the slot/subslot-PUCCH (as defined in Subclause 7.3).

For a serving cell, and a UE configured with higher layer parameter *ul-STTI-Length*, if the UE is configured with simultaneous PUSCH and PUCCH transmission, in case subframe-PUSCH and/or subframe-PUCCH collide(s) with slot/subslot-PUSCH and slot/subslot-PUCCH, the UE is not expected to transmit either of subframe-PUSCH or subframe-PUCCH. The UE shall transmit the HARQ-ACK response corresponding to the subframe-PUSCH/PUCCH using the slot/subslot-PUCCH (as defined in Subclause 7.3).

For FDD or FDD-TDD and primary cell frame structure 1, with two configured serving cells and PUCCH format 1b with channel selection or for FDD with one or more configured serving cells, and the higher layer parameters *dl-STTI-Length='subslot'* and *ul-STTI-Length='slot'*, and PUCCH format 3 and without PUCCH format 4 configured, or for FDD with two or more configured serving cells and PUCCH format 3 and without PUCCH format 4/5 configured,

$$n_{\text{HARQ}} = \sum_{c=0}^{N_{\text{cells}}^{\text{DL}}-1} N_c^{\text{received}} \quad \text{where } N_{\text{cells}}^{\text{DL}} \text{ is the number of configured cells and } N_c^{\text{received}} \text{ is the number of transport blocks or the SPS release PDCCH/EPDCCH/SPDCCH, if any, received in serving cell } c, \text{ and in}$$

- subframe $n-4$
- slot $n-4$
- any of the subslots given in Table 10.1-1 according to the value of X_p when the slot-PUCCH is transmitted in subframe m .

Table 10.1-1: Set of subslot numbers for n_{HARQ} calculation

| X_p | Slot number | Subslot numbers |
|-------|--------------------------|--|
| 4 | $\text{mod}(n_s, 2) = 0$ | {0,1,2} in subframe $m-1$ |
| | $\text{mod}(n_s, 2) = 1$ | {3,4,5} in subframe $m-1$ |
| 6 | $\text{mod}(n_s, 2) = 0$ | {0} in subframe $m-1$ {4,5} in subframe $m-2$ |
| | $\text{mod}(n_s, 2) = 1$ | {1,2,3} in subframe $m-1$ |
| 8 | $\text{mod}(n_s, 2) = 0$ | {2,3,4} in subframe $m-2$ |
| | $\text{mod}(n_s, 2) = 1$ | {0,1} in subframe $m-1$ {5} in subframe $m-2$ |

For TDD and a UE not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell, if a UE is configured with one serving cell, or the UE is configured with more than one serving cell and the UL/DL configurations of all serving cells are the same, then

- For TDD with two configured serving cells and PUCCH format 1b with channel selection and a subframe n with $M = 1$, or for TDD UL/DL configuration 0 and PUCCH format 3, $n_{\text{HARQ}} = \sum_{c=0}^{N_{\text{cells}}^{\text{DL}}-1} \sum_{k \in K} N_{k,c}^{\text{received}}$, where

$N_{k,c}^{\text{received}}$ is the number of transport blocks or the SPS release PDCCH/EPDCCH/SPDCCH, if any, received in subframe/slot $n-k$ in serving cell c , where $k \in K$, and M is the number of elements in K .

- For TDD UL/DL configurations 1-6 and PUCCH format 3 and without PUCCH format 4/5 configured, or for TDD with two configured serving cells and PUCCH format 1b with channel selection and $M = 2$,

$$n_{\text{HARQ}} = \sum_{c=0}^{N_{\text{cells}}^{\text{DL}}-1} \left(\left((V_{\text{DAI}, c}^{\text{DL}} - U_{\text{DAI}, c}) \bmod 4 \right) \cdot n_c^{\text{ACK}} + \sum_{k \in K} N_{k, c}^{\text{received}} \right) \text{ where } V_{\text{DAI}, c}^{\text{DL}} \text{ is the } V_{\text{DAI}}^{\text{DL}} \text{ in serving cell } c,$$

$U_{\text{DAI}, c}$ is the U_{DAI} in serving cell c , and n_c^{ACK} is the number of HARQ-ACK bits corresponding to the configured DL transmission mode on serving cell c . In case spatial HARQ-ACK bundling is applied, $n_c^{\text{ACK}} = 1$ and $N_{k, c}^{\text{received}}$ is the number of PDCCH/EPDCCH or PDSCH without a corresponding PDCCH/EPDCCH received in subframe $n-k$ and serving cell c , where $k \in K$ and M is the number of elements in K . In case spatial HARQ-ACK bundling is not applied, $N_{k, c}^{\text{received}}$ is the number of transport blocks received or the SPS release PDCCH/EPDCCH received in subframe $n-k$ in serving cell c , where $k \in K$ and M is the number of elements in K . $V_{\text{DAI}, c}^{\text{DL}} = 0$ if no transport block or SPS release PDCCH/EPDCCH is detected in subframe(s) $n-k$ in serving cell c , where $k \in K$.

- For TDD with two configured serving cells and PUCCH format 1b with channel selection and $M = 3$ or 4, $n_{\text{HARQ}} = 2$ if UE receives PDSCH or PDCCH/EPDCCH indicating downlink SPS release only on one serving cell within subframes $n-k$, where $k \in K$; otherwise $n_{\text{HARQ}} = 4$.

For TDD if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and primary cell frame structure 2, then

- For PUCCH format 3 without PUCCH format 4/5 configured, or for two configured serving cells and PUCCH format 1b with channel selection and $M \leq 2$ (defined in Subclause 10.1.3.2.1 for TDD and Subclause 10.1.3A for FDD-TDD),

$$n_{\text{HARQ}} = \sum_{c=0}^{N_{\text{cells}}^{\text{DL}}-1} \left(\left((V_{\text{DAI}, c}^{\text{DL}} - U_{\text{DAI}, c}) \bmod 4 \right) \cdot n_c^{\text{ACK}} + \sum_{k \in K} N_{k, c}^{\text{received}} \right) \text{ where } V_{\text{DAI}, c}^{\text{DL}} \text{ is the } V_{\text{DAI}}^{\text{DL}} \text{ in serving cell } c,$$

$U_{\text{DAI}, c}$ is the U_{DAI} in serving cell c , and n_c^{ACK} is the number of HARQ-ACK bits corresponding to the configured DL transmission mode on serving cell c . In case spatial HARQ-ACK bundling is applied, $n_c^{\text{ACK}} = 1$ and $N_{k, c}^{\text{received}}$ is the number of PDCCH/EPDCCH/SPDCCH or PDSCH without a corresponding PDCCH/EPDCCH/SPDCCH received in subframe/slot/subslot $n-k$ and serving cell c , where $k \in K$ and $K = K_c$ (defined in Subclause 7.3.2.2 for TDD and Subclause 7.3.4 for FDD-TDD). In case spatial HARQ-ACK bundling is not applied, $N_{k, c}^{\text{received}}$ is the number of transport blocks received or the SPS release PDCCH/EPDCCH received in subframe/slot/subslot $n-k$ in serving cell c , where $k \in K$ and $K = K_c$ (defined in Subclause 7.3.2.2 for TDD and Subclause 7.3.4 for FDD-TDD). $V_{\text{DAI}, c}^{\text{DL}} = 0$ if no transport block or SPS release PDCCH/EPDCCH/SPDCCH is detected in subframe(s) $n-k$ in serving cell c , where $k \in K$ and $K = K_c$ (defined in Subclause 7.3.2.2 for TDD and Subclause 7.3.4 for FDD-TDD). For a serving cell c , set $V_{\text{DAI}, c}^{\text{DL}} = U_{\text{DAI}, c}$ if the DL-reference UL/DL configuration (defined in Subclause 10.2) for serving cell c is TDD UL/DL configuration 0,

- For two configured serving cells and PUCCH format 1b with channel selection and $M = 3$ or 4 (defined in Subclause 10.1.3.2.1 for TDD and Subclause 10.1.3A for FDD-TDD), $n_{\text{HARQ}} = 2$ if UE receives PDSCH or PDCCH/EPDCCH indicating downlink SPS release only on one serving cell within subframes $n-k$, where $k \in K$ and $K = K_c$ (defined in Subclause 7.3.2.2 for TDD and Subclause 7.3.4 for FDD-TDD); otherwise $n_{\text{HARQ}} = 4$.

Throughout the following Subclauses, subframes are numbered in monotonically increasing order; if the last subframe of a radio frame is denoted as k , the first subframe of the next radio frame is denoted as $k+1$.

Throughout the following Subclauses for a non-BL/CE UE, if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space then for FDD or FDD-TDD primary cell frame structure type 1 $N_{\text{PUCCH}}^{(1)}$ is given by *n1PUCCH-AN-shortPT* else if the UE is configured with higher layer parameter *n1PUCCH-AN-r11* then $N_{\text{PUCCH}}^{(1)}$ is given by *n1PUCCH-AN-r11*, else $N_{\text{PUCCH}}^{(1)}$ is given by higher layer parameter *n1PUCCH-AN*.

10.1.1 PUCCH format information

Using the PUCCH formats defined in Subclause 5.4.1, 5.4.2, 5.4.2A, 5.4.2B, 5.4.2C, 5.4A.2, 5.4A.3, and 5.4A.4 in [3], the following combinations of UCI on PUCCH are supported:

- Format 1a for 1-bit HARQ-ACK or in case of FDD or FDD-TDD primary cell frame structure type 1 for 1-bit HARQ-ACK with positive SR.
- Format 1b for 2-bit HARQ-ACK or for 2-bit HARQ-ACK with positive SR.
- Format 1b for up to 4-bit HARQ-ACK with channel selection when the UE is configured with more than one serving cell or, in the case of TDD, when the UE is configured with a single serving cell.
- Format 1 for positive SR.
- Format 2 for a CSI report when not multiplexed with HARQ-ACK.
- Format 2a for a CSI report multiplexed with 1-bit HARQ-ACK for normal cyclic prefix.
- Format 2b for a CSI report multiplexed with 2-bit HARQ-ACK for normal cyclic prefix.
- Format 2 for a CSI report multiplexed with HARQ-ACK for extended cyclic prefix.
- For subframe-PUCCH, format 3 for up to 10-bit HARQ-ACK for FDD or FDD-TDD primary cell frame structure type 1 and for up to 20-bit HARQ-ACK for TDD and for up to 21 bit HARQ-ACK for FDD-TDD primary cell frame structure type 2.
- For subframe-PUCCH, format 3 for up to 11-bit corresponding to 10-bit HARQ-ACK and 1-bit positive/negative SR for FDD or FDD-TDD and for up to 21-bit corresponding to 20-bit HARQ-ACK and 1-bit positive/negative SR for TDD and for up to 22-bit corresponding to 21-bit HARQ-ACK and 1-bit positive/negative SR for FDD-TDD primary cell frame structure type 2.
- For subframe-PUCCH, format 3 for HARQ-ACK, 1-bit positive/negative SR (if any) and CSI report(s).
- For subframe-PUCCH, format 3 for up to 22 bits of UCI including HARQ-ACK, SR (if any) and periodic CSI report(s) (if any) for UE configured with Format 4 or Format 5 or for UE configured with more than 5 serving cells..
- For slot-PUCCH, Format 3 for up to 11-bits of UCI including HARQ-ACK, SR.
- For subframe-PUCCH, format 4 for more than 22 bits of UCI including HARQ-ACK, SR (if any) and periodic CSI report(s) (if any).
- For slot-PUCCH, Format 4 for more than 11 bits of UCI including HARQ-ACK, SR (if any) for UE configured with slot-PUCCH format 3
- For slot-PUCCH, Format 4 for more than 2 bits of UCI including HARQ-ACK, SR (if any) for UE not configured with slot-PUCCH format 3
- For subslot-PUCCH, Format 4 for more than 3 bits of UCI including HARQ-ACK, SR (if any)
- For subframe-PUCCH, format 5 for more than 22 bits of UCI including HARQ-ACK, SR (if any) and periodic CSI report(s) (if any).
- For subframe-PUCCH, format 4 for more than one CSI report, SR (if any) and HARQ-ACK corresponding to PDSCH transmission only on the primary cell (if any).
- For subframe-PUCCH, format 5 for more than one CSI report, SR (if any) and HARQ-ACK corresponding to PDSCH transmission only on the primary cell (if any).

For slot-PUCCH only PUCCH formats 1/1a/1b, 3, 4 are supported. For subslot-PUCCH only PUCCH formats 1/1a/1b, and 4 are supported.

For a UE configured with PUCCH format 3, not configured with PUCCH format 4/5, and for HARQ-ACK transmission on PUSCH or using PUCCH format 3, or for a UE configured with two serving cells and PUCCH format 1b with channel selection and HARQ-ACK transmission on PUSCH, or for a non BL/CE UE configured with one serving cell and PUCCH format 1b with channel selection according to Tables 10.1.3-5, 10.1.3-6, 10.1.3-7 and HARQ-ACK transmission on PUSCH or for a UE configured with PUCCH format 4/5 and HARQ-ACK transmission on PUSCH or using PUCCH format 3/4/5:

- for subframe-PDSCH, if the configured downlink transmission mode for a serving cell supports up to 2 transport blocks and only one transport block is received in a subframe, the UE shall generate a NACK for the other transport block if spatial HARQ-ACK bundling is not applied.
- if neither PDSCH nor PDCCH/EPDCCCH/SPDCCCH indicating downlink SPS release is detected in a subframe/slot/subslot for a serving cell, the UE shall generate two NACKs when the configured downlink transmission mode supports up to 2 transport blocks and the UE shall generate a single NACK when the configured downlink transmission mode supports a single transport block.

For a UE configured with PUCCH format 4/5 and with a transmission mode supporting two transport blocks in at least one serving cell, the HARQ-ACK response for subframe-PDSCH, and for a serving cell configured with a transmission mode supporting one transport block is associated with the first codeword. The UE shall generate a NACK for the second codeword if spatial bundling is not applied, and shall generate the same HARQ-ACK response for the second codeword as that for the first codeword if spatial bundling is applied.

For a BL/CE UE configured with PUCCH format 1b with channel selection according to Tables 10.1.3-5, 10.1.3-6, 10.1.3-7, if neither PDSCH nor MPDCCH indicating downlink SPS release is detected in a subframe for a serving cell, the UE shall generate a single NACK.

The scrambling initialization of PUCCH format 2, 2a, 2b, 3, 4 and 5 is by C-RNTI.

For a non-BL/CE UE that is configured with a single serving cell and is not configured with PUCCH format 3, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, the periodic CSI report is multiplexed with HARQ-ACK on PUCCH if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE*, otherwise the CSI is dropped.

A UE that is configured with PUCCH format 4/5 is not expected to be configured with different values for *simultaneousAckNackAndCQI-Format3* and *simultaneousAckNackAndCQI-Format4-Format5*.

For a BL/CE UE,

- if both *pucch-NumRepetitionCE-format1* and *pucch-NumRepetitionCE-format2* equal 1, in case of collision among two or more of a periodic CSI report, an HARQ-ACK and a SR in a same subframe without PUSCH, the UE behavior follows that of a non-BL/CE UE.
- if at least one of *pucch-NumRepetitionCE-format1* and *pucch-NumRepetitionCE-format2* is larger than 1, in case of collision among two or more of a periodic CSI report, an HARQ-ACK, and a SR in a same subframe without PUSCH, the highest priority UCI is transmitted, where the priority of HARQ-ACK is higher than SR and the priority of SR is higher than periodic CSI report.

For TDD and for a UE that is configured with a single serving cell and with PUCCH format 3, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* or if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*, the periodic CSI report is multiplexed with HARQ-ACK or dropped as described in Subclause 7.3, otherwise the CSI is dropped.

For FDD or for FDD-TDD and primary cell frame structure type 1 and for a UE that is configured with more than one serving cell and is not configured with PUCCH format 4/5, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH,

- if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* and if the HARQ-ACK corresponds to a PDSCH transmission or PDCCH/EPDCCCH indicating downlink SPS release only on the primary cell,

then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using PUCCH format 2/2a/2b

- else if the UE is configured with PUCCH format 3 and if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*, and if PUCCH resource is determined according to Subclause 10.1.2.2.2, and
 - if the total number of bits in the subframe corresponding to HARQ-ACKs, SR (if any), and the CSI is not larger than 22 or
 - if the total number of bits in the subframe corresponding to spatially bundled HARQ-ACKs, SR (if any), and the CSI is not larger than 22

then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using the determined PUCCH format 3 resource according to [4]

- otherwise,
CSI is dropped.

For FDD or for FDD-TDD and primary cell frame structure type 1, for a UE configured with PUCCH format 4 or PUCCH format 5, and if the UE has HARQ-ACK/SR and periodic CSI reports to transmit in a subframe,

- if a PUCCH format 3 is determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.3 or 10.1.2.2.4, the UE shall use the determined PUCCH format 3 for transmission of the HARQ-ACK/SR and periodic CSI report(s) if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE*; otherwise, the UE shall drop the periodic CSI report(s) and transmit only HARQ-ACK/SR;
- if a PUCCH format 4 is determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.3 or a PUCCH format 5 is determined to transmit the HARQ-ACK/SR according to 10.1.2.2.4, the UE shall use the determined PUCCH format 4 or PUCCH format 5 for transmission of the HARQ-ACK/SR and periodic CSI report(s) if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*; otherwise, the UE shall drop the periodic CSI report(s) and transmit only HARQ-ACK/SR;
- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.3 and there is no PUCCH format 3 or 5 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.4 and there are more than one periodic CSI report(s) in the subframe,
 - if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with a single PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, the PUCCH format 4 resource $n_{\text{PUCCH}}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
 - if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with a PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ according to higher layer parameter *format5-MultiCSI-resourceConfiguration*, the PUCCH format 5 resource $n_{\text{PUCCH}}^{(5)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s);
 - if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE* and if the UE is configured with two PUCCH format 4 resources $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ according to higher layer parameter *format4-MultiCSI-resourceConfiguration*, if $(O^{ACK} + O^{SR} + O_{\text{CSI}} + O_{\text{CRC}}) \leq \min(M_{\text{RB},1}^{\text{PUCCH4}}, M_{\text{RB},2}^{\text{PUCCH4}}) \cdot N_{\text{sc}}^{\text{PUCCH4}} \cdot N_{\text{symb}}^{\text{PUCCH4}} \cdot 2 \cdot r$, the PUCCH format 4 resource with the smaller $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s); otherwise, the PUCCH format 4 resource with the larger $M_{\text{RB},i}^{\text{PUCCH4}}$ between $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ is used for transmission of the HARQ-ACK/SR and periodic CSI report(s), where
 - O^{ACK} is the total number of HARQ-ACK bits in the subframe;
 - $O^{SR} = 0$ if there no scheduling request bit in the subframe and $O^{SR} = 1$ otherwise
 - O_{CSI} is the total number of CSI report bits in the subframe;
 - O_{CRC} is the number of CRC bits;

- $M_{\text{RB},i}^{\text{PUCCH4}}$, $i = 1,2$, is the number of PRBs for $n_{\text{PUCCH}_1}^{(4)}$ and $n_{\text{PUCCH}_2}^{(4)}$ respectively, according to higher layer parameter *numberOfPRB-format4-r13* according to Table 10.1.1-2;
- $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1) - 1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot (N_{\text{symb}}^{\text{UL}} - 1)$ otherwise; and
- r is the code rate given by higher layer parameter *maximumPayloadCoderate-r13* according to Table 10.1.1-1;
- otherwise, the UE shall drop the periodic CSI report(s) and transmit only HARQ-ACK/SR;
- if there is no PUCCH format 3 or 4 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.3 and there is no PUCCH format 3 or 5 determined to transmit the HARQ-ACK/SR according to Subclause 10.1.2.2.4 and there are only one periodic CSI report in the subframe,
 - if there is no positive SR and the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* and if the HARQ-ACK corresponds to a PDSCH transmission or PDCCH/EPDCCH indicating downlink SPS release only on the primary cell, then the periodic CSI report is multiplexed with HARQ-ACK on PUCCH using PUCCH format 2/2a/2b
 - else, the UE shall drop the CSI and transmit the HARQ-ACK according to Subclause 10.1.2.2.3 or 10.1.2.2.4 when UE shall transmit HARQ-ACK only or UE shall drop the CSI and transmit the HARQ-ACK and SR according to the procedure for FDD with PUCCH format 1a/1b when there is positive SR.
- If a UE transmits HARQ-ACK/SR and periodic CSI report(s) using either a PUCCH format 4 $n_{\text{PUCCH}}^{(4)}$ or PUCCH format 5 $n_{\text{PUCCH}}^{(5)}$ in a subframe
 - if $(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}}) \leq 2 \cdot N_{\text{RE}} \cdot r$, the UE shall transmit the HARQ-ACK/SR and periodic CSI bits using the PUCCH format 4 $n_{\text{PUCCH}}^{(4)}$ or the PUCCH format 5 $n_{\text{PUCCH}}^{(5)}$;
 - if $(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}}) > 2 \cdot N_{\text{RE}} \cdot r$, the UE shall select $N_{\text{CSI,reported}}$ CSI report(s) for transmission together with HARQ-ACK/SR in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$, where $\text{Pri}_{\text{CSI}}(y, s, c, t)$, N_{RE} and r are determined according to Subclause 7.2.2; the value of $N_{\text{CSI,reported}}$ satisfies $O^{ACK} + O^{SR} + \sum_{n=1}^{N_{\text{CSI,reported}}} O_{\text{P-CSI},n} + O_{\text{CRC}} \leq 2 \cdot N_{\text{RE}} \cdot r$ and $O_{\text{P-CSI},n}$ is the number of CSI report bits for the n th CSI report in ascending order of $\text{Pri}_{\text{CSI}}(y, s, c, t)$.

For a UE configured with higher layer parameter *shortTTI*, if the UE has subslot-SR and subframe-PUSCH/PUCCH including more than 2 HARQ-ACK bits either on the same serving cell or on different serving cells in a subframe when the UE is not capable of simultaneous transmission of different uplink signal durations on different serving cells as indicated by the UE capability *simultaneousTx-differentTx-duration*, and if the UE does not have HARQ-ACK bits corresponding to any subslot-PDSCH in the subslot in which the subslot-SR to be transmitted:

- if the UE is configured with a single subslot-PUCCH format 4 resource $n_{\text{SPUCCH},\text{SR}}^{(4)}$ according to the higher layer parameter *format4-MultiResource-subslotConfiguration*, the UE shall multiplex HARQ-ACK and SR bits on $n_{\text{SPUCCH},\text{SR}}^{(4)}$.
- if the UE is configured with two subslot-PUCCH format 4 resources $n_{\text{SPUCCH},\text{SR},1}^{(4)}$ and $n_{\text{SPUCCH},\text{SR},2}^{(4)}$ according to the higher layer parameter *format4-MultiResource-subslotConfiguration*, if $(O^{ACK} + O^{SR} + O_{\text{CRC}}) \leq \min(M_{\text{RB},1}^{\text{SPUCCH4}}, M_{\text{RB},2}^{\text{SPUCCH4}}) \cdot N_{\text{sc}}^{\text{RB}} \cdot 2 \cdot r$, the subslot-PUCCH format 4 resource with the smaller $M_{\text{RB},i}^{\text{SPUCCH4}}$ between $n_{\text{SPUCCH},\text{SR},1}^{(4)}$ and $n_{\text{SPUCCH},\text{SR},2}^{(4)}$ is used for transmission of the HARQ-ACK/SR; otherwise, the

subslot-PUCCH format 4 resource with the larger $M_{RB,i}^{SPUCCH4}$ between $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ is used for transmission of the HARQ-ACK/SR, where

- O^{ACK} is the total number of HARQ-ACK bits on the subframe-PUSCH/PUCCH;
- $O^{SR} = 1$
- O_{CRC} is the number of CRC bits;
- $M_{RB,i}^{SPUCCH4}$, $i = 1, 2$, is the number of PRBs for $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ respectively, according to higher layer parameter $n4numberOfPRBSsubslot$ according to Table 10.1.1-2;
- r is the code rate given by higher layer parameter $n4maxCoderateSubslotPUCCHt-r15$ according to Table 10.1.1-1;

For a UE configured with higher layer parameter *shortTTI*, if the UE has slot-SR and subframe-PUSCH/PUCCH including more than 2 HARQ-ACK bits either on the same serving cell or on different serving cells when the UE is not capable of simultaneous transmission of different uplink signal durations on different serving cells as indicated by the UE capability *simultaneousTx-differentTx-duration*, and if the UE does not have HARQ-ACK bits corresponding to any subslot/slot-PDSCH in the slot in which the slot-SR to be transmitted:

- if the UE is either not configured with a slot-PUCCH format 4 according to the higher layer parameter *format4-MultiResource-slotConfiguration*, or the number of HARQ-ACK and SR bits is smaller than or equal to 11 bits, the UE shall multiplex HARQ-ACK and SR bits on slot-PUCCH format 3 resource $n_{SPUCCH \cdot SR}^{(3)}$.
- if the UE is configured with a single PUCCH format 4 resource $n_{SPUCCH \cdot SR}^{(4)}$ according to the higher layer parameter *format4-MultiResource-slotConfiguration*, and if either the UE is not configured with a slot-PUCCH resource $n_{SPUCCH \cdot SR}^{(3)}$ or the number of HARQ-ACK and SR bits is larger than 11 bits, the UE shall multiplex HARQ-ACK and SR bits on $n_{SPUCCH \cdot SR}^{(4)}$.
- if the UE is not configured with a slot-PUCCH resource $n_{SPUCCH \cdot SR}^{(3)}$ or if the number of HARQ-ACK and SR bits is larger than 11 bits, and if the UE is configured with two slot-PUCCH format 4 resources $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ according to the higher-layer parameter *format4-MultiResource-slotConfiguration*, if $(O^{ACK} + O^{SR} + O_{CRC}) \leq \min(M_{RB,1}^{SPUCCH4}, M_{RB,2}^{SPUCCH4}) \cdot N_{sc}^{RB} \cdot N_{symb}^{SPUCCH4} \cdot 2 \cdot r$, the slot-PUCCH format 4 resource with the smaller $M_{RB,i}^{SPUCCH4}$ between $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ is used for transmission of the HARQ-ACK/SR; otherwise, the slot-PUCCH format 4 resource with the larger $M_{RB,i}^{SPUCCH4}$ between $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ is used for transmission of the HARQ-ACK/SR, where
- O^{ACK} is the total number of HARQ-ACK bits on the subframe-PUSCH/PUCCH;
- $O^{SR} = 1$
- O_{CRC} is the number of CRC bits;
- $M_{RB,i}^{SPUCCH4}$, $i = 1, 2$, is the number of PRBs for $n_{SPUCCH \cdot SR1}^{(4)}$ and $n_{SPUCCH \cdot SR2}^{(4)}$ respectively, according to higher layer parameter $n4numberOfPRB$ according to Table 10.1.1-2;
- $N_{symb}^{PUCCH4} = (N_{symb}^{UL} - 2)$ if shortened slot-PUCCH format 4 is used and $N_{symb}^{PUCCH4} = (N_{symb}^{UL} - 1)$ otherwise; and
- r is the code rate given by higher layer parameter $n4maxCoderateSlotPUCCH-r15$ according to Table 10.1.1-1;

For TDD or for FDD-TDD and primary cell frame structure type 2 and for a UE that is configured with more than one serving cell, in case of collision between a periodic CSI report and an HARQ-ACK in a same subframe without PUSCH, if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *TRUE* or if the parameter *simultaneousAckNackAndCQI-Format3-r11* provided by higher layers is set *TRUE* or if the parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* provided by higher layers is set *TRUE*, the periodic CSI report is multiplexed with HARQ-ACK or dropped as described in Subclause 7.3, otherwise the CSI is dropped.

In case of collision between a periodic CSI report and a HARQ-ACK in a same subframe with PUSCH, the periodic CSI is multiplexed with the HARQ-ACK in the PUSCH transmission in that subframe if the UE is not configured by higher layers for simultaneous PUCCH and PUSCH transmissions or if the UE is provided by higher layers a parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* that is set *FALSE*. If the UE is configured by higher layers for simultaneous PUCCH and PUSCH transmissions, and if the UE does not determine PUCCH format 4/5 for periodic CSI and HARQ-ACK transmission or if the UE is provided by higher layers a parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* that is set *FALSE*, the HARQ-ACK is transmitted in the PUCCH and the periodic CSI is transmitted in the PUSCH (other than a LAA SCell). If the UE is configured by higher layers for simultaneous PUCCH and PUSCH transmissions and if the UE determines PUCCH format 4/5 for periodic CSI and HARQ-ACK transmission and if the UE is provided by higher layers a parameter *simultaneousAckNackAndCQI-Format4-Format5-r13* that is set *TRUE*, the periodic CSI and HARQ-ACK is transmitted in PUCCH format 4/5.

In case of collision between a periodic CSI report and a HARQ-ACK in a same subframe with PUSCH and if an aperiodic CSI report is not triggered for the same subframe, and if a UE is transmitting PUSCH only on LAA SCell(s), the HARQ-ACK and periodic CSI transmission follows the procedure for the case of collision between a periodic CSI report and a HARQ-ACK in the same subframe without PUSCH.

For a BL/CE UE, in case of collision between a UCI and a PUSCH transmission in a same subframe, if the number of PUCCH repetitions defined for the UCI in [3] is larger than 1 or if the indicated PUSCH repetition number in DCI format 6-0A/6-0B is larger than 1 or if the PUSCH resource assignment is using uplink resource allocation type 5, the PUSCH transmission is dropped in that subframe.

For a BL/CE UE in half-duplex FDD operation, in case of collision between a PUCCH format 2 transmission including half-duplex guard subframe and a PDSCH reception with repetitions, the PUCCH format 2 transmission is dropped if:

- the PUCCH is transmitted starting in subframe n , and the MPDCCH scheduling the PDSCH ends in subframe k , with $n-k \geq 4$, or
- the PDSCH is semi-statically scheduled.

For a BL/CE UE, in case of collision between at least one physical resource block to be used for transmission of UCI on PUCCH (defined in [3]) and physical resource blocks corresponding to configured PRACH resources for BL/CE UEs or non-BL/CE UEs (defined in [3]) in a same subframe, the PUCCH is dropped in that subframe.

If a UE is configured with higher layer parameter *shortTTI*, the UE is not expected to transmit slot-PUCCH in UpPTS of the special subframe in frame structure type 2.

If each of the serving cells configured for the UE has frame structure type 1, UE procedures for HARQ-ACK feedback are given in Subclause 10.1.2.

If each of the serving cells configured for the UE has frame structure type 2, UE procedures for HARQ-ACK feedback are given in Subclause 10.1.3.

If the UE is configured for more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 1, UE procedure for HARQ-ACK feedback is given in Subclause 10.1.2A.

If the UE is configured for more than one serving cell, and if the frame structure type of any two configured serving cells is different, and if the primary cell is frame structure type 2, UE procedure for HARQ-ACK feedback is given in Subclause 10.1.3A.

Table 10.1.1-1: code rate r corresponding to higher layer parameter *maximumPayloadCoderate-r13* or *n4maxCoderateSlotPUCCH-r15* or *n4maxCoderateSubslotPUCCH-r15*

| Value of <i>maximumPayloadCoderate-r13</i> or <i>n4maxCoderateSlotPUCCH-r15</i> or <i>n4maxCoderateSubslotPUCCH-r15</i> | Code rate r |
|---|---------------|
| 0 | 0.08 |
| 1 | 0.15 |
| 2 | 0.25 |
| 3 | 0.35 |
| 4 | 0.45 |
| 5 | 0.60 |
| 6 | 0.80 |
| 7 | Reserved |

Table 10.1.1-2: Number of PRBs for PUCCCH format 4 $M_{\text{RB}}^{\text{PUCCCH4}}$ corresponding to higher layer parameter $\text{numberOfPRB-format4-r13}$ or $n4\text{numberOfPRBSubslot}$ or $n4\text{numberOfPRB}$

| Value of $\text{numberOfPRB-format4-r13}$ or $n4\text{numberOfPRBSubslot}$ or $n4\text{numberOfPRB}$ | $M_{\text{RB}}^{\text{PUCCCH4}}$ |
|--|----------------------------------|
| 0 | 1 |
| 1 | 2 |
| 2 | 3 |
| 3 | 4 |
| 4 | 5 |
| 5 | 6 |
| 6 | 8 |
| 7 | Reserved |

If a UE is configured with more than 5 serving cells and is configured with PUCCCH format 3 and not configured with PUCCCH format 4/5:

- The UE can assume that the total number of bits in a given
 - subframe corresponding to HARQ-ACK (if any), SR (if any), and periodic CSI (if any) is not larger than 22.
 - slot corresponding to HARQ-ACK (if any), SR (if any) is not larger than 11.
- For calculating the HARQ-ACK bits to be transmitted, the UE shall follow the procedure in subclauses 10.1.2.2.3, 10.1.2A, 10.1.3.2.3, 10.1.3A by assuming that PUCCCH format 4 is configured.

10.1.2 FDD HARQ-ACK feedback procedures

For FDD and for a UE not configured with PUCCCH format 4/5 and transmitting HARQ-ACK using PUCCCH format 1b with channel selection or PUCCCH format 3, the UE shall determine the number of HARQ-ACK bits, o , based on the number of configured serving cells and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that support up to two transport blocks; and one HARQ-ACK bit otherwise.

If a UE is configured with higher layer parameters shortTTI , $\text{codebooksizedetermination} = cc$, and $\text{codebooksizedeterminationsSTTI} = cc$ for a PUCCCH group and transmitting slot/subslot-PUCCCH, the UE shall determine the number of HARQ-ACK bits, o , based on the number of configured serving cells for subframe-PDSCH, number of configured serving cells for slot/subslot-PDSCH and the downlink transmission modes configured for each serving cell.

A UE that supports aggregating at most 2 serving cells with frame structure type 1 shall use PUCCCH format 1b with channel selection for transmission of HARQ-ACK corresponding to subframe-PDSCH when configured with more than one serving cell with frame structure type 1.

A UE that supports aggregating more than 2 serving cells with frame structure type 1 is configured by higher layers to use either PUCCCH format 1b with channel selection or PUCCCH format 3/4/5 for transmission of HARQ-ACK corresponding to subframe-PDSCH when configured with more than one serving cell with frame structure type 1.

The FDD HARQ-ACK feedback procedure for one configured serving cell is given in Subclause 10.1.2.1 and procedures for more than one configured serving cell are given in Subclause 10.1.2.2.

10.1.2.1 FDD HARQ-ACK procedure for one configured serving cell

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCCH format 1a/1b.

For FDD and one configured serving cell, the UE shall use PUCCCH resource $n_{\text{PUCCCH}}^{(1, \tilde{p})}$ for transmission of HARQ-ACK in subframe n for \tilde{p} mapped to antenna port p for PUCCCH format 1a/1b [3], where

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n - k_p$, or for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_p$, the UE shall use

$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding DCI assignment and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers. For two antenna port transmission the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.

- for a non-BL/CE UE, and for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .
- for a PDSCH transmission indicated by the detection of a corresponding EPDCCH in subframe $n-4$, or for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n-4$, the UE shall use
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE},q} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e}1)}$$
 - if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e}1)}$$

for antenna port p_0 , where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q , Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N_{\text{PUCCH},q}^{(\text{e}1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in Subclause 6.8A.5 in [3]. For two antenna port transmission the PUCCH resource for antenna port p_1 is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{ECCE},q} + 1 + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e}1)}$$
- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + 1 + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e}1)}$$
- for a BL/CE UE, and for a PDSCH on the primary cell where there is not a corresponding MPDCCH detected and subframe $n-k$ is the last subframe in which the PDSCH is transmitted, the value of $n_{\text{PUCCH}}^{(1,p_0)}$ is determined according to higher layer configuration and Table 9.2-2.
- for a PDSCH transmission indicated by the detection of a corresponding MPDCCH, or for an MPDCCH indicating downlink SPS release (defined in Subclause 9.2) where subframe $n-k$ is the last subframe in which the PDSCH is transmitted, or for HD-FDD HARQ-ACK bundling, subframe $n-k$ is the last subframe in which the PDSCH is detected, the UE shall use

- if MPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,p_0)} = n_{\text{ECCE},q} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m1)}$$

- if MPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,p_0)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m1)}$$

for antenna port p_0 , where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the MPDCCH) used for transmission of the corresponding DCI assignment in MPDCCH-PRB-set q , or for HD-FDD HARQ-ACK bundling $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the MPDCCH) in the last detected MPDCCH used for transmission of the corresponding DCI assignment in MPDCCH-PRB-set q , Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding MPDCCH as given in Table 10.1.2.1-1, $N_{\text{PUCCH},q}^{(m1)}$ for MPDCCH-PRB-set q is configured

- by the higher layer parameter $n1PUCCH-AN-r13$, if configured; otherwise:
- by the higher layer parameter $n1PUCCH-AN-InfoList-r13$ for the corresponding CE level,

$N_{\text{RB}}^{\text{ECCE},q}$ for MPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3] where the same $N_{\text{RB}}^{\text{ECCE},q}$ value is used for each subframe containing a repeat of a MPDCCH transmission, n' is determined from the antenna port used for localized MPDCCH transmission which is described in Subclause 6.8A.5 in [3]. When an MPDCCH-PRB-set p is 2+4, following procedures is applied.

- if the last detected MPDCCH is located within 2 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by above procedure.
- if the last detected MPDCCH is located within 4 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is the sum between $2N_{\text{RB}}^{\text{ECCE},q}$ and the value obtained by above procedure.
- if the last detected MPDCCH is MPDCCH format 5, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by the above procedure with $n_{\text{ECCE},q} = 0$.

Table 10.1.2.1-1: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D/6-1A/6-1B to Δ_{ARO} values

| ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D | Δ_{ARO} |
|---|-----------------------|
| 0 | 0 |
| 1 | -1 |
| 2 | -2 |
| 3 | 2 |

For slot-PUCCH, and for transmission of up to 2 HARQ-ACK bits in slot n , when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in

- slot $n-4$ or
- when scheduling request is sent in slot n on a resource configured by higher layer parameter $sr-slotSPUCCH-IndexFH$ or $sr-slotSPUCCH-IndexNoFH$,

the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in slot n for \tilde{p} mapped to antenna port p for slot-PUCCH transmission using format 1a/1b [3], where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.1-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 10.1.2.1-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

Table 10.1.2.1-2: PUCCH Resource Value for HARQ-ACK Resource for slot-PUCCH

| Value of 'SPUCCH resource indication' field as defined in section 5.3.3.1.17 of [4] | $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ or $(n_{\text{PUCCH}}^{(1,\tilde{p}_0)}, n_{\text{PUCCH}}^{(1,\tilde{p}_1)})$ |
|---|--|
| '00' | The 1 st PUCCH resource value configured by the higher layers |
| '01' | The 2 nd PUCCH resource value configured by the higher layers |
| '10' | The 3 rd PUCCH resource value configured by the higher layers |
| '11' | The 4 th PUCCH resource value configured by the higher layers |

NOTE: $(n_{\text{PUCCH}}^{(1,\tilde{p}_0)}, n_{\text{PUCCH}}^{(1,\tilde{p}_1)})$ are respectively determined from the first and second PUCCH resource lists configured by $n1\text{SlotSPUCCH-hoppingAN-List}$ in [11] for slot-PUCCH when hopping is enabled, and by $n1\text{SlotSPUCCH-nohoppingAN-List}$ in [11] for slot-PUCCH when hopping is disabled.

For subslot-PUCCH, and for transmission of up to 2 HARQ-ACK bits, in subslot n , when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subslot $n - X_p$ or a semi-persistently scheduled subslot-PDSCH transmission in subslot $n - X_p$ or for a PDCCH/SPDCCH indicating downlink SPS release in subslot $n - X_p$ or when scheduling request is sent in subslot n on a resource configured by higher layer parameter $sr\text{-subslotSPUCCH-Resource}$, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(1,p)}$ for transmission of HARQ-ACK in subslot n for \tilde{p} mapped to antenna port p for subslot-PUCCH transmission using format 1a/1b [3], where

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subslot $n - X_p$ or a semi-persistently scheduled subslot-PDSCH transmission in subslot $n - X_p$ or for a PDCCH/SPDCCH indicating downlink SPS release in subslot $n - X_p$, PUCCH resource group is determined by higher layer configuration and Table 10.1.2.1-3, and $n_{\text{PUCCH}}^{(1,p)}$ is determined according to higher layer configuration and Table 10.1.2.1-4 for PUCCH format 1a, and according to higher layer configuration and Table 10.1.2.1-5 for PUCCH format 1b.

Table 10.1.2.1-3: PUCCH Resource Group Value for HARQ-ACK Resource for PUCCH

| Value of 'SPUCCH' resource indication field' | PUCCH resource group |
|--|--|
| '00' | The 1 st PUCCH resource group value configured by the higher layers |
| '01' | The 2 nd PUCCH resource group value configured by the higher layers |
| '10' | The 3 rd PUCCH resource group value configured by the higher layers |
| '11' | The 4 th PUCCH resource group value configured by the higher layers |

Table 10.1.2.1-4: Transmission of Format 1a HARQ-ACK for subslot-PUCCH

| HARQ-ACK | $n_{PUCCH}^{(1,p)}$ |
|----------|---|
| NACK | The 1st PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |
| ACK | The 2 nd PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |

Table 10.1.2.1-5: Transmission of Format 1b HARQ-ACK for subslot-PUCCH

| HARQ-ACK(0) | HARQ-ACK(1) | $n_{PUCCH}^{(1,p)}$ |
|-------------|-------------|---|
| NACK | NACK | The 1 st PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |
| ACK | NACK | The 2 nd PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |
| NACK | ACK | The 3 rd PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |
| ACK | ACK | The 4 th PUCCH resource value configured by the higher layers for the indicated PUCCH resource group |

10.1.2.2 FDD HARQ-ACK procedures for more than one configured serving cell

The FDD HARQ-ACK feedback procedures for more than one configured serving cell are either based on a PUCCH format 1b with channel selection HARQ-ACK procedure as described in Subclause 10.1.2.2.1 or a PUCCH format 3 HARQ-ACK procedure as described in Subclause 10.1.2.2.2 or a PUCCH format 4 HARQ-ACK procedure as described in Subclause 10.1.2.2.3 or a PUCCH format 5 HARQ-ACK procedure as described in Subclause 10.1.2.2.4.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and FDD with two configured serving cells.

10.1.2.2.1 PUCCH format 1b with channel selection HARQ-ACK procedure

For two configured serving cells and PUCCH format 1b with channel selection, the UE shall transmit $b(0)b(1)$ on PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for \tilde{p} mapped to antenna port p using PUCCH format 1b where

- $n_{PUCCH}^{(1,\tilde{p}_0)} = n_{PUCCH}^{(1)}$ for antenna port p_0 where $n_{PUCCH}^{(1)}$ is selected from A PUCCH resources, $n_{PUCCH,j}^{(1)}$ where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Table 10.1.2.2.1-3, Table 10.1.2.2.1-4, Table 10.1.2.2.1-5 in subframe n . HARQ-ACK(j) denotes the ACK/NACK/DTX response for a transport block or SPS release PDCCH/EPDCCH associated with serving cell c , where the transport block and serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.2.2.1-1.
- $n_{PUCCH}^{(1,\tilde{p}_1)}$ for antenna port p_1 , where $n_{PUCCH}^{(1,\tilde{p}_1)}$ is selected from A PUCCH resources, $n_{PUCCH,j}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Table 10.1.2.2.1-3, Table 10.1.2.2.1-4, Table 10.1.2.2.1-5 by replacing $n_{PUCCH}^{(1)}$ with $n_{PUCCH}^{(1,\tilde{p}_1)}$ and replacing $n_{PUCCH,j}^{(1)}$ with $n_{PUCCH,j}^{(1,\tilde{p}_1)}$ in subframe n , when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

A UE configured with a transmission mode that supports up to two transport blocks on serving cell c , shall use the same HARQ-ACK response for both the transport blocks in response to a PDSCH transmission with a single transport block or a PDCCH/EPDCCH indicating downlink SPS release associated with the serving cell c .

Table 10.1.2.2.1-1: Mapping of Transport Block and Serving Cell to HARQ-ACK(j) for PUCCH format 1b HARQ-ACK channel selection

| A | HARQ-ACK(j) | | | |
|----------|---------------------------------|--------------------|--------------------|--------------------|
| | HARQ-ACK(0) | HARQ-ACK(1) | HARQ-ACK(2) | HARQ-ACK(3) |
| 2 | TB1 Primary cell | TB1 Secondary cell | NA | NA |
| 3 | TB1 Serving cell1 | TB2 Serving cell1 | TB1 Serving cell2 | NA |
| 4 | TB1 Primary cell | TB2 Primary cell | TB1 Secondary cell | TB2 Secondary cell |

The UE shall determine the A PUCCH resources, $n_{\text{PUCCH},j}^{(1)}$ associated with HARQ-ACK(j) where $0 \leq j \leq A-1$ in Table 10.1.2.2.1-1, according to

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n-4$ on the primary cell or in subframe $n-3$ if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space on the primary cell, or for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n-4$ on the primary cell, the PUCCH resource is $n_{\text{PUCCH},j}^{(1)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$, and for transmission mode that supports up to two transport blocks, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by $n_{\text{PUCCH},j+1}^{(1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$ where n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers.
- for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n-4$, the value of $n_{\text{PUCCH},j}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. For transmission mode that supports up to two transport blocks, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by $n_{\text{PUCCH},j+1}^{(1)} = n_{\text{PUCCH},j}^{(1)} + 1$

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n-k_p$ on the secondary cell, the value of $n_{\text{PUCCH},j}^{(1)}$, and the value of $n_{\text{PUCCH},j+1}^{(1)}$ for the transmission mode that supports up to two transport blocks is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. For a UE configured for a transmission mode that supports up to two transport blocks a PUCCH resource value in Table 10.1.2.2.1-2 maps to two PUCCH resources $(n_{\text{PUCCH},j}^{(1)}, n_{\text{PUCCH},j+1}^{(1)})$, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH},j}^{(1)}$.

- for a PDSCH transmission indicated by the detection of a corresponding EPDCCH in subframe $n-4$ on the primary cell, or for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n-4$ on the primary cell, the PUCCH resource is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},j}^{(1)} = n_{\text{ECCE},q} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},j}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{ECCE,q}} \right\rfloor \cdot N_{\text{RB}}^{ECCE,q} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q , Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-

1, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in Subclause 6.8A.5 in [3].

For transmission mode that supports up to two transport blocks, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},j+1}^{(1)} = n_{\text{ECCE},q} + 1 + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},j+1}^{(1)} = \left\lceil \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rceil \cdot N_{\text{RB}}^{\text{ECCE},q} + 1 + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

Table 10.1.2.2.1-2: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

| Value of 'TPC command for PUCCH' | $n_{\text{PUCCH},j}^{(1)}$ or $(n_{\text{PUCCH},j}^{(1)}, n_{\text{PUCCH},j+1}^{(1)})$ |
|----------------------------------|--|
| '00' | The 1 st PUCCH resource value configured by the higher layers |
| '01' | The 2 nd PUCCH resource value configured by the higher layers |
| '10' | The 3 rd PUCCH resource value configured by the higher layers |
| '11' | The 4 th PUCCH resource value configured by the higher layers |

NOTE: $(n_{\text{PUCCH},j}^{(1)}, n_{\text{PUCCH},j+1}^{(1)})$ are determined from the first and second PUCCH resource lists configured by *n1PUCCH-AN-CS-List-r10* in [11], respectively.

Table 10.1.2.2.1-3: Transmission of Format 1b HARQ-ACK channel selection for $A = 2$

| HARQ-ACK(0) | HARQ-ACK(1) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|-------------|-------------|----------------------------|------------|
| ACK | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1,1 |
| NACK/DTX | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0,0 |
| NACK | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,0 |
| DTX | NACK/DTX | No Transmission | |

Table 10.1.2.2.1-4: Transmission of Format 1b HARQ-ACK channel selection for $A = 3$

| HARQ-ACK(0) | HARQ-ACK(1) | HARQ-ACK(2) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|-------------|-------------|-------------|----------------------------|------------|
| ACK | ACK | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1,0 |
| NACK/DTX | ACK | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0,1 |
| NACK/DTX | NACK/DTX | ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1,1 |
| ACK | ACK | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1,0 |
| NACK/DTX | ACK | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,1 |
| NACK/DTX | NACK/DTX | NACK | $n_{\text{PUCCH},2}^{(1)}$ | 0,0 |
| NACK | NACK/DTX | DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,0 |
| NACK/DTX | NACK | DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,0 |
| DTX | DTX | DTX | No Transmission | |

Table 10.1.2.2.1-5: Transmission of Format 1b HARQ-ACK channel selection for $A = 4$

| HARQ-ACK(0) | HARQ-ACK(1) | HARQ-ACK(2) | HARQ-ACK(3) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|-------------|-------------|-------------|-------------|----------------------------|------------|
| ACK | ACK | ACK | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | ACK | ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0,1 |
| NACK/DTX | ACK | ACK | ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0,1 |
| NACK/DTX | NACK/DTX | ACK | ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1,1 |
| ACK | ACK | ACK | NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1,0 |
| ACK | NACK/DTX | ACK | NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0,0 |
| NACK/DTX | ACK | ACK | NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0,0 |
| NACK/DTX | NACK/DTX | ACK | NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 1,0 |
| ACK | ACK | NACK/DTX | ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | NACK/DTX | ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1,0 |
| NACK/DTX | ACK | NACK/DTX | ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0,1 |
| NACK/DTX | NACK/DTX | NACK/DTX | ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0,0 |
| ACK | ACK | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1,1 |
| ACK | NACK/DTX | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1,0 |
| NACK/DTX | ACK | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,1 |
| NACK/DTX | NACK | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,0 |
| NACK | NACK/DTX | NACK/DTX | NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0,0 |
| DTX | DTX | NACK/DTX | NACK/DTX | No Transmission | |

10.1.2.2.2 PUCCH format 3 HARQ-ACK procedure

For PUCCH format 3, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe/slot n for \tilde{p} mapped to antenna port p where

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH with DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subframe $n - k_p$, or for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - 4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding PDCCH and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.
- for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n - 4$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to

two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- for transmission of up to 2 HARQ-ACK bits in slot n , when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot/subslot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in
 - slot $n - 4$ or
 - in a subslot that is X_p subslots before slot n or
 - when scheduling request is sent in slot n on a resource configured by higher layer parameter $sr-slotSPUCCH-IndexFH$ or $sr-slotSPUCCH-IndexNoFH$,

the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.1-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 10.1.2.1-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_p$ with DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 . A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCH/EPDCCH assignments in a given subframe.
- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - 4$, or for a EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - 4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE},q} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

for antenna port p_0 , where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q ,

Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1, $N_{PUCCH,q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCH transmission which is described in Subclause 6.8A.5 in [3]. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by.

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{PUCCH}^{(1,\tilde{p}_1)} = n_{ECCE,q} + 1 + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$$

Table 10.1.2.2-1: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

| Value of 'TPC command for PUCCH' or 'HARQ-ACK resource offset' or 'SPUCCH resource indication' field | $n_{PUCCH}^{(3,\tilde{p})}$ |
|--|--|
| '00' | The 1 st PUCCH resource value configured by the higher layers |
| '01' | The 2 nd PUCCH resource value configured by the higher layers |
| '10' | The 3 rd PUCCH resource value configured by the higher layers |
| '11' | The 4 th PUCCH resource value configured by the higher layers |

- for transmission of 3-11 HARQ-ACK bits on slot-PUCCH when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot/subslot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in
 - slot $n - 4$ or
 - any of the subslots given in Table 10.1-1 according to the value of X_p when the slot-PUCCH is transmitted in subframe m or
 - - when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-slotSPUCCH-IndexFH* or *sr-slotSPUCCH-IndexNoFH*,

the UE shall use PUCCH format 3, if configured by higher layers, and PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ is determined according to higher layer configuration *n3SPUCCH-AN-List* and Table 10.1.2.2-1.

10.1.2.3 PUCCH format 4 HARQ-ACK procedure

For PUCCH format 4, the UE shall use PUCCH resource $n_{PUCCH}^{(4)}$ or $n_{PUCCH}^{(3,\tilde{p})}$ or $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe/slot/subslot n for \tilde{p} mapped to antenna port p where

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH with DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subframe $n - k_p$, or for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - 4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ with $n_{PUCCH}^{(1,\tilde{p}_0)} = n_{CCE} + N_{PUCCH}^{(1)}$ for

antenna port p_0 , where n_{CCE} is the number of the first CCE (i.e. lowest CCE index used to construct the PDCCH) used for transmission of the corresponding PDCCH and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{CCE}} + 1 + N_{\text{PUCCH}}^{(1)}$.

- for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected in subframe $n - 4$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .
- for transmission of up to 2 HARQ-ACK bits,
- in slot n for slot-PUCCH when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot/subslot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in
 - slot $n - 4$ or
 - any of the subslots given in Table 10.1-1 according to the value of X_p when the slot-PUCCH is transmitted in subframe m
 - when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-slotSPUCCH-IndexFH* or *sr-slotSPUCCH-IndexNoFH*,

the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.1-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 10.1.2.1-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- in subslot n for subslot-PUCCH when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subslot $n - X_p$ or a semi-persistently scheduled subslot-PDSCH transmission in subslot $n - X_p$ or for a PDCCH/SPDCCH indicating downlink SPS release in subslot $n - X_p$ or when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-subslotSPUCCH-Resource*, the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(1,p)}$ for transmission of HARQ-ACK in subslot n for \tilde{p} mapped to antenna port p for subslot-PUCCH transmission using format 1a/1b [3], where *PUCCH resource group* is determined by higher layer configuration and Table 10.1.2.1-3, and $n_{\text{PUCCH}}^{(1,p)}$ is determined according to higher layer configuration and Table 10.1.2.1-4 for PUCCH format 1a, and according to higher layer configuration and Table 10.1.2.1-5 for PUCCH format 1b.
- for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_p$ with DCI formats other than DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G,

- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{CSI} (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCH resource $n_{PUCCH}^{(4)}$ where the value of $n_{PUCCH}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1.

The TPC field in the DCI format of the corresponding PDCCCH/EPDCCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCCH assignments in a given subframe.

- If the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{CSI} (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ where the value of $n_{PUCCH}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1. The TPC field in the DCI format of the corresponding PDCCCH/EPDCCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ for antenna port p_0 and the second PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ for antenna port p_0 . A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in each DCI format of the corresponding secondary cell PDCCCH assignments in a given subframe.
- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCCH in subframe $n - 4$, or for a EPDCCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - 4$ on the primary cell, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ given by
 - if EPDCCCH-PRB-set q is configured for distributed transmission

$$n_{PUCCH}^{(1,\tilde{p}_0)} = n_{ECCE,q} + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$$

- if EPDCCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + n' + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$$

for antenna port p_0 , where $n_{ECCE,q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCCH) used for transmission of the corresponding DCI assignment in EPDCCCH-PRB-set q , Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCCH as given in Table 10.1.2.1-1, $N_{PUCCH,q}^{(e1)}$ for EPDCCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for localized EPDCCCH transmission which is described in Subclause 6.8A.5 in [3]. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by.

- if EPDCCCH-PRB-set q is configured for distributed transmission $n_{PUCCH}^{(1,\tilde{p}_1)} = n_{ECCE,q} + 1 + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$
- if EPDCCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + 1 + n' + \Delta_{ARO} + N_{PUCCH,q}^{(e1)}$$

Table 10.1.2.2.3-1: PUCCH Resource Value for HARQ-ACK Resource for PUCCH

| Value of 'TPC command for PUCCH' or 'HARQ-ACK resource offset' or 'SPUCCH resource indication' field | $n_{\text{PUCCH}}^{(4,\tilde{p})}$ |
|--|--|
| '00' | The 1 st PUCCH resource value configured by the higher layers |
| '01' | The 2 nd PUCCH resource value configured by the higher layers |
| '10' | The 3 rd PUCCH resource value configured by the higher layers |
| '11' | The 4 th PUCCH resource value configured by the higher layers |

- for transmission of more than 2 HARQ-ACK bits, the UE shall use PUCCH format 4, and PUCCH resource $n_{\text{PUCCH}}^{(4,p)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1,
 - for slot-PUCCH and when the UE is not configured with PUCCH format 3, and at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in
 - slot $n - 4$ or
 - any of the subslots given in Table 10.1-1 according to the value of X_p when the slot-PUCCH is transmitted in subframe m or
 - when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-slotSPUCCH-IndexFH* or *sr-slotSPUCCH-IndexNoFH*,
 - for subslot-PUCCH and when at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G in subslot $n - X_p$ or a semi-persistently scheduled slot-PDSCH transmission in subslot $n - X_p$ or for a PDCCH/SPDCCH indicating downlink SPS release in subslot $n - X_p$ or when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-subslotSPUCCH-Resource*
 - The UE is not expected to transmit PUCCH corresponding to 21 or 22 HARQ-ACK bits in a subslot if higher layer parameter *n4numberOfPRBSubslot* indicates single resource block for PUCCH transmission.
- for slot-PUCCH and for transmission of 12 or more HARQ-ACK bits, the UE shall use PUCCH format 4, and PUCCH resource $n_{\text{PUCCH}}^{(4,p)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1, when the UE is configured with PUCCH format 3, and at least one HARQ-ACK bit is sent in response to a PDSCH transmission indicated by the detection of a corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G or a semi-persistently scheduled slot-PDSCH transmission or for a PDCCH/SPDCCH indicating downlink SPS release in
 - slot $n - 4$ or
 - any of the subslots given in Table 10.1-1 according to the value of X_p when the slot-PUCCH is transmitted in subframe m or
 - when scheduling request is sent in slot n on a resource configured by higher layer parameter *sr-slotSPUCCH-IndexFH* or *sr-slotSPUCCH-IndexNoFH*.

10.1.2.2.4 PUCCH format 5 HARQ-ACK procedure

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in Subclause 10.1.2.2.3, by replacing $n_{\text{PUCCH}}^{(4)}$ with $n_{\text{PUCCH}}^{(5)}$.

10.1.2A FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 1

For a UE transmitting HARQ-ACK using PUCCH format 1b with channel selection, the UE shall determine the number of HARQ-ACK bits corresponding to subframe-PDSCH, o in subframe n , based on the number of configured serving cells with subframe $n - 4$ configured as a downlink or special subframe according to the DL-reference UL/DL configuration (defined in Subclause 10.2) of each serving cell and the downlink transmission modes configured for each serving cell. For a UE not configured with PUCCH format 4/5 and transmitting HARQ-ACK using PUCCH format 3, the UE shall determine the number of HARQ-ACK bits, o in subframe n , based on the number of configured serving cells with subframe $n - 4$ configured as a downlink or special subframe except a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP according to the DL-reference UL/DL configuration (defined in Subclause 10.2) of each serving cell and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that support up to two transport blocks; and one HARQ-ACK bit otherwise.

A UE that supports aggregating at most 2 serving cells shall use PUCCH format 1b with channel selection for transmission of HARQ-ACK corresponding to subframe-PDSCH when configured with primary cell frame structure type 1 and secondary cell frame structure type 2.

A UE that supports aggregating more than 2 serving cells with primary cell frame structure type 1 is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK corresponding to subframe-PDSCH when configured with more than one serving cell and primary cell frame structure type 1 and at least one secondary cell with frame structure type 2.

For HARQ-ACK transmission in subframe n with PUCCH format 1b with channel selection, the FDD-TDD HARQ-ACK procedure follows HARQ-ACK procedure described in Subclause 10.1.2.1 if subframe $n - k_p$ is an uplink or a special subframe of configurations 0, 5 and 10 if configured by *ssp10-CRS-LessDwPTS* with normal downlink CP or of configurations 0 and 4 with extended downlink CP for the secondary cell according to the higher layer parameter *subframeAssignment* for UE not configured with either higher layer parameter *EIMTA-MainConfigServCell-r12* or higher layer parameter *harq-ReferenceConfig-r14*, and according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* for UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and HARQ-ACK procedure described in Subclause 10.1.2.2.1 otherwise.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 3 HARQ-ACK procedure as described in Subclause 10.1.2.2.2.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 4 HARQ-ACK procedure is as described in Subclause 10.1.2.2.3.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in Subclause 10.1.2.2.4.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and with two configured serving cells.

10.1.3 TDD HARQ-ACK feedback procedures

For TDD and a UE that does not support aggregating more than one serving cell with frame structure type 2, two HARQ-ACK feedback modes are supported by higher layer configuration.

- HARQ-ACK bundling and
- HARQ-ACK multiplexing

For TDD and a BL/CE UE,

- if the UE is configured with *csi-NumRepetitionCE* equal to 1 and *mPDCCH-NumRepetition* equal to 1,
 - the UE may be configured with HARQ-ACK bundling or HARQ-ACK multiplexing;

- HARQ-ACK multiplexing can be configured only if *pucch-NumRepetitionCE-format1* equal 1 and HARQ-ACK multiplexing is performed according to the set of Tables 10.1.3-5/6/7
- else
 - the UE is not expected to receive more than one PDSCH transmission, or more than one of PDSCH and MPDCCH indicating downlink SPS releases, with transmission ending within subframe(s) $n - k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE;

For TDD UL/DL configuration 5 and a UE that does not support aggregating more than one serving cell with frame structure type 2 and the UE is not configured with *EIMTA-MainConfigServCell-r12* for the serving cell, only HARQ-ACK bundling is supported.

A UE that supports aggregating more than one serving cell with frame structure type 2 is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK corresponding to subframe-PDSCH when configured with more than one serving cell with frame structure type 2.

For subframe-PUCCH and a UE that supports aggregating more than one serving cell with frame structure type 2 and is not configured with the parameter *EIMTA-MainConfigServCell-r12* for any serving cell is configured by higher layers to use HARQ-ACK bundling, PUCCH format 1b with channel selection according to the set of Tables 10.1.3-2/3/4 or according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3 for transmission of HARQ-ACK when configured with one serving cell with frame structure type 2.

For subframe-PUCCH and a UE that is configured with the parameter *EIMTA-MainConfigServCell-r12* and configured with one serving cell is configured by higher layers to use PUCCH format 1b with channel selection according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3 for transmission of HARQ-ACK. A UE that is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and configured with more than one serving cell is configured by higher layers to use PUCCH format 1b with channel selection according to the set of Tables 10.1.3-5/6/7, or PUCCH format 3/4/5 for transmission of HARQ-ACK.

PUCCH format 1b with channel selection according to the set of Tables 10.1.3-2/3/4 or according to the set of Tables 10.1.3-5/6/7 is not supported for TDD UL/DL configuration 5.

TDD HARQ-ACK bundling is performed per codeword across M multiple subframes/slots in downlink or special subframes associated with a single UL subframe/slot n , where M is the number of elements in the set K defined in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise, by a logical AND operation of all the individual PDSCH transmission (with and without corresponding PDCCH/EPDCCH/MPDCCH/SPDCCH) HARQ-ACKs and ACK in response to PDCCH/EPDCCH/MPDCCH/SPDCCH indicating downlink SPS release. For one configured serving cell the bundled 1 or 2 HARQ-ACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

For TDD HARQ-ACK multiplexing and a subframe n with $M > 1$, where M is the number of elements in the set K defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed by a logical AND operation of all the corresponding individual HARQ-ACKs. PUCCH format 1b with channel selection is used in case of one configured serving cell. For TDD HARQ-ACK multiplexing and a subframe n with $M = 1$, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is not performed, 1 or 2 HARQ-ACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively for one configured serving cell.

In the case of TDD and more than one configured serving cell with PUCCH format 1b with channel selection and more than 4 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n , where M is defined in Subclause 10.1.3.2.1, and for the configured serving cells, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe for all configured cells is performed and the bundled HARQ-ACK bits for each configured serving cell is transmitted using PUCCH format 1b with channel selection. For TDD and more than one configured serving cell with PUCCH format 1b with channel selection and up to 4 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n , where M is defined in Subclause 10.1.3.2.1, and for the configured serving cells, spatial HARQ-ACK bundling is not performed and the HARQ-ACK bits are transmitted using PUCCH format 1b with channel selection.

In the case of TDD and more than one configured serving cell with PUCCH format 3 and without PUCCH format 4/5 configured and more than 20 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n , where M is the number of elements in the set K defined in Subclause 10.1.3.2.2 and for the configured serving cells, spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for each serving cell by a logical AND operation of all of the corresponding individual HARQ-ACKs and PUCCH format 3 is used. For TDD and more than one configured serving cell with PUCCH format 3 and up to 20 HARQ-ACK bits for M multiple downlink or special subframes associated with a single UL subframe n , where M is the number of elements in the set K defined in Subclause 10.1.3.2.2 and for the configured serving cells, spatial HARQ-ACK bundling is not performed and the HARQ-ACK bits are transmitted using PUCCH format 3.

For TDD with PUCCH format 3 without PUCCH format 4/5 configured, a UE shall determine the number of HARQ-ACK bits, O , associated with an UL subframe/slot n

according to $O = \sum_{c=1}^{N_{cells}^{DL}} O_c^{ACK}$ where N_{cells}^{DL} is the number of configured cells, and O_c^{ACK} is the number of HARQ-bits for the c -th serving cell defined in Subclause 7.3.

TDD HARQ-ACK feedback procedures for one configured serving cell are given in Subclause 10.1.3.1 and procedures for more than one configured serving cell are given in Subclause 10.1.3.2.

10.1.3.1 TDD HARQ-ACK procedure for one configured serving cell

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1a/1b with TDD HARQ-ACK bundling feedback mode and for PUCCH format 3.

A UE that supports aggregating more than one serving cell with frame structure type 2 can be configured by higher layers for HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) for PUCCH format 1b with channel selection.

The TDD HARQ-ACK procedure for a UE configured with PUCCH format 3 is as described in Subclause 10.1.3.2.2 when the UE receives PDSCH and/or SPS release PDCCH/EPDCCH only on the primary cell.

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and the UE is not configured with the higher layer parameter *shortProcessingTime*, for TDD HARQ-ACK bundling or TDD HARQ-ACK multiplexing for one configured serving cell and a subframe n with $M = 1$ where M is the number of elements in the set K defined in Table 10.1.3.1-1, the UE shall use PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for \tilde{p} mapped to antenna port p for PUCCH format 1a/1b, where

- If there is PDSCH transmission indicated by the detection of corresponding PDCCH/EPDCCH or there is PDCCH/EPDCCH indicating downlink SPS release within subframe(s) $n - k$, where $k \in K$ and K (defined in Table 10.1.3.1-1) is a set of M elements $\{k_0, k_1, \dots, k_{M-1}\}$ depending on the subframe n and the UL/DL configuration (defined in Table 4.2-2 in [3]), and if PDCCH indicating PDSCH transmission or downlink SPS release is detected in subframe $n - k_m$, where k_m is the smallest value in set K such that UE detects a PDCCH/EPDCCH indicating PDSCH transmission or downlink SPS release within subframe(s) $n - k$ and $k \in K$, the UE first selects a c value out of $\{0, 1, 2, 3\}$ which makes $N_c \leq n_{CCE} < N_{c+1}$ and shall use $n_{PUCCH}^{(1,\tilde{p}_0)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{CCE} + N_{PUCCH}^{(1)}$ for antenna port p_0 , where $N_{PUCCH}^{(1)}$ is configured by higher layers, $N_c = \max \left\{ 0, \left\lfloor [N_{RB}^{DL} \cdot (N_{sc}^{RB} \cdot c - 4)] / 36 \right\rfloor \right\}$, and n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ and the corresponding m . When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for HARQ-ACK bundling for antenna port p_1 is given by $n_{PUCCH}^{(1,\tilde{p}_1)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{CCE} + 1 + N_{PUCCH}^{(1)}$.
- For a non-BL/CE UE and if there is only a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and K is defined in Table 10.1.3.1-1, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ with the value of $n_{PUCCH}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission

for PUCCH format 1a/1b and HARQ-ACK bundling, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- If there is PDSCH transmission indicated by the detection of corresponding PDCCH/EPDCCH or there is PDCCH/EPDCCH indicating downlink SPS release within subframe(s) $n - k$, where $k \in K$ and K (defined in Table 10.1.3.1-1) is a set of M elements $\{k_0, k_1, \dots, k_{M-1}\}$ depending on the subframe n and the UL/DL configuration (defined in Table 4.2-2 in [3]), and if EPDCCH indicating PDSCH transmission or downlink SPS release is detected in subframe $n - k_m$, where k_m is the smallest value in set K such that UE detects a PDCCH/EPDCCH indicating PDSCH transmission or downlink SPS release within subframe(s) $n - k$ and $k \in K$, the UE shall use
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

for antenna port p_0 , where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$ and the corresponding m , $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i1}$. For normal downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for HARQ-ACK bundling for antenna port p_1 is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{ECCE},q} + 1 + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + 1 + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- For a BL/CE UE, if there is only a PDSCH transmission within one or more consecutive BL/CE downlink subframe(s) where subframe $n - k$, is the last subframe in which the PDSCH is transmitted where $k \in K$ and K is defined in Table 10.1.3.1-1 and there is not a corresponding MPDCCH, the UE shall use PUCCH format 1a and PUCCH resource $n_{\text{PUCCH}}^{(1,p_0)}$ where the value of $n_{\text{PUCCH}}^{(1,p_0)}$ is determined according to higher layer configuration and Table 9.2-2.
- If there is PDSCH transmission indicated by the detection of corresponding MPDCCH or there is MPDCCH indicating downlink SPS release within subframe(s) $n - k$, where $k \in K$ and K (defined in Table 10.1.3.1-1) is a set of M elements $\{k_0, k_1, \dots, k_{M-1}\}$ depending on the subframe n and the UL/DL configuration (defined in Table 4.2-2 in [3]) and subframe $n - k_m$ is the last subframe in which the PDSCH or MPDCCH indicating downlink SPS release is transmitted and there is no $k_{m'} \in K$ where $k_{m'} < k_m$ and subframe $n - k_{m'}$ is the last subframe in which a PDSCH indicated by the detection of corresponding MPDCCH or MPDCCH indicating downlink SPS release is transmitted, the UE shall use
 - if MPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,p_0)} = n_{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m1)}$$

- if MPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,p_0)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m1)}$$

for antenna port p_0 , where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the MPDCCH) used for transmission of the corresponding DCI assignment in MPDCCH-PRB-set q , $N_{\text{PUCCH},q}^{(m1)}$ for MPDCCH-PRB-set q is configured

- by the higher layer parameter $n1PUCCH-AN-r13$, if configured; otherwise:
- by the higher layer parameter $n1PUCCH-AN-InfoList-r13$ for the corresponding CE level,

$N_{\text{RB}}^{\text{ECCE},q}$ for MPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for the MPDCCH transmission which is described in Subclause 6.8A.5 in [3]. If $m=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding MPDCCH as given in Table 10.1.2.1-1. If $m>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding MPDCCH as given in Table 10.1.3.1-2. If subframe $n - k_{i_1}$ is a BL/CE downlink subframe, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs in MPDCCH-PRB-set q configured for that UE in subframe $n - k_{i_1}$. If subframe $n - k_{i_1}$ is not a BL/CE downlink subframe, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. If subframe $n - k_{i_1}$ is a BL/CE downlink special subframe in which MPDCCH is not supported, the UE shall calculate $N_{\text{ECCE},q,n-k_{i_1}}$ by assuming $N_{\text{EREG}}^{\text{ECCE}} = 4$ for normal cyclic prefix and $N_{\text{EREG}}^{\text{ECCE}} = 8$ for extended cyclic prefix. If an MPDCCH-PRB-set p is 2+4, then $N_{\text{ECCE},q,n-k_{i_1}} = 6 \cdot N_{\text{RB}}^{\text{ECCE},q}$. When an MPDCCH-PRB-set p is 2+4, following procedures is applied.

- if the detected MPDCCH is located within 2 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by above procedure.

- if the detected MPDCCH is located within 4 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is the sum between $2N_{RB}^{\text{ECCE},q}$ and the value obtained by above procedure.
- if the detected MPDCCH is MPDCCH format 5, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by the above procedure with $n_{\text{ECCE},q} = 0$.

Table 10.1.3.1-1: Downlink association set $K : \{k_0, k_1, \dots, k_{M-1}\}$ for TDD

| UL/DL Configuration | Subframe n | | | | | | | | | | |
|---------------------|--------------|---|------------------------------|--|------------|------|---|---|------------|---|---|
| | 0 | 1 | 2 | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | - | - | 6 | | - | 4 | - | - | 6 | - | 4 |
| 1 | - | - | 7, 6 | | 4 | - | - | - | 7, 6 | 4 | - |
| 2 | - | - | 8, 7, 4, 6 | | - | - | - | - | 8, 7, 4, 6 | - | - |
| 3 | - | - | 7, 6, 11 | | 6, 5 | 5, 4 | - | - | - | - | - |
| 4 | - | - | 12, 8, 7, 11 | | 6, 5, 4, 7 | - | - | - | - | - | - |
| 5 | - | - | 13, 12, 9, 8, 7, 5, 4, 11, 6 | | - | - | - | - | - | - | - |
| 6 | - | - | 7 | | 7 | 5 | - | - | 7 | 7 | - |

Table 10.1.3.1-1A: eIMTA downlink association set $K^A : \{k_0^A, k_1^A, \dots, k_{M^A-1}^A\}$ for TDD

| Higher layer parameter 'eimta-HARQ-ReferenceConfig-r12' | Higher layer parameter 'subframeAssignment' | Subframe n | | | | | | | | | | |
|---|---|--------------|---|--------------------|--|---------|---|---|---|-------|---|---|
| | | 0 | 1 | 2 | | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 2 | 0 | - | - | 7,8,4 | | - | - | - | - | 7,8,4 | - | - |
| | 1 | - | - | 8,4 | | - | - | - | - | 8,4 | - | - |
| | 6 | - | - | 6,8,4 | | - | - | - | - | 8,6,4 | - | - |
| 4 | 0 | - | - | 12,7,11,8 | | 7,4,5,6 | - | - | - | - | - | - |
| | 1 | - | - | 12,8,11 | | 7,5,6 | - | - | - | - | - | - |
| | 3 | - | - | 12,8 | | 4,7 | - | - | - | - | - | - |
| | 6 | - | - | 12,11,8 | | 4,5,6 | - | - | - | - | - | - |
| 5 | 0 | - | - | 12,7,11,13,8,4,9,5 | | - | - | - | - | - | - | - |
| | 1 | - | - | 13,12,8,11,4,9,5 | | - | - | - | - | - | - | - |
| | 2 | - | - | 13,12,9,11,5 | | - | - | - | - | - | - | - |
| | 3 | - | - | 13,12,5,4,8,9 | | - | - | - | - | - | - | - |
| | 4 | - | - | 13,5,4,6,9 | | - | - | - | - | - | - | - |
| | 6 | - | - | 13,12,11,6,8,4,9,5 | | - | - | - | - | - | - | - |

Table 10.1.3.1-1B: Downlink association set $K^A : \{k_0^A, k_1^A, \dots, k_{M^A-1}^A\}$ for TDD and UE configured with higher layer parameter *shortProcessingTime*

| UL/DL Configuration | Subframe n | | | | | | | | | |
|---------------------|--------------|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | - | - | - | 3 | 3 | - | - | - | 3 | 3 |
| 1 | - | - | 3 | 3 | - | - | - | 3 | 3 | - |
| 2 | - | - | 3 | - | - | - | - | 3 | - | - |
| 3 | - | - | 5 | 4 | 3 | - | - | - | - | - |
| 4 | - | - | 6 | 3 | - | - | - | - | - | - |
| 5 | - | - | 3 | - | - | - | - | - | - | - |
| 6 | - | - | 6 | 4 | 4 | - | - | 6 | 3 | - |

Table 10.1.3.1-1C: Downlink association set $K : \{k_0, k_1, \dots, k_{M-1}\}$ for TDD with special subframe configuration 1, 2, 6, 7 and UE configured with higher layer parameter *shortTTI*

| UL/DL Configuration | slot <i>n</i> | | | | | | | | | | | | | | | | | | |
|---------------------|---------------|---|---|---|---|--------------------------------------|------------------|-----------|---------|---|----|----|----|----|----|------------|-------------|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | | | | | 4 | 4 | 4 | | | | | | | | | 4 | 4 | 4 | |
| 1 | | | | | 6,5 | 5,4 | 4 | | | | | | | | | 6,5 | 5,4 | 4 | |
| 2 | | | | | 8,7, 12 | 7,6, 5,4 | | | | | | | | | | 8,7,1 2 | 7,6,5 ,4 | | |
| 3 | | | | | 14, 13, 12 | 12,1 1, 10 | 10, 9 | 9,8 | 8, 7 | 7 | | | | | | | | | |
| 4 | | | | | 16, 15, 14, 13 | 13,1 2, 11,1 0 | 10, 9, 8,7 | 7,6, 5 | | | | | | | | | | | |
| 5 | | | | | 18, 17, 16, 15, 14, 13, 12,22 | 12,1 1, 10,9, 8,7,6 ,5,4 | | | | | | | | | | | | | |
| 6 | | | | | 6 | 6 | 6 | 6 | 6 | | | | | | | 4 | 4 | 4 | |

Table 10.1.3.1-1D: Downlink association set $K : \{k_0, k_1, \dots, k_{M-1}\}$ for TDD with special subframe configuration 3, 4 or 8 and UE configured with higher layer parameter *shortTTI*

| UL/DL Configuration | slot <i>n</i> | | | | | | | | | | | | | | | | | | |
|---------------------|---------------|---|---|---|--|--------------------------------------|------------------|-------------|-------------------|---|----|----|----|----|----|---------------|-------------|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | | | | | 4 | 4 | 4 | 4 | | | | | | | | 4 | 4 | 4 | 4 |
| 1 | | | | | 6,5 | 5,4 | 4 | 4 | | | | | | | | 6,5 | 5,4 | 4 | 4 |
| 2 | | | | | 8,7, 12,11 | 7,6, 5,4 | | | | | | | | | | 8,7,1 2,11 | 7,6,5 ,4 | | |
| 3 | | | | | 14, 13, 12 | 12,1 1, 10 | 10, 9 | 9,8 | 8, 7 , 6 | 7 | | | | | | | | | |
| 4 | | | | | 16, 15, 14, 13 | 13,1 2, 11,1 0 | 10, 9, 8,7 | 7,6, 5,4 | | | | | | | | | | | |
| 5 | | | | | 18, 17, 16, 15, 14, 13, 12,22 ,21 | 12,1 1, 10,9, 8,7,6 ,5,4 | | | | | | | | | | | | | |
| 6 | | | | | 6 | 6 | 6 | 6 | 6 | 6 | | | | | | 4 | 4 | 4 | 4 |

Table 10.1.3.1-1E: Downlink association set $K : \{k_0, k_1, \dots, k_{M-1}\}$ for TDD with special subframe configuration 0, 5, 9, 10 and UE configured with higher layer parameter $shortTTI$

| UL/DL Configuration | slot n | | | | | | | | | | | | | | | | | | |
|---------------------|--------|---|---|---|---|--------------------------------------|------------------|-----------|---------|---|----|----|----|----|----|------------|-------------|----|----|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | | | | | 4 | 4 | 4 | | | | | | | | | 4 | 4 | 4 | |
| 1 | | | | | 6,5 | 5 | 5 | 5 | | | | | | | | 6,5 | 5 | 5 | 5 |
| 2 | | | | | 8,7, 12 | 7,6, 5,4 | | | | | | | | | | 8,7,1 2 | 7,6,5 ,4 | | |
| 3 | | | | | 14, 13, 12 | 12,1 1, 10 | 10, 9 | 9,8 | 8, 7 | 7 | | | | | | | | | |
| 4 | | | | | 16, 15, 14, 13 | 13,1 2, 11,1 0 | 10, 9, 8,7 | 7,6, 5 | | | | | | | | | | | |
| 5 | | | | | 18, 17, 16, 15, 14, 13, 12,22 | 12,1 1, 10,9, 8,7,6 ,5,4 | | | | | | | | | | | | | |
| 6 | | | | | 6,5 | | 6,5 | | 6 | | | | | | | 4 | 4 | 4 | |

Table 10.1.3.1-2: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D/6-1A/6-1B to Δ_{ARO} values for TDD when $m > 0$

| ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D | Δ_{ARO} |
|---|---|
| 0 | 0 |
| 1 | $-\sum_{i=0}^{m-1} N_{ECCE,q,n-k_{i1}} - 2$ |
| 2 | $-\sum_{i=1=m-\lceil m/3 \rceil}^{m-1} N_{ECCE,q,n-k_{i1}} - 1$ |
| 3 | 2 |

Table 10.1.3.1-3: Mapping of ACK/NACK Resource offset Field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D to Δ'_{ARO} values for TDD when $i4 = M'$ and $i5 \neq 0$

| ACK/NACK Resource offset field in DCI format 1A/1B/1D/1/2A/2/2B/2C/2D | Δ'_{ARO} |
|---|---|
| 0 | 0 |
| 1 | $-\sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k'_{i1}} - \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} - 2$ |
| 2 | $-\sum_{i1=\min(i4, i4-\delta+i5)}^{i4-1} N'_{ECCE,q,n-k'_{i1}} - \sum_{i1=\max(0, i5-\delta)}^{i5-1} N'_{ECCE,q,n-k^A_{i1}} - 1 , \delta = \left\lceil \frac{(i4+i5)}{3} \right\rceil$ |
| 3 | 2 |

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and the UE is not configured with the higher layer parameter *shortProcessingTime*, for TDD HARQ-ACK multiplexing and sub-frame n with $M > 1$ and one configured serving cell, where M is the number of elements in the set K defined in Table

10.1.3.1-1, denote $n_{\text{PUCCH},i}^{(1)}$ as the PUCCH resource derived from sub-frame $n - k_i$ and HARQ-ACK(i) as the ACK/NACK/DTX response from sub-frame $n - k_i$, where $k_i \in K$ (defined in Table 10.1.3.1-1) and $0 \leq i \leq M - 1$.

- For a PDSCH transmission indicated by the detection of corresponding PDCCH or a PDCCH indicating downlink SPS release in sub-frame $n - k_i$ where $k_i \in K$, the PUCCH resource

$$n_{\text{PUCCH},i}^{(1)} = (M - i - 1) \cdot N_c + i \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}, \text{ where } c \text{ is selected from } \{0, 1, 2, 3\} \text{ such that}$$

$N_c \leq n_{\text{CCE},i} < N_{c+1}$, $N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$, $n_{\text{CCE},i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_i$, and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers.

- For a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected in subframe $n - k_i$, the value of $n_{\text{PUCCH},i}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.
- For a non-BL/CE UE and for a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n - k_i$ where $k_i \in K$, the UE shall use
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{i-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{i-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_i$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*,

$N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_i$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_i$ which is described in Subclause 6.8A.5 in [3]. If $i = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $i > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2, where the variable m in the table is substituted with i . If the UE is configured to monitor EPDCCH in subframe $n - k_i$,

$N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_i$. If the UE is not configured to monitor EPDCCH in subframe $n - k_i$, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_i$. For normal downlink CP, if subframe $n - k_i$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_i}$ is equal to 0. For extended downlink CP, if subframe $n - k_i$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_i}$ is equal to 0.

- For a BL/CE UE, for a PDSCH transmission detected in subframe $n - k_i$ without a corresponding MPDCCH, the value of $n_{\text{PUCCH},i}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.
- For a BL/CE UE, for a PDSCH transmission in sub-frame $n - k_i$ where $k_i \in K$ indicated by the detection of corresponding MPDCCH or a MPDCCH indicating downlink SPS release in sub-frame $n - k_i$ where $k_i \in K$, the UE shall use

- if MPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{i-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m)}$$

- if MPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{i-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(m)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the MPDCCH) used for transmission of the corresponding DCI assignment in MPDCCH-PRB-set q , $N_{\text{PUCCH},q}^{(m)}$ for MPDCCH-PRB-set q is configured

- by the higher layer parameter $n1\text{PUCCCH-AN-r13}$, if configured; otherwise:
- by the higher layer parameter $n1\text{PUCCCH-AN-InfoList-r13}$ for the corresponding CE level,

$N_{\text{RB}}^{\text{ECCE},q}$ for MPDCCH-PRB-set q is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for the MPDCCH transmission which is described in Subclause 6.8A.5 in [3]. If $i=0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding MPDCCH as given in Table 10.1.2.1-1. If $i>0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding MPDCCH as given in Table 10.1.3.1-2, where the variable m in the table is substituted with i . If subframe $n-k_i$ is a BL/CE downlink subframe, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs in MPDCCH-PRB-set q configured for that UE in subframe $n-k_i$. If subframe $n-k_i$ is not a BL/CE downlink subframe, $N_{\text{ECCE},q,n-k_i}$ is equal to 0. If subframe $n-k_i$ is a BL/CE downlink special subframe in which MPDCCH is not supported, the UE shall calculate $N_{\text{ECCE},q,n-k_i}$ by assuming $N_{\text{EREG}}^{\text{ECCE}}=4$ for normal cyclic prefix and $N_{\text{EREG}}^{\text{ECCE}}=8$ for extended cyclic prefix. If an MPDCCH-PRB-set p is 2+4, then $N_{\text{ECCE},q,n-k_i}=6 \cdot N_{\text{RB}}^{\text{ECCE},q}$. When an MPDCCH-PRB-set p is 2+4, following procedures is applied.

- if the detected MPDCCH is located within 2 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by above procedure.
- if the detected MPDCCH is located within 4 PRB set, $n_{\text{PUCCH}}^{(1,p_0)}$ is the sum between $2N_{\text{RB}}^{\text{ECCE},q}$ and the value obtained by above procedure.
- if the detected MPDCCH is MPDCCH format 5, $n_{\text{PUCCH}}^{(1,p_0)}$ is obtained by the above procedure with $n_{\text{ECCE},q}=0$.

If a UE is configured with the higher layer parameter $EIMTA\text{-MainConfigServCell-r12}$, or the UE is configured with the higher layer parameter $shortProcessingTime$, then $K'=K$ where the set K is defined in Table 10.1.3.1-1B if the UE is configured with higher layer parameter $shortProcessingTime$ and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise (where "UL/DL configuration" in the table refers to the higher layer parameter $subframeAssignment$ if the UE is configured with the higher layer parameter $EIMTA\text{-MainConfigServCell-r12}$), and M ' is the number of elements in set K' .

If a UE is configured with the higher layer parameter $EIMTA\text{-MainConfigServCell-r12}$, or the UE is configured with the higher layer parameter $shortProcessingTime$, then the set K for the rest of this Subclause is as defined in Subclause 10.2, and M is the number of elements for subframe n in the set K

If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, or the UE is configured with the higher layer parameter *shortProcessingTime*, for TDD HARQ-ACK multiplexing and sub-frame n , denote $n_{\text{PUCCH},i0}^{(1)}$ as the PUCCH resource derived from sub-frame $n - k_i$ and HARQ-ACK(i0) as the ACK/NACK/DTX response from sub-frame $n - k_i$, where $k_i \in K$, and $0 \leq i \leq M - 1$.

- $i0$ corresponding to each subframe $n - k_i, \forall i, 0 \leq i \leq M - 1$ is determined as follows

Set $b = 0$;

for $i2 = 0, 1, \dots, M' - 1$

if the value of k'_{i2} is the same as the value of an element k_i in set K , where $k'_{i2} \in K'$,

$i0$ corresponding to subframe $n - k_i = b$;

$b = b + 1$

end if

end for

for $i3 = 0, 1, \dots, M^A - 1$

if the value of k'_{i3}^A is same as the value of an element k_i in set K , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, or Table 10.1.3.1-1B if the UE is configured with the higher layer parameter *shortProcessingTime*)

$i0$ corresponding to subframe $n - k_i = b$;

$b = b + 1$

end if

end for

- For a PDSCH transmission indicated by the detection of corresponding PDCCH or a PDCCH indicating downlink SPS release in sub-frame $n - k_i$,

- if the value of k_i is same as the value of an element k'_{i2} in set K' , the PUCCH resource $n_{\text{PUCCH},i0}^{(1)}$ is given by $n_{\text{PUCCH},i0}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}$;
- if the value of k_i is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*), the PUCCH resource $n_{\text{PUCCH},i0}^{(1)}$ is given by $n_{\text{PUCCH},i0}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}$;
- if the value of k_i is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1B if the UE is configured with the higher layer parameter *shortProcessingTime*), the PUCCH resource $n_{\text{PUCCH},i0}^{(1)}$ is given by $n_{\text{PUCCH},i0}^{(1)} = M' \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}$;

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, or Table 10.1.3.1-1B if the UE is configured with the higher layer parameter *shortProcessingTime*, c is selected from $\{0, 1, 2, 3\}$ such that

$$N_c \leq n_{\text{CCE},i} < N_{c+1}, \quad N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}, \quad n_{\text{CCE},i} \text{ is the number of the first CCE used}$$

for transmission of the corresponding PDCCH in subframe $n - k_i$, and $N_{\text{PUCCH}}^{\text{KA}}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

- For a PDSCH transmission where there is not a corresponding PDCCH/EPDCCH detected in subframe $n - k_i$, the value of $n_{\text{PUCCH},i0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.
- For a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n - k_i$ where $k_i \in K$, the UE shall use

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i0}^{(1)} = n_{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{\text{ECCE},q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{\text{ECCE},q,n-k_{i1}^A} + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i0}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{\text{ECCE},q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{\text{ECCE},q,n-k_{i1}^A} + n' + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where

- if the value of k_i is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$ and $i5 = 0$;
- otherwise, if the value of k_i is same as the value of an index k_{i3}^A , where $k_{i3}^A \in K^A$, then $i4 = M'$ and $i5 = i3$;

, and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_i$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_i$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_i$ which is described in Subclause 6.8A.5 in [3].

Δ'_{ARO} is determined as follows

- If $i4 = 0$ and $i5 = 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1.
- If $0 < i4 < M'$ and $i5 = 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2, where the variable Δ_{ARO} in the table is substituted with Δ'_{ARO} , the variable m in the table is substituted with $i4$, the variable N in the table is substituted with N' and the variable k_{i1} in the table is substituted with k'_{i1} .
- If $i4 = M'$ and $i5 \neq 0$, Δ'_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-3,

For a given subframe u , $N'_{\text{ECCE},q,u}$ is determined as follows

- If the UE is configured to monitor EPDCCH in subframe u , $N'_{\text{ECCE},q,u}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe u .

- If the UE is not configured to monitor EPDCCH in subframe u , $N'_{ECCE,q,u}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe u .
- For normal downlink CP, if subframe u is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N'_{ECCE,q,u}$ is equal to 0.
- For extended downlink CP, if subframe u is a special subframe with special subframe configuration 0 or 4 or 7, $N'_{ECCE,q,u}$ is equal to 0.

For a non-BL/CE UE, if the UE is not configured with two antenna port transmission for PUCCH format 1b with channel selection, and if the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, based on higher layer signalling the UE configured with a single serving cell will perform channel selection either according to the set of Tables 10.1.3-2, 10.1.3-3, and 10.1.3-4 or according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

If a UE is configured with two antenna port transmission for PUCCH format 1b with channel selection, and if the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then the UE will perform channel selection according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, the UE configured with a single serving cell will perform channel selection according to the set of Tables 10.1.3-5, 10.1.3-6, and 10.1.3-7.

For the selected table set, the UE shall transmit $b(0), b(1)$ on PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ in sub-frame n for \tilde{p} mapped to antenna port p using PUCCH format 1b according to Subclause 5.4.1 in [3] where

- $n_{PUCCH}^{(1,\tilde{p})} = n_{PUCCH}^{(1)}$ for antenna port p_0 and the value of $b(0), b(1)$ and the PUCCH resource $n_{PUCCH}^{(1)}$ are generated by channel selection according to the selected set of Tables for $M = 2, 3$, and 4 respectively
- $n_{PUCCH}^{(1,\tilde{p}_1)}$ for antenna port p_1 , where $n_{PUCCH}^{(1,\tilde{p}_1)}$ is selected from PUCCH resources $n_{PUCCH,i}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \leq i \leq M - 1$, according to selected set of Tables for $M = 2, 3$, and 4 respectively by replacing $n_{PUCCH}^{(1)}$ with $n_{PUCCH}^{(1,\tilde{p}_1)}$ and replacing $n_{PUCCH,i}^{(1)}$ with $n_{PUCCH,i}^{(1,\tilde{p}_1)}$, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

Table 10.1.3-2: Transmission of HARQ-ACK multiplexing for $M = 2$

| HARQ-ACK(0), HARQ-ACK(1) | $n_{PUCCH}^{(1)}$ | $b(0), b(1)$ |
|--------------------------|---------------------|--------------|
| ACK, ACK | $n_{PUCCH,1}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX | $n_{PUCCH,0}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK | $n_{PUCCH,1}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK | $n_{PUCCH,1}^{(1)}$ | 1, 0 |
| NACK, DTX | $n_{PUCCH,0}^{(1)}$ | 1, 0 |
| DTX, DTX | No transmission | |

Table 10.1.3-3: Transmission of HARQ-ACK multiplexing for $M = 3$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2) | $n_{\text{PUCCH}}^{(1)}$ | $b(0), b(1)$ |
|--|----------------------------|--------------|
| ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| DTX, DTX, NACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| DTX, NACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| NACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 |
| DTX, DTX, DTX | No transmission | |

Table 10.1.3-4: Transmission of HARQ-ACK multiplexing for $M = 4$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3) | $n_{\text{PUCCH}}^{(1)}$ | $b(0), b(1)$ |
|--|----------------------------|--------------|
| ACK, ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 |
| ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| NACK/DTX, NACK/DTX, NACK, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| NACK, DTX, DTX, DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 |
| ACK, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, NACK/DTX, NACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| ACK, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 |
| ACK, NACK/DTX, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK, DTX, DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 |
| NACK/DTX, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| NACK/DTX, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 0 |
| NACK/DTX, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 |
| DTX, DTX, DTX, DTX | No transmission | |

Table 10.1.3-5: Transmission of HARQ-ACK multiplexing for $M = 2$

| HARQ-ACK(0), HARQ-ACK(1) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|--------------------------|----------------------------|------------|
| ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX | No Transmission | |

Table 10.1.3-6: Transmission of HARQ-ACK multiplexing for $M = 3$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|---------------------------------------|----------------------------|------------|
| ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX, NACK/DTX | No Transmission | |

Table 10.1.3-7: Transmission of HARQ-ACK multiplexing for $M = 4$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|--|----------------------------|------------|
| ACK, ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 |
| ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 |
| ACK, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 |
| ACK, NACK/DTX, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 |
| NACK/DTX, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 0 |
| NACK/DTX, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 |
| NACK, NACK/DTX, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX, NACK/DTX, NACK/DTX | No Transmission | |

10.1.3.2 TDD HARQ-ACK procedure for more than one configured serving cell

If a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell, "UL/DL configuration" of the serving cell in the rest of this Subclause refers to the UL/DL configuration given by the parameter *eimta-HARQ-ReferenceConfig-r12* for the serving cell unless specified otherwise.

For TDD serving cell not configured for PUSCH/PUCCH transmission, "UL/DL configuration" of the serving cell in the rest of this Subclause refers to the UL/DL configuration given by the parameter *harq-ReferenceConfig-r14* for the serving cell unless specified otherwise.

The TDD HARQ-ACK feedback procedures for more than one configured serving cell are either based on a PUCCH format 1b with channel selection HARQ-ACK procedure as described in Subclause 10.1.3.2.1 or a PUCCH format 3 HARQ-ACK procedure as described in Subclause 10.1.3.2.2 or a PUCCH format 4 HARQ-ACK procedure as described in Subclause 10.1.3.2.3 or a PUCCH format 5 HARQ-ACK procedure as described in Subclause 10.1.3.2.4.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3 and TDD with more than one configured serving cell.

If a UE is configured with more than one serving cell and the TDD UL/DL configurations of all serving cells are the same, TDD UL/DL configuration 5 with PUCCH format 3 is only supported for up to two configured serving cells. If a UE is configured with two serving cells and the TDD UL/DL configuration of the two serving cells is the same, TDD UL/DL configuration 5 with PUCCH format 1b with channel selection for two configured serving cells is not supported. If a UE is configured with two serving cells and if the TDD UL/DL configuration of the two serving cells are not the same and if the DL-reference UL/DL configuration (as defined in Subclause 10.2) of at least one serving cell is TDD UL/DL Configuration 5, PUCCH format 1b with channel selection is not supported.

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and is configured with PUCCH format 3 without PUCCH format 4/5 configured, the UE is not expected to be configured with more than two serving cells having UL/DL Configuration 5 as a DL-reference UL/DL configuration.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and TDD with two configured serving cells.

10.1.3.2.1 PUCCH format 1b with channel selection HARQ-ACK procedure

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K' .

If a UE is configured with two serving cells with the same UL/DL configurations, then in the rest of this subclause, K is as defined in Subclause 10.2 and M is the number of elements for subframe n in the set K , and $M_{primary} = M$.

If a UE is configured with two serving cells with different UL/DL configurations,

- then the UE shall determine M for a subframe n in this Subclause as $M = \max(M_{primary}, M_{secondary})$, where
 - $M_{primary}$ denotes the number of elements for subframe n in the set K for the primary cell (as defined in Subclause 10.2)
 - $M_{secondary}$ denotes the number of elements for subframe n in the set K_c for the secondary serving cell (as defined in Subclause 10.2)
- if $M_{secondary} < M$, then the UE shall, for the secondary serving cell, set HARQ-ACK(j) to DTX for $j = M_{secondary}$ to $M - 1$.
- if $M_{primary} < M$, then the UE shall, for the primary cell, set HARQ-ACK(j) to DTX for $j = M_{primary}$ to $M - 1$.

If the UE is configured with two serving cells with different UL/DL configurations, then in the rest of this Subclause, $K = K_c$ where K_c is defined in Subclause 10.2.

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and two configured serving cells and a subframe n with $M = 1$, a UE shall determine the number of HARQ-ACK bits, σ , based on the number of configured serving cells and the downlink transmission modes configured for each serving cell. The UE shall use two HARQ-ACK bits for a serving cell configured with a downlink transmission mode that supports up to two transport blocks; and one HARQ-ACK bit otherwise.

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and two configured serving cells and a subframe n with $M \leq 2$, the UE shall transmit $b(0)b(1)$ on PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for \tilde{p} mapped to antenna port p using PUCCH format 1b where

- $n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources, $n_{\text{PUCCH},j}^{(1)}$ where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Tables 10.1.3.2-1, 10.1.3.2-2, and 10.1.3.2-3 in subframe n using PUCCH format 1b.
- $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , where $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ selected from A PUCCH resources, $n_{\text{PUCCH},j}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \leq j \leq A-1$ and $A \in \{2,3,4\}$, according to Tables 10.1.3.2-1, 10.1.3.2-2, and 10.1.3.2-3 by replacing $n_{\text{PUCCH}}^{(1)}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ and replacing $n_{\text{PUCCH},i}^{(1)}$ with $n_{\text{PUCCH},i}^{(1,\tilde{p}_1)}$ in subframe n , when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection,

and for a subframe n with $M = 1$, HARQ-ACK(j) denotes the ACK/NACK/DTX response for a transport block or SPS release PDCCH/EPDCCH associated with serving cell, where the transport block and serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.2.2.1-1. For a subframe n with $M = 2$, HARQ-ACK(j) denotes the ACK/NACK/DTX response for a PDSCH transmission or SPS release PDCCH/EPDCCH within subframe(s) given by set K on each serving cell, where the subframes on each serving cell for HARQ-ACK(j) and A PUCCH resources are given by Table 10.1.3.2-4.

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, the UE shall determine the A PUCCH resources, $n_{\text{PUCCH},j}^{(1)}$ associated with HARQ-ACK(j) where $0 \leq j \leq A-1$ in Table 10.1.2.2.1-1 for $M = 1$ and Table 10.1.3.2-4 for $M = 2$, according to

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ on the primary cell, or for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ on the primary cell, the PUCCH resource is

$$n_{\text{PUCCH},j}^{(1)} = (M_{\text{primary}} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$$
such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max \left\{ 0, \lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, and for a subframe n with $M = 1$ and a transmission mode that supports up to two transport blocks on the serving cell where the corresponding PDSCH transmission occurs, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by $n_{\text{PUCCH},j+1}^{(1)} = (M_{\text{primary}} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + 1 + N_{\text{PUCCH}}^{(1)}$ where $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding DCI assignment and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers.
- for a PDSCH transmission on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$, the value of $n_{\text{PUCCH},j}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.
- For a PDSCH transmission indicated by the detection of corresponding EPDCCH or a EPDCCH indicating downlink SPS release in sub-frame $n - k_m$ where $k_m \in K$ on the primary cell, the PUCCH resource $n_{\text{PUCCH},j}^{(1)}$ is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},j}^{(1)} = n_{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},j}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i_1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i_1}$. For normal downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. For a subframe n with $M = 1$ and a transmission mode that supports up to two transport blocks on the serving cell where the corresponding PDSCH transmission occurs, the PUCCH resource $n_{\text{PUCCH},j+1}^{(1)}$ is given by

- if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{ECCE},q} + 1 + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + 1 + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$ on the secondary cell, the value of $n_{\text{PUCCH},j}^{(1)}$, and the value of $n_{\text{PUCCH},j+1}^{(1)}$ for a subframe n with $M = 2$ or for a subframe n with $M = 1$ and a transmission mode on the secondary cell that supports up to two transport blocks is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. For a UE configured for a transmission mode on the secondary cell that supports up to two transport blocks and a subframe n with $M = 1$, or for a subframe n with $M = 2$, a PUCCH resource value in Table 10.1.2.2.1-2 maps to two PUCCH resources $(n_{\text{PUCCH},j}^{(1)}, n_{\text{PUCCH},j+1}^{(1)})$, otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH},j}^{(1)}$. A UE shall assume that the same HARQ-ACK PUCCH

resource value is transmitted in the TPC field on all PDCCH/EPDCCH assignments on the secondary cell within subframe(s) $n - k$, where $k \in K$.

Table 10.1.3.2-1: Transmission of HARQ-ACK multiplexing for $A = 2$

| HARQ-ACK(0), HARQ-ACK(1) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|--------------------------|----------------------------|------------|
| ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX | No Transmission | |

Table 10.1.3.2-2: Transmission of HARQ-ACK multiplexing for $A = 3$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|---------------------------------------|----------------------------|------------|
| ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX, NACK/DTX | No Transmission | |

Table 10.1.3.2-3: Transmission of HARQ-ACK multiplexing for $A = 4$

| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3) | $n_{\text{PUCCH}}^{(1)}$ | $b(0)b(1)$ |
|--|----------------------------|------------|
| ACK, ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 |
| ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 |
| ACK, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 |
| ACK, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 |
| ACK, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 |
| ACK, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 |
| ACK, NACK/DTX, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 |
| NACK/DTX, ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 |
| NACK/DTX, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 |
| NACK/DTX, ACK, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 0 |
| NACK/DTX, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 |
| NACK, NACK/DTX, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 |
| DTX, NACK/DTX, NACK/DTX, NACK/DTX | No Transmission | |

Table 10.1.3.2-4: Mapping of subframes on each serving cell to HARQ-ACK(j) for PUCCH format 1b HARQ-ACK channel selection for TDD with $M = 2$

| A | HARQ-ACK(j) | | | |
|---|------------------------------------|-------------------------------------|--------------------------------------|---------------------------------------|
| | HARQ-ACK(0) | HARQ-ACK(1) | HARQ-ACK(2) | HARQ-ACK(3) |
| 4 | The first subframe of Primary cell | The second subframe of Primary cell | The first subframe of Secondary cell | The second subframe of Secondary cell |

For TDD HARQ-ACK multiplexing with PUCCH format 1b with channel selection and sub-frame n with $M > 2$ and two configured serving cells, denotes $n_{\text{PUCCH},i}^{(1)}$, $0 \leq i \leq 3$ as the PUCCH resource derived from the transmissions in M downlink or special sub-frames associated with the UL subframe n . $n_{\text{PUCCH},0}^{(1)}$ and $n_{\text{PUCCH},1}^{(1)}$ are associated with the PDSCH transmission(s) or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) on the primary cell and $n_{\text{PUCCH},2}^{(1)}$ and $n_{\text{PUCCH},3}^{(1)}$ are associated with the PDSCH transmission(s) on the secondary cell.

For Primary cell:

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, and if there is a PDSCH transmission on the primary cell without a corresponding PDCCH/EPDCCH detected within the subframe(s) $n - k$, where $k \in K$,
 - the value of $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.

- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1', the PUCCH resource

$$n_{\text{PUCCH},1}^{(1)} = (M_{\text{primary}} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)} \quad \text{where } c \text{ is selected from } \{0, 1, 2, 3\}$$

such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$, where $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ and $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers.

- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lceil \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rceil \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{el})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i_1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i_1}$. For normal downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, and if there is a PDSCH transmission on the primary cell without a corresponding PDCCH/EPDCCH detected within the subframe(s) $n - k$, where $k \in K$,
 - the value of $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2.

- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_i$, where $k_i \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_i$, where $k_i \in K$ with the DAI value in the PDCCH equal to '1',
- if the value of k_i is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}$;
- otherwise, if the value of k_i is same as the value of an element k_{i3}^A in set K^A , where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{K^A}$;

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},i} < N_{c+1}$, $N_c = \max \left\{ 0, \lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},i}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_i$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

- for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_i$, where $k_i \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_i$, where $k_i \in K$ with the DAI value in the EPDCCH equal to '1', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{\text{ECCE},q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{\text{ECCE},q,n-k_{i1}^A} + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i1=0}^{i4-1} N'_{\text{ECCE},q,n-k'_{i1}} + \sum_{i1=0}^{i5-1} N'_{\text{ECCE},q,n-k_{i1}^A} + n' + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where

- if the value of k_i is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$ and $i5 = 0$;
- otherwise, if the value of k_i is same as the value of an index k_{i3}^A , where $k_{i3}^A \in K^A$, then $i4 = M'$ and $i5 = i3$;

, and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_i$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter $pucch-ResourceStartOffset-r11$, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_i$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{\text{ECCE},q,n-k'_{i1}}$, $N'_{\text{ECCE},q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1.

- HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH transmission without a corresponding PDCCH/EPDCCH. For $1 \leq j \leq M - 1$, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to 'j' or a PDCCH/EPDCCH indicating downlink SPS release and with DAI value in the PDCCH/EPDCCH equal to 'j' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.
- Otherwise,
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2' or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resource $n_{\text{PUCCH},i}^{(1)} = (M_{\text{primary}} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$$
, where $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, $i = 0$ for the corresponding PDCCH with the DAI value equal to '1' and $i = 1$ for the corresponding PDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration $i = 0$ for the corresponding PDCCH.
 - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2' or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the PDCCH equal to either '1' or '2',
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ is given by $n_{\text{PUCCH},i}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A), the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ is given by

$$n_{\text{PUCCH},i}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$
 where M^A is the number of elements in the set K^A , where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers. Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, $i = 0$ for the corresponding PDCCH with the DAI value equal to '1' and $i = 1$ for the corresponding PDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration $i = 0$ for the corresponding PDCCH.
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2' or an EPDCCH indicating downlink SPS

release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_i$, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_i$. If the UE is not configured to monitor EPDCCH in subframe $n - k_i$, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_i$. For normal downlink CP, if subframe $n - k_i$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_i}$ is equal to 0. For extended downlink CP, if subframe $n - k_i$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_i}$ is equal to 0.

Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} $i = 0$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 1$ for the corresponding EPDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i = 0$ for the corresponding EPDCCH.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell for a PDSCH transmission on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2' or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ and for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} the DAI value in the EPDCCH equal to either '1' or '2', the PUCCH resource is given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{i4-1} N_{\text{ECCE},q,n-k_i} + \sum_{i=0}^{i5-1} N_{\text{ECCE},q,n-k_i^A} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{i=4-1} N_{\text{ECCE},q,n-k_{i1}'} + \sum_{i=0}^{i=5-1} N_{\text{ECCE},q,n-k_{i1}^A} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where

- if the value of k_m is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k_{i3}^A , where $k_{i3}^A \in K^A$, then $i4 = i3$;

, and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3].. Δ'_{ARO} , $N_{\text{ECCE},q,n-k_{i1}'}$, $N_{\text{ECCE},q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1. Here, for TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6} $i = 0$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 1$ for the corresponding EPDCCH with the DAI value equal to '2', and for the primary cell with TDD UL/DL configuration 0 $i = 0$ for the corresponding EPDCCH.

- For $0 \leq j \leq M - 1$ and TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,6}, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to ' $j + 1$ ' or a PDCCH/EPDCCH indicating downlink SPS release and with DAI value in the PDCCH/EPDCCH equal to ' $j + 1$ ' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX. For $0 \leq j \leq M - 1$ and the primary cell with TDD UL/DL configuration 0, if a PDSCH transmission with a corresponding PDCCH/EPDCCH or a PDCCH/EPDCCH indicating downlink SPS release is received, HARQ-ACK(0) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.

For Secondary cell:

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH on the primary cell in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources $n_{\text{PUCCH},i}^{(1)} = (M_{\text{primary}} - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max \{ 0, \lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \rfloor \}$, where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, $i = 2$ for the corresponding PDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding PDCCH with the DAI value equal to '2'.
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH on the primary cell in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2',
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ is given by $n_{\text{PUCCH},i}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A , where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter

subframeAssignment), the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ is given by

$$n_{\text{PUCCH},i}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$, $N_c = \max \left\{ 0, \lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $n_{\text{PUCCH},i}^{(1)}$, are configured by higher layers. Here, $i = 2$ for the corresponding PDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding PDCCH with the DAI value in the PDCCH equal to either '1' or '2'.

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding EPDCCH on the primary cell in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources are given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i_1=0}^{m-1} N_{\text{ECCE},q,n-k_{i_1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i_1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i_1}$. For normal downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. Here, $i = 2$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding EPDCCH with the DAI value equal to '2'.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding EPDCCH on the primary cell in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to either '1' or '2', the PUCCH resources are given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i_1=0}^{i_4-1} N'_{\text{ECCE},q,n-k'_{i_1}} + \sum_{i_1=0}^{i_5-1} N'_{\text{ECCE},q,n-k^A_{i_1}} + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i_1=0}^{i_4-1} N'_{\text{ECCE},q,n-k'_{i_1}} + \sum_{i_1=0}^{i_5-1} N'_{\text{ECCE},q,n-k^A_{i_1}} + n' + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{el})}$$

where

- if the value of k_m is same as the value of an index k'_{i_2} , where $k'_{i_2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index $k^A_{i_3}$, where $k^A_{i_3} \in K^A$, then $i4 = i3$;

and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$,

$N_{\text{PUCCH},q}^{(\text{el})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{\text{ECCE},q,n-k'_{i_1}}$, $N'_{\text{ECCE},q,n-k^A_{i_1}}$ are determined as described in Subclause 10.1.3.1. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. Here, $i = 2$ for the corresponding EPDCCH with the DAI value equal to '1' and $i = 3$ for the corresponding EPDCCH with the DAI value equal to '2'.

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH/EPDCCH within the subframe(s) $n - k$, where $k \in K$ on the secondary cell, the value of $n_{\text{PUCCH},2}^{(1)}$ and $n_{\text{PUCCH},3}^{(1)}$ is determined according to higher layer configuration and Table 10.1.2.2.1-2. The TPC field in the DCI format of the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource values from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.1-2. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted in the TPC field on all PDCCH/EPDCCH assignments on the secondary cell within subframe(s) $n - k$, where $k \in K$.
- For $0 \leq j \leq M - 1$, if a PDSCH transmission with a corresponding PDCCH/EPDCCH and DAI value in the PDCCH/EPDCCH equal to ' $j + 1$ ' is received, HARQ-ACK(j) is the corresponding ACK/NACK/DTX response; otherwise HARQ-ACK(j) shall be set to DTX.

A UE shall perform channel selection according to the Tables 10.1.3.2-5, and 10.1.3.2-6 and transmit $b(0), b(1)$ on PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for \tilde{p} mapped to antenna port p using PUCCH format 1b according to Subclause 5.4.1 in [3] where

- $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = n_{\text{PUCCH}}^{(1)}$ in sub-frame n for \tilde{p} mapped to antenna port p_0 where "any" in Tables 10.1.3.2-5, and 10.1.3.2-6 represents any response of ACK, NACK, or DTX. The value of $b(0), b(1)$ and the PUCCH resource $n_{\text{PUCCH}}^{(1)}$ are generated by channel selection according to Tables 10.1.3.2-5, and 10.1.3.2-6 for $M = 3$, and 4 respectively.
- $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , where $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ selected from PUCCH resources, $n_{\text{PUCCH}_i}^{(1,\tilde{p}_1)}$ configured by higher layers where $0 \leq i \leq 3$ according Tables 10.1.3.2-5, and 10.1.3.2-6 for $M = 3$, and 4 respectively by replacing $n_{\text{PUCCH}}^{(1)}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ and replacing $n_{\text{PUCCH}_i}^{(1)}$ with $n_{\text{PUCCH}_i}^{(1,\tilde{p}_1)}$, where "any" in Tables 10.1.3.2-5, and 10.1.3.2-6 represents any response of ACK, NACK, or DTX, when the UE is configured with two antenna port transmission for PUCCH format 1b with channel selection.

Table 10.1.3.2-5: Transmission of HARQ-ACK multiplexing for $M = 3$

| Primary Cell | Secondary Cell | Resource | Constellation | RM Code Input Bits |
|--|--|----------------------------|----------------------|---------------------------|
| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2) | HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2) | $n_{\text{PUCCH}}^{(1)}$ | $b(0), b(1)$ | $o(0), o(1), o(2), o(3)$ |
| ACK, ACK, ACK | ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 | 1,1,1,1 |
| ACK, ACK, NACK/DTX | ACK, ACK, ACK | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 | 1,0,1,1 |
| ACK, NACK/DTX, any | ACK, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 | 0,1,1,1 |
| NACK/DTX, any, any | ACK, ACK, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 | 0,0,1,1 |
| ACK, ACK, ACK | ACK, ACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 | 1,1,1,0 |
| ACK, ACK, NACK/DTX | ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 1, 0 | 1,0,1,0 |
| ACK, NACK/DTX, any | ACK, ACK, NACK/DTX | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 | 0,1,1,0 |
| NACK/DTX, any, any | ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 | 0,0,1,0 |
| ACK, ACK, ACK | ACK, NACK/DTX, any | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 | 1, 1, 0, 1 |
| ACK, ACK, NACK/DTX | ACK, NACK/DTX, any | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 | 1, 0, 0, 1 |
| ACK, NACK/DTX, any | ACK, NACK/DTX, any | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 | 0, 1, 0, 1 |
| NACK/DTX, any, any | ACK, NACK/DTX, any | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 | 0, 0, 0, 1 |
| ACK, ACK, ACK | NACK/DTX, any, any | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 | 1, 1, 0, 0 |
| ACK, ACK, NACK/DTX | NACK/DTX, any, any | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 | 1, 0, 0, 0 |
| ACK, NACK/DTX, any | NACK/DTX, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 | 0, 1, 0, 0 |
| NACK, any, any | NACK/DTX, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 | 0, 0, 0, 0 |
| DTX, any, any | NACK/DTX, any, any | No Transmission | | 0, 0, 0, 0 |

Table 10.1.3.2-6: Transmission of HARQ-ACK multiplexing for $M = 4$

| Primary Cell | Secondary Cell | Resource | Constellation | RM Code Input Bits |
|--|--|----------------------------|---------------|--------------------------|
| HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3) | HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3) | $n_{\text{PUCCH}}^{(1)}$ | $b(0), b(1)$ | $o(0), o(1), o(2), o(3)$ |
| ACK, ACK, ACK, NACK/DTX | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1 | 1, 1, 1, 1 |
| ACK, ACK, NACK/DTX, any | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0 | 1, 0, 1, 1 |
| ACK, DTX, DTX, DTX | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 | 0, 1, 1, 1 |
| ACK, ACK, ACK, ACK | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 1, 1 | 0, 1, 1, 1 |
| NACK/DTX, any, any, any | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 | 0, 0, 1, 1 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | ACK, ACK, ACK, NACK/DTX | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 | 0, 0, 1, 1 |
| ACK, ACK, ACK, NACK/DTX | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},0}^{(1)}$ | 1, 0 | 1, 1, 1, 0 |
| ACK, ACK, NACK/DTX, any | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},3}^{(1)}$ | 1, 0 | 1, 0, 1, 0 |
| ACK, DTX, DTX, DTX | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 | 0, 1, 1, 0 |
| ACK, ACK, ACK, ACK | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1 | 0, 1, 1, 0 |
| NACK/DTX, any, any, any | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 | 0, 0, 1, 0 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | ACK, ACK, NACK/DTX, any | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 | 0, 0, 1, 0 |
| ACK, ACK, ACK, NACK/DTX | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 | 1, 1, 0, 1 |
| ACK, ACK, ACK, NACK/DTX | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1 | 1, 1, 0, 1 |
| ACK, ACK, NACK/DTX, any | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 | 1, 0, 0, 1 |
| ACK, ACK, NACK/DTX, any | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 1 | 1, 0, 0, 1 |
| ACK, DTX, DTX, DTX | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 | 0, 1, 0, 1 |
| ACK, DTX, DTX, DTX | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 | 0, 1, 0, 1 |
| ACK, ACK, ACK, ACK | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 | 0, 1, 0, 1 |
| ACK, ACK, ACK, ACK | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 1, 0 | 0, 1, 0, 1 |
| NACK/DTX, any, any, any | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 | 0, 0, 0, 1 |
| NACK/DTX, any, any, any | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 | 0, 0, 0, 1 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | ACK, DTX, DTX, DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 | 0, 0, 0, 1 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | ACK, ACK, ACK, ACK | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 | 0, 0, 0, 1 |
| ACK, ACK, ACK, NACK/DTX | NACK/DTX, any, any, any | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 | 1, 1, 0, 0 |
| ACK, ACK, ACK, NACK/DTX | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0 | 1, 1, 0, 0 |
| ACK, ACK, NACK/DTX, any | NACK/DTX, any, any, any | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 | 1, 0, 0, 0 |
| ACK, ACK, NACK/DTX, any | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 | 1, 0, 0, 0 |

| | | | | |
|--|--|----------------------------|------|------------|
| ACK, DTX, DTX, DTX | NACK/DTX, any, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 | 0, 1, 0, 0 |
| ACK, DTX, DTX, DTX | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 | 0, 1, 0, 0 |
| ACK, ACK, ACK, ACK | NACK/DTX, any, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 | 0, 1, 0, 0 |
| ACK, ACK, ACK, ACK | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1 | 0, 1, 0, 0 |
| NACK, any, any, any | NACK/DTX, any, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 | 0, 0, 0, 0 |
| NACK, any, any, any | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 | 0, 0, 0, 0 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | NACK/DTX, any, any, any | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 | 0, 0, 0, 0 |
| (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | $n_{\text{PUCCH},0}^{(1)}$ | 0, 0 | 0, 0, 0, 0 |
| DTX, any, any, any | NACK/DTX, any, any, any | No Transmission | | 0, 0, 0, 0 |
| DTX, any, any, any | (ACK, NACK/DTX, any, any), except for (ACK, DTX, DTX, DTX) | No Transmission | | 0, 0, 0, 0 |

10.1.3.2.2 PUCCH format 3 HARQ-ACK procedure

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K' .

If a UE is configured with one serving cell, or if a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this Subclause K is as defined in Sec 10.2, and M is the number of elements in the set K .

If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this Subclause refers to K_c (as defined in Subclause 10.2), and M is the number of elements in the set K .

For TDD HARQ-ACK transmission with PUCCH format 3 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K , the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK in subframe n for \tilde{p} mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',

- the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with
 $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,
 $N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{SC}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$, and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b, and
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A , where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer

parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lceil \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rceil \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_i$, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_i$. If the UE is not configured to monitor EPDCCH in subframe $n - k_i$, $N_{\text{ECCE},q,n-k_i}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_i$. For normal downlink CP, if subframe $n - k_i$ is a special subframe with special subframe configuration 0, 5 or 10 if

configured by *ssp10-CRS-LessDwPTS*, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{PUCCH}^{(1,\tilde{p}_1)} = n_{PUCCH}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ given by
 - if EPDCCH-PRB-set q is configured for distributed transmission
$$n_{PUCCH}^{(1,\tilde{p})} = n_{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$
 - if EPDCCH-PRB-set q is configured for localized transmission
$$n_{PUCCH}^{(1,\tilde{p})} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + n' + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

where

- if the value of k_m is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k_{i3}^A , where $k_{i3}^A \in K^A$, then $i4 = i3$;

and where $n_{ECCE,q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{PUCCH,q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{ECCE,q,n-k_{i1}'}$, $N'_{ECCE,q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{PUCCH}^{(1,\tilde{p}_1)} = n_{PUCCH}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ with the value of $n_{PUCCH}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{PUCCH}^{(1,\tilde{p}_0)}$ for

antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X), or
 - for an additional PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1',
 - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as

$$n_{\text{PUCCH},1}^{(1)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$$
 where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$$
 , and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$.
 - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by

$$n_{\text{PUCCH},1}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A}$$
 where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$$
 , $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{\text{PUCCH},2}^{(1)}$ is determined as $n_{\text{PUCCH},2}^{(1)} = n_{\text{PUCCH},1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X), or
 - for an additional EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1',
 - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$
 - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lceil \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rceil \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_i$,

$N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i1}$. For normal downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{PUCCH,0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{PUCCH,1}^{(1)}$ is determined as

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{PUCCH,i}^{(1)} = n_{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH,i}^{(1)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + n' + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

where

- if the value of k_m is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k'_{i3}^A , where $k'_{i3}^A \in K^A$, then $i4 = i3$;
- and where $n_{ECCE,q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{PUCCH,q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{ECCE,q,n-k_{i1}'}$, $N'_{ECCE,q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{PUCCH,2}^{(1)}$ is determined as $n_{PUCCH,2}^{(1)} = n_{PUCCH,1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1' (defined in Table 7.3-X), or
- for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1', or
- for $M = 9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', or
- for $M = 9$ and for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1',
 - the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in a PDCCH assignment with DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1' (defined in Table 7.3-X), or
 - for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1', or
 - for $M = 9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', or
 - for $M = 9$ and for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1',
 - the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with DAI value greater than '1' or with DAI value equal to '1' (defined in Table 7.3-X), not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- If the UL/DL configurations of all serving cells are the same, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding

PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For TDD UL/DL configurations 1-6, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1' (defined in Table 7.3-X), shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For TDD UL/DL configurations 1-6, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$.

- If the UL/DL configurations of at least two serving cells are different, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in Subclause 10.2, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in Subclause 10.2, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determined the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$.
 - For PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ and a UE configured for two antenna port transmission, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 .

10.1.3.2.3 PUCCH format 4 HARQ-ACK procedure

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 4 and *codebooksizedetermination-r13 = cc* is described in Subclause 10.1.3.2.3.1.

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13 = dai* is described in Subclause 10.1.3.2.3.2.

10.1.3.2.3.1 PUCCH format 4 HARQ-ACK procedure without adaptive codebook

The procedure in this Subclause applies to a UE configured with PUCCH format 4 and *codebooksizeDetermination-r13 = cc*.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K' .

If a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this Subclause K is as defined in Sec 10.2, and M is the number of elements in the set K .

If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this Subclause refers to K_c (as defined in Subclause 10.2), and M is the number of elements in the set K .

For TDD HARQ-ACK transmission with PUCCH format 4 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K , the UE shall use PUCCH resource $n_{\text{PUCCH}}^{(4)}$ or $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe n for \tilde{p} mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,
 $N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$, and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the PDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b, and
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;

- otherwise, if the value of k_m is same as the value of an element k_{i3}^A in set K^A , where $k_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$

where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$N_c = \max \left\{ 0, \lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \rfloor \right\}$ where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',

- the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE},q} + \sum_{i1=0}^{m-1} N_{\text{ECCE},q,n-k_{i1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i1=0}^{m-1} N_{\text{ECCE},q,n-k_{i1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs computed

assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i_1}$. For normal downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{ECCE,q,n-k_{i_1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i_1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{PUCCH}^{(1,\tilde{p}_1)} = n_{PUCCH}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1' (defined in Table 7.3-X), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and for a TDD UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} the DAI value in the EPDCCH is equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ given by
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{PUCCH}^{(1,\tilde{p})} = n_{ECCE,q} + \sum_{i_1=0}^{i_4-1} N'_{ECCE,q,n-k_{i_1}^{'}} + \sum_{i_1=0}^{i_5-1} N'_{ECCE,q,n-k_{i_1}^A} + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH}^{(1,\tilde{p})} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i_1=0}^{i_4-1} N'_{ECCE,q,n-k_{i_1}^{'}} + \sum_{i_1=0}^{i_5-1} N'_{ECCE,q,n-k_{i_1}^A} + n' + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

where

- if the value of k_m is same as the value of an index k'_{i_2} , where $k'_{i_2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index $k_{i_3}^A$, where $k_{i_3}^A \in K^A$, then $i4 = i3$;

and where $n_{ECCE,q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{PUCCH,q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{ECCE,q,n-k_{i_1}^{'}}$, $N'_{ECCE,q,n-k_{i_1}^A}$ are determined as described in Subclause 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{PUCCH}^{(1,\tilde{p}_1)} = n_{PUCCH}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ with the value of $n_{PUCCH}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH

resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X), or
 - for an additional PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1',
 - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as

$$n_{\text{PUCCH},1}^{(1)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)},$$
 where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\},$$
 and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$.
 - If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by

$$n_{\text{PUCCH},1}^{(1)} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$
 where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from $\{0, 1, 2, 3\}$ such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\},$$
 $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.

- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{\text{PUCCH},2}^{(1)}$ is determined as $n_{\text{PUCCH},2}^{(1)} = n_{\text{PUCCH},1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X), or
 - for an additional EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1',
 - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$
 - If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_i$,

$N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{ECCE,q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i1}$. For normal downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0, 5 or 10 if configured by *ssp10-CRS-LessDwPTS*, $N_{ECCE,q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{ECCE,q,n-k_{i1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{PUCCH,0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{PUCCH,1}^{(1)}$ is determined as

- If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{PUCCH,i}^{(1)} = n_{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{PUCCH,i}^{(1)} = \left\lfloor \frac{n_{ECCE,q}}{N_{RB}^{ECCE,q}} \right\rfloor \cdot N_{RB}^{ECCE,q} + \sum_{i1=0}^{i4-1} N'_{ECCE,q,n-k_{i1}'} + \sum_{i1=0}^{i5-1} N'_{ECCE,q,n-k_{i1}^A} + n' + \Delta'_{ARO} + N_{PUCCH,q}^{(e1)}$$

where

- if the value of k_m is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k'_{i3}^A , where $k'_{i3}^A \in K^A$, then $i4 = i3$;
- and where $n_{ECCE,q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{PUCCH,q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{RB}^{ECCE,q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{ECCE,q,n-k_{i1}'}$, $N'_{ECCE,q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{PUCCH,2}^{(1)}$ is determined as $n_{PUCCH,2}^{(1)} = n_{PUCCH,1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of the DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of the DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and

- for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1' (defined in Table 7.3-X), or
- for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH greater than '1', or
- for $M = 9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', or
- for $M = 9$ and for a PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the PDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1',
- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P_CSI} (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCH resource $n_{PUCCH}^{(4)}$ where the value of $n_{PUCCH}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in a PDCCH assignment with DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P_CSI} (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ where the value of $n_{PUCCH}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in a PDCCH assignment with DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1' (defined in Table 7.3-X), or
 - for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH greater than '1', or
 - for $M = 9$ and for a PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', or

- for $M = 9$ and for an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with the DAI value in the EPDCCH equal to '1' (defined in Table 7.3-X) not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1',
- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P-CSI} (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCH resource $n_{PUCCH}^{(4)}$ where the value of $n_{PUCCH}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with DAI value greater than '1' or with DAI value equal to '1' (defined in Table 7.3-X), not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P-CSI} (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ where the value of $n_{PUCCH}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with DAI value greater than '1' or with DAI value equal to '1' (defined in Table 7.3-X), not being the first PDCCH/EPDCCH assignment in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four PUCCH resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments used to determine the PUCCH resource values within the subframe(s) $n - k$, where $k \in K$.
- If the UL/DL configurations of all serving cells are the same and the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P-CSI} (if any) is more than 22, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 4 and PUCCH resource $n_{PUCCH}^{(4)}$ where the value of $n_{PUCCH}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. For TDD UL/DL configurations 1-6, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1' (defined in Table 7.3-X), shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For TDD UL/DL configurations 1-6, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$.

- If the UL/DL configurations of at least two serving cells are different and the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P_CSI} (if any) is more than 22, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 4 and PUCCH resource $n_{PUCCH}^{(4)}$ where the value of $n_{PUCCH}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in Subclause 10.2, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in Subclause 10.2, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$.
- If the UL/DL configurations of all serving cells are the same, and the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits O_{P_CSI} (if any) is no more than 22, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{PUCCH}^{(3,\tilde{p})}$ where the value of $n_{PUCCH}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For TDD UL/DL configurations 1-6, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1' (defined in Table 7.3-X), shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For TDD UL/DL configurations 1-6, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two

PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0 .

- If the UL/DL configurations of at least two serving cells are different and the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is no more than 22, for a PDSCH transmission on the secondary cell indicated by the detection of a corresponding PDCCH/EPDCCH within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1 and the TPC field in the corresponding PDCCH/EPDCCH shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if a PDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or a PDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the TPC field in the PDCCH with the DAI value greater than '1' (defined in Table 7.3-X) or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all PDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For a UL/DL configuration of the primary cell belonging to {1,2,3,4,5,6} as defined in subclause 10.2, if an EPDCCH corresponding to a PDSCH on the primary cell within subframe(s) $n - k$, where $k \in K$, or an EPDCCH indicating downlink SPS release (defined in subclause 9.2) within subframe(s) $n - k$, where $k \in K$, is detected, the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH assignment with the DAI value greater than '1' or with DAI value equal to '1', not being the first PDCCH/EPDCCH transmission in subframe(s) $n - k$, where $k \in K$ with the DAI value equal to '1', shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on all EPDCCH assignments in the primary cell and in each secondary cell that are used to determine the PUCCH resource value within the subframe(s) $n - k$, where $k \in K$. For a UE configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ for antenna port p_0 .

10.1.3.2.3.2 PUCCH format 4 HARQ-ACK procedure with adaptive codebook

The procedure in this Subclause applies to a UE configured with PUCCH format 4 and $\text{codebooksizetermination-r13} = \text{dai}$.

If a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, then $K' = K$ where the set K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), and M' is the number of elements in set K' .

If a UE is configured with more than one serving cells and the UL/DL configuration of all serving cells is same, then in the rest of this Subclause K is as defined in Sec 10.2, and M is the number of elements in the set K .

If a UE is configured with more than one serving cell and if at least two cells have different UL/DL configurations, then K in this Subclause refers to K_c (as defined in Subclause 10.2), and M is the number of elements in the set K .

For TDD HARQ-ACK transmission with PUCCH format 4 and sub-frame n with $M \geq 1$ and more than one configured serving cell, where M is the number of elements in the set K , the UE shall use PUCCH resource

$n_{\text{PUCCH}}^{(4)}$ or $n_{\text{PUCCH}}^{(3,\tilde{p})}$ or $n_{\text{PUCCH}}^{(1,\tilde{p})}$ for transmission of HARQ-ACK and scheduling request (if any) and periodic CSI (if any) in subframe n for \tilde{p} mapped to antenna port p where

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with $n_{\text{PUCCH}}^{(1,\tilde{p}_0)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$ for antenna port p_0 , where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$$
, and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
 - for a single PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the PDCCH are equal to '1',
 - the UE shall use PUCCH format 1a/1b, and
 - if the value of k_m is same as the value of an element k'_{i2} , where $k'_{i2} \in K'$, the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M' - i2 - 1) \cdot N_c + i2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element k'_{i3}^A in set K^A , where $k'_{i3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is given by $n_{\text{PUCCH}}^{(1,\tilde{p})} = (M^A - i3 - 1) \cdot N_c + i3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A}$; where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,

$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\}$$
 where $N_{\text{RB}}^{\text{DL}}$ is determined from the primary cell, $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$
 - If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,

- for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
- for a single EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_{i1}} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_{i1}} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i1}$, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i1}$. For normal downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 5, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i1}}$ is equal to 0. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell,
 - for a single PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCH in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1' (defined in Table 7.3.2.1-1), or
 - for a single EPDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$, and both the counter DAI value and the total DAI value in the EPDCCH are equal to '1',
 - the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ given by
 - if EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{ECCE},q} + \sum_{i_1=0}^{i_4-1} N'_{\text{ECCE},q,n-k'_{i_1}} + \sum_{i_1=0}^{i_5-1} N'_{\text{ECCE},q,n-k^A_{i_1}} + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

- if EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH}}^{(1,\tilde{p})} = \left\lceil \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rceil \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i_1=0}^{i_4-1} N'_{\text{ECCE},q,n-k'_{i_1}} + \sum_{i_1=0}^{i_5-1} N'_{\text{ECCE},q,n-k^A_{i_1}} + n' + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where

- if the value of k_m is same as the value of an index k'_{i_2} , where $k'_{i_2} \in K'$, then $i_4 = i_2$;
- otherwise, if the value of k_m is same as the value of an index $k^A_{i_3}$, where $k^A_{i_3} \in K^A$, then $i_4 = i_3$;

and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter $\text{pucch-ResourceStartOffset-r11}$, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{\text{ECCE},q,n-k'_{i_1}}$, $N'_{\text{ECCE},q,n-k^A_{i_1}}$ are determined as described in Subclause 10.1.3.1. When two antenna port transmission is configured for PUCCH format 1a/1b, the PUCCH resource for antenna port p_1 is given by $n_{\text{PUCCH}}^{(1,\tilde{p}_1)} = n_{\text{PUCCH}}^{(1,\tilde{p}_0)} + 1$.

- for a single PDSCH transmission only on the primary cell where there is not a corresponding PDCCH/EPDCCH detected within subframe(s) $n - k$, where $k \in K$ and no PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) within subframe(s) $n - k$, where $k \in K$, the UE shall use PUCCH format 1a/1b and PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p})}$ with the value of $n_{\text{PUCCH}}^{(1,\tilde{p})}$ is determined according to higher layer configuration and Table 9.2-2. For a UE configured for two antenna port transmission for PUCCH format 1a/1b, a PUCCH resource value in Table 9.2-2 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(1,\tilde{p}_0)}$ for antenna port p_0 .
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding PDCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding PDCCH in subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH equal to '1' (defined in Table 7.3.2.1-1), or
 - for an additional PDCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the PDCCH equal to '1',
 - the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.

- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
$$n_{\text{PUCCH},1}^{(1)} = (M - m - 1) \cdot N_c + m \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)},$$
where $N_{\text{PUCCH}}^{(1)}$ is configured by higher layers, c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,
$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\},$$
and $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$ where $k_m \in K$.
- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - if the value of k_m is same as the value of an element k'_{i_2} , where $k'_{i_2} \in K'$, the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by $n_{\text{PUCCH},1}^{(1)} = (M' - i_2 - 1) \cdot N_c + i_2 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{(1)}$;
 - otherwise, if the value of k_m is same as the value of an element $k'_{i_3}^A$ in set K^A , where $k'_{i_3}^A \in K^A$ (defined in Table 10.1.3.1-1A, where "UL/DL configuration" in the table refers to the higher layer parameter *subframeAssignment*), the PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is given by
$$n_{\text{PUCCH},1}^{(1)} = (M^A - i_3 - 1) \cdot N_c + i_3 \cdot N_{c+1} + n_{\text{CCE},m} + N_{\text{PUCCH}}^{K^A};$$
where M^A is the number of elements in the set K^A defined in Table 10.1.3.1-1A, where c is selected from {0, 1, 2, 3} such that $N_c \leq n_{\text{CCE},m} < N_{c+1}$,
$$N_c = \max \left\{ 0, \left\lfloor [N_{\text{RB}}^{\text{DL}} \cdot (N_{\text{sc}}^{\text{RB}} \cdot c - 4)] / 36 \right\rfloor \right\},$$
 $n_{\text{CCE},m}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n - k_m$, and $N_{\text{PUCCH}}^{K^A}$, $N_{\text{PUCCH}}^{(1)}$, are configured by higher layers.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{\text{PUCCH},2}^{(1)}$ is determined as $n_{\text{PUCCH},2}^{(1)} = n_{\text{PUCCH},1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding PDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of both the counter DAI field and total DAI field in the corresponding DCI format is equal to '1' or for the PDCCH indicating downlink SPS release for which the value of both the counter DAI field and total DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding PDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'.
- for $M > 1$, and
 - for a PDSCH transmission only on the primary cell where there is not a corresponding EPDCCCH detected within subframe(s) $n - k$, where $k \in K$, and
 - for an additional PDSCH transmission only on the primary cell indicated by the detection of a corresponding EPDCCCH in subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the EPDCCCH equal to '1' (defined in Table 7.3.2.1-1), or
 - for an additional EPDCCCH indicating downlink SPS release (defined in Subclause 9.2) in subframe $n - k_m$, where $k_m \in K$ with both the counter DAI value and the total DAI value in the EPDCCCH equal to '1',

- the UE shall transmit $b(0), b(1)$ in subframe n using PUCCH format 1b on PUCCH resource $n_{\text{PUCCH}}^{(1)}$ selected from A PUCCH resources $n_{\text{PUCCH},i}^{(1)}$ where $0 \leq i \leq A-1$, according to Table 10.1.3.2-1 and Table 10.1.3.2-2 for $A = 2$ and $A = 3$, respectively. For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, $A = 3$; otherwise, $A = 2$.
- If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},1}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},1}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{m-1} N_{\text{ECCE},q,n-k_i} + n' + \Delta_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(e1)}$ for EPDCCH-PRB-set q is configured by the higher layer parameter pucch-ResourceStartOffset-r11, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. If $m = 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.2.1-1. If $m > 0$, Δ_{ARO} is determined from the HARQ-ACK resource offset field in the DCI format of the corresponding EPDCCH as given in Table 10.1.3.1-2. If the UE is configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs in EPDCCH-PRB-set q configured for that UE in subframe $n - k_{i_1}$. If the UE is not configured to monitor EPDCCH in subframe $n - k_{i_1}$, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to the number of ECCEs computed assuming EPDCCH-PRB-set q is configured for that UE in subframe $n - k_{i_1}$. For normal downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 5, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0. For extended downlink CP, if subframe $n - k_{i_1}$ is a special subframe with special subframe configuration 0 or 4 or 7, $N_{\text{ECCE},q,n-k_{i_1}}$ is equal to 0.

- If the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* on the primary cell, the PUCCH resource $n_{\text{PUCCH},0}^{(1)}$ is determined according to higher layer configuration and Table 9.2-2. The PUCCH resource $n_{\text{PUCCH},1}^{(1)}$ is determined as
 - If EPDCCH-PRB-set q is configured for distributed transmission

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{ECCE},q} + \sum_{i=0}^{i4-1} N'_{\text{ECCE},q,n-k'_{i_1}} + \sum_{i=0}^{i5-1} N'_{\text{ECCE},q,n-k''_{i_1}} + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(e1)}$$

- If EPDCCH-PRB-set q is configured for localized transmission

$$n_{\text{PUCCH},i}^{(1)} = \left\lfloor \frac{n_{\text{ECCE},q}}{N_{\text{RB}}^{\text{ECCE},q}} \right\rfloor \cdot N_{\text{RB}}^{\text{ECCE},q} + \sum_{i=0}^{i4-1} N'_{\text{ECCE},q,n-k_{i1}'} + \sum_{i=0}^{i5-1} N'_{\text{ECCE},q,n-k_{i1}^A} + n' + \Delta'_{\text{ARO}} + N_{\text{PUCCH},q}^{(\text{e1})}$$

where

- if the value of k_m is same as the value of an index k'_{i2} , where $k'_{i2} \in K'$, then $i4 = i2$;
- otherwise, if the value of k_m is same as the value of an index k_{i3}^A , where $k_{i3}^A \in K^A$, then $i4 = i3$;
- and where $n_{\text{ECCE},q}$ is the number of the first ECCE (i.e. lowest ECCE index used to construct the EPDCCH) used for transmission of the corresponding DCI assignment in EPDCCH-PRB-set q in subframe $n - k_m$, $N_{\text{PUCCH},q}^{(\text{e1})}$ for EPDCCH-PRB-set q is configured by the higher layer parameter *pucch-ResourceStartOffset-r11*, $N_{\text{RB}}^{\text{ECCE},q}$ for EPDCCH-PRB-set q in subframe $n - k_m$ is given in Subclause 6.8A.1 in [3], n' is determined from the antenna port used for EPDCCH transmission in subframe $n - k_m$ which is described in Subclause 6.8A.5 in [3]. Δ'_{ARO} , $N'_{\text{ECCE},q,n-k_{i1}'}$, $N'_{\text{ECCE},q,n-k_{i1}^A}$ are determined as described in Subclause 10.1.3.1.
- For a UE configured with a transmission mode that supports up to two transport blocks on the primary cell, the PUCCH resource $n_{\text{PUCCH},2}^{(1)}$ is determined as $n_{\text{PUCCH},2}^{(1)} = n_{\text{PUCCH},1}^{(1)} + 1$. HARQ-ACK(0) is the ACK/NACK/DTX response for the PDSCH without a corresponding EPDCCH detected. HARQ-ACK(1) is the ACK/NACK/DTX response for the first transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1' or for the EPDCCH indicating downlink SPS release for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'. HARQ-ACK(2) is the ACK/NACK/DTX response for the second transport block of the PDSCH indicated by the detection of a corresponding EPDCCH for which the value of both the counter DAI field and the total DAI field in the corresponding DCI format is equal to '1'.
- if a PDSCH transmission is indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k_m$, where $k_m \in K$ with either the counter DAI value or the total DAI value in the PDCCH/EPDCCH greater than '1' (defined in Table 7.3.2.1-1) on the primary cell, or
- if a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) is detected in subframe $n - k_m$, where $k_m \in K$ with either the counter DAI value or the total DAI value in the PDCCH/EPDCCH greater than '1' on the primary cell, or
- if a PDSCH transmission is indicated by the detection of a corresponding PDCCH/EPDCCH in subframe $n - k$, where $k \in K$ on a secondary cell,
 - if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is more than 22, the UE shall use PUCCH format 4 and PUCCCH resource $n_{\text{PUCCH}}^{(4)}$ where the value of $n_{\text{PUCCH}}^{(4)}$ is determined according to higher layer configuration and Table 10.1.2.2.3-1. Denote C as the set of configured serving cells for the UE. Denote k_{smallest} is the smallest value in $\bigcup_{c \in C} K_c$ such that PDCCH/EPDCCH scheduling PDSCH or indicating DL SPS release is detected in subframe $n - k_{\text{smallest}}$ on serving cell \tilde{C} and $k_{\text{smallest}} \in K_{\tilde{C}}$. The TPC field in a PDCCH/EPDCCH scheduling

PDSCH or indicating downlink SPS release in subframe $n - k_{\text{smallest}}$ on a serving cell \mathcal{C} satisfying $k_{\text{smallest}} \in K_c$ shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.3-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on any PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n - k_{\text{smallest}}$ on any serving cell \mathcal{C} satisfying $k_{\text{smallest}} \in K_c$.

- if the total number of HARQ-ACK bits O^{ACK} and scheduling request bit O^{SR} (if any) and periodic CSI bits $O_{\text{P-CSI}}$ (if any) is no more than 22, the UE shall use PUCCH format 3 and PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p})}$ where the value of $n_{\text{PUCCH}}^{(3,\tilde{p})}$ is determined according to higher layer configuration and Table 10.1.2.2.2-1. Denote \mathcal{C} as the set of configured serving cells for the UE. Denote k_{smallest} is the smallest value in $\bigcup_{c \in \mathcal{C}} K_c$ such that PDCCH/EPDCCH scheduling PDSCH or indicating DL SPS release is detected in subframe $n - k_{\text{smallest}}$ on serving cell \tilde{c} and $k_{\text{smallest}} \in K_{\tilde{c}}$. The TPC field in a PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n - k_{\text{smallest}}$ on a serving cell \mathcal{C} satisfying $k_{\text{smallest}} \in K_c$ shall be used to determine the PUCCH resource value from one of the four resource values configured by higher layers, with the mapping defined in Table 10.1.2.2.2-1. A UE shall assume that the same HARQ-ACK PUCCH resource value is transmitted on any PDCCH/EPDCCH scheduling PDSCH or indicating downlink SPS release in subframe $n - k_{\text{smallest}}$ on any serving cell \mathcal{C} satisfying $k_{\text{smallest}} \in K_c$. If a UE is configured for two antenna port transmission for PUCCH format 3, a PUCCH resource value in Table 10.1.2.2.2-1 maps to two PUCCH resources with the first PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{\text{PUCCH}}^{(3,\tilde{p}_0)}$ for antenna port p_0 .

10.1.3.2.4 PUCCH format 5 HARQ-ACK procedure

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 5 and *codebooksizeDetermination-r13 = cc* is described in Subclause 10.1.3.2.4.1.

TDD HARQ-ACK feedback procedures for a UE configured with PUCCH format 5 and *codebooksizeDetermination-r13 = dai* is described in Subclause 10.1.3.2.4.2.

10.1.3.2.4.1 PUCCH format 5 HARQ-ACK procedure without adaptive codebook

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in Subclause 10.1.3.2.3.1, by replacing $n_{\text{PUCCH}}^{(4)}$ with $n_{\text{PUCCH}}^{(5)}$.

10.1.3.2.4.2 PUCCH format 5 HARQ-ACK procedure with adaptive codebook

The HARQ-ACK feedback procedure for PUCCH format 5 HARQ-ACK procedure is as described in Subclause 10.1.3.2.3.2, by replacing $n_{\text{PUCCH}}^{(4)}$ with $n_{\text{PUCCH}}^{(5)}$.

10.1.3A FDD-TDD HARQ-ACK feedback procedures for primary cell frame structure type 2

A UE is configured by higher layers to use either PUCCH format 1b with channel selection or PUCCH format 3/4/5 for transmission of HARQ-ACK.

For a serving cell, if the serving cell is frame structure type 1, and a UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, set K is defined in Table 10.1.3A-1, otherwise set K is defined in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* for slot-PDSCH, in Table 10.1.3.1-

1B if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PDSCH and in Table 10.1.3.1-1 otherwise.

PUCCH format 1b with channel selection is not supported if a UE is configured with more than two serving cells, or if the DL-reference UL/DL configuration 5 (as defined in Subclause 10.2) is defined for any serving cell, or if the DL-reference UL/DL configuration of a serving cell with frame structure type 1 belongs to {2, 3, 4} and the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell.

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell and is configured with PUCCH format 3 without PUCCH format 4/5 configured, the UE is not expected to be configured with more than two serving cells having DL-reference UL/DL configuration 5.

If a UE is configured to use PUCCH format 1b with channel selection for HARQ-ACK transmission, for the serving cells,

- if more than 4 HARQ-ACK bits for M multiple downlink and special subframes associated with a single UL subframe n , where M is as defined in Subclause 10.1.3.2.1 for case where the UE is configured with two serving cells with different UL/DL configurations,
 - spatial HARQ-ACK bundling across multiple codewords within a downlink or special subframe is performed for each serving cell by a logical AND operation of all the corresponding individual HARQ-ACKs, and the bundled HARQ-ACK bits for each serving cell is transmitted using PUCCH format 1b with channel selection,
- otherwise,
 - spatial HARQ-ACK bundling is not performed, and the HARQ-ACK bits are transmitted using PUCCH format 1b with channel selection.

If a UE is configured to use PUCCH format 3 without PUCCH format 4/5 configured for HARQ-ACK transmission, for the serving cells,

- if more than 21 HARQ-ACK bits for M multiple subframes in downlink and special subframes associated with a single UL subframe n , where M as defined in Subclause 10.1.3.2.2 for the case of UE configured with more than one serving cell and if at least two cells have different UL/DL configurations,
 - spatial HARQ-ACK bundling across multiple codewords within a downlink subframe or a special subframe is performed for each serving cell by a logical AND operation of all of the corresponding individual HARQ-ACKs, and PUCCH format 3 is used,
- otherwise,
 - spatial HARQ-ACK bundling is not performed, and the HARQ-ACK bits are transmitted using PUCCH format 3.

- UE shall determine the number of HARQ-ACK bits, O , associated with an UL subframe/slot n according to

$$O = \sum_{c=1}^{N_{cells}^{DL}} O_c^{ACK} \text{ where } N_{cells}^{DL} \text{ is the number of configured cells, and } O_c^{ACK} \text{ is the number of HARQ-bits for the}$$

c -th serving cell defined in Subclause 7.3.4. If a UE is not configured to monitor PDCCH/EPDCCH/SPDCCH in another serving cell for scheduling a serving cell with frame structure type 1, and the DL-reference UL/DL configuration of the serving cell belongs to {2, 3, 4, 5}, then the UE is not expected to be configured with N_{cells}^{DL} which result in $O > 21$.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 3.

HARQ-ACK transmission on two antenna ports ($p \in [p_0, p_1]$) is supported for PUCCH format 1b with channel selection and with two configured serving cells.

The FDD-TDD HARQ-ACK feedback procedure for PUCCH format 1b with channel selection follows the HARQ-ACK procedure described in Subclause 10.1.3.2.1 for the case of UE configured with two serving cells with different UL/DL configurations, and for PUCCH format 3/4/5 follows the HARQ-ACK procedure described in Subclause

10.1.3.2.2/10.1.3.2.3/10.2.3.2.4 for the case of UE configured with more than one serving cell and if at least two cells have different UL/DL configurations.

Table 10.1.3A-1: Downlink association set $K : \{k_0, k_1, \dots, k_{M-1}\}$ for FDD-TDD and serving cell frame structure type 1

| DL-reference UL/DL Configuration | Subframe n | | | | | | | | | |
|----------------------------------|--------------|---|----------------------------------|------------|------|---|---|---------------|---------|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | - | - | 6, 5 | 5, 4 | 4 | - | - | 6, 5 | 5, 4 | 4 |
| 1 | - | - | 7, 6 | 6, 5, 4 | - | - | - | 7, 6 | 6, 5, 4 | - |
| 2 | - | - | 8, 7, 6, 5, 4 | - | - | - | - | 8, 7, 6, 5, 4 | - | - |
| 3 | - | - | 11, 10, 9, 8, 7, 6 | 6, 5 | 5, 4 | - | - | - | - | - |
| 4 | - | - | 12, 11, 10, 9, 8, 7 | 7, 6, 5, 4 | - | - | - | - | - | - |
| 5 | - | - | 13, 12, 11, 10, 9, 8, 7, 6, 5, 4 | - | - | - | - | - | - | - |
| 6 | - | - | 8, 7 | 7, 6 | 6, 5 | - | - | 7 | 7, 6, 5 | - |

10.1.4 HARQ-ACK Repetition procedure

For a non-BL/CE UE, HARQ-ACK repetition is enabled or disabled by a UE specific parameter $ackNackRepetition$ configured by higher layers. Once enabled, the UE shall repeat any HARQ-ACK transmission with a repetition factor N_{ANRep} , where N_{ANRep} is provided by higher layers and includes the initial HARQ-ACK transmission, until HARQ-ACK repetition is disabled by higher layers. For a PDSCH transmission without a corresponding PDCCH/EPDCCCH detected, the UE shall transmit the corresponding HARQ-ACK response N_{ANRep} times using PUCCH resource $n_{PUCCH}^{(1,\tilde{p})}$ configured by higher layers. For a PDSCH transmission with a corresponding PDCCH/EPDCCCH detected, or for a PDCCH/EPDCCCH indicating downlink SPS release, the UE shall first transmit the corresponding HARQ-ACK response once using PUCCH resource derived from the corresponding PDCCH CCE index or EPDCCCH ECCE index (as described in Subclauses 10.1.2 and 10.1.3), and repeat the transmission of the corresponding HARQ-ACK response $N_{ANRep} - 1$ times always using PUCCH resource $n_{PUCCH,ANRep}^{(1,\tilde{p})}$, where $n_{PUCCH,ANRep}^{(1,\tilde{p})}$ is configured by higher layers.

HARQ-ACK repetition is only applicable for UEs configured with one serving cell for FDD and TDD. For TDD, HARQ-ACK repetition is only applicable for HARQ-ACK bundling.

HARQ-ACK repetition can be enabled with PUCCH format 1a/1b on two antenna ports. For a UE configured for two antenna port transmission for HARQ-ACK repetition with PUCCH format 1a/1b, a PUCCH resource value $n_{PUCCH,ANRep}^{(1,\tilde{p})}$ maps to two PUCCH resources with the first PUCCH resource $n_{PUCCH,ANRep}^{(1,\tilde{p}_0)}$ for antenna port p_0 and the second PUCCH resource $n_{PUCCH,ANRep}^{(1,\tilde{p}_1)}$ for antenna port p_1 , otherwise, the PUCCH resource value maps to a single PUCCH resource $n_{PUCCH,ANRep}^{(1,\tilde{p}_0)}$ for antenna port p_0 .

10.1.5 Scheduling Request (SR) procedure

A non-BL/CE UE is configured by higher layers to transmit the SR on one antenna port or two antenna ports.

For a non-BL/CE UE, the scheduling request shall be transmitted on the PUCCH resource(s) $n_{\text{PUCCH}}^{(1,\tilde{p})} = n_{\text{PUCCH,SRI}}^{(1,\tilde{p})}$ for \tilde{p} mapped to antenna port p as defined in [3], where $n_{\text{PUCCH,SRI}}^{(1,\tilde{p})}$ is configured by higher layers unless the SR coincides in time with the transmission of HARQ-ACK using PUCCH Format 3/4/5 in which case the SR is multiplexed with HARQ-ACK according to Subclause 5.2.3.1 of [4]. The subframe-SR configuration for SR transmission periodicity $SR_{\text{PERIODICITY}}$ and SR subframe offset $N_{\text{OFFSET,SR}}$ is defined in Table 10.1.5-1 by the parameter *sr-ConfigIndex* I_{SR} given by higher layers.

Subframe-SR transmission instances are the uplink subframes satisfying

$$(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{\text{OFFSET,SR}}) \bmod SR_{\text{PERIODICITY}} = 0.$$

The slot-SR configuration for SR transmission periodicity $SR_{\text{PERIODICITY}}$ and SR slot offset $N_{\text{OFFSET,SR}}$ is defined in Table 10.1.5-1A by the parameter *sr-ConfigIndexSlot* I_{SR} given by higher layers.

Slot-SR transmission instances are the uplink slots satisfying

$$(20 \times n_f + n_s - N_{\text{OFFSET,SR}}) \bmod SR_{\text{PERIODICITY}} = 0.$$

The subslot-SR configuration for SR transmission periodicity $SR_{\text{PERIODICITY}}$ and SR subslot offset $N_{\text{OFFSET,SR}}$ is defined in Table 10.1.5-1B by the parameter *sr-ConfigIndexSubslot* I_{SR} given by higher layers.

Subslot-SR transmission instances are the uplink slots satisfying

$$(60 \times n_f + 6 \times \lfloor n_s / 2 \rfloor + n_{\text{sub}} - N_{\text{OFFSET,SR}}) \bmod SR_{\text{PERIODICITY}} = 0, \text{ where } n_{\text{sub}} \text{ is the subslot index within a subframe.}$$

For a BL/CE UE, the scheduling request shall be transmitted on the PUCCH resource(s) $n_{\text{PUCCH}}^{(1)} = n_{\text{PUCCH,SRI}}^{(1)}$ mapped to antenna port p_0 as defined in [3], where $n_{\text{PUCCH,SRI}}^{(1)}$ is configured by higher layers. The SR configuration for SR transmission periodicity $SR_{\text{PERIODICITY}}$ and SR subframe offset $N_{\text{OFFSET,SR}}$ is defined in Table 10.1.5-1 by the parameter *sr-ConfigIndex* I_{SR} given by higher layers. The SR transmission instances are $N_{\text{PUCCH,rep}}^{(m)}$ consecutive BL/CE uplink subframes when $N_{\text{PUCCH,rep}}^{(m)} > 1$, or one uplink subframe (which may or may not be a BL/CE UL subframe) when $N_{\text{PUCCH,rep}}^{(m)} = 1$, where $N_{\text{PUCCH,rep}}^{(m)}$ is provided by higher layer parameter *NumRepetitionCE-format1*, starting from a subframe satisfying

$$(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{\text{OFFSET,SR}}) \bmod SR_{\text{PERIODICITY}} = 0.$$

Table 10.1.5-1: UE-specific SR periodicity and subframe offset configuration for subframe-SR

| SR configuration Index I_{SR} | SR periodicity (ms) $SR_{PERIODICITY}$ | SR subframe offset $N_{OFFSET,SR}$ |
|---|--|--|
| 0 – 4 | 5 | I_{SR} |
| 5 – 14 | 10 | $I_{SR} - 5$ |
| 15 – 34 | 20 | $I_{SR} - 15$ |
| 35 – 74 | 40 | $I_{SR} - 35$ |
| 75 – 154 | 80 | $I_{SR} - 75$ |
| 155 – 156 | 2 | $I_{SR} - 155$ |
| 157 | 1 | $I_{SR} - 157$ |

Table 10.1.5-1A: UE-specific SR periodicity and slot offset configuration for slot-SR

| SR configuration Index I_{SR} | SR periodicity (number of slots) $SR_{PERIODICITY}$ | SR slot offset $N_{OFFSET,SR}$ |
|---|---|--|
| 0 | 1 | I_{SR} |
| 1 – 2 | 2 | $I_{SR} - 1$ |
| 3 – 6 | 4 | $I_{SR} - 3$ |
| 7 – 16 | 10 | $I_{SR} - 7$ |
| 17 – 36 | 20 | $I_{SR} - 17$ |

Table 10.1.5-1B: UE-specific SR periodicity and subslot offset configuration for subslot-SR

| SR configuration Index I_{SR} | SR periodicity (number of subslots) $SR_{PERIODICITY}$ | SR subslot offset $N_{OFFSET,SR}$ |
|---|--|---|
| 0 | 1 | I_{SR} |
| 1 – 2 | 2 | $I_{SR} - 1$ |
| 3 – 5 | 3 | $I_{SR} - 3$ |
| 6 – 9 | 4 | $I_{SR} - 6$ |
| 10 – 14 | 5 | $I_{SR} - 10$ |
| 15 – 20 | 6 | $I_{SR} - 15$ |
| 21 – 32 | 12 | $I_{SR} - 21$ |
| 33 – 62 | 30 | $I_{SR} - 33$ |
| 63 – 122 | 60 | $I_{SR} - 63$ |

10.2 Uplink HARQ-ACK timing

For TDD or for FDD-TDD and primary cell frame structure type 2 or for FDD-TDD and primary cell frame structure type 1, if a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell, "UL/DL configuration" of the serving cell in Subclause 10.2 refers to the UL/DL configuration given by the parameter *eimta-HARQ-ReferenceConfig-r12* for the serving cell unless specified otherwise.

For TDD serving cell not configured for PUSCH/PUCCH transmission, "UL/DL configuration" of the serving cell in Subclause 10.2 refers to the UL/DL configuration given by the parameter *harq-ReferenceConfig-r14* for the serving cell unless specified otherwise

For a non-BL/CE UE, for FDD or for FDD-TDD and primary cell frame structure type 1, the UE shall upon detection of a PDSCH transmission in subframe $n-4$ intended for the UE and for which an HARQ-ACK shall be provided, transmit the HARQ-ACK response in subframe n . If HARQ-ACK repetition is enabled, upon detection of a PDSCH transmission in subframe $n-4$ intended for the UE and for which HARQ-ACK response shall be provided, and if the UE is not repeating the transmission of any HARQ-ACK in subframe n corresponding to a PDSCH transmission in subframes $n - N_{ANRep} - 3, \dots, n - 5$, the UE:

- shall transmit only the HARQ-ACK response (corresponding to the detected PDSCH transmission in subframe $n-4$) on PUCCH in subframes $n, n+1, \dots, n + N_{ANRep} - 1$;
- shall not transmit any other signal/channel in subframes $n, n+1, \dots, n + N_{ANRep} - 1$; and
- shall not transmit any HARQ-ACK response repetitions corresponding to any detected PDSCH transmission in subframes $n-3, \dots, n + N_{ANRep} - 5$.

For TDD and a UE configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, the DL-reference UL/DL configuration for a serving cell is the UL/DL configuration of the serving cell.

For FDD-TDD and primary cell frame structure type 1, if a serving cell is a secondary serving cell with frame structure type 2, the DL-reference UL/DL configuration for the serving cell is the UL/DL configuration of the serving cell.

For TDD, if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if a serving cell is a primary cell, then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell or if a serving cell is a secondary cell with frame structure type 1, then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For TDD and if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if the UE is not configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell, or for FDD-TDD and primary cell frame structure type 2 and if the UE is not configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary cell with frame structure type 2

- if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 1 in Table 10.2-1 or
- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 2 or Set 3 in Table 10.2-1 or
- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 4 or Set 5 in Table 10.2-1

then the DL-reference UL/DL configuration for the serving cell is defined in the corresponding Set in Table 10.2-1.

For TDD and if the UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations and if the UE is configured with *harqTimingTDD = TRUE* and if a serving cell is a secondary

cell, or for FDD-TDD and primary cell frame structure type 2 and if the UE is configured with $harqTimingTDD = TRUE$ and if a serving cell is a secondary cell with frame structure type 2

- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and if the pair formed by (primary cell UL/DL configuration, serving cell UL/DL configuration) belongs to Set 1 or Set 4 or Set 5 in Table 10.2-1, then the DL-reference UL/DL configuration for the serving cell is defined in the corresponding Set in Table 10.2-1;
- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, and then the primary cell UL/DL configuration is the DL-reference UL/DL configuration for the serving cell.

For a UE not configured with PUCCH format 4 or PUCCH format 5, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations or for FDD-TDD and primary cell frame structure type 2, if the DL-reference UL/DL configuration for at least one serving cell is TDD UL/DL Configuration 5, then the UE is not expected to be configured with more than two serving cells.

For TDD and a non-BL/CE UE not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, if the UE is configured with one serving cell, or the UE is configured with more than one serving cell and the UL/DL configurations of all serving cells is same, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n - k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n .

For a UE not configured with $harqTimingTDD = TRUE$, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or if a UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and primary cell frame structure type 2 and if a serving cell c is frame structure type 2, then the UE shall upon detection of a PDSCH transmission within subframe(s) $n - k$ for serving cell c , where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n , wherein set K_c contains values of $k \in K$ such that subframe $n - k$ corresponds to a DL subframe or a special subframe for serving cell c , where DL subframe or special subframe of serving cell c is according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for serving cell c and according to *harq-ReferenceConfig-r14* if configured; K defined in Table 10.1.3.1-1 (where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n .

For a UE configured with $harqTimingTDD = TRUE$, for TDD and if a UE is configured with more than one serving cell and if at least two serving cells have different UL/DL configurations, or for FDD-TDD and primary cell frame structure type 2 and if a serving cell c is frame structure type 2,

- if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c , then the UE shall upon detection of a PDSCH transmission within subframe(s) $n - k$ for serving cell c , where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n , wherein set K_c contains values of $k \in K$ such that subframe $n - k$ corresponds to a DL subframe or a special subframe for serving cell c , where K is defined in Table 10.1.3.1-1 (where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n .
- if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c , then the UE shall upon detection of a PDSCH transmission within subframe(s) $n - k$ for serving cell c , where $k \in K_c$ intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in UL subframe n , wherein set K_c contains values of $k \in K$ such that subframe $n - k$ corresponds to a DL subframe or a special subframe for serving cell c , where K is defined in Table 10.1.3A-1 (where "UL/DL configuration" in Table 10.1.3A-1 refers to the "DL-reference UL/DL configuration") is associated with subframe n .

For a non-BL/CE UE, and for FDD-TDD and primary cell frame structure type 2, if a serving cell c is frame structure type 1 and a UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell c , then the UE shall upon detection of a PDSCH transmission within subframe(s) $n - k$ for serving cell c , where

$k \in K_c$, $K_c = K$ and K is defined in Table 10.1.3A-1 intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in subframe n .

For FDD-TDD and primary cell frame structure type 2, if a serving cell c is frame structure type 1 and a UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling serving cell c , then the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$ for serving cell c , where $k \in K_c$, $K_c = K$ and K is defined in Table 10.1.3.1-1, intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response in subframe n , where "UL/DL configuration" in Table 10.1.3.1-1 refers to the "DL-reference UL/DL configuration" of serving cell c .

For TDD, if HARQ-ACK repetition is enabled, upon detection of a PDSCH transmission within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE and for which HARQ-ACK response shall be provided, and if the UE is not repeating the transmission of any HARQ-ACK in subframe n corresponding to a PDSCH transmission in a downlink or special subframe earlier than subframe $n-k$, the UE:

- shall transmit only the HARQ-ACK response (corresponding to the detected PDSCH transmission in subframe $n-k$) on PUCCH in UL subframe n and the next $N_{ANRep} - 1$ UL subframes denoted as $n_1, \dots, n_{N_{ANRep}-1}$;
- shall not transmit any other signal/channel in UL subframe n , $n_1, \dots, n_{N_{ANRep}-1}$; and
- shall not transmit any HARQ-ACK response repetitions corresponding to any detected PDSCH transmission in subframes $n_i - k$, where $k \in K_i$, K_i is the set defined in Table 10.1.3.1-1 corresponding to UL subframe n_i , and $1 \leq i \leq N_{ANRep} - 1$.

For TDD, HARQ-ACK bundling, if the UE detects that at least one downlink assignment has been missed as described in Subclause 7.3, the UE shall not transmit HARQ-ACK on PUCCH if HARQ-ACK is the only UCI present in a given subframe.

For FDD, a BL/CE UE shall upon detection of a PDSCH intended for the UE and for which an HARQ-ACK shall be provided, transmit the HARQ-ACK response using the same $n_{PUCCH}^{(1,p_0)}$ derived according to Subclause 10.1.2.1 in subframe(s) $n+k_i$ with $i=0, 1, \dots, N-1$, where

- subframe $n-k$ is the last subframe in which the PDSCH is transmitted, where
 - if the UE is in half-duplex FDD operation and is configured with CEModeA and higher layer parameter *ce-HARQ-AckBundling* and the 'HARQ-ACK bundling flag' in the corresponding DCI is set to 1, or if the UE is configured with higher layer parameter *ce-SchedulingEnhancement*
 - k is given by the 'HARQ-ACK delay' field in the corresponding DCI, and the HARQ-ACK delay value k is determined based on the higher layer parameters according to Table 7.3.1-2;
 - otherwise
 - $k = 4$
- $0 \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of $N = N_{PUCCH,rep}^{(m)}$ and $N_{PUCCH,rep}^{(m)}$ is provided by higher layer parameter *pucch-NumRepetitionCE-format1*, if configured, otherwise it is provided by higher layer parameter *pucch-NumRepetitionCE-Msg4-Level0-r13*, *pucch-NumRepetitionCE-Msg4-Level1-r13*, *pucch-NumRepetitionCE-Msg4-Level2-r13* or *pucch-NumRepetitionCE-Msg4-Level3-r13* depending on whether the most recent PRACH coverage enhancement level for the UE is 0, 1, 2 or 3, respectively; and
 - if $N > 1$
 - subframe(s) $n+k_i$ with $i=0, 1, \dots, N-1$ are N consecutive BL/CE UL subframe(s) immediately after subframe $n-1$, and the set of BL/CE UL subframes are configured by higher layers;
 - otherwise
 - $k_0 = 0$

For TDD, a BL/CE UE shall upon detection of a PDSCH within subframe(s) $n - k$, where $k \in K$ and K is defined in Table 10.1.3.1-1 intended for the UE and for which HARQ-ACK response shall be provided, transmit the HARQ-ACK response using the same $n_{\text{PUCCH}}^{(1,p_0)}$ derived according to Subclause 10.1.3.1 in subframe(s) $n+k_i$ with $i = 0, 1, \dots, N-1$, where

- subframe $n-k$ is the last subframe in which the PDSCH is transmitted; and
- $0 \leq k_0 < k_1 < \dots, k_{N-1}$ and the value of $N = N_{\text{PUCCH},\text{rep}}^{(\text{m})}$ and $N_{\text{PUCCH},\text{rep}}^{(\text{m})}$ is provided by higher layers parameter *pucch-NumRepetitionCE-format1*, if configured, otherwise it is provided by higher layer parameter *pucch-NumRepetitionCE-Msg4-Level0-r13*, *pucch-NumRepetitionCE-Msg4-Level1-r13*, *pucch-NumRepetitionCE-Msg4-Level2-r13* or *pucch-NumRepetitionCE-Msg4-Level3-r13* depending on whether the most recent PRACH coverage enhancement level for the UE is 0, 1, 2 or 3, respectively; and

if $N > I$

- subframe(s) $n+k_i$ with $i = 0, 1, \dots, N-1$ are N consecutive BL/CE UL subframe(s) immediately after subframe $n-1$, and the set of BL/CE UL subframes are configured by higher layers;

otherwise

- $k_0 = 0$

The uplink timing for the ACK corresponding to a detected PDCCH/EPDCCH indicating downlink SPS release shall be the same as the uplink timing for the HARQ-ACK corresponding to a detected PDSCH, as defined above.

For a BL/CE UE, the uplink timing for the ACK corresponding to a detected MPDCCH indicating downlink SPS release shall be the same as the uplink timing for the HARQ-ACK corresponding to a detected PDSCH, as defined above.

For a BL/CE UE, if a first HARQ-ACK transmission associated to a first set of PDSCH partially collides with a second HARQ-ACK transmission associated to a second set of PDSCH transmissions, the last PDSCH of the first set of PDSCH transmissions being detected before the last PDSCH of the second set of PDSCH transmissions, the UE shall drop the second HARQ-ACK transmission.

Table 10.2-1: DL-reference UL/DL configuration for serving cell based on pair formed by (primary cell UL/DL configuration, secondary cell UL/DL configuration)

| Set # | (Primary cell UL/DL configuration, Secondary cell UL/DL configuration) | DL-reference UL/DL configuration |
|-------|---|-------------------------------------|
| Set 1 | (0,0) | 0 |
| | (1,0),(1,1),(1,6) | 1 |
| | (2,0),(2,2),(2,1),(2,6) | 2 |
| | (3,0),(3,3),(3,6) | 3 |
| | (4,0),(4,1),(4,3),(4,4),(4,6) | 4 |
| | (5,0),(5,1),(5,2),(5,3),(5,4),(5,5),(5,6) | 5 |
| | (6,0),(6,6) | 6 |
| Set 2 | (0,1),(6,1) | 1 |
| | (0,2),(1,2),(6,2) | 2 |
| | (0,3),(6,3) | 3 |
| | (0,4),(1,4),(3,4),(6,4) | 4 |
| | (0,5),(1,5),(2,5),(3,5),(4,5),(6,5) | 5 |
| | (0,6) | 6 |
| Set 3 | (3,1),(1,3) | 4 |
| | (3,2),(4,2),(2,3),(2,4) | 5 |
| Set 4 | (0,1),(0,2),(0,3),(0,4),(0,5),(0,6) | 0 |
| | (1,2),(1,4),(1,5) | 1 |
| | (2,5) | 2 |
| | (3,4),(3,5) | 3 |
| | (4,5) | 4 |
| | (6,1),(6,2),(6,3),(6,4),(6,5) | 6 |
| Set 5 | (1,3) | 1 |
| | (2,3),(2,4) | 2 |
| | (3,1),(3,2) | 3 |
| | (4,2) | 4 |

11 Physical Multicast Channel (PMCH) related procedures

11.1 UE procedure for receiving the PMCH

A UE is not expected to receive PMCH with $\Delta f = 1.25$ kHz (Δf defined in [3]) or $\Delta f = 7.5$ kHz in an MBSFN subframe with non-zero-size non-MBSFN region.

A UE is not expected to receive PMCH with Δf other than $\Delta f = 1.25$ kHz or $\Delta f = 7.5$ kHz in an MBSFN subframe with zero-size non-MBSFN region.

The UE shall decode the PMCH when configured by higher layers. The UE may assume that an eNB transmission on the PMCH is performed according to Subclause 6.5 of [3].

The I_{MCS} for the PMCH is configured by higher layers. If the UE is configured by higher layers to decode the PMCH based on QPSK, 16QAM, 64QAM, and 256QAM then the UE shall use I_{MCS} and Table 7.1.7.1-1A to determine the modulation order (Q_m) and TBS index (I_{TBS}) used in the PMCH. Else the UE shall use I_{MCS} for the PMCH and Table 7.1.7.1-1 to determine the modulation order (Q_m) and TBS index (I_{TBS}) used in the PMCH.

The UE shall then follow the procedure in Subclause 7.1.7.2.1 to determine the transport block size, assuming N_{PRB} is equal to $N_{\text{RB}}^{\text{DL}}$. The UE shall set the redundancy version to 0 for the PMCH.

A UE may optionally report parameters *mbms-MaxBW*(T), *mbms-ScaleFactor1dot25* ($A^{(7.5)}$) and *mbms-ScaleFactor7dot5* ($A^{(7.5)}$) to indicate a limitation on baseband capability provided by the following inequality

$$T \geq \sum_{c=1}^C (R_c B_c I_c^{(15\text{kHz})} + A^{(7.5)} B_c I_c^{(7.5\text{kHz})} + A^{(1.25)} B_c I_c^{(1.25\text{kHz})})$$

where

- T is the maximum bandwidth capability of the UE, indicated by *mbms-MaxBW*:
- if *mbms-MaxBW* is set to *implicitValue*, then

$$T = \text{round} \left(\frac{\text{Maximum number of DL-SCH transport block bits received within a TTI}}{\text{Maximum TBS for 2 layers for the maximum supported modulation scheme}} \right) \times 20\text{MHz}$$

where the numerator and the denominator correspond to the corresponding columns of the maximum indicated *ue-CategoryDL* in [12].

- if *mbms-MaxBW* is set to *explicitValue*, then $T = \text{explicitValue} \times 40\text{MHz}$
- C is the number of serving cells the UE is configured with, or receiving PMCH from.
- R_c is the number of spatial layers the UE can receive in the c -th serving cell according to *MIMO-CapabilityDL*.
- B_c is the bandwidth (in MHz) of the c -th serving cell.
- If the UE is receiving PMCH with 1.25kHz numerology in serving cell c , then
 - $I_c^{(1.25\text{kHz})} = 1, I_c^{(7.5\text{kHz})} = 0, I_c^{(15\text{kHz})} = 0$
- else, if the UE is receiving PMCH with 7.5kHz numerology in serving cell c , then
 - $I_c^{(1.25\text{kHz})} = 0, I_c^{(7.5\text{kHz})} = 1, I_c^{(15\text{kHz})} = 0$
- else,
 - $I_c^{(1.25\text{kHz})} = 0, I_c^{(7.5\text{kHz})} = 0, I_c^{(15\text{kHz})} = 1$

11.2 UE procedure for receiving MCCH and system information change notification

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the M-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 11.2-1.

Table 11.2-1: PDCCH configured by M-RNTI

| DCI format | Search Space |
|---------------|--------------|
| DCI format 1C | Common |

The 8-bit information for MCCH change notification [11], as signalled on the PDCCH, shall be delivered to higher layers.

The [1]-bit information for System information change notification [11], as signalled on the PDCCH, shall be delivered to higher layers.

12 Assumptions independent of physical channel

A UE shall not assume that two antenna ports are quasi co-located unless specified otherwise.

A UE may assume the antenna ports 0 – 3 of a serving cell are quasi co-located (as defined in [3]) with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

For the purpose of discovery-signal-based measurements, a UE shall not assume any other signals or physical channels are present other than the discovery signal.

If a UE supports *discoverySignalsInDeactSCell-r12*, and if the UE is configured with discovery-signal-based RRM measurements on a carrier frequency applicable for a secondary cell on the same carrier frequency, and if the secondary cell is deactivated, and if the UE is not configured by higher layers to receive MBMS on the secondary cell, the UE shall, except for discovery-signal transmissions, assume that PSS, SSS, PBCH, CRS, PCFICH, PDSCH, PDCCH, EPDCCH, PHICH, DMRS and CSI-RS may be not transmitted by the secondary cell until the subframe where an activation command is received for the secondary cell.

For BL/CE UE, if CEModeA or CEModeB is not configured, UE shall assume the following configuration:

- For a BL/CE UE with the PRACH coverage enhancement level 0/1, UE shall assume CEModeA.
- For a BL/CE UE with the PRACH coverage enhancement level 2/3, UE shall assume CEModeB.

If a UE is configured by higher layers to operate in an MBMS-dedicated serving cell, or if a UE is configured by higher layers to operate in an FeMBMS/Unicast-mixed serving cell and is configured with a carrier indicator field in the FeMBMS/Unicast-mixed serving cell,

- the UE shall assume that physical signals or physical channels may not be transmitted by the serving cell in a non-zero-size non-MBSFN region of an MBSFN subframe not assumed to be used for PMCH, regardless of whether there is any physical signal or physical channel being transmitted in the MBSFN region of such an MBSFN subframe.

If a UE is not configured with a carrier indicator field on a serving cell, the UE can assume that physical signals and physical channels are present in a non-zero-size non-MBSFN region of an MBSFN subframe on the serving cell.

13 Uplink/Downlink configuration determination procedure for Frame Structure Type 2

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

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

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

For each serving cell

If the UE is not configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*,

- the UE shall set the UL/DL configuration equal to the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers.

If the UE is configured by higher layers with the parameter *EIMTA-MainConfigServCell-r12*, then for each radio frame,

- the UE shall determine eIMTA-UL/DL-configuration as described in Subclause 13.1.
- the UE shall set the UL/DL configuration for each radio frame equal to the eIMTA-UL/DL-configuration of that radio frame.
- For a serving cell c , a UE is not expected to be configured with parameter *harq-ReferenceConfig-r14* if a subframe indicated as an uplink subframe by *harq-ReferenceConfig-r14* is not indicated as an uplink subframe by the UL-reference UL/DL configuration if it is configured, otherwise, indicated as uplink subframe by UL/DL configuration.

13.1 UE procedure for determining eIMTA-uplink/downlink configuration

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the eIMTA-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 13.1-1.

Table 13.1-1: PDCCH configured by eIMTA-RNTI

| DCI format | Search Space |
|---------------|--------------|
| DCI format 1C | Common |

The subframes in which the UE monitors PDCCH with CRC scrambled by eIMTA-RNTI are configured by higher layers.

For each serving cell,

- if $T = 10$,
 - if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in subframe 0 of a radio frame m or if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in a subframe other than subframe 0 of a radio frame $m-1$,
 - the eIMTA-UL/DL-configuration for radio frame m is given by the UL/DL configuration indication signalled on the PDCCH as described in [4],
 - the UE may assume that the same UL/DL configuration indication is indicated by PDCCH with CRC scrambled by eIMTA-RNTI in subframe 0 of radio frame m and in all the subframes other than subframe 0 of radio frame $m-1$ in which PDCCH with CRC scrambled by eIMTA-RNTI is monitored,
 - otherwise
 - the eIMTA-UL/DL-configuration for radio frame m is same as the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers;
- if T is a value other than 10,
 - if the UE detects PDCCH with CRC scrambled by eIMTA-RNTI in a subframe in radio frame $mT/10$,

- the eIMTA-UL/DL-configuration for radio frames $\{mT/10+1, mT/10+2, \dots, (m+1)T/10\}$ is given by the UL/DL configuration indication signalled on the PDCCH as described [4],
- the UE may assume that the same UL/DL configuration indication is indicated by PDCCH with CRC scrambled by eIMTA-RNTI in all the subframes of radio frame $mT/10$ in which PDCCH with CRC scrambled by eIMTA-RNTI is monitored,
- otherwise
 - the eIMTA-UL/DL-configuration for radio frames $\{mT/10+1, mT/10+2, \dots, (m+1)T/10\}$ is same as the UL/DL configuration (i.e., the parameter *subframeAssignment*) indicated by higher layers.

where T denotes the value of parameter *eimta-CommandPeriodicity-r12*.

For a serving cell c , if subframe i is indicated as uplink subframe or a special subframe by higher layer parameter *eimta-HARQ-ReferenceConfig-r12*, the UE is not expected to receive a PDCCH with CRC scrambled by eIMTA-RNTI containing an UL/DL configuration for serving cell c that would indicate subframe i as a downlink subframe.

For a serving cell c , if subframe i is indicated as downlink subframe or a special subframe by higher layer parameter *subframeAssignment*, the UE is not expected to receive a PDCCH with CRC scrambled by eIMTA-RNTI containing an UL/DL configuration for serving cell c that would indicate subframe i as an uplink subframe.

For a serving cell c , a UE is not expected to be configured with parameter *eimta-HARQ-ReferenceConfig-r12* if a subframe indicated as an uplink subframe by *eimta-HARQ-ReferenceConfig-r12* is not indicated as an uplink subframe by the UL-reference UL/DL configuration.

If UE is not configured with the parameter *EIMTA-MainConfigServCell-r12* for any activated serving cell, the UE is not expected to monitor PDCCH with CRC scrambled by eIMTA-RNTI.

If the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, the UE is not expected to monitor PDCCH with CRC scrambled by eIMTA-RNTI outside of the Active Time defined in [8] in order to determine the configured CSI-RS or CSI-IM REs in subframe 6 for CSI reporting purposes. If the UE doesn't detect an UL/DL configuration indication for radio frame m , the UE determines the configured CSI-RS and CSI-IM REs in subframe 6 according to the UL/DL configuration indicated by higher layer parameter *subframeAssignment* for the serving cell.

13A Subframe configuration for Frame Structure Type 3

If a UE detects PDCCH with DCI CRC scrambled by CC-RNTI in subframe $n-1$ or subframe n of a LAA Scell, the UE may assume the configuration of occupied OFDM symbols in subframe n of the LAA Scell according to the 'Subframe configuration for LAA' field in the detected DCI in subframe $n-1$ or subframe n .

The 'Subframe configuration for LAA' field indicates the configuration of occupied OFDM symbols (i.e., OFDM symbols used for transmission of downlink physical channels and/or physical signals) in current and/or next subframe according to Table 13A-1.

If the configuration of occupied OFDM symbols for subframe n is indicated by the Subframe configuration for LAA field in both subframe $n-1$ and subframe n , the UE may assume that the same configuration of occupied OFDM symbols is indicated in both subframe $n-1$ and subframe n .

If a UE detects PDCCH with DCI CRC scrambled by CC-RNTI in subframe n , and the UE does not detect PDCCH with DCI CRC scrambled by CC-RNTI in subframe $n-1$, and if the number of occupied OFDM symbols for subframe n indicated by the Subframe configuration for LAA field in subframe n is less than 14, the UE is not required to receive any other physical channels in subframe n except for PDCCH with DCI format 0A/0B/4A/4B if configured.

If a UE does not detect PDCCH with DCI CRC scrambled by CC-RNTI containing 'Subframe Configuration for LAA' field set to other than '1110' and '1111' in subframe n and the UE does not detect PDCCH with DCI CRC scrambled by CC-RNTI containing 'Subframe Configuration for LAA' field set to other than '1110' and '1111' in subframe $n-1$, the UE is not required to use subframe n for updating CSI measurement.

The UE may detect PDCCH with DCI CRC scrambled by CC-RNTI by monitoring the following PDCCH candidates according to DCI Format 1C.

- one PDCCH candidate at aggregation level L=4 with the CCEs corresponding to the PDCCH candidate given by CCEs numbered 0,1,2,3

- one PDCCH candidate at aggregation level L=8 with the CCEs corresponding to the PDCCH candidate given by CCEs numbered 0,1,2,3,4,5,6,7

If a serving cell is a LAA Scell, and if the higher layer parameter *subframeStartPosition* for the Scell indicates 's07', and if the UE detects PDCCH/EPDCCH intended for the UE starting in the second slot of a subframe, the UE may assume that OFDM symbols in the first slot of the subframe are not occupied, and all OFDM symbols in the second slot of the subframe are occupied,

If subframe n is a subframe in which OFDM symbols in the first slot are not occupied, the UE may assume that all the OFDM symbols are occupied in subframe n+1.

Table 13A-1: Subframe configuration for LAA in current and next subframe

| Value of 'Subframe configuration for LAA' field in current subframe | Configuration of occupied OFDM symbols (current subframe, next subframe) |
|---|--|
| 0000 | (-,14) |
| 0001 | (-,12) |
| 0010 | (-,11) |
| 0011 | (-,10) |
| 0100 | (-,9) |
| 0101 | (-,6) |
| 0110 | (-,3) |
| 0111 | (14,*) |
| 1000 | (12,-) |
| 1001 | (11,-) |
| 1010 | (10,-) |
| 1011 | (9,-) |
| 1100 | (6,-) |
| 1101 | (3,-) |
| 1110 | reserved |
| 1111 | reserved |

NOTE:

- (-, Y) means UE may assume the first Y symbols are occupied in next subframe and other symbols in the next subframe are not occupied.
- (X, -) means UE may assume the first X symbols are occupied in current subframe and other symbols in the current subframe are not occupied.
- (X, *) means UE may assume the first X symbols are occupied in current subframe, and at least the first OFDM symbol of the next subframe is not occupied.

If a UE is configured with a LAA SCell for UL transmissions, and the UE detects PDCCH with DCI CRC scrambled by CC-RNTI in subframe *n*, the UE may be configured with a 'UL duration' and 'UL offset' for subframe *n* according to the 'UL duration and offset' field in the detected DCI. The 'UL duration and offset' field indicates the 'UL duration' and 'UL offset' according to Table 13A-2.

If the 'UL duration and offset' field configures an 'UL offset' *l* and an 'UL duration' *d* for subframe *n*, the UE is not required to receive any downlink physical channels and/or physical signals in subframe(s) *n+l+i* with *i* = 0, 1, ..., *d*-1.

Table 13A-2: UL duration and offset.

| Value of 'UL duration and offset' field | UL offset, l (in subframes) | UL duration, d (in subframes) |
|--|---|---|
| 00000 | Not configured | Not configured |
| 00001 | 1 | 1 |
| 00010 | 1 | 2 |
| 00011 | 1 | 3 |
| 00100 | 1 | 4 |
| 00101 | 1 | 5 |
| 00110 | 1 | 6 |
| 00111 | 2 | 1 |
| 01000 | 2 | 2 |
| 01001 | 2 | 3 |
| 01010 | 2 | 4 |
| 01011 | 2 | 5 |
| 01100 | 2 | 6 |
| 01101 | 3 | 1 |
| 01110 | 3 | 2 |
| 01111 | 3 | 3 |
| 10000 | 3 | 4 |
| 10001 | 3 | 5 |
| 10010 | 3 | 6 |
| 10011 | 4 | 1 |
| 10100 | 4 | 2 |
| 10101 | 4 | 3 |
| 10110 | 4 | 4 |
| 10111 | 4 | 5 |
| 11000 | 4 | 6 |
| 11001 | 6 | 1 |
| 11010 | 6 | 2 |
| 11011 | 6 | 3 |
| 11100 | 6 | 4 |
| 11101 | 6 | 5 |
| 11110 | 6 | 6 |
| 11111 | reserved | reserved |

14 UE procedures related to Sidelink

A UE can be configured by higher layers with one or more PSSCH resource configuration(s). A PSSCH resource configuration can be for reception of PSSCH, or for transmission of PSSCH. The physical sidelink shared channel related procedures are described in Subclause 14.1.

A UE can be configured by higher layers with one or more PSCCH resource configuration(s). A PSCCH resource configuration can be for reception of PSCCH, or for transmission of PSCCH and the PSCCH resource configuration is associated with either sidelink transmission mode 1,2,3 or sidelink transmission mode 4. The physical sidelink control channel related procedures are described in Subclause 14.2.

A UE can be configured by higher layers with one or more PSDCH resource configuration(s). A PSDCH resource configuration can be for reception of PSDCH, or for transmission of PSDCH. The transmissions of PSDCH according to a PSDCH resource configuration are associated with either sidelink discovery type 1 or sidelink discovery type 2B. The physical sidelink discovery channel related procedures are described in Subclause 14.3.

The physical sidelink synchronization related procedures are described in Subclause 14.4.

Except in the case of secondary sidelink synchronization signal transmission, sidelink transmission power shall not change during a sidelink subframe. For a UE transmitting PSBCH, the transmit power of PSBCH (P_{PSBCH}) is same as the transmit power of primary sidelink synchronisation signal P_{PSSS} .

A UE is not expected to be configured with PSCCH resource configuration(s) such that, in a given subframe, the total number of resource blocks across the resource block pools (as described in Subclause 14.2.3) indicated by the PSCCH resource configuration(s) exceeds 50 in sidelink transmission mode 1 or 2.

In sidelink transmission mode 3 or 4, a UE is

- not expected to attempt to decode more than 10 or 20 PSCCHs in a subframe depending on the configuration of *v2x-HighReception-r14*.
- not expected to attempt to decode more than 100 or 136 RBs in a subframe depending on the configuration of *v2x-HighReception-r14*.
- not expected to attempt to decode more than 10 or 20 PSCCHs in a subframe depending on the configuration of *v2x-HighReception-r15* and *v2x-BandwidthClassRxSL-r15*.
- not expected to attempt to decode more than 100 or 136 RBs in a subframe depending on the configuration of *v2x-HighReception-r15* and *v2x-BandwidthClassRxSL-r15*.
- not expected to attempt to decode more than 15 or 30 PSCCHs in a subframe depending on the configuration of *v2x-HighReception-r15* and *v2x-BandwidthClassRxSL-r15*.
- not expected to attempt to decode more than 150 or 204 RBs in a subframe depending on the configuration of *v2x-HighReception-r15* and *v2x-BandwidthClassRxSL-r15*.
- not expected to combine PSCCH transmitted in different subframes.
- not required to perform PSSCH-RSRP measurement in a subframe that occurs before the reception of a successfully decoded associated SCI format 1.

If the UE does not indicate capability *v2x-HighReception-r14* or *v2x-HighReception-r15*, it shall implement a mechanism to avoid systematic dropping of PSCCH when the number of PSCCH candidates exceeds the UE's capability. UE applies the PSSCH-RSRP measured in a subframe that occurs at the reception of a successfully decoded associated SCI format 1 to a subframe that is indicated by the SCI format 1 but occurs before the reception of the SCI format 1. UE applies the PSSCH-RSRP measured in a subframe that occurs at the reception of a successfully decoded associated SCI format 1 to a subframe that is indicated by the SCI format 1 if SCI format 1 scheduling the same transport block is successfully decoded in only one subframe. UE is not expected to decode PSSCH that occurs before the reception of a successfully decoded associated SCI format 1.

If a UE uplink transmission that is not a PRACH transmission in subframe $n+1$ of a serving cell overlaps in time domain with a PSDCH transmission or a SLSS transmission for PSDCH by the UE in subframe n and subframe $n+1$ is

included in *discTxGapConfig* [11], then the UE shall drop the uplink transmission in subframe $n+1$. Else, if a UE uplink transmission in subframe $n+1$ of a serving cell overlaps in time domain with sidelink transmission/reception for sidelink transmission mode 1 or 2 by the UE in subframe n of the serving cell, then the UE shall drop the sidelink transmission/reception in subframe n .

If a UE uplink transmission of a serving cell overlaps in time domain with a sidelink transmission for sidelink transmission mode 3 or 4 of the same serving cell and the value in "Priority" field of the corresponding SCI is smaller than the high layer parameter *thresSL-TxPrioritization*, then the UE shall drop the uplink transmission. Else, if a UE uplink transmission of a serving cell overlaps in time domain with sidelink transmission for sidelink transmission mode 3 or 4 of the same serving cell, then the UE shall drop the sidelink transmission.

For a given carrier frequency, a UE is not expected to receive sidelink physical channels/signals with different cyclic prefix lengths in the same sidelink subframe.

For a given carrier frequency, in a sidelink subframe, if a UE has a sidelink transmission, the sidelink transmission shall occur only in contiguous physical resource blocks in sidelink transmission mode 1 or 2.

In sidelink transmission mode 1 or 2, if a UE's sidelink transmission does not occur on a serving cell with its uplink transmission(s), and if the UE's sidelink transmission in a subframe overlaps in time with its uplink transmission(s), the UE shall adjust the sidelink transmission power such that its total transmission power does not exceed P_{CMAX} defined in [6] on any overlapped portion. In this case, calculation of the adjustment to the sidelink transmission power is not specified.

In sidelink transmission mode 3 or 4, if a UE's sidelink transmission has SCI whose "Priority" field is set to a value smaller than the high layer parameter *thresSL-TxPrioritization*, and if the UE's sidelink transmission in a subframe overlaps in time with its uplink transmission(s) occurring on serving cell(s) where the sidelink transmission does not occur, the UE shall adjust the uplink transmission power such that its total transmission power does not exceed P_{CMAX} defined in [6] on any overlapped portion. In this case, calculation of the adjustment to the uplink transmission power is not specified.

In sidelink transmission mode 3 or 4, if a UE's sidelink transmission has SCI whose "Priority" field is set to a value greater than or equal to the high layer parameter *thresSL-TxPrioritization*, and if the UE's sidelink transmission in a subframe overlaps in time with its uplink transmission(s) occurring on serving cell(s) where the sidelink transmission does not occur, the UE shall adjust the sidelink transmission power such that its total transmission power does not exceed P_{CMAX} defined in [6] on any overlapped portion. In this case, calculation of the adjustment to the sidelink transmission power is not specified.

In sidelink transmission mode 3 or 4, if a UE's sidelink transmission on a carrier overlaps in time with sidelink transmission on other carrier(s) and its total transmission power exceeds P_{CMAX} defined in [6], the UE shall adjust the transmission power of the sidelink transmission which has SCI whose "Priority" field is set to the largest value among all the "Priority" values of the overlapped sidelink transmissions such that its total transmission power does not exceed P_{CMAX} defined in [6]. In this case, calculation of the adjustment to the sidelink transmission power is not specified. If the transmission power still exceeds P_{CMAX} defined in [6] after this power adjustment, the UE shall drop the sidelink transmission with the largest "Priority" field in its SCI and repeat this procedure over the non-dropped carriers. It is not specified which sidelink transmission the UE adjusts when sidelink transmissions overlapping in time on two or more carriers have the same value for the "Priority" field.

14.1 Physical Sidelink Shared Channel related procedures

14.1.1 UE procedure for transmitting the PSSCH

If the UE transmits SCI format 0 on PSCCH according to a PSCCH resource configuration in subframe n belonging to a PSCCH period (described in Subclause 14.2.3), then for the corresponding PSSCH transmissions

- the transmissions occur in a set of subframes in the PSCCH period and in a set of resource blocks within the set of subframes. The first PSSCH transport block is transmitted in the first four subframes in the set, the second transport block is transmitted in the next four subframes in the set, and so on.
- for sidelink transmission mode 1,

- the set of subframes is determined using the subframe pool indicated by the PSSCH resource configuration (described in Subclause 14.1.4) and using time resource pattern (I_{TRP}) in the SCI format 0 as described in Subclause 14.1.1.1.
- the set of resource blocks is determined using Resource block assignment and hopping allocation in the SCI format 0 as described in Subclause 14.1.1.2.
- for sidelink transmission mode 2,
 - the set of subframes is determined using the subframe pool indicated by the PSSCH resource configuration (described in Subclause 14.1.3) and using time resource pattern (I_{TRP}) in the SCI format 0 as described in Subclause 14.1.1.3.
 - the set of resource blocks is determined using the resource block pool indicated by the PSSCH resource configuration (described in Subclause 14.1.3) and using Resource block assignment and hopping allocation in the SCI format 0 as described in Subclause 14.1.1.4.
- the modulation order is determined using the "modulation and coding scheme" field (I_{MCS}) in SCI format 0. For $0 \leq I_{MCS} \leq 28$, the modulation order is set to $Q' = \min(4, Q'_m)$, where Q'_m is determined from Table 8.6.1-1.
- the TBS index (I_{TBS}) is determined based on I_{MCS} and Table 8.6.1-1, and the transport block size is determined using I_{TBS} and the number of allocated resource blocks (N_{PRB}) using the procedure in Subclause 7.1.7.2.1.

If the UE transmits SCI format 1 on PSCCH according to a PSCCH resource configuration in subframe n , then for the corresponding PSSCH transmissions of one TB

- for sidelink transmission mode 3,
 - the set of subframes and the set of resource blocks are determined using the subframe pool indicated by the PSSCH resource configuration (described in Subclause 14.1.5) and using "Retransmission index and Time gap between initial transmission and retransmission" field and "Frequency resource location of the initial transmission and retransmission" field in the SCI format 1 as described in Subclause 14.1.1.4A.
- for sidelink transmission mode 4,
 - the set of subframes and the set of resource blocks are determined using the subframe pool indicated by the PSSCH resource configuration (described in Subclause 14.1.5) and using "Retransmission index and Time gap between initial transmission and retransmission" field and "Frequency resource location of the initial transmission and retransmission" field in the SCI format 1 as described in Subclause 14.1.1.4B.
- if higher layer indicates that rate matching for the last symbol in the subframe is used for the given PSSCH
 - Transmission Format of corresponding SCI format 1 is set to 1,
 - the modulation order is determined using the "modulation and coding scheme" field (I_{MCS}) in SCI format 1.
 - for $0 \leq I_{MCS} \leq 28$, the TBS index (I_{TBS}) is determined based on I_{MCS} and Table 8.6.1-1,
 - for $29 \leq I_{MCS} \leq 31$, the TBS index (I_{TBS}) is determined based on I_{MCS} and Table 14.1.1-2,
 - the transport block size is determined by using I_{TBS} and setting the Table 7.1.7.2.1-1 column indicator to $\max\{\lfloor N'_{PRB} \times 0.8 \rfloor, 1\}$, where N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Subclause 14.1.1.4A and 14.1.1.4B.
- otherwise
 - Transmission Format of SCI format 1 is set to 0 if present,

- the modulation order is determined using the "modulation and coding scheme" field (I_{MCS}) in SCI format 1. For $0 \leq I_{MCS} \leq 28$, the modulation order is set to $Q' = \min(4, Q'_m)$, where Q'_m is determined from Table 8.6.1-1.
- the TBS index (I_{TBS}) is determined based on I_{MCS} and Table 8.6.1-1, and the transport block size is determined using I_{TBS} and the number of allocated resource blocks (N_{PRB}) using the procedure in Subclause 7.1.7.2.1.

For sidelink transmission mode 3 and 4, the parameter P_{step} is given by table 14.1.1-1.

Table 14.1.1-1: Determination of P_{step} for sidelink transmission mode 3 and 4

| | P_{step} |
|--------------------------------|------------|
| TDD with UL/DL configuration 0 | 60 |
| TDD with UL/DL configuration 1 | 40 |
| TDD with UL/DL configuration 2 | 20 |
| TDD with UL/DL configuration 3 | 30 |
| TDD with UL/DL configuration 4 | 20 |
| TDD with UL/DL configuration 5 | 10 |
| TDD with UL/DL configuration 6 | 50 |
| Otherwise | 100 |

Table 14.1.1-2: Modulation and TBS index table for $29 \leq I_{MCS} \leq 31$

| MCS Index I_{MCS} | Modulation Order Q'_m | TBS Index I_{TBS} |
|-------------------------------|-----------------------------------|-------------------------------|
| 29 | 6 | 30 |
| 30 | 6 | 31 |
| 31 | 6 | 33 |

14.1.1.1 UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 1

Within the PSCCH period (described in Subclause 14.2.3), the subframes used for PSSCH are determined as follows:

- a subframe indicator bitmap $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ and N_{TRP} are determined using the procedure described in Subclause 14.1.1.1.1.
- a bitmap $(b_0, b_1, \dots, b_{L_{PSSCH}-1})$ is determined using $b_j = b'_{j \bmod N_{TRP}}$ and a subframe l_j^{PSSCH} in the subframe pool is used for PSSCH if $b_j = 1$, otherwise the subframe l_j^{PSSCH} is not used for PSSCH, where $(l_0^{PSSCH}, l_1^{PSSCH}, \dots, l_{L_{PSSCH}-1}^{PSSCH})$ and L_{PSSCH} are described in Subclause 14.1.4. The subframes used for PSSCH are denoted by $(n_0^{PSSCH}, n_1^{PSSCH}, \dots, n_{N_{PSSCH}-1}^{PSSCH})$ arranged in increasing order of subframe index and where N_{PSSCH} is the number of subframes that can be used for PSSCH transmission in a PSCCH period and is a multiple of 4.

14.1.1.1.1 Determination of subframe indicator bitmap

For FDD and TDD with UL/DL configuration belonging to {1,2,4,5}, N_{TRP} is 8, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ is given by table 14.1.1.1.1-1.

For TDD with UL/DL configuration 0, N_{TRP} is 7, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ is given by table 14.1.1.1.1-2.

For TDD with UL/DL configuration belonging to {3,6}, N_{TRP} is 6, and the mapping between Time Resource pattern Index (I_{TRP}) and subframe indicator bitmap $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ is given by table 14.1.1.1.1-3.

Table 14.1.1.1.1-1: Time Resource pattern Index mapping for $N_{TRP} = 8$

| I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ |
|-----------|-----------|---------------------------------------|-----------|-----------|---------------------------------------|-----------|-----------|---------------------------------------|
| 0 | 1 | (1,0,0,0,0,0,0) | 37 | 4 | (1,1,1,0,1,0,0) | 74 | 4 | (0,1,1,1,0,0,1) |
| 1 | 1 | (0,1,0,0,0,0,0) | 38 | 4 | (1,1,0,1,1,0,0) | 75 | 4 | (1,1,0,0,1,0,1) |
| 2 | 1 | (0,0,1,0,0,0,0) | 39 | 4 | (1,0,1,1,1,0,0) | 76 | 4 | (1,0,1,0,1,0,1) |
| 3 | 1 | (0,0,0,1,0,0,0) | 40 | 4 | (0,1,1,1,1,0,0) | 77 | 4 | (0,1,1,0,1,0,1) |
| 4 | 1 | (0,0,0,0,1,0,0) | 41 | 4 | (1,1,1,0,0,1,0) | 78 | 4 | (1,0,0,1,1,0,1) |
| 5 | 1 | (0,0,0,0,0,1,0) | 42 | 4 | (1,1,0,1,0,1,0) | 79 | 4 | (0,1,0,1,1,0,1) |
| 6 | 1 | (0,0,0,0,0,0,1) | 43 | 4 | (1,0,1,1,0,1,0) | 80 | 4 | (0,0,1,1,1,0,1) |
| 7 | 1 | (0,0,0,0,0,0,1) | 44 | 4 | (0,1,1,1,0,1,0) | 81 | 4 | (1,1,0,0,0,1,0) |
| 8 | 2 | (1,1,0,0,0,0,0) | 45 | 4 | (1,1,0,0,1,1,0) | 82 | 4 | (1,0,1,0,0,1,0) |
| 9 | 2 | (1,0,1,0,0,0,0) | 46 | 4 | (1,0,1,0,1,1,0) | 83 | 4 | (0,1,1,0,0,1,0) |
| 10 | 2 | (0,1,1,0,0,0,0) | 47 | 4 | (0,1,1,0,1,1,0) | 84 | 4 | (1,0,0,1,0,1,0) |
| 11 | 2 | (1,0,0,1,0,0,0) | 48 | 4 | (1,0,0,1,1,1,0) | 85 | 4 | (0,1,0,1,0,1,0) |
| 12 | 2 | (0,1,0,1,0,0,0) | 49 | 4 | (0,1,0,1,1,1,0) | 86 | 4 | (0,0,1,1,0,1,0) |
| 13 | 2 | (0,0,1,1,0,0,0) | 50 | 4 | (0,0,1,1,1,1,0) | 87 | 4 | (1,0,0,0,1,1,0) |
| 14 | 2 | (1,0,0,0,1,0,0) | 51 | 4 | (1,1,1,0,0,0,1) | 88 | 4 | (0,1,0,0,1,1,0) |
| 15 | 2 | (0,1,0,0,1,0,0) | 52 | 4 | (1,1,0,1,0,0,1) | 89 | 4 | (0,0,1,0,1,1,0) |
| 16 | 2 | (0,0,1,0,1,0,0) | 53 | 4 | (1,0,1,1,0,0,1) | 90 | 4 | (0,0,0,1,1,1,0) |
| 17 | 2 | (0,0,0,1,1,0,0) | 54 | 4 | (0,1,1,1,0,0,1) | 91 | 4 | (1,1,0,0,0,0,1) |
| 18 | 2 | (1,0,0,0,0,1,0) | 55 | 4 | (1,1,0,0,1,0,1) | 92 | 4 | (1,0,1,0,0,0,1) |
| 19 | 2 | (0,1,0,0,0,1,0) | 56 | 4 | (1,0,1,0,1,0,1) | 93 | 4 | (0,1,1,0,0,0,1) |
| 20 | 2 | (0,0,1,0,0,1,0) | 57 | 4 | (0,1,1,0,1,0,1) | 94 | 4 | (1,0,0,1,0,0,1) |
| 21 | 2 | (0,0,0,1,0,1,0) | 58 | 4 | (1,0,0,1,1,0,1) | 95 | 4 | (0,1,0,1,0,0,1) |
| 22 | 2 | (0,0,0,0,1,1,0) | 59 | 4 | (0,1,0,1,1,0,1) | 96 | 4 | (0,0,1,1,0,0,1) |
| 23 | 2 | (1,0,0,0,0,0,1) | 60 | 4 | (0,0,1,1,1,0,1) | 97 | 4 | (1,0,0,0,1,0,1) |
| 24 | 2 | (0,1,0,0,0,0,1) | 61 | 4 | (1,1,0,0,0,1,1) | 98 | 4 | (0,1,0,0,1,0,1) |
| 25 | 2 | (0,0,1,0,0,0,1) | 62 | 4 | (1,0,1,0,0,1,1) | 99 | 4 | (0,0,1,0,1,0,1) |
| 26 | 2 | (0,0,0,1,0,0,1) | 63 | 4 | (0,1,1,0,0,1,1) | 100 | 4 | (0,0,0,1,1,0,1) |
| 27 | 2 | (0,0,0,0,1,0,1) | 64 | 4 | (1,0,0,1,0,1,1) | 101 | 4 | (1,0,0,0,0,1,1) |
| 28 | 2 | (0,0,0,0,0,1,1) | 65 | 4 | (0,1,0,1,0,1,1) | 102 | 4 | (0,1,0,0,0,1,1) |
| 29 | 2 | (1,0,0,0,0,0,0) | 66 | 4 | (0,0,1,1,0,1,1) | 103 | 4 | (0,0,1,0,0,1,1) |
| 30 | 2 | (0,1,0,0,0,0,0) | 67 | 4 | (1,0,0,0,1,1,1) | 104 | 4 | (0,0,0,1,0,1,1) |
| 31 | 2 | (0,0,1,0,0,0,0) | 68 | 4 | (0,1,0,0,1,1,1) | 105 | 4 | (0,0,0,0,1,1,1) |
| 32 | 2 | (0,0,0,1,0,0,0) | 69 | 4 | (0,0,1,0,1,1,1) | 106 | 8 | (1,1,1,1,1,1,1) |
| 33 | 2 | (0,0,0,0,1,0,0) | 70 | 4 | (0,0,0,1,1,1,1) | 107-127 | reserved | reserved |
| 34 | 2 | (0,0,0,0,0,1,0) | 71 | 4 | (1,1,1,0,0,0,0) | | | |
| 35 | 2 | (0,0,0,0,0,0,1) | 72 | 4 | (1,1,0,1,0,0,0) | | | |

| | | | | | | | | |
|----|---|-------------------|----|---|-------------------|--|--|--|
| 36 | 4 | (1,1,1,1,0,0,0,0) | 73 | 4 | (1,0,1,1,0,0,0,1) | | | |
|----|---|-------------------|----|---|-------------------|--|--|--|

Table 14.1.1.1.1-2: Time Resource pattern Index mapping for $N_{TRP} = 7$

| I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ |
|-----------|-----------|---------------------------------------|-----------|-----------|---------------------------------------|-----------|-----------|---------------------------------------|
| 0 | reserved | reserved | 44 | 3 | (0,0,1,1,0,1,0) | 88 | 3 | (0,0,0,1,1,0,1) |
| 1 | 1 | (1,0,0,0,0,0,0) | 45 | 4 | (1,0,1,1,0,1,0) | 89 | 4 | (1,0,0,1,1,0,1) |
| 2 | 1 | (0,1,0,0,0,0,0) | 46 | 4 | (0,1,1,1,0,1,0) | 90 | 4 | (0,1,0,1,1,0,1) |
| 3 | 2 | (1,1,0,0,0,0,0) | 47 | 5 | (1,1,1,1,0,1,0) | 91 | 5 | (1,1,0,1,1,0,1) |
| 4 | 1 | (0,0,1,0,0,0,0) | 48 | 2 | (0,0,0,0,1,1,0) | 92 | 4 | (0,0,1,1,1,0,1) |
| 5 | 2 | (1,0,1,0,0,0,0) | 49 | 3 | (1,0,0,0,1,1,0) | 93 | 5 | (1,0,1,1,1,0,1) |
| 6 | 2 | (0,1,1,0,0,0,0) | 50 | 3 | (0,1,0,0,1,1,0) | 94 | 5 | (0,1,1,1,1,0,1) |
| 7 | 3 | (1,1,1,0,0,0,0) | 51 | 4 | (1,1,0,0,1,1,0) | 95 | 6 | (1,1,1,1,1,0,1) |
| 8 | 1 | (0,0,0,1,0,0,0) | 52 | 3 | (0,0,1,0,1,1,0) | 96 | 2 | (0,0,0,0,0,1,1) |
| 9 | 2 | (1,0,0,1,0,0,0) | 53 | 4 | (1,0,1,0,1,1,0) | 97 | 3 | (1,0,0,0,0,1,1) |
| 10 | 2 | (0,1,0,1,0,0,0) | 54 | 4 | (0,1,1,0,1,1,0) | 98 | 3 | (0,1,0,0,0,1,1) |
| 11 | 3 | (1,1,0,1,0,0,0) | 55 | 5 | (1,1,1,0,1,1,0) | 99 | 4 | (1,1,0,0,0,1,1) |
| 12 | 2 | (0,0,1,1,0,0,0) | 56 | 3 | (0,0,0,1,1,1,0) | 100 | 3 | (0,0,1,0,0,1,1) |
| 13 | 3 | (1,0,1,1,0,0,0) | 57 | 4 | (1,0,0,1,1,1,0) | 101 | 4 | (1,0,1,0,0,1,1) |
| 14 | 3 | (0,1,1,1,0,0,0) | 58 | 4 | (0,1,0,1,1,1,0) | 102 | 4 | (0,1,1,0,0,1,1) |
| 15 | 4 | (1,1,1,1,0,0,0) | 59 | 5 | (1,1,0,1,1,1,0) | 103 | 5 | (1,1,1,0,0,1,1) |
| 16 | 1 | (0,0,0,0,1,0,0) | 60 | 4 | (0,0,1,1,1,1,0) | 104 | 3 | (0,0,0,1,0,1,1) |
| 17 | 2 | (1,0,0,0,1,0,0) | 61 | 5 | (1,0,1,1,1,1,0) | 105 | 4 | (1,0,0,1,0,1,1) |
| 18 | 2 | (0,1,0,0,1,0,0) | 62 | 5 | (0,1,1,1,1,1,0) | 106 | 4 | (0,1,0,1,0,1,1) |
| 19 | 3 | (1,1,0,0,1,0,0) | 63 | 6 | (1,1,1,1,1,1,0) | 107 | 5 | (1,1,0,1,0,1,1) |
| 20 | 2 | (0,0,1,0,1,0,0) | 64 | 1 | (0,0,0,0,0,0,1) | 108 | 4 | (0,0,1,1,0,1,1) |
| 21 | 3 | (1,0,1,0,1,0,0) | 65 | 2 | (1,0,0,0,0,0,1) | 109 | 5 | (1,0,1,1,0,1,1) |
| 22 | 3 | (0,1,1,0,1,0,0) | 66 | 2 | (0,1,0,0,0,0,1) | 110 | 5 | (0,1,1,1,0,1,1) |
| 23 | 4 | (1,1,1,0,1,0,0) | 67 | 3 | (1,1,0,0,0,0,1) | 111 | 6 | (1,1,1,1,0,1,1) |
| 24 | 2 | (0,0,0,1,1,0,0) | 68 | 2 | (0,0,1,0,0,0,1) | 112 | 3 | (0,0,0,0,1,1,1) |
| 25 | 3 | (1,0,0,1,1,0,0) | 69 | 3 | (1,0,1,0,0,0,1) | 113 | 4 | (1,0,0,0,1,1,1) |
| 26 | 3 | (0,1,0,1,1,0,0) | 70 | 3 | (0,1,1,0,0,0,1) | 114 | 4 | (0,1,0,0,1,1,1) |
| 27 | 4 | (1,1,0,1,1,0,0) | 71 | 4 | (1,1,1,0,0,0,1) | 115 | 5 | (1,1,0,0,1,1,1) |
| 28 | 3 | (0,0,1,1,1,0,0) | 72 | 2 | (0,0,0,1,0,0,1) | 116 | 4 | (0,0,1,0,1,1,1) |
| 29 | 4 | (1,0,1,1,1,0,0) | 73 | 3 | (1,0,0,1,0,0,1) | 117 | 5 | (1,0,1,0,1,1,1) |
| 30 | 4 | (0,1,1,1,1,0,0) | 74 | 3 | (0,1,0,1,0,0,1) | 118 | 5 | (0,1,1,0,1,1,1) |
| 31 | 5 | (1,1,1,1,1,0,0) | 75 | 4 | (1,1,0,1,0,0,1) | 119 | 6 | (1,1,1,0,1,1,1) |
| 32 | 1 | (0,0,0,0,1,0) | 76 | 3 | (0,0,1,1,0,0,1) | 120 | 4 | (0,0,0,1,1,1,1) |
| 33 | 2 | (1,0,0,0,0,1,0) | 77 | 4 | (1,0,1,1,0,0,1) | 121 | 5 | (1,0,0,1,1,1,1) |
| 34 | 2 | (0,1,0,0,0,1,0) | 78 | 4 | (0,1,1,1,0,0,1) | 122 | 5 | (0,1,0,1,1,1,1) |
| 35 | 3 | (1,1,0,0,0,1,0) | 79 | 5 | (1,1,1,1,0,0,1) | 123 | 6 | (1,1,0,1,1,1,1) |
| 36 | 2 | (0,0,1,0,0,1,0) | 80 | 2 | (0,0,0,0,1,0,1) | 124 | 5 | (0,0,1,1,1,1,1) |
| 37 | 3 | (1,0,1,0,0,1,0) | 81 | 3 | (1,0,0,0,1,0,1) | 125 | 6 | (1,0,1,1,1,1,1) |
| 38 | 3 | (0,1,1,0,0,1,0) | 82 | 3 | (0,1,0,0,1,0,1) | 126 | 6 | (0,1,1,1,1,1,1) |
| 39 | 4 | (1,1,1,0,0,1,0) | 83 | 4 | (1,1,0,0,1,0,1) | 127 | 7 | (1,1,1,1,1,1,1) |

| | | | | | | | | |
|----|---|-----------------|----|---|-----------------|--|--|--|
| 40 | 2 | (0,0,0,1,0,1,0) | 84 | 3 | (0,0,1,0,1,0,1) | | | |
| 41 | 3 | (1,0,0,1,0,1,0) | 85 | 4 | (1,0,1,0,1,0,1) | | | |
| 42 | 3 | (0,1,0,1,0,1,0) | 86 | 4 | (0,1,1,0,1,0,1) | | | |
| 43 | 4 | (1,1,0,1,0,1,0) | 87 | 5 | (1,1,1,0,1,0,1) | | | |

Table 14.1.1.1.1-3: Time Resource pattern Index mapping for $N_{TRP} = 6$

| I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots b'_{N_{TRP}-1})$ | I_{TRP} | k_{TRP} | $(b'_0, b'_1, \dots b'_{N_{TRP}-1})$ |
|-----------|-----------|--------------------------------------|-----------|-----------|--------------------------------------|-----------|-----------|--------------------------------------|
| 0 | reserved | reserved | 22 | 3 | (0,1,1,0,1,0) | 44 | 3 | (0,0,1,1,0,1) |
| 1 | 1 | (1,0,0,0,0,0) | 23 | 4 | (1,1,1,0,1,0) | 45 | 4 | (1,0,1,1,0,1) |
| 2 | 1 | (0,1,0,0,0,0) | 24 | 2 | (0,0,0,1,1,0) | 46 | 4 | (0,1,1,1,0,1) |
| 3 | 2 | (1,1,0,0,0,0) | 25 | 3 | (1,0,0,1,1,0) | 47 | 5 | (1,1,1,1,0,1) |
| 4 | 1 | (0,0,1,0,0,0) | 26 | 3 | (0,1,0,1,1,0) | 48 | 2 | (0,0,0,0,1,1) |
| 5 | 2 | (1,0,1,0,0,0) | 27 | 4 | (1,1,0,1,1,0) | 49 | 3 | (1,0,0,0,1,1) |
| 6 | 2 | (0,1,1,0,0,0) | 28 | 3 | (0,0,1,1,1,0) | 50 | 3 | (0,1,0,0,1,1) |
| 7 | 3 | (1,1,1,0,0,0) | 29 | 4 | (1,0,1,1,1,0) | 51 | 4 | (1,1,0,0,1,1) |
| 8 | 1 | (0,0,0,1,0,0) | 30 | 4 | (0,1,1,1,1,0) | 52 | 3 | (0,0,1,0,1,1) |
| 9 | 2 | (1,0,0,1,0,0) | 31 | 5 | (1,1,1,1,1,0) | 53 | 4 | (1,0,1,0,1,1) |
| 10 | 2 | (0,1,0,1,0,0) | 32 | 1 | (0,0,0,0,0,1) | 54 | 4 | (0,1,1,0,1,1) |
| 11 | 3 | (1,1,0,1,0,0) | 33 | 2 | (1,0,0,0,0,1) | 55 | 5 | (1,1,1,0,1,1) |
| 12 | 2 | (0,0,1,1,0,0) | 34 | 2 | (0,1,0,0,0,1) | 56 | 3 | (0,0,0,1,1,1) |
| 13 | 3 | (1,0,1,1,0,0) | 35 | 3 | (1,1,0,0,0,1) | 57 | 4 | (1,0,0,1,1,1) |
| 14 | 3 | (0,1,1,1,0,0) | 36 | 2 | (0,0,1,0,0,1) | 58 | 4 | (0,1,0,1,1,1) |
| 15 | 4 | (1,1,1,1,0,0) | 37 | 3 | (1,0,1,0,0,1) | 59 | 5 | (1,1,0,1,1,1) |
| 16 | 1 | (0,0,0,0,1,0) | 38 | 3 | (0,1,1,0,0,1) | 60 | 4 | (0,0,1,1,1,1) |
| 17 | 2 | (1,0,0,0,1,0) | 39 | 4 | (1,1,1,0,0,1) | 61 | 5 | (1,0,1,1,1,1) |
| 18 | 2 | (0,1,0,0,1,0) | 40 | 2 | (0,0,0,1,0,1) | 62 | 5 | (0,1,1,1,1,1) |
| 19 | 3 | (1,1,0,0,1,0) | 41 | 3 | (1,0,0,1,0,1) | 63 | 6 | (1,1,1,1,1,1) |
| 20 | 2 | (0,0,1,0,1,0) | 42 | 3 | (0,1,0,1,0,1) | 64-127 | reserved | reserved |
| 21 | 3 | (1,0,1,0,1,0) | 43 | 4 | (1,1,0,1,0,1) | | | |

14.1.1.2 UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 1

The set of resource blocks is determined using the procedure described in Subclause 14.1.1.2.1 and 14.1.1.2.2.

14.1.1.2.1 PSSCH resource allocation for sidelink transmission mode 1

The resource allocation and hopping field of the SCI format 0 is used to determine a set of indices denoted by n'_{VRB} ($0 \leq n'_{VRB} < N_{RB}^{\text{SL}}$), a starting index RB'_{START} , and a number of allocated PRBs L'_{CRBs} and N_{RB}^{PSSCH} using the procedure in Subclause 8.1.1, and 8.4 (for sidelink frequency hopping with type 1 or type 2 hopping) with the following exceptions:

- the term 'PUSCH' in Subclauses 8.1.1 and 8.4 is replaced with 'PSSCH'.
- the quantity n_{VRB} in Subclause 8.1.1 is replaced with n'_{VRB} .

- the quantity $N_{\text{RB}}^{\text{UL}}$ in Subclauses 8.1.1 and 8.4 is replaced with $N_{\text{RB}}^{\text{SL}}$.
- the quantity RB_{START} in Subclauses 8.1.1 and 8.4 is replaced with RB'_{START} .
- the quantity L_{CRBs} in Subclauses 8.1.1 and 8.4 is replaced with L'_{CRBs} .
- the quantity $N_{\text{RB}}^{\text{PUSCH}}$ in Subclause 8.4 is replaced with $N_{\text{RB}}^{\text{PSSCH}}$.
- the quantity $N_{\text{RB}}^{\text{HO}}$ is given by higher layer parameter *rb-Offset-r12* associated with the corresponding PSSCH resource configuration.
- the quantity N_{sb} is given by higher layer parameter *numSubbands-r12* associated with the corresponding PSSCH resource configuration.

14.1.1.2.2 PSSCH frequency hopping for sidelink transmission mode 1

If sidelink frequency hopping with type 1 hopping is enabled, the set of physical resource blocks for PSSCH transmission is determined using Subclause 8.4 with the following exceptions:

- the term 'PUSCH' is replaced with 'PSSCH'.
- only inter-subframe hopping shall be used.
- the quantity RB_{START} is replaced with RB'_{START} .
- the quantity $N_{\text{RB}}^{\text{UL}}$ is replaced with $N_{\text{RB}}^{\text{SL}}$.
- the quantity $N_{\text{RB}}^{\text{PUSCH}}$ is replaced with $N_{\text{RB}}^{\text{PSSCH}}$.
- the quantity $N_{\text{RB}}^{\text{HO}}$ is given by higher layer parameter *rb-Offset-r12* associated with the PSSCH resource configuration.
- the frequency hopping field in the SCI format 0 is used instead of DCI format 0.
- the quantity $n_{\text{PRB}}^{\text{S1}}(i)$ is replaced with $n_{\text{PRB}}^{\text{SL0}}$.
- the quantity $n_{\text{PRB}}(i)$ is replaced with $n_{\text{PRB}}^{\text{SL1}}$.
- for odd $n_{\text{ssf}}^{\text{PSSCH}}$ (described in Subclause 9.2.4 of [3]), the set of physical resource blocks for PSSCH transmission are L'_{CRBs} contiguous resource blocks starting from PRB with index $n_{\text{PRB}}^{\text{SL0}}$.
- for even $n_{\text{ssf}}^{\text{PSSCH}}$ (described in Subclause 9.2.4 of [3]), the set of physical resource blocks for PSSCH transmission are L'_{CRBs} contiguous resource blocks starting from PRB with index $n_{\text{PRB}}^{\text{SL1}}$.

14.1.1.3 UE procedure for determining subframes for transmitting PSSCH for sidelink transmission mode 2

For FDD or for TDD, and the UE not configured with the higher layer parameter *trpt-Subset-r12*

- The allowed values of I_{TRP} correspond to the values of k_{TRP} satisfying $k_{\text{TRP}} = k_i$, for a value of i in $0 \leq i < X_{\text{TRP}}$, where k_i and X_{TRP} are determined from table 14.1.1.3-1.

For FDD or for TDD with UL/DL configuration belonging to {0,1,2,3,4,6}, and the UE configured with the higher layer parameter *trpt-Subset-r12*

- The allowed values of I_{TRP} correspond to the values of k_{TRP} satisfying $k_{TRP} = k_i$, for values of i in $0 \leq i < X_{TRP}$ satisfying $a_i = 1$, $0 \leq i < X_{TRP}$ and where k_i and X_{TRP} are determined from table 14.1.1.3-1, and $(a_0, a_1, \dots, a_{X_{TRP}-1})$ is the bitmap indicated by *trpt-Subset-r12*.

Table 14.1.1.3-1: Determination of X_{TRP} and k_i for sidelink transmission mode 2

| | X_{TRP} | k_0 | k_1 | k_2 | k_3 | k_4 |
|--|-----------|-------|-------|-------|-------|-------|
| FDD and TDD with UL/DL configuration 1,2,4,5 | 3 | 1 | 2 | 4 | - | - |
| TDD with UL/DL configuration 0 | 5 | 1 | 2 | 3 | 4 | 5 |
| TDD with UL/DL configuration 3,6 | 4 | 1 | 2 | 3 | 4 | - |

Within a PSCCH period, the subframes used for PSSCH are determined as follows:

- a subframe indicator bitmap $(b'_0, b'_1, \dots, b'_{N_{TRP}-1})$ and N_{TRP} are determined using the procedure described in Subclause 14.1.1.1.1 from the allowed values of I_{TRP} described in this Subclause.
- a bitmap $(b_0, b_1, \dots, b_{L_{PSSCH}-1})$ is determined using $b_j = b'_{j \bmod N_{TRP}}$ and a subframe l_j^{PSSCH} in the subframe pool is used for PSSCH if $b_j = 1$, otherwise the subframe l_j^{PSSCH} is not used for PSSCH, where $(l_0^{PSSCH}, l_1^{PSSCH}, \dots, l_{L_{PSSCH}-1}^{PSSCH})$ and L_{PSSCH} are described in Subclause 14.1.3. The subframes used for PSSCH are denoted by $(n_0^{PSSCH}, n_1^{PSSCH}, \dots, n_{N_{PSSCH}-1}^{PSSCH})$ arranged in increasing order of subframe index and where N_{PSSCH} is the number of subframes that can be used for PSSCH transmission in a PSCCH period and is a multiple of 4.

14.1.1.4 UE procedure for determining resource blocks for transmitting PSSCH for sidelink transmission mode 2

The set of resource blocks within the resource block pool (defined in 14.1.3) is determined using the Subclause 14.1.1.2.1.

If sidelink frequency hopping with type 1 hopping is enabled, the set of physical resource blocks for PSSCH transmission is determined using Subclause 14.1.1.2.2 with the following exceptions

- the quantity N_{RB}^{UL} is replaced with $M_{RB}^{\text{PSSCH-RP}}$ (defined in 14.1.3).
- for odd $n_{\text{ssf}}^{\text{PSSCH}}$, the set of physical resource blocks for PSSCH transmission are given by L'_{CRBs} contiguous resource blocks $m_x, m_{x+1}, \dots, m_{x+L'_{\text{CRBs}}-1}$ belonging to the resource block pool, where $x = n_{\text{PRB}}^{\text{SL0}}$.
- for even $n_{\text{ssf}}^{\text{PSSCH}}$, the set of physical resource blocks for PSSCH transmission are given by L'_{CRBs} contiguous resource blocks $m_x, m_{x+1}, \dots, m_{x+L'_{\text{CRBs}}-1}$ belonging to the resource block pool, where $x = n_{\text{PRB}}^{\text{SL1}}$.

14.1.1.4A UE procedure for determining subframes and resource blocks for transmitting PSSCH for sidelink transmission mode 3

If the UE has a configured sidelink grant (described in [8]) in subframe t_n^{SL} with the corresponding PSCCH resource m (described in Subclause 14.2.4), the resource blocks and subframes of the corresponding PSSCH transmissions are determined according to 14.1.1.4C.

If the UE has a configured sidelink grant (described in [8]) for an SL SPS configuration activated by Subclause 14.2.1 and if a set of sub-channels in subframe t_m^{SL} is determined as the time and frequency resource for PSSCH transmission

corresponding to the configured sidelink grant (described in [8]) of the SL SPS configuration, the same set of sub-channels in subframes $t_{m+j \times P_{SPS}^{'}}^{SL}$ are also determined for PSSCH transmissions corresponding to the same sidelink grant where $j=1, 2, \dots$, $P_{SPS}^{'} = P_{step} \times P_{SPS} / 100$, and $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ is determined by Subclause 14.1.5. Here, P_{SPS} is the sidelink SPS interval of the corresponding SL SPS configuration.

14.1.1.4B UE procedure for determining subframes and resource blocks for transmitting PSSCH and reserving resources for sidelink transmission mode 4

If the UE has a configured sidelink grant (described in [8]) in subframe t_n^{SL} with the corresponding PSCCH resource m (described in Subclause 14.2.4), the resource blocks and subframes of the corresponding PSSCH transmissions are determined according to 14.1.1.4C.

The number of subframes in one set of the time and frequency resources for transmission opportunities of PSSCH is given by C_{resel} where $C_{resel} = 10 * \text{SL_RESOURCE_RESELECTION_COUNTER}$ [8] if configured else C_{resel} is set to 1.

If a set of sub-channels in subframe t_m^{SL} is determined as the time and frequency resource for PSSCH transmission corresponding to the configured sidelink grant (described in [8]), the same set of sub-channels in subframes $t_{m+j \times P_{rsvp_TX}^{'}}^{SL}$ are also determined for PSSCH transmissions corresponding to the same sidelink grant where $j=1, 2, \dots$, $C_{resel} - 1$, $P_{rsvp_TX}^{'} = P_{step} \times P_{rsvp_TX} / 100$, and $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ is determined by Subclause 14.1.5. Here, P_{rsvp_TX} is the resource reservation interval indicated by higher layers.

If a UE is configured with high layer parameter *cr-Limit* and transmits PSSCH in subframe n , the UE shall ensure the following limits for any priority value k :

$$\sum_{i \geq k} CR(i) \leq CR_{\text{Limit}}(k)$$

where $CR(i)$ is the CR evaluated in subframe $n-4$ for the PSSCH transmissions with "Priority" field in the SCI set to i , and $CR_{\text{Limit}}(k)$ corresponds to the high layer parameter *cr-Limit* that is associated with the priority value k and the CBR range which includes the CBR measured in subframe $n-4$. It is up to UE implementation how to meet the above limits, including dropping the transmissions in subframe n .

14.1.1.4C UE procedure for determining subframes and resource blocks for PSSCH transmission associated with an SCI format 1

The set of subframes and resource blocks for PSSCH transmission is determined by the resource used for the PSCCH transmission containing the associated SCI format 1, and "Frequency resource location of the initial transmission and retransmission" field, "Retransmission index" field, "Time gap between initial transmission and retransmission" field of the associated SCI format 1 as described below.

"Frequency resource location of the initial transmission and retransmission" field in the SCI format 1 is equal to resource indication value (*RIV*) corresponding to a starting sub-channel index (n_{subCH}^{start}) and a length in terms of contiguously allocated sub-channels ($L_{subCH} \geq 1$). The resource indication value is defined by

if $(L_{subCH} - 1) \leq \lfloor N_{subCH} / 2 \rfloor$ then

$$RIV = N_{subCH}(L_{subCH} - 1) + n_{subCH}^{start}$$

else

$$RIV = N_{subCH}(N_{subCH} - L_{subCH} + 1) + (N_{subCH} - 1 - n_{subCH}^{start})$$

where N_{subCH} is the total number of sub-channels in the pool determined by higher layer parameter *numSubchannel*.

For the SCI format 1 transmitted on the PSCCH resource m (described in subclause 14.2.4) in subframe t_n^{SL} , the set of subframes and sub-channels for the corresponding PSSCH are determined as follows:

- if SF_{gap} is zero,
 - the time and frequency resources for the corresponding PSSCH is given by
 - sub-channel(s) $m, m+1, \dots, m+L_{\text{subCH}}-1$ in subframe t_n^{SL} .
- else if "Retransmission index" in the SCI format 1 is zero,
 - the time and frequency resources for the corresponding PSSCH is given by
 - sub-channel(s) $m, m+1, \dots, m+L_{\text{subCH}}-1$ in subframe t_n^{SL} , and
 - sub-channels $n_{\text{subCH}}^{\text{start}}, n_{\text{subCH}}^{\text{start}}+1, \dots, n_{\text{subCH}}^{\text{start}}+L_{\text{subCH}}-1$ in subframe $t_{n+SF_{\text{gap}}}^{\text{SL}}$.
- else if "Retransmission index" in the SCI format 1 is one,
 - the time and frequency resources for the corresponding PSSCH is given by
 - sub-channels $n_{\text{subCH}}^{\text{start}}, n_{\text{subCH}}^{\text{start}}+1, \dots, n_{\text{subCH}}^{\text{start}}+L_{\text{subCH}}-1$ in subframe $t_{n-SF_{\text{gap}}}^{\text{SL}}$, and
 - sub-channels $m, m+1, \dots, m+L_{\text{subCH}}-1$ in subframe t_n^{SL} .

where SF_{gap} is the value indicated by "Time gap between initial transmission and retransmission" field the SCI format 1 and $(t_0^{\text{SL}}, t_1^{\text{SL}}, t_2^{\text{SL}}, \dots)$ is determined by Subclause 14.1.5.

When sub-channel(s) $m, m+1, \dots, m+L_{\text{subCH}}-1$ are determined in a subframe for the transmission of PSSCH, the set of resource blocks determined for the PSSCH transmission is given by $N_{\text{PSSCH}}^{\text{RB}}$ contiguous resource blocks with the physical resource block number $n_{\text{PRB}} = n_{\text{subCHR}B\text{start}} + m * n_{\text{subCHsize}} + j + \beta$ for $j = 0, \dots, N_{\text{PSSCH}}^{\text{RB}} - 1$. Here, $n_{\text{subCHR}B\text{start}}$ and $n_{\text{subCHsize}}$ are given by higher layer parameters *startRBSubchannel* and *sizeSubchannel*, respectively. The parameters $N_{\text{PSSCH}}^{\text{RB}}$ and β are given as follows:

- if a pool is (pre)configured such that a UE always transmits PSCCH and the corresponding PSSCH in adjacent resource blocks in a subframe, $\beta = 2$ and $N_{\text{PSSCH}}^{\text{RB}}$ is the largest integer that fulfills

$$N_{\text{PSSCH}}^{\text{RB}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq L_{\text{subCH}} * n_{\text{subCHsize}} - 2$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers

- if a pool is (pre)configured such that a UE may transmit PSCCH and the corresponding PSSCH in non-adjacent resource blocks in a subframe, $\beta = 0$ and $N_{\text{PSSCH}}^{\text{RB}}$ is the largest integer that fulfills

$$N_{\text{PSSCH}}^{\text{RB}} = 2^{\alpha_2} \cdot 3^{\alpha_3} \cdot 5^{\alpha_5} \leq L_{\text{subCH}} * n_{\text{subCHsize}}$$

where $\alpha_2, \alpha_3, \alpha_5$ is a set of non-negative integers.

14.1.1.5 UE procedure for PSSCH power control

For sidelink transmission mode 1 and PSCCH period i , the UE transmit power P_{PSSCH} for PSSCH transmission is given by the following

- if the TPC command field in configured sidelink grant (described in [8]) for PSCCH period i is set to 0

$$P_{\text{PSSCH}} = P_{\text{CMAX,PSSCH}}$$

- if the TPC command field in configured sidelink grant (described in [8]) for PSCCH period i is set to 1

$$P_{\text{PSSCH}} = \min \left\{ P_{\text{CMAX,PSSCH}}, 10 \log_{10}(M_{\text{PSSCH}}) + P_{\text{O}_{\text{PSSCH},1}} + \alpha_{\text{PSSCH},1} \cdot PL \right\} [\text{dBm}]$$

where $P_{\text{CMAX,PSSCH}}$ is defined in [6], and M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource block and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{\text{O}_{\text{PSSCH},1}}$ and $\alpha_{\text{PSSCH},1}$ are provided by higher layer parameters $p0-r12$ and $alpha-r12$, respectively and that are associated with the corresponding PSSCH resource configuration.

For sidelink transmission mode 2, the UE transmit power P_{PSSCH} for PSSCH transmission is given by

$$P_{\text{PSSCH}} = \min \left\{ P_{\text{CMAX,PSSCH}}, 10 \log_{10}(M_{\text{PSSCH}}) + P_{\text{O}_{\text{PSSCH},2}} + \alpha_{\text{PSSCH},2} \cdot PL \right\} [\text{dBm}],$$

where $P_{\text{CMAX,PSSCH}}$ is defined in [6], and M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource blocks and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{\text{O}_{\text{PSSCH},2}}$ and $\alpha_{\text{PSSCH},2}$ are provided by higher layer parameters $p0-r12$ and $alpha-r12$, respectively and that are associated with the corresponding PSSCH resource configuration.

For sidelink transmission mode 3, the UE transmit power P_{PSSCH} for PSSCH transmission is given by

$$\begin{aligned} P_{\text{PSSCH}} &= 10 \log_{10} \left(\frac{M_{\text{PSSCH}}}{M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}}} \right) \\ &\quad + \min \left\{ P_{\text{CMAX}}, 10 \log_{10} \left(M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}} \right) + P_{\text{O}_{\text{PSSCH},3}} + \alpha_{\text{PSSCH},3} \cdot PL \right\} [\text{dBm}], \end{aligned}$$

where P_{CMAX} is defined in [6], and M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource blocks and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{\text{O}_{\text{PSSCH},3}}$ and $\alpha_{\text{PSSCH},3}$ are provided by higher layer parameters $p0SL-V2V$ and $alphaSL-V2V$, respectively and that are associated with the corresponding PSSCH resource configuration.

For sidelink transmission mode 4, the UE transmit power P_{PSSCH} for PSSCH transmission in subframe n is given by

$$P_{\text{PSSCH}} = 10 \log_{10} \left(\frac{M_{\text{PSSCH}}}{M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}}} \right) + A [\text{dBm}],$$

where P_{CMAX} is defined in [6], M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource blocks, $M_{\text{PSCCH}} = 2$, and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{\text{O}_{\text{PSSCH},4}}$ and

$\alpha_{PSSCH,4}$ are provided by higher layer parameters $p0SL-V2V$ and $alphaSL-V2V$, respectively and that are associated with the corresponding PSSCH resource configuration. If higher layer parameter $maxTxPower$ is configured then

$$A = \min \left\{ P_{CMAX}, P_{MAX_CBR}, 10 \log_{10} \left(M_{PSSCH} + 10^{\frac{3}{10}} \times M_{PSCCH} \right) + P_{O_PSSCH,4} + \alpha_{PSSCH,4} \cdot PL \right\}$$

else

$$A = \min \left\{ P_{CMAX}, 10 \log_{10} \left(M_{PSSCH} + 10^{\frac{3}{10}} \times M_{PSCCH} \right) + P_{O_PSSCH,4} + \alpha_{PSSCH,4} \cdot PL \right\}$$

where P_{MAX_CBR} is set to a $maxTxPower$ value based on the priority level of the PSSCH and the CBR range which includes the CBR measured in subframe $n-4$.

14.1.1.6 UE procedure for determining the subset of resources to be reported to higher layers in PSSCH resource selection in sidelink transmission mode 4 and in sensing measurement in sidelink transmission mode 3

In sidelink transmission mode 4, when requested by higher layers in subframe n for a carrier, the UE shall determine the set of resources to be reported to higher layers for PSSCH transmission according to the steps described in this Subclause. Parameters L_{subCH} the number of sub-channels to be used for the PSSCH transmission in a subframe, P_{rsvp_TX} the resource reservation interval, and $prio_{TX}$ the priority to be transmitted in the associated SCI format 1 by the UE are all provided by higher layers (described in [8]). C_{resel} is determined according to Subclause 14.1.1.4B.

In sidelink transmission mode 3, when requested by higher layers in subframe n for a carrier, the UE shall determine the set of resources to be reported to higher layers in sensing measurement according to the steps described in this Subclause. Parameters L_{subCH} , P_{rsvp_TX} and $prio_{TX}$ are all provided by higher layers (described in [11]). C_{resel} is determined by $C_{resel} = 10 * SL_RESOURCE_RESELECTION_COUNTER$, where $SL_RESOURCE_RESELECTION_COUNTER$ is provided by higher layers [11].

If partial sensing is not configured by higher layers then the following steps are used:

- 1) A candidate single-subframe resource for PSSCH transmission $R_{x,y}$ is defined as a set of L_{subCH} contiguous sub-channels with sub-channel $x+j$ in subframe t_y^{SL} where $j = 0, \dots, L_{subCH}-1$. The UE shall assume that any set of L_{subCH} contiguous sub-channels included in the corresponding PSSCH resource pool (described in 14.1.5) within the time interval $[n+T_1, n+T_2]$ corresponds to one candidate single-subframe resource, where selections of T_1 and T_2 are up to UE implementations under $T_1 \leq 4$ and $T_{2min}(prio_{TX}) \leq T_2 \leq 100$, if $T_{2min}(prio_{TX})$ is provided by higher layers for $prio_{TX}$, otherwise $20 \leq T_2 \leq 100$. UE selection of T_2 shall fulfil the latency requirement. The total number of the candidate single-subframe resources is denoted by M_{total} .
- 2) The UE shall monitor subframes $t_{n'-10 \times P_{step}}^{SL}, t_{n'-10 \times P_{step}+1}^{SL}, \dots, t_{n'-1}^{SL}$ except for those in which its transmissions occur, where $t_{n'}^{SL} = n$ if subframe n belongs to the set $(t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL})$, otherwise subframe $t_{n'}^{SL}$ is the first subframe after subframe n belonging to the set $(t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL})$. The UE shall perform the behaviour in the following steps based on PSCCH decoded and S-RSSI measured in these subframes.
- 3) The parameter $Th_{a,b}$ is set to the value indicated by the i-th $SL-ThresPSSCH-RSRP$ field in $SL-ThresPSSCH-RSRP-List$ where $i = (a - 1) * 8 + b$.

- 4) The set S_A is initialized to the union of all the candidate single-subframe resources. The set S_B is initialized to an empty set.
- 5) The UE shall exclude any candidate single-subframe resource $R_{x,y}$ from the set S_A if it meets all the following conditions:
- the UE has not monitored subframe t_z^{SL} in Step 2.
 - there is an integer j which meets $y + j \times P'_{rsvp_TX} = z + P_{step} \times k \times q$ where $j=0, 1, \dots, C_{resel}-1$,
 $P'_{rsvp_TX} = P_{step} \times P_{rsvp_TX} / 100$, k is any value allowed by the higher layer parameter
 $restrictResourceReservationPeriod$ and $q=1, 2, \dots, Q$. Here, $Q = \frac{1}{k}$ if $k < 1$ and $n' - z \leq P_{step} \times k$, where
 $t_n^{SL} = n$ if subframe n belongs to the set $t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL}$, otherwise subframe t_n^{SL} is the first subframe
belonging to the set $t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL}$ after subframe n ; and $Q = 1$ otherwise.
- 6) The UE shall exclude any candidate single-subframe resource $R_{x,y}$ from the set S_A if it meets all the following conditions:
- the UE receives an SCI format 1 in subframe t_m^{SL} , and "Resource reservation" field and "Priority" field in the received SCI format 1 indicate the values P_{rsvp_RX} and $prio_{RX}$, respectively according to Subclause 14.2.1.
 - PSSCH-RSRP measurement according to the received SCI format 1 is higher than $Th_{prio_{RX}, prio_{RX}}$.
 - the SCI format received in subframe t_m^{SL} or the same SCI format 1 which is assumed to be received in subframe(s) $t_{m+q \times P_{step} \times P_{rsvp_RX}}^{SL}$ determines according to 14.1.1.4C the set of resource blocks and subframes which overlaps with $R_{x,y+j \times P'_{rsvp_TX}}$ for $q=1, 2, \dots, Q$ and $j=0, 1, \dots, C_{resel}-1$. Here, $Q = \frac{1}{P_{rsvp_RX}}$ if $P_{rsvp_RX} < 1$ and $n' - m \leq P_{step} \times P_{rsvp_RX}$, where $t_n^{SL} = n$ if subframe n belongs to the set $(t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL})$, otherwise subframe t_n^{SL} is the first subframe after subframe n belonging to the set $(t_0^{SL}, t_1^{SL}, \dots, t_{T_{max}}^{SL})$; otherwise $Q = 1$.
- 7) If the number of candidate single-subframe resources remaining in the set S_A is smaller than $0.2 \cdot M_{total}$, then Step 4 is repeated with $Th_{a,b}$ increased by 3 dB.
- 8) For a candidate single-subframe resource $R_{x,y}$ remaining in the set S_A , the metric $E_{x,y}$ is defined as the linear average of S-RSSI measured in sub-channels $x+k$ for $k = 0, \dots, L_{subCH}-1$ in the monitored subframes in Step 2 that can be expressed by $t_{y-P_{step} \times j}^{SL}$ for a non-negative integer j if $P_{rsvp_TX} \geq 100$, and $t_{y-P'_{rsvp_TX} \times j}^{SL}$ for a non-negative integer j otherwise.
- 9) The UE moves the candidate single-subframe resource $R_{x,y}$ with the smallest metric $E_{x,y}$ from the set S_A to S_B . This step is repeated until the number of candidate single-subframe resources in the set S_B becomes greater than or equal to $0.2 \cdot M_{total}$,

10) When the UE is configured by upper layers to transmit using resource pools on multiple carriers, it shall exclude a candidate single-subframe resource $R_{x,y}$ from S_B if the UE does not support transmission in the candidate single-subframe resource in the carrier under the assumption that transmissions take place in other carrier(s) using the already selected resources due to its limitation in the number of simultaneous transmission carriers, its limitation in the supported carrier combinations, or interruption for RF retuning time [10].

The UE shall report set S_B to higher layers.

If partial sensing is configured by higher layers then the following steps are used:

- 1) A candidate single-subframe resource for PSSCH transmission $R_{x,y}$ is defined as a set of L_{subCH} contiguous sub-channels with sub-channel $x+j$ in subframe t_y^{SL} where $j = 0, \dots, L_{\text{subCH}} - 1$. The UE shall determine by its implementation a set of subframes which consists of at least Y subframes within the time interval $[n + T_1, n + T_2]$ where selections of T_1 and T_2 are up to UE implementations under $T_1 \leq 4$ and $T_{2\min}(\text{prio}_{TX}) \leq T_2 \leq 100$, if $T_{2\min}(\text{prio}_{TX})$ is provided by higher layers for prio_{TX} , otherwise $20 \leq T_2 \leq 100$. UE selection of T_2 shall fulfil the latency requirement and Y shall be greater than or equal to the high layer parameter minNumCandidateSF . The UE shall assume that any set of L_{subCH} contiguous sub-channels included in the corresponding PSSCH resource pool (described in 14.1.5) within the determined set of subframes correspond to one candidate single-subframe resource. The total number of the candidate single-subframe resources is denoted by M_{total} .
- 2) If a subframe t_y^{SL} is included in the set of subframes in Step 1, the UE shall monitor any subframe $t_{y-k \times P_{\text{step}}}^{SL}$ if k-th bit of the high layer parameter $\text{gapCandidateSensing}$ is set to 1. The UE shall perform the behaviour in the following steps based on PSCCH decoded and S-RSSI measured in these subframes.
- 3) The parameter $Th_{a,b}$ is set to the value indicated by the i-th *SL-ThresPSSCH-RSRP* field in *SL-ThresPSSCH-RSRP-List* where $i = (a - 1) * 8 + b$.
- 4) The set S_A is initialized to the union of all the candidate single-subframe resources. The set S_B is initialized to an empty set.
- 5) The UE shall exclude any candidate single-subframe resource $R_{x,y}$ from the set S_A if it meets all the following conditions:
 - the UE receives an SCI format 1 in subframe t_m^{SL} , and "Resource reservation" field and "Priority" field in the received SCI format 1 indicate the values P_{rsvp_RX} and prio_{RX} , respectively according to Subclause 14.2.1.
 - PSSCH-RSRP measurement according to the received SCI format 1 is higher than $Th_{\text{prio}_{TX}, \text{prio}_{RX}}$.
 - the SCI format received in subframe t_m^{SL} or the same SCI format 1 which is assumed to be received in subframe(s) $t_{m+q \times P_{\text{step}} \times P_{\text{rsvp}_RX}}^{SL}$ determines according to 14.1.1.4C the set of resource blocks and subframes which overlaps with $R_{x,y+j \times P_{\text{rsvp}_TX}}$ for $q=1, 2, \dots, Q$ and $j=0, 1, \dots, C_{\text{resel}} - 1$. Here, $Q = \frac{1}{P_{\text{rsvp}_RX}}$ if $P_{\text{rsvp}_RX} < 1$ and $y' - m \leq P_{\text{step}} \times P_{\text{rsvp}_RX} + P_{\text{step}}$, where $t_{y'}^{SL}$ is the last subframe of the Y subframes, and $Q = 1$ otherwise.
- 6) If the number of candidate single-subframe resources remaining in the set S_A is smaller than $0.2 \cdot M_{\text{total}}$, then Step 4 is repeated with $Th_{a,b}$ increased by 3 dB.

- 7) For a candidate single-subframe resource $R_{x,y}$ remaining in the set S_A , the metric $E_{x,y}$ is defined as the linear average of S-RSSI measured in sub-channels $x+k$ for $k = 0, \dots, L_{\text{subCH}} - 1$ in the monitored subframes in Step 2 that can be expressed by $t_{y-P_{\text{step}}}^{SL} * j$ for a non-negative integer j .
- 8) The UE moves the candidate single-subframe resource $R_{x,y}$ with the smallest metric $E_{x,y}$ from the set S_A to S_B . This step is repeated until the number of candidate single-subframe resources in the set S_B becomes greater than or equal to $0.2 \cdot M_{\text{total}}$.
- 9) When the UE is configured by upper layers to transmit using resource pools on multiple carriers, it shall exclude a candidate single-subframe resource $R_{x,y}$ from S_B if the UE does not support transmission in the candidate single-subframe resource in the carrier under the assumption that transmissions take place in other carrier(s) using the already selected resources due to its limitation in the number of simultaneous transmission carriers, its limitation in the supported carrier combinations, or interruption for RF retuning time [10].

The UE shall report set S_B to higher layers.

If transmission based on random selection is configured by upper layers and when the UE is configured by upper layers to transmit using resource pools on multiple carriers, the following steps are used:

- 1) A candidate single-subframe resource for PSSCH transmission $R_{x,y}$ is defined as a set of L_{subCH} contiguous sub-channels with sub-channel $x+j$ in subframe t_y^{SL} where $j = 0, \dots, L_{\text{subCH}} - 1$. The UE shall assume that any set of L_{subCH} contiguous sub-channels included in the corresponding PSSCH resource pool (described in 14.1.5) within the time interval $[n+T_1, n+T_2]$ corresponds to one candidate single-subframe resource, where selections of T_1 and T_2 are up to UE implementations under $T_1 \leq 4$ and $T_{2\min}(\text{prio}_{TX}) \leq T_2 \leq 100$, if $T_{2\min}(\text{prio}_{TX})$ is provided by higher layers for prio_{TX} , otherwise $20 \leq T_2 \leq 100$. UE selection of T_2 shall fulfil the latency requirement. The total number of the candidate single-subframe resources is denoted by M_{total} .
- 2) The set S_A is initialized to the union of all the candidate single-subframe resources. The set S_B is initialized to an empty set.
- 3) The UE moves the candidate single-subframe resource $R_{x,y}$ from the set S_A to S_B .
- 4) The UE shall exclude a candidate single-subframe resource $R_{x,y}$ from S_B if the UE does not support transmission in the candidate single-subframe resource in the carrier under the assumption that transmissions take place in other carrier(s) using the already selected resources due to its limitation in the number of simultaneous transmission carriers, its limitation in the supported carrier combinations, or interruption for RF retuning time [10].

The UE shall report set S_B to higher layers.

14.1.1.7 Conditions for selecting resources when the number of HARQ transmissions is two in sidelink transmission mode 4

When a set of subframes $t_{n+j \times P'_{\text{rsvp_TX}}}^{SL}$ for $j = 0, 1, \dots, J - 1$ have been selected for a set of transmission opportunities of PSSCH, a set of subframes $t_{n+k+j \times P'_{\text{rsvp_TX}}}^{SL}$ for $j = 0, 1, \dots, J - 1$ for another set of transmission opportunities of PSSCH shall meet the conditions $-15 \leq k \leq 15$ and $k \neq 0$ where $P'_{\text{rsvp_TX}} = P_{\text{step}} \times P_{\text{rsvp_TX}} / 100$ and J is

the maximum number of transmission opportunities of PSSCH in a selected subframe set. Here, $P_{\text{rsvp_TX}}$ is the resource reservation interval provided by higher layers.

14.1.2 UE procedure for receiving the PSSCH

For sidelink transmission mode 1, a UE upon detection of SCI format 0 on PSCCH can decode PSSCH according to the detected SCI format 0.

For sidelink transmission mode 2, a UE upon detection of SCI format 0 on PSCCH can decode PSSCH according to the detected SCI format 0, and associated PSSCH resource configuration configured by higher layers.

For sidelink transmission mode 3, a UE upon detection of SCI format 1 on PSCCH can decode PSSCH according to the detected SCI format 1, and associated PSSCH resource configuration configured by higher layers.

For sidelink transmission mode 4, a UE upon detection of SCI format 1 on PSCCH can decode PSSCH according to the detected SCI format 1, and associated PSSCH resource configuration configured by higher layers.

14.1.3 UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 2

For a PSCCH period associated with the PSCCH resource configuration (determined in Subclause 14.2.3) which is also associated with the PSSCH resource configuration, the UE determines a PSSCH pool consisting of a subframe pool and resource block pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- Within the PSCCH period, the uplink subframes with subframe index greater than or equal to $j_{\text{begin}} + O_2$ are denoted by $(l_0, l_1, \dots, l_{N'-1})$ arranged in increasing order of subframe index, where j_{begin} is described in Subclause 14.2.3 and O_2 is the *offsetIndicator-r12* indicated by the PSSCH resource configuration, where N' denotes the number of uplink subframes within the PSCCH period with subframe index greater than or equal to $j_{\text{begin}} + O_2$.
- A bitmap $b_0, b_1, b_2, \dots, b_{N'-1}$ is determined using $b_j = a_{j \bmod N_B}$, for $0 \leq j < N'$, where $a_0, a_1, a_2, \dots, a_{N_B-1}$ and N_B are the bitmap and the length of the bitmap indicated by *subframeBitmap-r12*, respectively.
- A subframe l_j ($0 \leq j < N'$) belongs to the subframe pool if $b_j = 1$. The subframes in the subframe pool are denoted by $(l_0^{\text{PSSCH}}, l_1^{\text{PSSCH}}, \dots, l_{L_{\text{PSSCH}}-1}^{\text{PSSCH}})$ arranged in increasing order of subframe index and L_{PSSCH} denotes the number of subframes in the subframe pool.
- A PRB with index q ($0 \leq q < N_{\text{RB}}^{\text{SL}}$) belongs to the resource block pool if $S1 \leq q < S1 + M$ or if $S2 - M < q \leq S2$, where $S1$, $S2$, and M denote the *prb-Start-r12*, *prb-End-r12* and *prb-Num-r12* indicated by the PSSCH resource configuration respectively.
- The resource blocks in the resource block pool are denoted by $(m_0^{\text{PSSCH}}, m_1^{\text{PSSCH}}, \dots, m_{M_{\text{RB}}^{\text{PSSCH_RP}}-1}^{\text{PSSCH}})$ arranged in increasing order of resource block indices and $M_{\text{RB}}^{\text{PSSCH_RP}}$ is the number of resource blocks in the resource block pool.

14.1.4 UE procedure for determining subframe pool for sidelink transmission mode 1

For a PSCCH period associated with the PSCCH resource configuration (described in Subclause 14.2.3) which is also associated with the PSSCH resource configuration, the UE determines a PSSCH pool consisting of a subframe pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- Each uplink subframe with subframe index greater than or equal to $l_{L_{PSCCH}-1}^{PSCCH} + 1$ belongs to the subframe pool for PSSCH, where $l_{L_{PSCCH}-1}^{PSCCH} + 1$ and L_{PSCCH} are described in Subclause 14.2.3.
- The subframes in the subframe pool for PSSCH are denoted by $(l_0^{PSSCH}, l_1^{PSSCH}, \dots, l_{L_{PSSCH}-1}^{PSSCH})$ arranged in increasing order of subframe index and L_{PSSCH} denotes the number of subframes in the subframe pool.

14.1.5 UE procedure for determining resource block pool and subframe pool for sidelink transmission mode 3 and 4

The set of subframes that may belong to a PSSCH resource pool for sidelink transmission mode 3 or 4 is denoted by $(t_0^{SL}, t_1^{SL}, \dots, t_{T_{\max}}^{SL})$ where

- $0 \leq t_i^{SL} < 10240$,
- the subframe index is relative to subframe#0 of the radio frame corresponding to SFN 0 of the serving cell or DFN 0 (described in [11]),
- the set includes all the subframes except the following subframes,
 - subframes in which SLSS resource is configured,
 - downlink subframes and special subframes if the sidelink transmission occurs in a TDD cell,
 - reserved subframes which are determined by the following steps:
 - 1) the remaining subframes excluding N_{slss} and N_{dssf} subframes from the set of all the subframes are denoted by $(l_0, l_1, \dots, l_{(10240-N_{slss}-N_{dssf}-1)})$ arranged in increasing order of subframe index, where N_{slss} is the number of subframes in which SLSS resource is configured within 10240 subframes and N_{dssf} is the number of downlink subframes and special subframes within 10240 subframes if the sidelink transmission occurs in a TDD cell.
 - 2) a subframe $l_r (0 \leq r < (10240 - N_{slss} - N_{dssf}))$ belongs to the reserved subframes if

$$r = \left\lfloor \frac{m \cdot (10240 - N_{slss} - N_{dssf})}{N_{reserved}} \right\rfloor \text{ where } m = 0, \dots, N_{reserved} - 1 \text{ and}$$

$$N_{reserved} = (10240 - N_{slss} - N_{dssf}) \bmod L_{bitmap}.$$

Here, L_{bitmap} the length of the bitmap is configured by higher layers.
- the subframes are arranged in increasing order of subframe index.

The UE determines the set of subframes assigned to a PSSCH resource pool as follows:

- A bitmap $(b_0, b_1, \dots, b_{L_{bitmap}-1})$ associated with the resource pool is used where L_{bitmap} the length of the bitmap is configured by higher layers.
- A subframe $t_k^{SL} (0 \leq k < (10240 - N_{slss} - N_{dssf} - N_{reserved}))$ belongs to the subframe pool if $b_{k'} = 1$ where $k' = k \bmod L_{bitmap}$.

The UE determines the set of resource blocks assigned to a PSSCH resource pool as follows:

- The resource block pool consists of N_{subCH} sub-channels where N_{subCH} is given by higher layer parameter *numSubchannel*.
- The sub-channel m for $m = 0, 1, \dots, N_{subCH} - 1$ consists of a set of $n_{subCHsize}$ contiguous resource blocks with the physical resource block number $n_{PRB} = n_{subCHRBstart} + m * n_{subCHsize} + j$ for $j = 0, 1, \dots, n_{subCHsize} - 1$ where $n_{subCHRBstart}$ and $n_{subCHsize}$ are given by higher layer parameters *startRBSubchannel* and *sizeSubchannel*, respectively

14.2 Physical Sidelink Control Channel related procedures

For sidelink transmission mode 1, if a UE is configured by higher layers to receive DCI format 5 with the CRC scrambled by the SL-RNTI, the UE shall decode the PDCCH/EPDCCH according to the combination defined in Table 14.2-1.

Table 14.2-1: PDCCH/EPDCCH configured by SL-RNTI

| DCI format | Search Space |
|--------------|--|
| DCI format 5 | For PDCCH: Common and UE specific by C-RNTI For EPDCCH: UE specific by C-RNTI |

For sidelink transmission mode 3, if a UE is configured by higher layers to receive DCI format 5A with the CRC scrambled by the SL-V-RNTI or SL-SPS-V-RNTI, the UE shall decode the PDCCH/EPDCCH according to the combination defined in Table 14.2-2. A UE is not expected to receive DCI format 5A with size larger than DCI format 0 in the same search space that DCI format 0 is defined on.

Table 14.2-2: PDCCH/EPDCCH configured by SL-V-RNTI or SL-SPS-V-RNTI

| DCI format | Search Space |
|---------------|--|
| DCI format 5A | For PDCCH: Common and UE specific by C-RNTI For EPDCCH: UE specific by C-RNTI |

The carrier indicator field value in DCI format 5A corresponds to *v2x-InterFreqInfo*.

14.2.1 UE procedure for transmitting the PSCCH

For sidelink transmission mode 1 and PSCCH period i ,

- the UE shall determine the subframes and resource blocks for transmitting SCI format 0 as follows.
 - SCI format 0 is transmitted in two subframes in the subframe pool and one physical resource block per slot in each of the two subframes, wherein the physical resource blocks belong to the resource block pool, where the subframe pool and the resource block pool are indicated by the PSCCH resource configuration (as defined in Subclause 14.2.3)
 - the two subframes and the resource blocks are determined using "Resource for PSCCH" field (n_{PSCCH}) in the configured sidelink grant (described in [8]) as described in Subclause 14.2.1.1.
 - the UE shall set the contents of the SCI format 0 as follows:

- the UE shall set the Modulation and coding scheme field according to the Modulation and coding scheme indicated by the higher layer parameter *mcs-r12* if the parameter is configured by higher layers.
- the UE shall set the Frequency hopping flag according to the "Frequency hopping flag" field in the configured sidelink grant.
- the UE shall set the Resource block assignment and hopping resource allocation according to the "Resource block assignment and hopping resource allocation" field in the configured sidelink grant.
- the UE shall set the Time resource pattern according to the "Time resource pattern" field in the configured sidelink grant .
- the UE shall set the eleven-bit Timing advance indication to $I_{TAI} = \left\lfloor \frac{N_{TA}}{16} \right\rfloor$ to indicate sidelink reception timing adjustment value using the N_{TA} (defined in [3]) value for the UE in the subframe that is no earlier than subframe $l_{bl}^{PSCCH} - 4$ (l_{bl}^{PSCCH} described in Subclause 14.2.1.1).

For sidelink transmission mode 2,

- SCI format 0 is transmitted in two subframes in the subframe pool and one physical resource block per slot in each of the two subframes, wherein the physical resource blocks belongs to the resource block pool, where the subframe pool and the resource block pool are indicated by the PSCCH resource configuration (as defined in Subclause 14.2.3)
- the two subframes and the resource blocks are determined using the procedure described in Subclause 14.2.1.2
- the UE shall set the eleven-bit Timing advance indication I_{TAI} in the SCI format 0 to zero.

For sidelink transmission mode 3,

- The UE shall determine the subframes and resource blocks for transmitting SCI format 1 as follows:
 - SCI format 1 is transmitted in two physical resource blocks per slot in each subframe where the corresponding PSSCH is transmitted.
 - If the UE receives in subframe n DCI format 5A with the CRC scrambled by the SL-V-RNTI, one transmission of PSCCH is in the PSCCH resource L_{init} (described in Subclause 14.2.4) in the first subframe t_q^{SL} that is included in $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ and that starts not earlier than $T_{DL} - \frac{N_{TA}}{2} \times T_S + (4 + m) \times 10^{-3}$. L_{init} is the value indicated by "Lowest index of the sub-channel allocation to the initial transmission" associated with the configured sidelink grant (described in [8]) if the field "Lowest index of the sub-channel allocation to the initial transmission" in the corresponding DCI format 5A is present and $L_{init} = 0$ otherwise, $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ is determined by Subclause 14.1.5, the value m is indicated by 'SL index' field in the corresponding DCI format 5A according to Table 14.2.1-1 if this field is present and $m=0$ otherwise, T_{DL} is the start of the downlink subframe carrying the DCI, and N_{TA} and T_S are described in [3].
 - If "Time gap between initial transmission and retransmission" in the configured sidelink grant (described in [8]) is not equal to zero, another transmission of PSCCH is in the PSCCH resource L_{ReTX} in subframe $t_{q+SF_{gap}}^{SL}$, where SF_{gap} is the value indicated by "Time gap between initial transmission and retransmission" field in the configured sidelink grant. L_{ReTX} corresponds to the value n_{subCH}^{start} determined by the procedure in Subclause 14.1.1.4C with the RIV set to the value indicated by "Frequency resource location of the initial transmission and retransmission" field in the configured sidelink grant.
 - If the UE receives in subframe n DCI format 5A with the CRC scrambled by the SL-SPS-V-RNTI, the UE shall consider the received DCI information as a valid sidelink semi-persistent activation or release only for the SPS configuration indicated by the SL SPS configuration index field. If the received DCI activates an SL SPS configuration, one transmission of PSCCH is in the PSCCH resource L_{init} (described in Subclause 14.2.4) in the first subframe t_q^{SL} that is included in $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ and that starts not earlier than $T_{DL} -$

$\frac{N_{TA}}{2} \times T_S + (4 + m) \times 10^{-3}$. L_{init} is the value indicated by "Lowest index of the sub-channel allocation to the initial transmission" associated with the configured sidelink grant (described in [8]) if the field "Lowest index of the sub-channel allocation to the initial transmission" in the corresponding DCI format 5A is present and $L_{Init} = 0$ otherwise, $(t_0^{SL}, t_1^{SL}, t_2^{SL}, \dots)$ is determined by Subclause 14.1.5, the value m is indicated by 'SL index' field in the corresponding DCI format 5A according to Table 14.2.1-1 if this field is present and $m=0$ otherwise, T_{DL} is the start of the downlink subframe carrying the DCI, and N_{TA} and T_S are described in [3]..

- If "Time gap between initial transmission and retransmission" in the configured sidelink grant (described in [8]) is not equal to zero, another transmission of PSCCH is in the PSCCH resource L_{ReTX} in subframe $t_{q+SF_{gap}}^{SL}$, where SF_{gap} is the value indicated by "Time gap between initial transmission and retransmission" field in the configured sidelink grant. L_{ReTX} corresponds to the value n_{subCH}^{start} determined by the procedure in Subclause 14.1.1.4C with the RIV set to the value indicated by "Frequency resource location of the initial transmission and retransmission" field in the configured sidelink grant.

- The UE shall set the contents of the SCI format 1 as follows:
 - the UE shall set the Modulation and coding scheme as indicated by higher layers.
 - the UE shall set the "Priority" field according to the highest priority among those priority(s) indicated by higher layers corresponding to the transport block. Priority field '000' corresponds to priority '1', priority field '001' corresponds to priority '2', and so on.
 - the UE shall set the Time gap between initial transmission and retransmission field, the Frequency resource location of the initial transmission and retransmission field, and the Retransmission index field such that the set of time and frequency resources determined for PSSCH according to Subclause 14.1.1.4C is in accordance with the PSSCH resource allocation indicated by the configured sidelink grant.
 - the UE shall set the Resource reservation according to table 14.2.1-2 based on indicated value X , where X is equal to the Resource reservation interval provided by higher layers divided by 100.
 - Each transmission of SCI format 1 is transmitted in one subframe and two physical resource blocks per slot of the subframe.
- The UE shall randomly select the cyclic shift $n_{cs,\lambda}$ among {0, 3, 6, 9} in each PSCCH transmission.

For sidelink transmission mode 4,

- The UE shall determine the subframes and resource blocks for transmitting SCI format 1 as follows:
 - SCI format 1 is transmitted in two physical resource blocks per slot in each subframe where the corresponding PSSCH is transmitted.
 - If the configured sidelink grant from higher layer indicates the PSCCH resource in subframe t_n^{SL} , one transmission of PSCCH is in the indicated PSCCH resource m (described in Subclause 14.2.4) in subframe t_n^{SL} .
 - If "Time gap between initial transmission and retransmission" in the configured sidelink grant (described in [8]) is not equal to zero, another transmission of PSCCH is in the PSCCH resource L_{ReTX} in subframe $t_{n+SF_{gap}}^{SL}$ where SF_{gap} is the value indicated by "Time gap between initial transmission and retransmission" field in the configured sidelink grant, L_{ReTX} corresponds to the value n_{subCH}^{start} determined by the procedure in Subclause 14.1.1.4C with the RIV set to the value indicated by "Frequency resource location of the initial transmission and retransmission" field in the configured sidelink grant.
- the UE shall set the contents of the SCI format 1 as follows:

- the UE shall set the Modulation and coding scheme as indicated by higher layers.
- the UE shall set the "Priority" field according to the highest priority among those priority(s) indicated by higher layers corresponding to the transport block. Priority field '000' corresponds to priority '1', priority field '001' corresponds to priority '2', and so on.
- the UE shall set the Time gap between initial transmission and retransmission field, the Frequency resource location of the initial transmission and retransmission field, and the Retransmission index field such that the set of time and frequency resources determined for PSSCH according to Subclause 14.1.1.4C is in accordance with the PSSCH resource allocation indicated by the configured sidelink grant.
- the UE shall set the Resource reservation field according to table 14.2.1-2 based on indicated value X , where X is equal to the Resource reservation interval provided by higher layers divided by 100.
- Each transmission of SCI format 1 is transmitted in one subframe and two physical resource blocks per slot of the subframe.
- The UE shall randomly select the cyclic shift $n_{cs,\lambda}$ among {0, 3, 6, 9} in each PSCCH transmission.

Table 14.2.1-1: Mapping of DCI format 5A offset field to indicated value m

| SL index field in DCI format 5A | Indicated value m |
|---------------------------------|---------------------|
| '00' | 0 |
| '01' | 1 |
| '10' | 2 |
| '11' | 3 |

Table 14.2.1-2: Determination of the Resource reservation field in SCI format 1

| Resource reservation field in SCI format 1 | Indicated value X | Condition |
|--|---------------------------------|---|
| '0001', '0010', ..., '1010' | Decimal equivalent of the field | The higher layer decides to keep the resource for the transmission of the next transport block and the value X meets $1 \leq X \leq 10$. |
| '1011' | 0.5 | The higher layer decides to keep the resource for the transmission of the next transport block and the value X is 0.5. |
| '1100' | 0.2 | The higher layer decides to keep the resource for the transmission of the next transport block and the value X is 0.2. |
| '0000' | 0 | The higher layer decides not to keep the resource for the transmission of the next transport block. |
| '1101', '1110', '1111' | Reserved | |

14.2.1.1 UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 1

For $0 \leq n_{PSCCH} < \lfloor M_{RB}^{PSCCH_RP} / 2 \rfloor \cdot L_{PSCCH}$,

- one transmission of the PSCCH is in resource block m_{a1}^{PSCCH} of subframe l_{b1}^{PSCCH} of the PSCCH period, where $a1 = \lfloor n_{PSCCH} / L_{PSCCH} \rfloor$ and $b1 = n_{PSCCH} \bmod L_{PSCCH}$.
- the other transmission of the PSCCH is in resource block m_{a2}^{PSCCH} of subframe l_{b2}^{PSCCH} of the PSCCH period, where $a2 = \lfloor n_{PSCCH} / L_{PSCCH} \rfloor + \lfloor M_{RB}^{PSCCH_RP} / 2 \rfloor$ and $b2 = (n_{PSCCH} + 1 + \lfloor n_{PSCCH} / L_{PSCCH} \rfloor \bmod (L_{PSCCH} - 1)) \bmod L_{PSCCH}$.

where $(l_0^{PSCCH}, l_1^{PSCCH}, \dots, l_{L_{PSCCH}-1}^{PSCCH})$, $(m_0^{PSCCH}, m_1^{PSCCH}, \dots, m_{M_{RB}^{PSCCH_RP}-1}^{PSCCH})$, L_{PSCCH} and $M_{RB}^{PSCCH_RP}$ are described in Subclause 14.2.3.

14.2.1.2 UE procedure for determining subframes and resource blocks for transmitting PSCCH for sidelink transmission mode 2

The allowed values for PSCCH resource selection are given by $0, 1, \dots, (\lfloor M_{RB}^{PSCCH_RP} / 2 \rfloor \cdot L_{PSCCH} - 1)$ where L_{PSCCH} and $M_{RB}^{PSCCH_RP}$ described in Subclause 14.2.3. The two subframes and the resource blocks are determined using selected resource value n_{PSCCH} (described in [8]) and the procedure described in Subclause 14.2.1.1.

14.2.1.3 UE procedure for PSCCH power control

For sidelink transmission mode 1 and PSCCH period i , the UE transmit power P_{PSCCH} for PSCCH transmission is given by the following

- if the TPC command field in the configured sidelink grant (described in [8]) for PSCCH period i is set to 0

$$P_{PSCCH} = P_{CMAX,PSCCH}$$

- if the TPC command field in the configured sidelink grant (described in [8]) for PSCCH period i is set to 1

$$P_{PSCCH} = \min \left\{ P_{CMAX,PSCCH}, 10 \log_{10}(M_{PSCCH}) + P_{O_{PSCCH},1} + \alpha_{PSCCH,1} \cdot PL \right\} [\text{dBm}]$$

where $P_{CMAX,PSCCH}$ is defined in [6], and $M_{PSCCH}=1$ and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1.

$P_{O_{PSCCH},1}$ and $\alpha_{PSCCH,1}$ are provided by higher layer parameters $p0-r12$ and $alpha-r12$, respectively and are associated with the corresponding PSCCH resource configuration.

For sidelink transmission mode 2, the UE transmit power P_{PSCCH} for PSCCH transmission is given by

$$P_{PSCCH} = \min \left\{ P_{CMAX,PSCCH}, 10 \log_{10}(M_{PSCCH}) + P_{O_{PSCCH},2} + \alpha_{PSCCH,2} \cdot PL \right\} [\text{dBm}],$$

where $P_{CMAX,PSCCH}$ is the $P_{CMAX,c}$ configured by higher layers and $M_{PSCCH}=1$ and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{O_{PSCCH},2}$ and $\alpha_{PSCCH,2}$ are provided by higher layer parameters $p0-r12$ and $alpha-r12$, respectively and are associated with the corresponding PSCCH resource configuration.

For sidelink transmission mode 3, the UE transmit power P_{PSCCH} for PSCCH transmission is given by

$$P_{PSCCH} = 10 \log_{10} \left(\frac{10^{\frac{3}{10}} \times M_{PSCCH}}{M_{PSSCH} + 10^{\frac{3}{10}} \times M_{PSCCH}} \right) + \min \left\{ P_{CMAX}, 10 \log_{10} \left(M_{PSSCH} + 10^{\frac{3}{10}} \times M_{PSCCH} \right) + P_{O_{PSSCH},3} + \alpha_{PSSCH,3} \cdot PL \right\} [\text{dBm}],$$

where P_{CMAX} is defined in [6], M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource block, $M_{PSCCH}=2$, and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{O_{PSSCH},3}$ and $\alpha_{PSSCH,3}$ are provided by higher layer parameters $p0SL-V2V$ and $alphaSL-V2V$, respectively and that are associated with the corresponding PSSCH resource configuration.

For sidelink transmission mode 4, the UE transmit power P_{PSCCH} for PSCCH transmission in subframe n is given by

$$P_{\text{PSCCH}} = 10 \log_{10} \left(\frac{10^{\frac{3}{10}} \times M_{\text{PSCCH}}}{M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}}} \right) + B \text{ [dBm]},$$

where P_{CMAX} is defined in [6], M_{PSSCH} is the bandwidth of the PSSCH resource assignment expressed in number of resource block, $M_{\text{PSCCH}} = 2$, and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. $P_{O_{\text{PSSCH},4}}$ and $\alpha_{\text{PSSCH},4}$ are provided by higher layer parameters $p0SL\text{-}V2V$ and $alphaSL\text{-}V2V$, respectively and that are associated with the corresponding PSSCH resource configuration. If higher layer parameter $maxTxpower$ is configured then

$$B = \min \left\{ P_{\text{CMAX}}, P_{\text{MAX_CBR}}, 10 \log_{10} \left(M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}} \right) + P_{O_{\text{PSSCH},4}} + \alpha_{\text{PSSCH},4} \cdot PL \right\}$$

else

$$B = \min \left\{ P_{\text{CMAX}}, 10 \log_{10} \left(M_{\text{PSSCH}} + 10^{\frac{3}{10}} \times M_{\text{PSCCH}} \right) + P_{O_{\text{PSSCH},4}} + \alpha_{\text{PSSCH},4} \cdot PL \right\}$$

where $P_{\text{MAX_CBR}}$ is set to a $maxTxpower$ value based on the priority level of the PSSCH and the CBR range which includes the CBR measured in subframe $n-4$.

14.2.2 UE procedure for receiving the PSCCH

For each PSCCH resource configuration associated with sidelink transmission mode 1, a UE configured by higher layers to detect SCI format 0 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration, and using the Group destination IDs indicated by higher layers.

For each PSCCH resource configuration associated with sidelink transmission mode 2, a UE configured by higher layers to detect SCI format 0 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration, and using the Group destination IDs indicated by higher layers.

For each PSCCH resource configuration associated with sidelink transmission mode 3, a UE configured by higher layers to detect SCI format 1 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration. The UE is not required to decode more than one PSCCH at each PSCCH resource candidate. The UE shall not assume any value for the "Reserved bits" before decoding a SCI format 1.

For each PSCCH resource configuration associated with sidelink transmission mode 4, a UE configured by higher layers to detect SCI format 1 on PSCCH shall attempt to decode the PSCCH according to the PSCCH resource configuration. The UE is not required to decode more than one PSCCH at each PSCCH resource candidate. The UE shall not assume any value for the "Reserved bits" before decoding a SCI format 1.

14.2.3 UE procedure for determining resource block pool and subframe pool for PSCCH

The following procedure is used for sidelink transmission mode 1 and 2.

A PSCCH resource configuration for transmission/reception is associated with a set of periodically occurring time-domain periods (known as PSCCH periods). The i -th PSCCH period begins at subframe with subframe index

$j_{\text{begin}} = O + i \cdot P$ and ends in subframe with subframe index $j_{\text{end}} = O + (i+1) \cdot P - 1$, where

- $0 \leq j_{\text{begin}}, j_{\text{end}} < 10240$,

- the subframe index is relative to subframe#0 of the radio frame corresponding to SFN 0 of the serving cell or DFN 0 (described in [11]),
- O is the *offsetIndicator-r12* indicated by the PSCCH resource configuration,
- P is the *sc-Period-r12* indicated by the PSCCH resource configuration.

For a PSCCH period, the UE determines a PSCCH pool consisting of a subframe pool and a resource block pool as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSCCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- The first N' uplink subframes are denoted by $(l_0, l_1, \dots, l_{N'-1})$ arranged in increasing order of subframe index, where N' is the length of the bitmap *subframeBitmap-r12* indicated by the PSCCH resource configuration.
- A subframe l_j ($0 \leq j < N'$) belongs to the subframe pool if $a_j = 1$, where $(a_0, a_1, a_2, \dots, a_{N'-1})$ is the bitmap *subframeBitmap-r12* indicated by the PSCCH resource configuration. The subframes in the subframe pool are denoted by $(l_0^{PSCCH}, l_1^{PSCCH}, \dots, l_{L_{PSCCH}-1}^{PSCCH})$ arranged in increasing order of subframe index and L_{PSCCH} is the number of subframes in the subframe pool. A PRB with index q ($0 \leq q < N_{RB}^{SL}$) belongs to the resource block pool if $S1 \leq q < S1 + M$ or if $S2 - M < q \leq S2$, where $S1$, $S2$, and M denote the *prb-Start-r12*, *prb-End-r12* and *prb-Num-r12* indicated by the PSCCH resource configuration respectively.
- The resource blocks in the resource block pool are denoted by $(m_0^{PSCCH}, m_1^{PSCCH}, \dots, m_{M_{RB}^{PSCCH_RP}-1}^{PSCCH})$ arranged in increasing order of resource block indices and $M_{RB}^{PSCCH_RP}$ is the number of resource blocks in the resource block pool.

14.2.4 UE procedure for determining resource block pool for PSCCH in sidelink transmission mode 3 and 4

The following procedure is used for sidelink transmission mode 3 and 4.

If a pool is (pre)configured such that a UE always transmits PSCCH and the corresponding PSSCH in adjacent resource blocks in a subframe, the PSCCH resource m is the set of two contiguous resource blocks with the physical resource block number $n_{PRB} = n_{subCHRBstart} + m * n_{subCHsize} + j$ for $j=0$ and 1 where $n_{subCHRBstart}$ and $n_{subCHsize}$ are given by higher layer parameters *startRBSubchannel* and *sizeSubchannel*, respectively.

If a pool is (pre)configured such that a UE may transmit PSCCH and the corresponding PSSCH in non-adjacent resource blocks in a subframe, the PSCCH resource m is the set of two contiguous resource blocks with the physical resource block number $n_{PRB} = n_{PSCCHstart} + 2 * m + j$ for $j=0$ and 1 where $n_{PSCCHstart}$ is given by higher layer parameter *startRBPSCHPool*.

14.3 Physical Sidelink Discovery Channel related procedures

14.3.1 UE procedure for transmitting the PSDCH

If a UE is configured by higher layers to transmit PSDCH according to a PSDCH resource configuration, in a PSDCH period i ,

- the number of transmissions for a transport block on PSDCH is $N_{SLD}^{\text{TX}} = n + 1$ where n is given by the higher layer parameter *numRetx-r12*, and each transmission corresponds to one subframe belonging to a set of subframes, and in each subframe, the PSDCH is transmitted on two physical resource blocks per slot.

- for sidelink discovery type 1,
 - the allowed values for PSDCH resource selection are given by $0, 1 \dots (N_t \cdot N_f - 1)$, where $N_t = \lfloor L_{PSDCH} / N_{SLD}^{\text{TX}} \rfloor$ and $N_f = \lfloor M_{RB}^{PSDCH_RP} / 2 \rfloor$, and
 - the j -th transmission ($1 \leq j \leq N_{SLD}^{\text{TX}}$) for the transport block occurs in contiguous resource blocks $m_{2a_j^{(i)}}^{\text{PSDCH}}$ and $m_{2a_j^{(i)}+1}^{\text{PSDCH}}$ of subframe $l_{N_{SLD}^{\text{TX}}, b_1^{(i)}+j-1}^{\text{PSDCH}}$ of the PSDCH period, where
 - $a_j^{(i)} = ((j-1) \cdot \lfloor N_f / N_{SLD}^{\text{TX}} \rfloor + \lfloor n_{PSDCH} / N_t \rfloor) \bmod N_f$ and $b_1^{(i)} = n_{PSDCH} \bmod N_t$ and using selected resource value n_{PSDCH} (described in [8]).
 - $(l_0^{\text{PSDCH}}, l_1^{\text{PSDCH}}, \dots, l_{L_{PSDCH}-1}^{\text{PSDCH}}), (m_0^{\text{PSDCH}}, m_1^{\text{PSDCH}}, \dots, m_{M_{RB}^{PSDCH_RP}-1}^{\text{PSDCH}}), L_{PSDCH}$ and $M_{RB}^{PSDCH_RP}$ are described in Subclause 14.3.3.
 - for sidelink discovery type 2B,
 - The j -th transmission ($1 \leq j \leq N_{SLD}^{\text{TX}}$) for the transport block occurs in contiguous resource blocks $m_{2a_j^{(i)}}^{\text{PSDCH}}$ and $m_{2a_j^{(i)}+1}^{\text{PSDCH}}$ of subframe $l_{N_{SLD}^{\text{TX}}, b_1^{(i)}+j-1}^{\text{PSDCH}}$ of the PSDCH period, where
 - $a_1^{(i)} = ((N_{PSDCH}^{(2)} + n') \bmod 10 + \lfloor (a_1^{(i-1)} + N_f \cdot b_1^{(i-1)}) / N_t \rfloor) \bmod N_f$
 - $b_1^{(i)} = (N_{PSDCH}^{(1)} + N_{PSDCH}^{(3)} \cdot a_1^{(i-1)} + N_f \cdot b_1^{(i-1)}) \bmod N_t$
 - $a_j^{(i)} = ((j-1) \cdot \lfloor N_f / N_{SLD}^{\text{TX}} \rfloor + a_1^{(i)}) \bmod N_f$ for $1 < j \leq N_{SLD}^{\text{TX}}$
 - $N_t = \lfloor L_{PSDCH} / N_{SLD}^{\text{TX}} \rfloor$ and $N_f = \lfloor M_{RB}^{PSDCH_RP} / 2 \rfloor$, and $(l_0^{\text{PSDCH}}, l_1^{\text{PSDCH}}, \dots, l_{L_{PSDCH}-1}^{\text{PSDCH}}), (m_0^{\text{PSDCH}}, m_1^{\text{PSDCH}}, \dots, m_{M_{RB}^{PSDCH_RP}-1}^{\text{PSDCH}}), L_{PSDCH}$ and $M_{RB}^{PSDCH_RP}$ are described in Subclause 14.3.3.
 - $a_1^{(0)}$ and $b_1^{(0)}$ are given by higher layer parameters *discPRB-Index* and *discSF-Index*, respectively and that associated with the PSDCH resource configuration.
 - $N_{PSDCH}^{(1)}, N_{PSDCH}^{(2)}$ and $N_{PSDCH}^{(3)}$ are given by higher layer parameters *a-r12*, *b-r12*, and *c-r12*, respectively and that are associated with the PSDCH resource configuration.
 - n' is the number of PSDCH periods since $N_{PSDCH}^{(2)}$ was received.
 - the transport block size is 232

For sidelink discovery, the UE transmit power P_{PSDCH} for PSDCH transmission is given by the following

$$P_{PSDCH} = \min \left\{ P_{CMAX,PSDCH}, 10 \log_{10}(M_{PSDCH}) + P_{O_PSDCH,1} + \alpha_{PSDCH,1} \cdot PL \right\} [\text{dBm}]$$

where $P_{CMAX,PSDCH}$ is defined in [6], and $M_{PSDCH}=2$ and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1 where \mathcal{C}

is the serving cell if the sidelink discovery transmission occurs on the uplink carrier frequency of a serving cell, or
is the cell indicated by higher layers on downlink carrier frequency indicated by *discCarrierRef-r13*[11] if sidelink discovery transmission does not occur on the uplink carrier frequency of a serving cell.

$P_{O_{PSDCH,1}}$ and $\alpha_{PSDCH,1}$ are provided by higher layer parameters $p0-r12$ and $alpha-r12$, respectively and are associated with the corresponding PSDCH resource configuration.

A UE shall drop any PSDCH transmissions that are associated with sidelink discovery type 1 in a sidelink subframe if the UE has a PSDCH transmission associated with sidelink discovery type 2B in that subframe.

14.3.2 UE procedure for receiving the PSDCH

For sidelink discovery type 1, for each PSDCH resource configuration associated with reception of PSDCH, a UE configured by higher layers to detect a transport block on PSDCH can decode the PSDCH according to the PSDCH resource configuration.

For sidelink discovery type 2B, for each PSDCH resource configuration associated with reception of PSDCH, a UE configured by higher layers to detect a transport block on PSDCH can decode the PSDCH according to the PSDCH resource configuration.

14.3.3 UE procedure for determining resource block pool and subframe pool for sidelink discovery

A PSDCH resource configuration for transmission/reception is associated with a set of periodically occurring time-domain periods (known as PSDCH periods). The i -th PSDCH period begins at subframe with subframe index

$j_{begin} = O_3 + i \cdot P$ and ends in subframe with subframe index $j_{end} = O_3 + (i+1) \cdot P - 1$, where

$$0 \leq j_{begin} < 10240,$$

- the subframe index is relative to subframe#0 of a radio frame corresponding to SFN 0 of the serving cell or DFN 0 (described in [11]),
- O_3 is the *offsetIndicator-r12* indicated by the PSDCH resource configuration
- P is the *discPeriod-r12* indicated by the PSDCH resource configuration.

For a PSDCH period, the UE determines a discovery pool consisting of a subframe pool and a resource block pool for PSDCH as follows.

- For TDD, if the parameter *tdd-Config-r12* is indicated by the PSDCH resource configuration, the TDD UL/DL configuration used for determining the subframe pool is given by the parameter *tdd-Config-r12*, otherwise, the TDD UL/DL configuration used for determining the subframe pool is given by the UL/DL configuration (i.e. parameter *subframeAssignment*) for the serving cell.
- A bitmap $b_0, b_1, b_2, \dots, b_{N'-1}$ is obtained using $b_j = a_{j \bmod N_B}$, for $0 \leq j < N'$, where $a_0, a_1, a_2, \dots, a_{N_B-1}$ and N_B are the bitmap and the length of the bitmap indicated by *subframeBitmap-r12*, respectively, and $N' = N_B \cdot N_R$, where N_R is the *numRepetition-r12* indicated by the PSDCH resource configuration.
 - The first N' uplink subframes are denoted by $(l_0, l_1, \dots, l_{N'-1})$ arranged in increasing order of subframe index.
 - A subframe l_j ($0 \leq j < N'$) belongs to the subframe pool if $b_j = 1$. The subframes in the subframe pool are denoted by $(l_0^{PSDCH}, l_1^{PSDCH}, \dots, l_{L_{PSDCH}-1}^{PSDCH})$ arranged in increasing order of subframe index and L_{PSDCH} denotes the number of subframes in the subframe pool.
 - A PRB with index q ($0 \leq q < N_{RB}^{SL}$) belongs to the resource block pool if $S1 \leq q < S1 + M$ or if $S2 - M < q \leq S2$, where $S1$, $S2$, and M denote the *prb-Start-r12*, *prb-End-r12* and *prb-Num-r12* indicated by the PSDCH resource configuration respectively.

- The resource blocks in the resource block pool are denoted by $(m_0^{PSDCH}, m_1^{PSDCH}, \dots, m_{M_{RB}^{PSDCH_RP}-1}^{PSDCH})$ arranged in increasing order of resource block indices and $M_{RB}^{PSDCH_RP}$ is the number of resource blocks in the resource block pool.

14.4 Physical Sidelink Synchronization related procedures

The synchronization resource configuration(s) for the UE are given by the higher layer parameter *SL-SyncConfig-r12* or *v2x-SyncConfig*.

A UE shall transmit sidelink synchronisation signals according to Subclause 5.10.7 in [11].

A UE may assume that sidelink synchronization signals are signals transmitted by an eNB as described in Subclause 6.11 of [3] or are signals transmitted by a UE as described in [11].

A UE is not expected to blindly detect the cyclic prefix length of sidelink synchronization signals transmitted by another UE.

For a sidelink synchronization resource configuration associated with PSDCH reception, if cell c is indicated by the parameter *physCellId-r12* and if the parameter *discSyncWindow-r12* is configured with value $w1$ for cell c , the UE may assume that sidelink synchronization signals are transmitted in cell c and that they are received within a reference synchronization window of size $+/-w1$ ms with respect to the sidelink synchronization resource of cell c indicated by higher layers. The sidelink synchronization identity associated with the sidelink synchronization resource is indicated by higher layers.

For PSDCH reception, if cell c is indicated by the parameter *physCellId-r12* and if the parameter *discSyncWindow-r12* is configured with value $w2$ for cell c , the UE may assume that PSDCH of UE in cell c is received within a reference synchronization window of size $+/-w2$ ms with respect to the discovery resource of cell c indicated by higher layers.

The UE transmit power of primary sidelink synchronization signal P_{PSSS} and the UE transmit power of secondary synchronization signal P_{SSSS} are given by

- If the UE is configured with sidelink transmission mode 1, and if the UE transmits sidelink synchronization signals in PSCCH period i , and if the TPC command field in the configured sidelink grant (described in [8]) for the PSCCH period i is set to 0

$$P_{PSSS} = P_{CMAX,PSBCH}$$

$$P_{SSSS} = P_{CMAX,SSSS}$$

- otherwise

$$P_{PSSS} = \min \left\{ P_{CMAX,PSBCH}, 10 \log_{10}(M_{PSSS}) + P_{O_PSSS} + \alpha_{PSSS} \cdot PL \right\}_{[\text{dBm}]},$$

$$P_{SSSS} = \min \left\{ P_{CMAX,SSSS}, 10 \log_{10}(M_{PSSS}) + P_{O_PSSS} + \alpha_{PSSS} \cdot PL \right\}_{[\text{dBm}]},$$

where $P_{CMAX,PSBCH}$ and $P_{CMAX,SSSS}$ are defined in [6]. $M_{PSSS} = 6$ and $PL = PL_c$ where PL_c is defined in Subclause 5.1.1.1. P_{O_PSSS} and α_{PSSS} are provided by higher layer parameters associated with the corresponding sidelink synchronization signal resource configuration.

If sidelink synchronization signals are transmitted for PSDCH, and if the PSDCH transmission does not occur on any serving cell configured for the UE, c is the cell indicated by higher layers on downlink carrier frequency indicated by *discCarrierRef* [11]. Otherwise, c is the serving cell on which the sidelink synchronization signals are transmitted. If sidelink synchronization signals are transmitted for PSDCH, then PSDCH and sidelink synchronization signal transmission occur on the same carrier frequency.

15 Void

16 UE Procedures related to narrowband IoT

16.1 Synchronization procedures

16.1.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the narrowband physical layer Cell ID.

If the higher layer parameter *operationModeInfo* indicates '*inband-SamePCI*' or *samePCI-Indicator* indicates '*samePCI*' for a cell, the UE may assume that the physical layer cell ID is same as the narrowband physical layer cell ID for the cell.

The following signals are transmitted in the downlink to facilitate cell search for Narrowband IoT: the narrowband primary and narrowband secondary synchronization signals.

A UE may assume the antenna ports 2000 – 2001 and the antenna port for the narrowband primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

16.1.2 Timing synchronization

Upon reception of a timing advance command, the UE shall adjust uplink transmission timing for NPUSCH, and SR if configured with higher layer parameter *sr-WithoutHARQ-ACK-Config*, based on the received timing advance command.

The timing advance command indicates the change of the uplink timing relative to the current uplink timing as multiples of $16 T_s$. The start timing of the random access preamble is specified in [3].

In case of random access response, an 11-bit timing advance command [8], T_A , indicates N_{TA} values by index values of $T_A = 0, 1, 2, \dots, 1536$, where an amount of the time alignment is given by $N_{TA} = T_A \times 16$. N_{TA} is defined in [3].

In other cases, a 6-bit timing advance command [8], T_A , indicates adjustment of the current N_{TA} value, $N_{TA,old}$, to the new N_{TA} value, $N_{TA,new}$, by index values of $T_A = 0, 1, 2, \dots, 63$, where $N_{TA,new} = N_{TA,old} + (T_A - 31) \times 16$. Here, adjustment of N_{TA} value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing by a given amount respectively.

For a timing advance command reception ending in DL subframe n , the corresponding adjustment of the uplink transmission timing shall apply from the first available NB-IoT uplink slot following the end of $n+12$ DL subframe and the first available NB-IoT uplink slot is the first slot of a NPUSCH transmission. When the UE's uplink NPUSCH transmissions in NB-IoT uplink slot n and NB-IoT uplink slot $n+1$ are overlapped due to the timing adjustment, the UE shall complete transmission of NB-IoT uplink slot n and not transmit the overlapped part of NB-IoT uplink slot $n+1$.

If the received downlink timing changes and is not compensated or is only partly compensated by the uplink timing adjustment without timing advance command as specified in [10], the UE changes N_{TA} accordingly.

16.2 Power control

16.2.1 Uplink power control

Uplink power control controls the transmit power of the different uplink physical channels.

16.2.1.1 Narrowband physical uplink shared channel

16.2.1.1.1 UE behaviour

The setting of the UE Transmit power for a Narrowband Physical Uplink Shared Channel (NPUSCH) transmission is defined as follows. For FDD, if the UE is capable of enhanced random access power control [12], and it is configured by higher layers, and for TDD, enhanced random access power control shall be applied for a UE which started the random access procedure in the first or second configured NPRACH repetition level.

The UE transmit power $P_{\text{NPUSCH},c}(i)$ for NPUSCH transmission in NB-IoT UL slot i for the serving cell c is given by:

For NPUSCH (re)transmissions corresponding to the random access response grant if enhanced random access power control is not applied, and for all other NPUSCH transmissions, when the number of repetitions of the allocated NPUSCH RUs is greater than 2:

$$P_{\text{NPUSCH},c}(i) = P_{\text{CMAX},c}(i) \text{ [dBm]}$$

otherwise

$$P_{\text{NPUSCH},c}(i) = \min \left\{ \begin{array}{l} P_{\text{CMAX},c}(i), \\ 10 \log_{10}(M_{\text{NPUSCH},c}(i)) + P_{\text{O_NPUSCH}_c}(j) + \alpha_c(j) \cdot PL_c \end{array} \right\} \text{ [dBm]}$$

where,

- $P_{\text{CMAX},c}(i)$ is the configured UE transmit power defined in [6] in NB-IoT UL slot i for serving cell c .
- $M_{\text{NPUSCH}_c}(i)$ is $\{1/4\}$ for 3.75 kHz subcarrier spacing and $\{1, 3, 6, 12\}$ for 15kHz subcarrier spacing
- $P_{\text{O_NPUSCH}_c}(j)$ is a parameter composed of the sum of a component $P_{\text{O_NOMINAL_NPUSCH}_c}(j)$ provided from higher layers and a component $P_{\text{O_UE_NPUSCH}_c}(j)$ provided by higher layers for $j=1$ and for serving cell c where $j \in \{1,2\}$. For NPUSCH (re)transmissions corresponding to a dynamic scheduled grant or a semi-persistent grant then $j=1$ and for NPUSCH (re)transmissions corresponding to the random access response grant then $j=2$. $P_{\text{O_UE_NPUSCH}_c}(2) = 0$. If enhanced random access power control is not applied, $P_{\text{O_NOMINAL_NPUSCH}_c}(2) = P_{\text{O_PRE}} + \Delta_{\text{PREAMBLE_Msg3}}$, where the parameter *preambleInitialReceivedTargetPower* [8] ($P_{\text{O_PRE}}$) and $\Delta_{\text{PREAMBLE_Msg3}}$ are signalled from higher layers for serving cell c . If enhanced random access power control is applied,

$$P_{\text{O_NOMINAL_NPUSCH}_c}(2) = \text{MSG3_RECEIVED_TARGET_POWER} + \Delta_{\text{PREAMBLE_Msg3}}$$

- For $j=1$, for NPUSCH format 2, $\alpha_c(j)=1$; for NPUSCH format 1, $\alpha_c(j)$ is provided by higher layers for serving cell c . For $j=2$, $\alpha_c(j)=1$.
- PL_c is the downlink path loss estimate calculated in the UE for serving cell c in dB and $PL_c = nrs\text{-Power} + nrs\text{-PowerOffsetNonAnchor} - \text{NRSRP}$, where *nrs-Power* is provided by higher layers and Subclause 16.2.2, and *nrs-powerOffsetNonAnchor* is set to zero if it is not provided by higher layers and NRSRP is defined in [5] for serving cell c .

16.2.1.1.2 Power headroom

If the UE transmits NPUSCH in NB-IoT UL slot i for serving cell c , power headroom is computed using

$$PH_c(i) = P_{\text{CMAX},c}(i) - \{ P_{\text{O_NPUSCH}_c}(1) + \alpha_c(1) \cdot PL_c \} \text{ [dB]}$$

where, $P_{\text{CMAX},c}(i)$, $P_{\text{O_NPUSCH},c}(1)$, $\alpha_c(1)$, and PL_c , are defined in Subclause 16.2.1.1.1.

The power headroom shall be rounded down to the closest value in the set [PH1, PH2, PH3, PH4] dB if enhanced PHR is not configured and [PH1, PH2, ..., PH15, PH16] dB if enhanced PHR is configured as defined in [10]. The power headroom is delivered by the physical layer to higher layers.

16.2.1.2 SR

16.2.1.2.1 UE behaviour

If the UE is configured with higher layer parameter *sr-WithoutHARQ-ACK-Config*, the setting of the UE transmit power for SR transmission without HARQ-ACK is defined as follows.

The UE transmit power $P_{\text{SR},c}(i)$ for SR transmission in NB-IoT UL slot i for the serving cell c is given by:

$$P_{\text{SR},c}(i) = \min \left\{ \begin{array}{l} P_{\text{CMAX},c}(i), \\ 10 \log_{10}(M_{\text{SR},c}(i)) + P_{\text{O}_{\text{SR}},c} + \alpha_c \cdot PL_c \end{array} \right\} [\text{dBm}]$$

where,

- $P_{\text{CMAX},c}(i)$ is the configured UE transmit power defined in [6] in NB-IoT UL slot i for serving cell c .
- $M_{\text{SR},c}(i)$ is {1/3} for NPRACH format 2 and {1} for NPRACH format 0/1.
- $P_{\text{O}_{\text{SR}},c}$ is signaled from higher layers for serving cell c .
- α_c is signaled from higher layers for serving cell c .
- PL_c is defined in Subclause 16.2.1.1.

16.2.2 Downlink power allocation

The eNodeB determines the downlink transmit energy per resource element.

For an NB-IoT cell, the UE may assume NRS EPRE is constant across the downlink NB-IoT system bandwidth and constant across all subframes that contain NRS, until different NRS power information is received.

The downlink NRS EPRE can be derived from the downlink narrowband reference-signal transmit power given by *nrs-Power + nrs-PowerOffsetNonAnchor*, where the parameter *nrs-Power* is provided by higher layers and *nrs-powerOffsetNonAnchor* is zero if it is not provided by higher layers. The downlink narrowband reference-signal transmit power is defined as the linear average over the power contributions (in [W]) of all resource elements that carry narrowband reference signals within the operating NB-IoT system bandwidth.

A UE may assume that the ratio of NWUS EPRE to NRS EPRE is 0 dB.

A UE may assume the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs (not applicable to NPDSCH REs with zero EPRE) is 0 dB for an NB-IoT cell with one NRS antenna port and -3 dB for an NB-IoT cell with two NRS antenna ports.

A UE may assume the ratio of NPBCH EPRE to NRS EPRE among NPBCH REs (not applicable to NPBCH REs with zero EPRE) is 0 dB for an NB-IoT cell with one NRS antenna port and -3 dB for an NB-IoT cell with two NRS antenna ports.

A UE may assume the ratio of NPDCCH EPRE to NRS EPRE among NPDCCH REs (not applicable to NPDCCH REs with zero EPRE) is 0 dB for an NB-IoT cell with one NRS antenna port and -3 dB for an NB-IoT cell with two NRS antenna ports.

If higher layer parameter *operationModeInfo* indicates '00' or *samePCI-Indicator* indicates 'samePCI' for a cell, the ratio of NRS EPRE to CRS EPRE is given by the parameter *nrs-CRS-PowerOffset* if the parameter *nrs-CRS-PowerOffset* is provided by higher layers, and the ratio of NRS EPRE to CRS EPRE may be assumed to be 0 dB if the parameter *nrs-CRS-PowerOffset* is not provided by higher layers. If *nrs-CRS-PowerOffset* is provided by higher layers and is a non-integer value, the value of *nrs-Power* is 0.23 dBm higher than indicated.

16.3 Random access procedure

Prior to initiation of the non-synchronized physical random access procedure, Layer 1 shall receive the following information from the higher layers:

- Narrowband Random access channel parameters (NPRACH configuration)

16.3.1 Physical non-synchronized random access procedure

From the physical layer perspective, the L1 random access procedure encompasses the transmission of narrowband random access preamble and narrowband random access response. The remaining messages are scheduled for transmission by the higher layer on the shared data channel and are not considered part of the L1 random access procedure. A random access channel occupies one subcarrier per set of consecutive symbols reserved for narrowband random access preamble transmissions.

The following steps are required for the L1 random access procedure:

- Layer 1 procedure is triggered upon request of a narrowband preamble transmission by higher layers.
- A target narrowband preamble received power (NARROWBAND_PREAMBLE_RECEIVED_TARGET_POWER), a corresponding RA-RNTI and a NPRACH resource are indicated by higher layers as part of the request.
- If enhanced random access power control is not applied, for the lowest configured repetition level; and if enhanced random access power control is applied then for all configured repetition levels, a narrowband preamble transmission power P_{NPRACH} is determined as

$$P_{\text{NPRACH}} = \min\{ P_{\text{CMAX},c}(i), \text{NARROWBAND_PREAMBLE_RECEIVED_TARGET_POWER} + PL_c \}$$
 where $P_{\text{CMAX},c}(i)$ is the configured UE transmit power for narrowband IoT transmission defined in [6] for subframe i of serving cell c and PL_c is the downlink path loss estimate calculated in the UE for serving cell c . If enhanced random access power control is not applied, for a repetition level other than the lowest configured repetition level, P_{NPRACH} is set to $P_{\text{CMAX},c}(i)$.
- The narrowband preamble is transmitted with transmission power P_{NPRACH} commencing on the indicated NPRACH resource. The narrowband preamble is transmitted for the number of NPRACH repetitions for the associated NPRACH repetition level as indicated by higher layers.
- Detection of a NPDCCH with DCI scrambled by RA-RNTI is attempted during a window controlled by higher layers (see [8], Subclause 5.1.4). If detected, the corresponding DL-SCH transport block is passed to higher layers. The higher layers parse the transport block and indicate the Nr-bit uplink grant to the physical layer, which is processed according to Subclause 16.3.3

16.3.2 Timing

For the L1 random access procedure, UE's uplink transmission timing after a random access preamble transmission is as follows.

- a) If a NPDCCH with associated RA-RNTI is detected and the corresponding DL-SCH transport block ending in subframe n contains a response to the transmitted preamble sequence, the UE shall, according to the information in the response, transmit an UL-SCH transport block according to Subclause 16.3.3.
- b) If a random access response is received and the corresponding DL-SCH transport block ending in subframe n does not contain a response to the transmitted preamble sequence, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe n .

- c) If no NPDCCH scheduling random access response is received in subframe n , where subframe n is the last subframe of the random access response window, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe n .
- d) If an NPDCCH scheduling random access response with associated RA-RNTI is detected and the corresponding DL-SCH transport block reception ending in subframe n cannot be successfully decoded, the UE shall, if requested by higher layers, be ready to transmit a new preamble sequence no later than the NB-IoT UL slot starting 12 milliseconds after the end of subframe n .

In case a random access procedure is initiated by a "PDCCH order" ending in subframe n , the UE shall, if requested by higher layers, start transmission of random access preamble at the end of the first subframe $n + k_2$, $k_2 \geq 8$, where a NPRACH resource is available.

The "PDCCH order" in DCI format N1 indicates to the UE,

- allocated subcarrier for NPRACH, $n_{sc} = I_{sc}$ where I_{sc} is the subcarrier indication field in the corresponding DCI, $I_{sc} = 48,49,\dots,63$ is reserved for preamble format 0/1, $I_{sc} = 144,145,\dots,255$ is reserved for preamble format 2 if *SystemInformationBlockType2-NB* or *SystemInformationBlockType23-NB* is configured and the UE indicates the *nprach-Format2* capability and Preamble format indicator is set to 1.
- a repetition number (N_{Rep}) for NPRACH determined by the repetition number field (I_{Rep}) in the corresponding DCI according to Table 16.3.2-1 where R_1 , R_2 (if any) and R_3 (if any) are given by the higher layer parameter *numRepetitionsPerPreambleAttempt* for each NPRACH resource, respectively. $R_1 < R_2 < R_3$.

Table 16.3.2-1: Number of repetitions (N_{Rep}) for NPRACH following a "PDCCH order"

| I_{Rep} | N_{Rep} |
|-----------|-----------|
| 0 | R_1 |
| 1 | R_2 |
| 2 | R_3 |
| 3 | Reserved |

The UE shall transmit random access preamble on the NB-IoT carrier indicated by "Carrier indication of NPRACH" field, if the field is present in the "PDCCH order". If the value of "Carrier indication of NPRACH" is non-zero, it indicates a NPRACH carrier derived from *SystemInformationBlockType22-NB* [11] for which the index in the list is equal to the carrier indication. If the value of "Carrier indication of NPRACH" is zero, the uplink carrier used for NPRACH is derived from *SystemInformationBlockType2-NB* [11].

If *SystemInformationBlockType2-NB* or *SystemInformationBlockType23-NB* is configured and the UE indicates the *nprach-Format2* capability, the UE shall transmit the preamble format indicated by "Preamble format indicator" field, otherwise the UE shall transmit preamble format 0/1.

16.3.3 Narrowband random access response grant

The higher layers indicate the Nr-bit UL Grant to the physical layer, as defined in 3GPP TS 36.321 [8]. This is referred to as the Narrowband Random Access Response Grant in the physical layer.

Nr-bit = 15, and the content of these 15 bits starting with the MSB and ending with the LSB are as follows:

- Uplink subcarrier spacing Δf is '0'=3.75 kHz or '1'=15 kHz – 1 bit
- Subcarrier indication field I_{sc} as determined in Subclause 16.5.1.1 – 6 bits
- Scheduling delay field (I_{Delay}) as determined in Subclause 16.5.1 with $k_0 = 12$ for $I_{Delay} = 0$, where NB-IoT DL subframe n is the last subframe in which the NPDSCH associated with the Narrowband Random Access Response Grant is transmitted – 2 bits

- Msg3 repetition number N_{Rep} as determined in Subclause 16.5.1.1 – 3 bits
- MCS index indicating TBS, modulation, and number of RUs for Msg3 – 3 bits

The redundancy version for the first transmission of Msg3 is 0.

If the UE is not using higher layer parameter *edt-Parameters*, or the UE is using higher layer parameter *edt-parameters* and $0 \leq I_{\text{MCS}} \leq 2$,

- the TBS, modulation, and number of RUs for Msg3 are determined according to Table 16.3.3-1

otherwise,

- if the UE is configured with higher layer parameter *edt-SmallTBS-Enabled* set to ‘false’,
 - the TBS is given by higher layer parameter *edt-TBS*
- otherwise,
 - the UE selects a TBS from the allowed TBS values according to Table 16.3.3-2
 - the repetition number for Msg3 is the smallest integer multiple of L value that is equal to or larger than $TBS_{\text{Msg3}}/TBS_{\text{Msg3,max}} \cdot N_{\text{Rep}}$ where TBS_{Msg3} is the selected TBS for Msg3, and $TBS_{\text{Msg3,max}}$ is given by higher layer parameter *edt-TBS*
 - if $\Delta f = 15 \text{ kHz}$ and $I_{sc} > 11$ and $N_{\text{Rep}} \geq 8$, then $L = 4$ is used in subclause 16.5.1.2, otherwise $L = 1$ is used
 - the number of RUs for Msg3 are determined according to Table 16.3.3-3
 - $\pi/4$ QPSK modulation is used for $\Delta f = 3.75 \text{ kHz}$ and for $\Delta f = 15 \text{ kHz}$ with $I_{sc} = 0, 1, \dots, 11$; QPSK modulation is used for $\Delta f = 15 \text{ kHz}$ with $I_{sc} > 11$

Table 16.3.3-1: MCS index for Msg3 NPUSCH

| MCS Index I_{MCS} | Modulation $\Delta f = 3.75 \text{ kHz}$ or $\Delta f = 15 \text{ kHz}$ and $I_{sc} = 0, 1, \dots, 11$ | Modulation $\Delta f = 15 \text{ kHz}$ and $I_{sc} > 11$ | Number of RUs N_{RU} | TBS |
|-------------------------------|---|---|----------------------------------|----------|
| '000' | pi/2 BPSK | QPSK | 4 | 88 bits |
| '001' | pi/4 QPSK | QPSK | 3 | 88 bits |
| '010' | pi/4 QPSK | QPSK | 1 | 88 bits |
| '011' | reserved | reserved | reserved | reserved |
| '100' | reserved | reserved | reserved | reserved |
| '101' | reserved | reserved | reserved | reserved |
| '110' | reserved | reserved | reserved | reserved |
| '111' | reserved | reserved | reserved | reserved |

Table 16.3.3-2: EDT TBS for Msg3 NPUSCH with *edt-SmallTBS-Enabled* set to ‘true’

| <i>edt-TBS</i> | <i>edt-SmallTBS-Subset</i> | Allowable TBS values |
|-----------------------|-----------------------------------|-----------------------------|
| 408 | not configured | 328, 408 |
| 504 | not configured | 328, 408, 504 |
| 504 | enabled | 408, 504 |
| 584 | not configured | 328, 408, 504, 584 |
| 584 | enabled | 408, 584 |
| 680 | not configured | 328, 456, 584, 680 |
| 680 | enabled | 456, 680 |
| 808 | not configured | 328, 504, 680, 808 |
| 808 | enabled | 504, 808 |
| 936 | not configured | 328, 504, 712, 936 |
| 936 | enabled | 504, 936 |
| 1000 | not configured | 328, 536, 776, 1000 |
| 1000 | enabled | 536, 1000 |

Table 16.3.3-3: MCS index for Msg3 NPUSCH and EDT

| MCS Index <i>I_{MCS}</i> | Number of RUs <i>N_{RU}</i> | | |
|--|---|-----------------------------|---|
| | <i>edt-TBS = 328, 408, 504, or 584</i> | <i>edt-TBS = 680</i> | <i>edt-TBS = 808, 936, or 1000</i> |
| '011' | 3 | 3 | 4 |
| '100' | 4 | 4 | 5 |
| '101' | 5 | 5 | 6 |
| '110' | 6 | 8 | 8 |
| '111' | 8 | 10 | 10 |

16.4 Narrowband physical downlink shared channel related procedures

A NB-IoT UE shall assume a subframe as a NB-IoT DL subframe if

- the UE determines that the subframe does not contain NPSS/NSSS/NPBCH/ *SystemInformationBlockType1-NB* transmission, and
- for a NB-IoT carrier that a UE receives higher layer parameter *operationModeInfo*, the subframe is configured as NB-IoT DL subframe or the subframe is a TDD special subframe configured for NB-IoT DL transmission after the UE has obtained *SystemInformationBlockType1-NB*.
- the subframe is configured as NB-IoT DL subframe by the higher layer parameter *downlinkBitmapNonAnchor*.
- except when the UE is configured with higher layer parameter *additionalTxSIB1-Config* set to *TRUE*, subframe #3 not containing additional *SystemInformationBlockType1-NB* transmission is assumed as a NB-IoT DL subframe if the UE monitors a NPDCCH UE-specific search space or decodes NPDSCH transmission scheduled by NPDCCH in the UE-specific search space.

For a NB-IoT UE that supports *twoHARQ-Procedures-r14*, there shall be a maximum of 2 downlink HARQ processes.

16.4.1 UE procedure for receiving the narrowband physical downlink shared channel

A UE shall upon detection on a given serving cell of a NPDCCH with DCI format N1, N2 ending in subframe *n* intended for the UE, decode, starting in

- *n*+5 DL subframe for FDD,
- *n*+5 subframe for TDD,

the corresponding NPDSCH transmission in *N* consecutive NB-IoT DL subframe(s) *n_i* with *i* = 0, 1, ..., *N*-1 according to the NPDCCH information, where

- subframe n is the last subframe in which the NPDCCH is transmitted and is determined from the starting subframe of NPDCCH transmission and the DCI subframe repetition number field in the corresponding DCI;
- subframe(s) n_i with $i=0, 1, \dots, N-1$ are N consecutive NB-IoT DL subframe(s) excluding subframes used for SI messages where, $n_0 < n_1 < \dots, n_{N-1}$,
- $N = N_{\text{Rep}} N_{\text{SF}}$, where the value of N_{Rep} is determined by the repetition number field in the corresponding DCI (see Subclause 16.4.1.3), and the value of N_{SF} is determined by the resource assignment field in the corresponding DCI (see Subclause 16.4.1.3), and
- k_0 is the number of NB-IoT DL subframe(s) starting in DL subframe $n+5$ for FDD or subframe $n+5$ for TDD, until DL subframe n_0 , where k_0 is determined by the scheduling delay field (I_{Delay}) for DCI format N1, and $k_0 = 0$ for DCI format N2. For DCI CRC scrambled by G-RNTI, k_0 is determined by the scheduling delay field (I_{Delay}) according to Table 16.4.1-1a, otherwise k_0 is determined by the scheduling delay field (I_{Delay}) according to Table 16.4.1-1. The value of R_{max} is according to Subclause 16.6 for the corresponding DCI format N1.

Table 16.4.1-1: k_0 for DCI format N1.

| I_{Delay} | k_0 | |
|--------------------|------------------------|---------------------------|
| | $R_{\text{max}} < 128$ | $R_{\text{max}} \geq 128$ |
| 0 | 0 | 0 |
| 1 | 4 | 16 |
| 2 | 8 | 32 |
| 3 | 12 | 64 |
| 4 | 16 | 128 |
| 5 | 32 | 256 |
| 6 | 64 | 512 |
| 7 | 128 | 1024 |

Table 16.4.1-1a: k_0 for DCI format N1 with DCI CRC scrambled by G-RNTI.

| I_{Delay} | k_0 |
|--------------------|-------|
| 0 | 0 |
| 1 | 4 |
| 2 | 8 |
| 3 | 12 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |

If a UE is configured with higher layer parameter *twoHARQ-ProceduresConfig*

- for FDD, the UE is not expected to receive transmissions in the Type B half duplex guard periods as specified in [3]

otherwise

- for FDD, the UE is not expected to receive transmissions in 3 DL subframes following the end of a NPUSCH transmission by the UE.
- for TDD, the UE is not expected to receive transmissions in 3 subframes following the end of a NPUSCH transmission by the UE.

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the P-RNTI, the UE shall decode the NPDCCH and the corresponding NPDSCH according to any of the combinations defined in Table 16.4.1-2. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by P-RNTI.

Table 16.4.1-2: NPDCCH and NPDSCH configured by P-RNTI

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|------------------|--|
| DCI format N2 | Type-1 Common | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the RA-RNTI, the UE shall decode the NPDCCH and the corresponding NPDSCH according to any of the combinations defined in Table 16.4.1-3. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by RA-RNTI.

Table 16.4.1-3: NPDCCH and NPDSCH configured by RA-RNTI

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|------------------|--|
| DCI format N1 | Type-2 Common | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the C-RNTI except during random access procedure, the UE shall decode the NPDCCH and the corresponding NPDSCH according to any of the combinations defined in Table 16.4.1-4. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by C-RNTI.

Table 16.4.1-4: NPDCCH and NPDSCH configured by C-RNTI

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|-----------------------|--|
| DCI format N1 | UE specific by C-RNTI | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the Temporary C-RNTI and is not configured to decode NPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the NPDCCH and the corresponding NPDSCH according to the combination defined in Table 16.4.1-5. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by Temporary C-RNTI.

If a UE is also configured by higher layers to decode NPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the NPDCCH and the corresponding NPDSCH according to the combination defined in Table 16.4.1-5. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by C-RNTI.

Table 16.4.1-5: NPDCCH and NPDSCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|------------------|--|
| DCI format N1 | Type-2 Common | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

For NPDSCH carrying *SystemInformationBlockType1-NB* and SI-messages, the UE shall decode NPDSCH according to the transmission scheme defined in Table 16.4.1-6. The scrambling initialization of NPDSCH is by SI-RNTI.

Table 16.4.1-6: NPDSCH configured by SI-RNTI

| Transmission scheme of NPDSCH | |
|---|--|
| If the number of NPBCH antenna ports is one, Single-antenna port, port 0 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). | |

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the SC-RNTI, the UE shall decode the NPDCCH and the corresponding NPDSCH according to any of the combinations defined in Table 16.4.1-7. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by SC-RNTI.

Table 16.4.1-7: NPDCCH and NPDSCH configured by SC-RNTI

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|-------------------|--|
| DCI format N2 | Type-1A Common | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

If a UE is configured by higher layers to decode NPDCCH with CRC scrambled by the G-RNTI, the UE shall decode the NPDCCH and the corresponding NPDSCH according to any of the combinations defined in Table 16.4.1-8. The scrambling initialization of NPDSCH corresponding to these NPDCCHs is by G-RNTI.

Table 16.4.1-8: NPDCCH and NPDSCH configured by G-RNTI

| DCI format | Search Space | Transmission scheme of NPDSCH corresponding to NPDCCH |
|---------------|-------------------|--|
| DCI format N1 | Type-2A Common | If the number of NPBCH antenna ports is one, Single-antenna port, port 2000 is used (see Subclause 16.4.1.1), otherwise Transmit diversity (see Subclause 16.4.1.2). |

A UE is not required to receive NPDSCH assigned by NPDCCH with DCI CRC scrambled by G-RNTI in subframes in which the UE monitors a Type1A-NPDCCH common search space or in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by SC-RNTI

A UE is not required to receive NPDSCH assigned by NPDCCH with DCI CRC scrambled by SC-RNTI or G-RNTI in subframes in which the UE monitors a Type1-NPDCCH common search space or in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by P-RNTI

A UE is not required to receive NPDSCH assigned by NPDCCH with DCI CRC scrambled by SC-RNTI or G-RNTI in subframes in which the UE monitors a Type2-NPDCCH common search space or in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by C-RNTI or Temporary C-RNTI.

The transmission schemes for NPDSCH are defined in the following Subclauses.

16.4.1.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 2000) of the NPDSCH, the UE may assume that an eNB transmission on the NPDSCH would be performed according to Subclause 6.3.4.1 of [3].

16.4.1.2 Transmit diversity scheme

For the transmit diversity transmission scheme of the NPDSCH, the UE may assume that an eNB transmission on the NPDSCH would be performed according to Subclause 6.3.4.3 of [3]

16.4.1.3 Resource allocation

The resource allocation information in DCI format N1, N2 (paging) for NPDSCH indicates to a scheduled UE

- a number of subframes (N_{SF}) determined by the resource assignment field (I_{SF}) in the corresponding DCI according to Table 16.4.1.3-1.
- a repetition number (N_{Rep}) determined by the repetition number field (I_{Rep}) in the corresponding DCI according to Table 16.4.1.3-2.

Table 16.4.1.3-1: Number of subframes (N_{SF}) for NPDSCH.

| I_{SF} | N_{SF} |
|----------|----------|
| 0 | 1 |
| 1 | 2 |
| 2 | 3 |
| 3 | 4 |
| 4 | 5 |
| 5 | 6 |
| 6 | 8 |
| 7 | 10 |

Table 16.4.1.3-2: Number of repetitions (N_{Rep}) for NPDSCH.

| I_{Rep} | N_{Rep} |
|-----------|-----------|
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |
| 8 | 192 |
| 9 | 256 |
| 10 | 384 |
| 11 | 512 |
| 12 | 768 |
| 13 | 1024 |
| 14 | 1536 |
| 15 | 2048 |

For FDD, the number of repetitions for the NPDSCH carrying *SystemInformationBlockType1-NB* is determined based on the parameter *schedulingInfoSIB1* configured by higher-layers and according to Table 16.4.1.3-3.

Table 16.4.1.3-3: Number of repetitions for NPDSCH carrying *SystemInformationBlockType1-NB*, FDD.

| Value of <i>schedulingInfoSIB1</i> | Number of NPDSCH repetitions |
|------------------------------------|------------------------------|
| 0 | 4 |
| 1 | 8 |
| 2 | 16 |
| 3 | 4 |
| 4 | 8 |
| 5 | 16 |
| 6 | 4 |
| 7 | 8 |
| 8 | 16 |
| 9 | 4 |
| 10 | 8 |
| 11 | 16 |
| 12-15 | Reserved |

For FDD, the starting radio frame for the first transmission of the NPDSCH carrying *SystemInformationBlockType1-NB* is determined according to Table 16.4.1.3-4.

Table 16.4.1.3-4: Starting radio frame for the first transmission of the NPDSCH carrying *SystemInformationBlockType1-NB*, FDD.

| Number of NPDSCH repetitions | $N_{ID}^{N_{cell}}$ | Starting radio frame number for <i>SystemInformationBlockType1-NB</i> repetitions ($n_f \bmod 256$) |
|------------------------------|---------------------------------|---|
| 4 | $N_{ID}^{N_{cell}} \bmod 4 = 0$ | 0 |
| | $N_{ID}^{N_{cell}} \bmod 4 = 1$ | 16 |
| | $N_{ID}^{N_{cell}} \bmod 4 = 2$ | 32 |
| | $N_{ID}^{N_{cell}} \bmod 4 = 3$ | 48 |
| 8 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | 0 |
| | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | 16 |
| 16 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | 0 |
| | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | 1 |

For the TDD NB-IoT carrier on which NPSS/NSSS/NPBCH are detected, the number of repetitions and subframe index for the NPDSCH carrying *SystemInformationBlockType1-NB* is determined based on the parameter *schedulingInfoSIB1* configured by higher-layers and according to Table 16.4.1.3-5.

Table 16.4.1.3-5: Number of repetitions and subframe index for NPDSCH carrying *SystemInformationBlockType1-NB*, TDD.

| Value of <i>schedulingInfoSIB1</i> | Number of NPDSCH repetitions | Subframe index |
|------------------------------------|------------------------------|----------------|
| 0 | 4 | 0 |
| 1 | 8 | 0 |
| 2 | 16 | 0 |
| 3 | 4 | 0 |
| 4 | 8 | 0 |
| 5 | 16 | 0 |
| 6 | 4 | 0 |
| 7 | 8 | 0 |
| 8 | 16 | 0 |
| 9 | 4 | 0 |
| 10 | 8 | 0 |
| 11 | 16 | 0 |
| 12-15 | 16 | 4 |

For the TDD NB-IoT carrier on which NPSS/NSSS/NPBCH are detected, the starting radio frame for the first transmission of the NPDSCH carrying *SystemInformationBlockType1-NB* is determined according to Table 16.4.1.3-6.

Table 16.4.1.3-6: Starting radio frame for the first transmission of the NPDSCH carrying *SystemInformationBlockType1-NB*, TDD.

| Subframe index | Number of NPDSCH repetitions | $N_{ID}^{N_{cell}}$ | Starting radio frame number for <i>SystemInformationBlockType1-NB</i> repetitions ($n_f \bmod 256$) |
|----------------|------------------------------|---------------------------------|---|
| 0 | 4 | $N_{ID}^{N_{cell}} \bmod 4 = 0$ | 1 |
| | | $N_{ID}^{N_{cell}} \bmod 4 = 1$ | 17 |

| | | | |
|---|----|---------------------------------|---------------------|
| | | $N_{ID}^{N_{cell}} \bmod 4 = 2$ | 33 |
| | | $N_{ID}^{N_{cell}} \bmod 4 = 3$ | 49 |
| 0 | 8 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | 1 |
| | | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | 17 |
| 0 | 16 | Any | $n_f \bmod 256 = 1$ |
| 4 | 16 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | $n_f \bmod 256 = 0$ |
| | | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | $n_f \bmod 256 = 1$ |

For a higher layer configured TDD NB-IoT carrier, the number of repetitions and subframe index for the NPDSCH carrying *SystemInformationBlockType1-NB* is determined based on the parameter *schedulingInfoSIB1* configured by higher-layers and according to Table 16.4.1.3-7.

Table 16.4.1.3-7: Number of repetitions and subframe index for NPDSCH carrying SystemInformationBlockType1-NB, TDD.

| Value of <i>schedulingInfoSIB1</i> | Number of NPDSCH repetitions | Subframe index |
|------------------------------------|------------------------------|----------------|
| 0 | 8 | 0, 5 |
| 1 | 16 | 0, 5 |
| 2 | 8 | 0, 5 |
| 3 | 16 | 0, 5 |
| 4 | 8 | 0, 5 |
| 5 | 16 | 0, 5 |
| 6 | 8 | 0, 5 |
| 7 | 16 | 0, 5 |

For a higher layer configured TDD NB-IoT carrier, the starting radio frame for the first transmission of the NPDSCH carrying *SystemInformationBlockType1-NB* is determined according to Table 16.4.1.3-8.

Table 16.4.1.3-8: Starting radio frame for the first transmission of the NPDSCH carrying SystemInformationBlockType1-NB, TDD.

| Number of NPDSCH repetitions | $N_{ID}^{N_{cell}}$ | Starting radio frame number for <i>SystemInformationBlockType1-NB</i> repetitions ($n_f \bmod 256$) |
|------------------------------|---------------------------------|---|
| 8 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | 0 |
| | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | 16 |
| 16 | $N_{ID}^{N_{cell}} \bmod 2 = 0$ | 0 |
| | $N_{ID}^{N_{cell}} \bmod 2 = 1$ | 1 |

16.4.1.4 NPDSCH starting position

The starting OFDM symbol for NPDSCH is given by index $l_{DataStart}$ in the first slot in a subframe k and is determined as follows

- if subframe k is a subframe used for receiving SIB1-NB
 - $l_{DataStart} = 3$ if the value of the higher layer parameter *operationModeInfo* is set to '00' or '01'

- $l_{\text{DataStart}} = 3$ if the value of the higher layer parameter *operationModeInfo* is set to '10' and the value of the higher layer parameter *sib-GuardbandInfo* is set to '10' or '11' for TDD
- $l_{\text{DataStart}} = 0$ otherwise
- elseif subframe k is a special subframe for NPDSCH without repetition
 - $l_{\text{DataStart}} = \min(2, l'_{\text{DataStart}})$ where $l'_{\text{DataStart}}$ is given by the higher layer parameter *eutraControlRegionSize* if the value of the higher layer parameter *eutraControlRegionSize* is present
 - $l_{\text{DataStart}} = 0$ otherwise
- else
 - $l_{\text{DataStart}}$ is given by the higher layer parameter *eutraControlRegionSize* if the value of the higher layer parameter *eutraControlRegionSize* is present
 - $l_{\text{DataStart}} = 0$ otherwise

16.4.1.5 Modulation order and transport block size determination

The UE shall use modulation order, $Q_m = 2$.

To determine the transport block size in the NPDSCH, the UE shall first,

- if NPDSCH carries SystemInformationBlockType1-NB
 - set I_{TBS} to the value of the parameter schedulingInfoSIB1 configured by higher-layers
- otherwise
 - read the 4-bit "modulation and coding scheme" field (I_{MCS}) in the DCI and set $I_{\text{TBS}} = I_{\text{MCS}}$.

and second,

- if NPDSCH carries SystemInformationBlockType1-NB
 - use Subclause 16.4.1.5.2 for determining its transport block size.
- otherwise,
 - read the 3-bit "resource assignment" field (I_{SF}) in the DCI and determine its TBS by the procedure in Subclause 16.4.1.5.1.

For a NPDCCH UE-specific search space, if the UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*

- the NDI and HARQ process ID as signalled on NPDCCH, and the TBS, as determined above, shall be delivered to higher layers,

otherwise

- the NDI as signalled on NPDCCH, and the TBS, as determined above, shall be delivered to higher layers. HARQ process ID of 0 shall be assumed.

16.4.1.5.1 Transport blocks not mapped for SystemInformationBlockType1-NB

The TBS is given by the $(I_{\text{TBS}}, I_{\text{SF}})$ entry of Table 16.4.1.5.1-1. For the value of the higher layer parameter *operationModeInfo* set to '00' or '01', $0 \leq I_{\text{TBS}} \leq 10$.

Table 16.4.1.5.1-1: Transport block size (TBS) table.

| I_{TBS} | I_{SF} | | | | | | | |
|------------------|-----------------|-----|-----|------|------|------|------|------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 16 | 32 | 56 | 88 | 120 | 152 | 208 | 256 |
| 1 | 24 | 56 | 88 | 144 | 176 | 208 | 256 | 344 |
| 2 | 32 | 72 | 144 | 176 | 208 | 256 | 328 | 424 |
| 3 | 40 | 104 | 176 | 208 | 256 | 328 | 440 | 568 |
| 4 | 56 | 120 | 208 | 256 | 328 | 408 | 552 | 680 |
| 5 | 72 | 144 | 224 | 328 | 424 | 504 | 680 | 872 |
| 6 | 88 | 176 | 256 | 392 | 504 | 600 | 808 | 1032 |
| 7 | 104 | 224 | 328 | 472 | 584 | 680 | 968 | 1224 |
| 8 | 120 | 256 | 392 | 536 | 680 | 808 | 1096 | 1352 |
| 9 | 136 | 296 | 456 | 616 | 776 | 936 | 1256 | 1544 |
| 10 | 144 | 328 | 504 | 680 | 872 | 1032 | 1384 | 1736 |
| 11 | 176 | 376 | 584 | 776 | 1000 | 1192 | 1608 | 2024 |
| 12 | 208 | 440 | 680 | 904 | 1128 | 1352 | 1800 | 2280 |
| 13 | 224 | 488 | 744 | 1032 | 1256 | 1544 | 2024 | 2536 |

16.4.1.5.2 Transport blocks mapped for *SystemInformationBlockType1-NB*

The TBS is given by the I_{TBS} entry of Table 16.4.1.5.2-1 for FDD, and Table 16.4.1.5.2-2 for TDD NB-IoT carrier on which NPSS/NSSS/NPBCH are detected and Table 16.4.1.5.2-3 for a higher layer configured TDD NB-IoT carrier.

Table 16.4.1.5.2-1: Transport block size (TBS) table for NPDSCH carrying *SystemInformationBlockType1-NB*, FDD

| I_{TBS} | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----------|----|
| TBS | 208 | 208 | 208 | 328 | 328 | 328 | 440 | 440 | 440 | 680 | 680 | 680 | | | Reserved | |

Table 16.4.1.5.2-2: Transport block size (TBS) table for NPDSCH carrying *SystemInformationBlockType1-NB*, TDD

| I_{TBS} | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TBS | 208 | 208 | 208 | 328 | 328 | 328 | 440 | 440 | 440 | 680 | 680 | 680 | 208 | 328 | 440 | 680 |

Table 16.4.1.5.2-3: Transport block size (TBS) table for NPDSCH carrying *SystemInformationBlockType1-NB*, TDD

| I_{TBS} | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| TBS | 208 | 208 | 328 | 328 | 440 | 440 | 680 | 680 |

16.4.2 UE procedure for reporting ACK/NACK

The UE shall upon detection of a NPDSCH transmission ending in NB-IoT subframe n intended for the UE and for which an ACK/NACK shall be provided, start, after the end of

- $n + k'_0 - 1$ DL subframe for FDD,
- $k'_0 - 1$ NB-IoT UL subframes following the end of $n+12$ subframe for TDD,

transmission of the NPUSCH carrying ACK/NACK response, and SR (if any) if the serving cell is FDD and the UE is configured with higher layer parameter *sr-with-HARQ-ACK-Config*, using NPUSCH format 2 in N consecutive NB-IoT UL slots, where

- $N = N_{\text{Rep}}^{AN} N_{\text{slots}}^{UL}$, where the value of N_{Rep}^{AN} is given by the higher layer parameter *ack-NACK-NumRepetitions-Msg4* configured for the associated NPRACH resource for Msg4 NPDSCH transmission, and higher layer

parameter *ack-NACK-NumRepetitions* otherwise, and the value of $N_{\text{slots}}^{\text{UL}}$ is the number of slots of the resource unit (defined in clause 10.1.2.3 of [3]),

- allocated subcarrier for ACK/NACK and value of k_0 is determined by the ACK/NACK resource field in the DCI format of the corresponding NPDCCH according to Table 16.4.2-1, and Table 16.4.2-2,

- for FDD, $k'_0 = k_0$.
- for TDD, $k'_0 = k_0 - 12$.

Table 16.4.2-1: ACK/NACK subcarrier and k_0 for NPUSCH with subcarrier spacing $\Delta f = 3.75 \text{ kHz}$.

| ACK/NACK resource field | ACK/NACK subcarrier | k_0 |
|-------------------------|---------------------|-------|
| 0 | 38 | 13 |
| 1 | 39 | 13 |
| 2 | 40 | 13 |
| 3 | 41 | 13 |
| 4 | 42 | 13 |
| 5 | 43 | 13 |
| 6 | 44 | 13 |
| 7 | 45 | 13 |
| 8 | 38 | 21 |
| 9 | 39 | 21 |
| 10 | 40 | 21 |
| 11 | 41 | 21 |
| 12 | 42 | 21 |
| 13 | 43 | 21 |
| 14 | 44 | 21 |
| 15 | 45 | 21 |

Table 16.4.2-2: ACK/NACK subcarrier and k_0 for NPUSCH with subcarrier spacing $\Delta f = 15 \text{ kHz}$.

| ACK/NACK resource field | ACK/NACK subcarrier | k_0 |
|-------------------------|---------------------|-------|
| 0 | 0 | 13 |
| 1 | 1 | 13 |
| 2 | 2 | 13 |
| 3 | 3 | 13 |
| 4 | 0 | 15 |
| 5 | 1 | 15 |
| 6 | 2 | 15 |
| 7 | 3 | 15 |
| 8 | 0 | 17 |
| 9 | 1 | 17 |
| 10 | 2 | 17 |
| 11 | 3 | 17 |
| 12 | 0 | 18 |
| 13 | 1 | 18 |
| 14 | 2 | 18 |
| 15 | 3 | 18 |

16.5 Narrowband physical uplink shared channel related procedures

For a NB-IoT UE that supports *twoHARQ-Procedures-r14*, there shall be a maximum of 2 uplink HARQ processes.

For TDD, a NB-IoT UE shall assume a subframe as a NB-IoT UL subframe if

- for a NB-IoT carrier, the subframe is configured as NB-IoT UL subframe by higher layers.

16.5.1 UE procedure for transmitting format 1 narrowband physical uplink shared channel

A UE shall upon detection on a given serving cell of a NPDCCH with DCI format N0 ending in NB-IoT DL subframe n intended for the UE, perform, at the end of

- $n+k_0$ DL subframe for FDD,
- k_0 NB-IoT UL subframes following the end of $n+8$ subframe for TDD,

a corresponding NPUSCH transmission using NPUSCH format 1 in N consecutive NB-IoT UL slots n_i with $i = 0, 1, \dots, N-1$ according to the NPDCCH information where

- subframe n is the last subframe in which the NPDCCH is transmitted and is determined from the starting subframe of NPDCCH transmission and the DCI subframe repetition number field in the corresponding DCI; and
- $N = N_{\text{Rep}} N_{\text{RU}} N_{\text{slots}}^{\text{UL}}$, where the value of N_{Rep} is determined by the repetition number field in the corresponding DCI (see Subclause 16.5.1.1), the value of N_{RU} is determined by the resource assignment field in the corresponding DCI (see Subclause 16.5.1.1), and the value of $N_{\text{slots}}^{\text{UL}}$ is the number of NB-IoT UL slots of the resource unit (defined in clause 10.1.2.3 of [3]) corresponding to the allocated number of subcarriers (as determined in Subclause 16.5.1.1) in the corresponding DCI,
- n_0 is the first NB-IoT UL slot starting after the end of subframe $n+k_0$ for FDD
- n_0 is the first NB-IoT UL slot starting after k_0 NB-IoT UL subframes following the end of $n+8$ subframe for TDD
- value of k_0 is determined by the scheduling delay field (I_{Delay}) in the corresponding DCI according to Table 16.5.1-1 for FDD and Table 16.5.1-1A for TDD.

Table 16.5.1-1: k_0 for DCI format N0 for FDD.

| I_{Delay} | k_0 |
|--------------------|-------|
| 0 | 8 |
| 1 | 16 |
| 2 | 32 |
| 3 | 64 |

Table 16.5.1-1A: k_0 for DCI format N0 for TDD.

| I_{Delay} | k_0 |
|--------------------|-------|
| 0 | 0 |
| 1 | 8 |
| 2 | 16 |
| 3 | 32 |

If a NPUSCH transmission without a corresponding NPDCCH collides partially or fully with a NPDSCH transmission, the NPUSCH transmission is dropped.

If a UE is configured by higher layers to decode NPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the NPDCCH according to the combination defined in Table 16.5.1-2 and transmit a corresponding NPUSCH. The scrambling initialization of this NPUSCH corresponding to these NPDCCHs and the NPUSCH retransmission for the same transport block is by C-RNTI.

Table 16.5.1-2: NPDCCH and NPUSCH configured by C-RNTI

| DCI format | Search Space |
|-------------------|-----------------------|
| DCI format N0 | UE specific by C-RNTI |

If a UE is configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the NPDCCH according to the combination defined in Table 16.5.1-3.

Table 16.5.1-3: NPDCCH configured as "PDCCH order" to initiate random access procedure

| DCI format | Search Space |
|-------------------|-----------------------|
| DCI format N1 | UE specific by C-RNTI |

If a UE is configured by higher layers to decode NPDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode NPDCCH with the CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the NPDCCH according to the combination defined in Table 16.5.1-4 and transmit the corresponding NPUSCH. The scrambling initialization of NPUSCH corresponding to these NPDCCHs is by Temporary C-RNTI.

If a Temporary C-RNTI is set by higher layers, the scrambling initialization of NPUSCH corresponding to the Narrowband Random Access Response Grant in Subclause 16.3.3 and any NPUSCH retransmission(s) for the same transport block is by Temporary C-RNTI. Otherwise, the scrambling initialization of NPUSCH corresponding to the Narrowband Random Access Response Grant in Subclause 16.3.3 and any NPUSCH retransmission(s) for the same transport block is by C-RNTI.

If a UE is also configured by higher layers to decode NPDCCH with CRC scrambled by the C-RNTI during random access procedure, the UE shall decode the NPDCCH according to the combination defined in Table 16.5.1-4 and transmit the corresponding NPUSCH. The scrambling initialization of NPUSCH corresponding to these NPDCCH is by C-RNTI.

Table 16.5.1-4: NPDCCH and NPUSCH configured by Temporary C-RNTI and/or C-RNTI during random access procedure

| DCI format | Search Space |
|-------------------|---------------------|
| DCI format N0 | Type-2 Common |

If a UE is configured by higher layers to decode NPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the NPDCCH according to the combination defined in Table 16.5.1-5 and transmit a corresponding NPUSCH if a transport block corresponding to the HARQ process of the NPUSCH transmission is generated as described in [8]. The scrambling initialization of this NPUSCH corresponding to these NPDCCHs and NPUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this NPUSCH without a corresponding NPDCCH and the NPUSCH retransmission for the same transport block is by SPS C-RNTI.

Table 16.5.1-5: NPDCCH and NPUSCH configured by SPS C-RNTI

| DCI format | Search Space |
|-------------------|-----------------------|
| DCI format N0 | UE specific by C-RNTI |

16.5.1.1 Resource allocation

The resource allocation information in uplink DCI format N0 for NPUSCH transmission indicates to a scheduled UE

- a set of contiguously allocated subcarriers (n_{sc}) of a resource unit determined by the Subcarrier indication field in the corresponding DCI,

- a number of resource units (N_{RU}) determined by the resource assignment field in the corresponding DCI according to Table 16.5.1.1-2,
- a repetition number (N_{Rep}) determined by the repetition number field in the corresponding DCI according to Table 16.5.1.1-3.

The subcarrier spacing Δf of NPUSCH transmission is determined by the uplink subcarrier spacing field in the Narrowband Random Access Response Grant according to Subclause 16.3.3.

For NPUSCH transmission with subcarrier spacing $\Delta f = 3.75 \text{ kHz}$, $n_{sc} = I_{sc}$ where I_{sc} is the subcarrier indication field in the DCI. $I_{sc} = 48, 49, \dots, 63$ is reserved.

For NPUSCH transmission with subcarrier spacing $\Delta f = 15 \text{ kHz}$, the subcarrier indication field (I_{sc}) in the DCI determines the set of contiguously allocated subcarriers (n_{sc}) according to Table 16.5.1.1-1.

Table 16.5.1.1-1: Allocated subcarriers for NPUSCH with $\Delta f = 15 \text{ kHz}$.

| Subcarrier indication field (I_{sc}) | Set of Allocated subcarriers (n_{sc}) |
|--|---|
| 0 – 11 | I_{sc} |
| 12-15 | $3(I_{sc}-12) + \{0,1,2\}$ |
| 16-17 | $6(I_{sc}-16) + \{0,1,2,3,4,5\}$ |
| 18 | $\{0,1,2,3,4,5,6,7,8,9,10,11\}$ |
| 19-63 | Reserved |

Table 16.5.1.1-2: Number of resource units (N_{RU}) for NPUSCH.

| I_{RU} | N_{RU} |
|----------|----------|
| 0 | 1 |
| 1 | 2 |
| 2 | 3 |
| 3 | 4 |
| 4 | 5 |
| 5 | 6 |
| 6 | 8 |
| 7 | 10 |

Table 16.5.1.1-3: Number of repetitions (N_{Rep}) for NPUSCH.

| I_{Rep} | N_{Rep} |
|-----------|-----------|
| 0 | 1 |
| 1 | 2 |
| 2 | 4 |
| 3 | 8 |
| 4 | 16 |
| 5 | 32 |
| 6 | 64 |
| 7 | 128 |

16.5.1.2 Modulation order, redundancy version and transport block size determination

To determine the modulation order, redundancy version and transport block size for the NPUSCH, the UE shall first

- read the "modulation and coding scheme" field (I_{MCS}) in the DCI, and
- read the "redundancy version" field (rv_{DCI}) in the DCI, and

- read the "resource assignment" field (I_{RU}) in the DCI, and
- compute the total number of allocated subcarriers (N_{sc}^{RU}), number of resource units (N_{RU}), and repetition number (N_{Rep}) according to Subclause 16.5.1.1.

If the UE is configured with higher layer parameter *edt-Parameters* and the most recent NPUSCH transmission including a transport block with EDT, the UE is not expected to receive a DCI indicating a NPUSCH retransmission as part of the contention based random access procedure with $3 \leq I_{MCS} \leq 14$.

If the UE is configured with higher layer parameter *edt-Parameters*, and for a NPUSCH retransmission of the same transport block including EDT as part of the contention based random access procedure with $I_{MCS} = 15$ in the DCI,

- the modulation order is set to $Q_m = 2$.
- if the UE is configured with higher layer parameter *edt-SmallTBS-Enabled* set to 'true', the repetition number for the NPUSCH retransmission is the smallest integer multiple of L value that is equal to or larger than $TBS_{Msg3}/TBS_{Msg3,max} \cdot N_{Rep}$ where TBS_{Msg3} is the TBS corresponding to the NPUSCH transmission scheduled by the Narrowband Random Access Response Grant, and $TBS_{Msg3,max}$ is given by the higher layer parameter *edt-TBS*.

elseif the UE is configured with higher layer parameter *edt-Parameters*, and if the DCI indicates a retransmission as part of the contention based random access procedure with $0 \leq I_{MCS} \leq 2$ and the most recent NPUSCH transmission including a transport block with EDT,

- the TBS and modulation are determined according to Table 16.3.3-1 in Subclause 16.3.3, for $0 \leq I_{MCS} \leq 2$ and the transport block does not include EDT

otherwise, the UE shall use modulation order, $Q_m = 2$ if $N_{sc}^{RU} > 1$. The UE shall use I_{MCS} and Table 16.5.1.2-1 to determine the modulation order to use for NPUSCH if $N_{sc}^{RU} = 1$.

Table 16.5.1.2-1: Modulation and TBS index table for NPUSCH with $N_{sc}^{RU} = 1$.

| MCS Index I_{MCS} | Modulation Order Q_m | TBS Index I_{TBS} |
|------------------------|---------------------------|------------------------|
| 0 | 1 | 0 |
| 1 | 1 | 2 |
| 2 | 2 | 1 |
| 3 | 2 | 3 |
| 4 | 2 | 4 |
| 5 | 2 | 5 |
| 6 | 2 | 6 |
| 7 | 2 | 7 |
| 8 | 2 | 8 |
| 9 | 2 | 9 |
| 10 | 2 | 10 |

NPUSCH is transmitted in N consecutive NB-IoT UL slots, n_i , $i=0,1,\dots,N-1$. The redundancy version $rv_{idx}(j)$ of the NPUSCH transmission in j^{th} block of B consecutive NB-IoT UL slots n_i ,

$$i = jB + b, \quad b = 0,1,\dots,B-1, \quad j = 0,1,\dots,\frac{N_{Rep}}{L}-1, \quad B = LN_{RU}N_{slots}^{UL} \quad \text{is determined by, } rv_{idx}(j) = 2 \cdot \text{mod}(rv_{DCI} + j, 2),$$

where $L = 1$ if $N_{sc}^{RU} = 1$, $L = \min\left(4, \lceil N_{Rep} / 2 \rceil\right)$ otherwise. Portion of NPUSCH codeword with $rv_{idx}(j)$ as defined in clause 6.3.2 in [4] mapped to slot $\left\lfloor \frac{b}{L} \right\rfloor$ of allocated N_{RU} resource unit(s) is transmitted in NB-IoT UL

slots n_i $i = jB + L \left\lfloor \frac{b}{L} \right\rfloor + l$, $l = 0, 1, \dots, L-1$ for $\Delta f = 3.75\text{kHz}$ and $i = jB + 2L \left\lfloor \frac{b}{2L} \right\rfloor + 2l + \text{mod}(\left\lfloor \frac{b}{L} \right\rfloor, 2)$, $l = 0, 1, \dots, L-1$
for $\Delta f = 15\text{kHz}$

The UE shall use $(I_{\text{TBS}}, I_{\text{RU}})$ and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH. I_{TBS} is given in Table 16.5.1.2-1 if $N_{\text{sc}}^{\text{RU}} = 1$, $I_{\text{TBS}} = I_{\text{MCS}}$ otherwise.

Table 16.5.1.2-2: Transport block size (TBS) table for NPUSCH.

| I_{TBS} | I_{RU} | | | | | | | |
|------------------|-----------------|-----|-----|------|------|------|------|------|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 0 | 16 | 32 | 56 | 88 | 120 | 152 | 208 | 256 |
| 1 | 24 | 56 | 88 | 144 | 176 | 208 | 256 | 344 |
| 2 | 32 | 72 | 144 | 176 | 208 | 256 | 328 | 424 |
| 3 | 40 | 104 | 176 | 208 | 256 | 328 | 440 | 568 |
| 4 | 56 | 120 | 208 | 256 | 328 | 408 | 552 | 680 |
| 5 | 72 | 144 | 224 | 328 | 424 | 504 | 680 | 872 |
| 6 | 88 | 176 | 256 | 392 | 504 | 600 | 808 | 1000 |
| 7 | 104 | 224 | 328 | 472 | 584 | 712 | 1000 | 1224 |
| 8 | 120 | 256 | 392 | 536 | 680 | 808 | 1096 | 1384 |
| 9 | 136 | 296 | 456 | 616 | 776 | 936 | 1256 | 1544 |
| 10 | 144 | 328 | 504 | 680 | 872 | 1000 | 1384 | 1736 |
| 11 | 176 | 376 | 584 | 776 | 1000 | 1192 | 1608 | 2024 |
| 12 | 208 | 440 | 680 | 1000 | 1128 | 1352 | 1800 | 2280 |
| 13 | 224 | 488 | 744 | 1032 | 1256 | 1544 | 2024 | 2536 |

For a NPDCC UE-specific search space, if the UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*

- the NDI and HARQ process ID as signalled on NPDCC, and the RV and TBS, as determined above, shall be delivered to higher layers,

otherwise

- the NDI as signalled on NPDCC, and the RV and TBS, as determined above, shall be delivered to higher layers.

16.5.2 UE procedure for NPUSCH retransmission

For a NPUSCH retransmission, the UE shall follow the HARQ information in DCI as specified in [8].

16.5.3 UE procedure for transmitting SR

If the UE is configured with higher layer parameter *sr-WithoutHARQ-ACK-Config*, the UE is configured with Narrowband Random access channel parameters (NPRACH configuration) for SR transmission by higher layers.

The UE shall, if requested by higher layers for transmitting SR, start transmission of a narrowband random access preamble on the NB-IoT carrier configured in *sr-NPRACH-Resource* at the next available NPRACH resource, unless the transmission would overlap with any subframe(s) of NPDSCH reception. The narrowband preamble is transmitted on the allocated subcarrier and a number of NPRACH repetitions for the associated NPRACH repetition level as indicated by higher layers. The narrowband random access preamble is transmitted with transmission power as determined in subclause 16.2.1.2, commencing on the indicated NPRACH resource.

16.6 Narrowband physical downlink control channel related procedures

A UE shall monitor a set of NPDCC candidates (described in Subclause 10.2.5.1 of [3]) as configured by higher layer signalling for control information, where monitoring implies attempting to decode each of the NPDCCs in the set according to all the monitored DCI formats.

The set of NPDCCH candidates to monitor are defined in terms of NPDCCH search spaces.

The UE shall monitor one or more of the following search spaces

- a Type1-NPDCCH common search space,
- a Type1A-NPDCCH common search space,
- a Type2-NPDCCH common search space,
- a Type2A-NPDCCH common search space, and
- a NPDCCH UE-specific search space.

A UE is not required to simultaneously monitor a NPDCCH UE-specific search space and a Type1-NPDCCH common search space.

A UE is not required to simultaneously monitor a NPDCCH UE-specific search space and a Type2-NPDCCH common search space.

A UE is not required to simultaneously monitor a Type1-NPDCCH common search space and a Type2-NPDCCH common search space.

A UE is not required to monitor Type1A-NPDCCH common search space or Type2A-NPDCCH common search space in subframes in which the UE monitors a Type1-NPDCCH common search space or in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by P-RNTI

A UE is not required to monitor Type1A-NPDCCH common search space or Type2A-NPDCCH common search space in subframes in which the UE monitors a Type2-NPDCCH common search space or in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by C-RNTI or Temporary C-RNTI.

A UE is not required to monitor Type2A-NPDCCH common search space in the same subframe in which it monitors Type1A-NPDCCH common search space.

UE is not required to monitor Type1A-NPDCCH common search space in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by SC-RNTI.

UE is not required to monitor Type2A-NPDCCH common search space in subframes in which the UE receives NPDSCH assigned by NPDCCH with DCI CRC scrambled by G-RNTI or SC-RNTI.

Until UE receives higher layer configuration of NPDCCH UE-specific search space, the UE monitors NPDCCH according to the same configuration of NPDCCH search space as that for NPDCCH scheduling Msg4.

An NPDCCH search space $NS_k^{(L',R)}$ at aggregation level L' ($L'=2$ for TDD special subframe, $L' \in \{1,2\}$ otherwise), and repetition level $R \in \{1,2,4,8,16,32,64,128,256,512,1024,2048\}$ is defined by a set of NPDCCH candidates where each candidate is repeated in a set of R consecutive NB-IoT downlink subframes excluding subframes used for transmission of SI messages starting with subframe k .

For NPDCCH UE-specific search space, the aggregation and repetition levels defining the search spaces and the corresponding NPDCCH candidates are listed in Table 16.6-1 by substituting the value of R_{max} with the higher layer configured parameter *npdcch-NumRepetitions*.

For Type1-NPDCCH common search space and Type1A-NPDCCH common search space, the aggregation and repetition levels defining the search spaces are listed in Table 16.6-2 by substituting the value of R_{max}

- with the higher layer configured parameter *npdcch-NumRepetitionPaging* for Type1-NPDCCH common search space;
- with the higher layer configured parameter *npdcch-NumRepetitions-SC-MCCH* for Type1A-NPDCCH common search space.

For Type2-NPDCCH common search space and Type2A-NPDCCH common search space, the aggregation and repetition levels defining the search spaces and the corresponding monitored NPDCCH candidates are listed in Table 16.6-3 by substituting the value of R_{max}

- with the higher layer configured parameter $npdcch\text{-}NumRepetitions\text{-}RA$ for Type2-NPDCCH common search space;
- with the higher layer configured parameter $npdcch\text{-}NumRepetitions\text{-}SC\text{-}MTCH$ for Type2A-NPDCCH common search space.

The locations of starting subframe k are given by $k = k_b$ where k_b is the b^{th} consecutive NB-IoT DL subframe from subframe k_0 , excluding subframes used for transmission of SI messages, and $b = u \cdot R$, and $u = 0, 1, \dots, \frac{R_{\max}}{R} - 1$, and where

- subframe k_0 is a subframe satisfying the condition $(10n_f + \lfloor n_s/2 \rfloor) \bmod T = \lfloor \alpha_{\text{offset}} \cdot T \rfloor$, where $T = R_{\max} \cdot G$, $T \geq 4$.
 - for NPDCCH UE-specific search space,
 - G is given by the higher layer parameter $npdcch\text{-}StartSF\text{-}USS$,
 - α_{offset} is given by the higher layer parameter $npdcch\text{-}Offset\text{-}USS$,
 - for NPDCCH Type2-NPDCCH common search space,
 - G is given by the higher layer parameter $npdcch\text{-}StartSF\text{-}CSS\text{-}RA$,
 - α_{offset} is given by the higher layer parameter $npdcch\text{-}Offset\text{-}RA$,
 - for NPDCCH Type2A-NPDCCH common search space,
 - G is given by the higher layer parameter $npdcch\text{-}startSF\text{-}SC\text{-}MTCH$,
 - α_{offset} is given by the higher layer parameter $npdcch\text{-}Offset\text{-}SC\text{-}MTCH$,

For Type1-NPDCCH common search space, $k = k_0$ and is determined from locations of NB-IoT paging opportunity subframes.

For Type1A-NPDCCH common search space, $k = k_0$ and subframe k_0 is a subframe satisfying the condition $(10n_f + \lfloor n_s/2 \rfloor) \bmod T = \lfloor \alpha_{\text{offset}} \cdot T \rfloor$, where $T = R_{\max} \cdot G$, $T \geq 4$ and

- G is given by the higher layer parameter $npdcch\text{-}StartSF\text{-}SC\text{-}MCCH$,
- α_{offset} is given by the higher layer parameter $npdcch\text{-}Offset\text{-}SC\text{-}MCCH$.

If the UE is configured by high layers with a NB-IoT carrier for monitoring of NPDCCH UE-specific search space,

- the UE shall monitor the NPDCCH UE-specific search space on the higher layer configured NB-IoT carrier,
- the UE is not expected to receive NPSS, NSSS, NPBCH on the higher layer configured NB-IoT carrier.

otherwise,

- the UE shall monitor the NPDCCH UE-specific search space on the same NB-IoT carrier on which NPSS/NSSS/NPBCH are detected.

Table 16.6-1: NPDCCH UE- specific search space candidates

| R_{\max} | R | DCI subframe repetition number | NCCE indices of monitored NPDCCH candidates | |
|--|----------------|---|---|-------|
| | | | L'=1 | L'=2 |
| 1 | 1 | 00 | {0},{1} | {0,1} |
| 2 | 1 | 00 | {0},{1} | {0,1} |
| | 2 | 01 | - | {0,1} |
| 4 | 1 | 00 | - | {0,1} |
| | 2 | 01 | - | {0,1} |
| | 4 | 10 | - | {0,1} |
| >=8 | $R_{\max} / 8$ | 00 | - | {0,1} |
| | $R_{\max} / 4$ | 01 | - | {0,1} |
| | $R_{\max} / 2$ | 10 | - | {0,1} |
| | R_{\max} | 11 | - | {0,1} |
| Note 1: {x}, {y} denotes NPDCCH Format 0 candidate with NCCE index 'x', and NPDCCH Format 0 candidate with NCCE index 'y' are monitored Note 2: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored. | | | | |

Table 16.6-2: Type 1/Type 1A - NPDCCH common search space candidates

| R_{\max} | R | | | | | | | | | NCCE indices of monitored NPDCCH candidates | |
|---|-----|-----|-----|-----|-----|-----|------|------|----|---|-------|
| | | | | | | | | | | L'=1 | L'=2 |
| 1 | 1 | - | - | - | - | - | - | - | - | - | {0,1} |
| 2 | 1 | 2 | - | - | - | - | - | - | - | - | {0,1} |
| 4 | 1 | 2 | 4 | - | - | - | - | - | - | - | {0,1} |
| 8 | 1 | 2 | 4 | 8 | - | - | - | - | - | - | {0,1} |
| 16 | 1 | 2 | 4 | 8 | 16 | - | - | - | -- | - | {0,1} |
| 32 | 1 | 2 | 4 | 8 | 16 | 32 | - | - | - | - | {0,1} |
| 64 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | - | - | - | {0,1} |
| 128 | 1 | 2 | 4 | 8 | 16 | 32 | 64 | 128 | - | - | {0,1} |
| 256 | 1 | 4 | 8 | 16 | 32 | 64 | 128 | 256 | - | - | {0,1} |
| 512 | 1 | 4 | 16 | 32 | 64 | 128 | 256 | 512 | - | - | {0,1} |
| 1024 | 1 | 8 | 32 | 64 | 128 | 256 | 512 | 1024 | - | - | {0,1} |
| 2048 | 1 | 8 | 64 | 128 | 256 | 512 | 1024 | 2048 | - | - | {0,1} |
| DCI subframe repetition number | 000 | 001 | 010 | 011 | 100 | 101 | 110 | 111 | | | |
| Note 1: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored. | | | | | | | | | | | |

Table 16.6-3: Type 2/Type 2A - NPDCCH common search space candidates

| R_{\max} | R | DCI subframe repetition number | NCCE indices of monitored NPDCCH candidates | |
|------------|----------------|---|---|-------|
| | | | L'=1 | L'=2 |
| 1 | 1 | 00 | - | {0,1} |
| 2 | 1 | 00 | - | {0,1} |
| | 2 | 01 | - | {0,1} |
| 4 | 1 | 00 | - | {0,1} |
| | 2 | 01 | - | {0,1} |
| | 4 | 10 | - | {0,1} |
| >=8 | $R_{\max} / 8$ | 00 | - | {0,1} |
| | $R_{\max} / 4$ | 01 | - | {0,1} |
| | $R_{\max} / 2$ | 10 | - | {0,1} |
| | R_{\max} | 11 | - | {0,1} |

Note 1: {x,y} denotes NPDCCH Format1 candidate corresponding to NCCEs 'x' and 'y' is monitored.

For a NPDCCH UE-specific search space, if a NB-IoT UE is configured with higher layer parameter *twoHARQ-ProcessesConfig* and if the NB-IoT UE detects NPDCCH with DCI Format N0 ending in subframe n , and if the corresponding NPUSCH format 1 transmission starts from $n+k$,

- the UE is not required to monitor an NPDCCH candidate in any subframe starting from subframe $n+k-2$ to subframe $n+k-1$; and
- - the UE does not expect to receive a DCI Format N0 before subframe $n+k-2$ for which the corresponding NPUSCH format 1 transmission ends later than subframe $n+k+255$.
- for TDD, and if the corresponding NPUSCH format1 transmission ends in subframe $n+m$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+k$ to subframe $n+m-1$.

otherwise

- if the NB-IoT UE detects NPDCCH with DCI Format N0 ending in subframe n or receives a NPDSCH carrying a random access response grant ending in subframe n , and if the corresponding NPUSCH format 1 transmission starts from $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.
- for TDD, if the NB-IoT UE detects NPDCCH with DCI Format N0 ending in subframe n or receives a NPDSCH carrying a random access response grant ending in subframe n , and if the corresponding NPUSCH format 1 transmission ends in $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k$.

For a NPDCCH UE-specific search space, if a NB-IoT UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*

- and if the NB-IoT UE detects NPDCCH with DCI Format N1 ending in subframe n , and if a NPDSCH transmission starts from $n+k$, the UE is not required to monitor an NPDCCH candidate in any subframe starting from subframe $n+k-2$ to subframe $n+k-1$;

otherwise

- if the NB-IoT UE detects NPDCCH with DCI Format N1 or N2 ending in subframe n , and if the corresponding NPDSCH transmission starts from $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE detects NPDCCH with DCI Format N1 ending in subframe n , and if the corresponding NPDSCH transmission starts from $n+k$, and

- for FDD, if the corresponding NPUSCH format 2 transmission starts from subframe $n+m$ the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+k$ to subframe $n+m-1$.
- for TDD, if the corresponding NPUSCH format 2 transmission ends in subframe $n+m$ the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+k$ to subframe $n+m-1$.

If a NB-IoT UE detects NPDCCH with DCI Format N1 for "PDCCH order" ending in subframe n , and

- for FDD, if the corresponding NPRACH transmission starts from subframe $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.
- for TDD, if the corresponding NPRACH transmission ends in subframe $n+k$, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+k-1$.

If a NB-IoT UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*

- and if the UE has a NPUSCH transmission ending in subframe n ,
- the UE is not required to receive transmissions in the Type B half-duplex guard periods as specified in [3] for FDD ; and
- the UE is not expected to receive an NPDCCH with DCI format N0/N1 for the same HARQ process ID as the NPUSCH transmission in any subframe starting from subframe $n+1$ to subframe $n+3$;

else if the UE is not using higher layer parameter *edt-Parameters* or if the UE is using higher layer parameter *edt-Parameters* and $0 \leq I_{MCS} \leq 2$

- if the NB-IoT UE has a NPUSCH transmission ending in subframe n , the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+3$.

otherwise,

- If the NB-IoT UE has a NPUSCH transmission for Msg3 ending in subframe n' with transport block size TBS_{Msg3} , whereas if $TBS_{Msg3,max}$ would have been selected the NPUSCH transmission would have ended in subframe n , the UE is not required to monitor NPDCCH in any subframe starting from subframe $n'+1$ to subframe $n+3$.

If a NB-IoT UE receives a NPDSCH transmission ending in subframe n , and if the UE is not required to transmit a corresponding NPUSCH format 2, the UE is not required to monitor NPDCCH in any subframe starting from subframe $n+1$ to subframe $n+12$.

If a NB-IoT UE is configured with higher layer parameter *twoHARQ-ProcessesConfig*

- the UE is not required to monitor an NPDCCH candidate of an NPDCCH search space if the candidate ends in subframe n , and if the UE is configured to monitor NPDCCH candidates of another NPDCCH search space having starting subframe k_0 before subframe $n+5$

otherwise

- the UE is not required to monitor NPDCCH candidates of an NPDCCH search space if an NPDCCH candidate of the NPDCCH search space ends in subframe n , and if the UE is configured to monitor NPDCCH candidates of another NPDCCH search space having starting subframe k_0 before subframe $n+5$.

An NB-IoT UE is not required to monitor NPDCCH candidates of an NPDCCH search space during an NPUSCH UL gap.

For an NB-IoT UE configured with higher layer parameter *sr-WithoutHARQ-ACK-Config*, if the transmission of a narrowband random access preamble for SR ends on subframe n ,

- in case of frame structure type 1 with NPRACH format 0 and 1 when the number of NPRACH repetitions is greater than or equal to 64, or NPRACH format 2 when the number of NPRACH repetitions is greater than or

equal to 16, the UE is not required to monitor NPDCCH UE-specific search space from subframe n to subframe $n+40$,

- otherwise, the UE is not required to monitor NPDCCH UE-specific search space from subframe n to subframe $n+3$.

16.6.1 NPDCCCH starting position

The starting OFDM symbol for NPDCCH given by index $l_{\text{NPDCCHStart}}$ in the first slot in a subframe k and is determined as follows

- if higher layer parameter *eutraControlRegionSize* is present
 - if subframe k is a special subframe for NPDCCH without repetition
 - $l_{\text{NPDCCHStart}} = \min(2, l'_{\text{NPDCCHStart}})$ where $l'_{\text{NPDCCHStart}}$ is given by the higher layer parameter *eutraControlRegionSize*
 - else $l_{\text{NPDCCHStart}}$ is given by the higher layer parameter *eutraControlRegionSize*
- otherwise
 - $l_{\text{NPDCCHStart}} = 0$

16.6.2 NPDCCCH control information procedure

A UE shall discard the NPDCCH if consistent control information is not detected.

16.6.3 NPDCCCH validation for semi-persistent scheduling

A UE shall validate a Semi-Persistent Scheduling assignment NPDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the NPDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field is set to '0'.

Validation is achieved if all the fields for the used DCI format N0 are set according to Table 16.6.3-1 or Table 16.6.3-2.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid semi-persistent activation or release.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 16.6.3-1: Special fields for Semi-Persistent Scheduling Activation NPDCCH Validation

| | DCI format N0 |
|---|---------------|
| HARQ process number (present if UE is configured with 2 uplink HARQ processes) | set to '0' |
| Redundancy version | set to '0' |
| Modulation and coding scheme | set to '0000' |
| Resource assignment | set to '000' |

Table 16.6.3-2: Special fields for Semi-Persistent Scheduling Release NPDCCH Validation

| | DCI format N0 |
|--|-----------------|
| HARQ process number (present if UE is configured with 2 uplink HARQ processes) | set to '0' |
| Redundancy version | set to '0' |
| Repetition number | set to '000' |
| Modulation and coding scheme | set to '1111' |
| Subcarrier indication | Set to all '1's |

16.7 Assumptions independent of physical channel related to narrowband IoT

A UE may assume the antenna ports 2000 – 2001 of a serving cell are quasi co-located (as defined in [3]) with respect to delay spread, Doppler spread, Doppler shift, average gain, and average delay.

16.8 UE procedure for acquiring cell-specific reference signal sequence and raster offset

If the higher layer parameter *operationModeInfo* indicates *inband-SamePCI* for a cell, the UE may derive cell-specific reference signal sequence and raster offset from the higher layer parameter *eutra-CRS-SequencelInfo* according to Table 16.8-1, where E-UTRA PRB index n'_{PRB} is defined as $n'_{\text{PRB}} = n_{\text{PRB}} - \lfloor N_{\text{RB}}^{\text{DL}} / 2 \rfloor$.

Table 16.8-1: Definition of eutra-CRS-SequencelInfo

| eutra-CRS-SequencelInfo | E-UTRA PRB index n'_{PRB} for odd number of $N_{\text{RB}}^{\text{DL}}$ | Raster offset | eutra-CRS-SequencelInfo | E-UTRA PRB index n'_{PRB} for even number of $N_{\text{RB}}^{\text{DL}}$ | Raster offset |
|-------------------------|--|---------------|-------------------------|---|---------------|
| 0 | -35 | -7.5 kHz | 14 | -46 | +2.5 kHz |
| 1 | -30 | | 15 | -41 | |
| 2 | -25 | | 16 | -36 | |
| 3 | -20 | | 17 | -31 | |
| 4 | -15 | | 18 | -26 | |
| 5 | -10 | | 19 | -21 | |
| 6 | -5 | | 20 | -16 | |
| 7 | 5 | | 21 | -11 | |
| 8 | 10 | | 22 | -6 | |
| 9 | 15 | | 23 | 5 | -2.5 kHz |
| 10 | 20 | | 24 | 10 | |
| 11 | 25 | | 25 | 15 | |
| 12 | 30 | | 26 | 20 | |
| 13 | 35 | | 27 | 25 | |
| | | | 28 | 30 | |
| | | | 29 | 35 | |
| | | | 30 | 40 | |
| | | | 31 | 45 | |

16.9 UE procedure for receiving narrowband wake up signal

A NB-IoT UE using NWUS can assume the actual duration of NWUS, starting in subframe $w0$, is one of the values in the set listed in Table 16.9-1 corresponding to the maximum duration of NWUS, $L_{\text{NWUS}_{\text{max}}}$, configured by higher layers. The maximum duration of NWUS starts in subframe $w0$ and ends in subframe $(g0-1)$, where $g0$ is defined by [14] and $w0$ is the latest subframe such that there is a total of $L_{\text{NWUS}_{\text{max}}}$ NB-IoT DL subframes and subframes #4 carrying *SystemInformationBlockType1-NB* in the maximum duration. The UE may assume that NWUS and its associated NB-IoT paging occasion subframes are on the same NB-IoT carrier.

Table 16.9-1: Actual NWUS durations in NB-IoT DL subframes or subframes containing SystemInformationBlockType1-NB.

| L_{NWUS_max} | Actual NWUS durations set |
|-----------------|---|
| 1 | {1} |
| 2 | {1, 2} |
| 4 | {1, 2, 4} |
| 8 | {1, 2, 4, 8} |
| 16 | {1, 2, 4, 8, 16} |
| 32 | {1, 2, 4, 8, 16, 32} |
| 64 | {1, 2, 4, 8, 16, 32, 64} |
| 128 | {1, 2, 4, 8, 16, 32, 64, 128} |
| 256 | {1, 2, 4, 8, 16, 32, 64, 128, 256} |
| 512 | {1, 2, 4, 8, 16, 32, 64, 128, 256, 512} |
| 1024 | {1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024} |

A NB-IoT UE using NWUS can assume there are at least 10 NB-IoT DL subframes between the end of the maximum duration of NWUS and the first associated NB-IoT paging occasion subframe.

17 Wake-up signal related procedures for BL/CE UE

A BL/CE UE using MWUS can assume the actual duration of MWUS, starting in subframe w_0 , is one of the values in the set listed in Table 17-1 corresponding to the maximum duration of MWUS, $L_{MWUS_{max}}$, configured by higher layers. The maximum duration of MWUS starts in subframe w_0 and ends in subframe (g_0-1) , where g_0 is defined by [14] and w_0 is the latest subframe such that there are $L_{MWUS_{max}}$ BL/CE DL subframes in the maximum duration. The UE may assume that MWUS and its first associated paging occasion subframes are in the same narrowband. In frame structure type 2, those special subframes, indicated as BL/CE DL subframes by higher layer *fdd-DownlinkOrTddSubframeBitmapBR*, are not counted in maximum duration and actual duration of MWUS.

Table 17-1: Actual MWUS durations in BL/CE DL subframes.

| L_{MWUS_max} | Actual MWUS durations set |
|-----------------|---------------------------|
| 1 | {1} |
| 2 | {1, 2} |
| 4 | {1, 2, 4} |
| 8 | {1, 2, 4, 8} |
| 16 | {1, 2, 4, 8, 16} |
| 32 | {1, 2, 4, 8, 16, 32} |
| 64 | {1, 2, 4, 8, 16, 32, 64} |

Annex A (informative): Change history

| Change history | | | | | | | |
|----------------|--------|-----------|------|-----|---|-------|-------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 2006-09 | | | | | Draft version created | | 0.0.0 |
| 2006-10 | | | | | Endorsed by RAN1 | 0.0.0 | 0.1.0 |
| 2007-01 | | | | | Inclusion of decisions from RAN1#46bis and RAN1#47 | 0.1.0 | 0.1.1 |
| 2007-01 | | | | | Endorsed by RAN1 | 0.1.1 | 0.2.0 |
| 2007-02 | | | | | Inclusion of decisions from RAN1#47bis | 0.2.0 | 0.2.1 |
| 2007-02 | | | | | Endorsed by RAN1 | 0.2.1 | 0.3.0 |
| 2007-02 | | | | | Editor's version including decisions from RAN1#48 & RAN1#47bis | 0.3.0 | 0.3.1 |
| 2007-03 | | | | | Updated Editor's version | 0.3.1 | 0.3.2 |
| 2007-03 | RAN-35 | RP-070171 | | | For information at RAN#35 | 0.3.2 | 1.0.0 |
| 2007-03 | | | | | Random access text modified to better reflect RAN1 scope | 1.0.0 | 1.0.1 |
| 2007-03 | | | | | Updated Editor's version | 1.0.1 | 1.0.2 |
| 2007-03 | | | | | Endorsed by RAN1 | 1.0.2 | 1.1.0 |
| 2007-05 | | | | | Updated Editor's version | 1.1.0 | 1.1.1 |
| 2007-05 | | | | | Updated Editor's version | 1.1.1 | 1.1.2 |
| 2007-05 | | | | | Endorsed by RAN1 | 1.1.2 | 1.2.0 |
| 2007-08 | | | | | Updated Editor's version | 1.2.0 | 1.2.1 |
| 2007-08 | | | | | Updated Editor's version – uplink power control from RAN1#49bis | 1.2.1 | 1.2.2 |
| 2007-08 | | | | | Endorsed by RAN1 | 1.2.2 | 1.3.0 |
| 2007-09 | | | | | Updated Editor's version reflecting RAN#50 decisions | 1.3.0 | 1.3.1 |
| 2007-09 | | | | | Updated Editor's version reflecting comments | 1.3.1 | 1.3.2 |
| 2007-09 | | | | | Updated Editor's version reflecting further comments | 1.3.2 | 1.3.3 |
| 2007-09 | | | | | Updated Editor's version reflecting further comments | 1.3.3 | 1.3.4 |
| 2007-09 | | | | | Updated Editor's version reflecting further comments | 1.3.4 | 1.3.5 |
| 2007-09 | RAN-37 | RP-070731 | | | Endorsed by RAN1 | 1.3.5 | 2.0.0 |
| 2007-09 | RAN-37 | RP-070737 | | | For approval at RAN#37 | 2.0.0 | 2.1.0 |
| 12/09/07 | RP-37 | RP-070737 | - | - | Approved version | 2.1.0 | 8.0.0 |
| 28/11/07 | RP-38 | RP-070949 | 0001 | 2 | Update of 36.213 | 8.0.0 | 8.1.0 |
| 05/03/08 | RP-39 | RP-080145 | 0002 | - | Update of TS 36.213 according to changes listed in cover sheet | 8.1.0 | 8.2.0 |
| 28/05/08 | RP-40 | RP-080434 | 0003 | 1 | PUCCH timing and other formatting and typo corrections | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0006 | 1 | PUCCH power control for non-unicast information | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0008 | - | UE ACK/NACK Procedure | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0009 | - | UL ACK/NACK timing for TDD | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0010 | - | Specification of UL control channel assignment | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0011 | - | Precoding Matrix for 2Tx Open-loop SM | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0012 | - | Clarifications on UE selected CQI reports | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0013 | 1 | UL HARQ Operation and Timing | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0014 | - | SRS power control | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0015 | 1 | Correction of UE PUSCH frequency hopping procedure | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0017 | 4 | Blind PDCCH decoding | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0019 | 1 | Tx Mode vs DCI format is clarified | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0020 | - | Resource allocation for distributed VRB | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0021 | 2 | Power Headroom | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0022 | - | Clarification for RI reporting in PUCCH and PUSCH reporting modes | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0025 | - | Correction of the description of PUSCH power control for TDD | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0026 | - | UL ACK/NACK procedure for TDD | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0027 | - | Indication of radio problem detection | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0028 | - | Definition of Relative Narrowband TX Power Indicator | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0029 | - | Calculation of $\Delta_{TF}(j)$ for UL-PC | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0030 | - | CQI reference and set S definition, CQI mode removal, and Miscellaneous | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0031 | - | Modulation order and TBS determination for PDSCH and PUSCH | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080434 | 0032 | - | On Sounding RS | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080426 | 0033 | - | Multiplexing of rank and CQI/PMI reports on PUCCH | 8.2.0 | 8.3.0 |
| 28/05/08 | RP-40 | RP-080466 | 0034 | - | Timing advance command responding time | 8.2.0 | 8.3.0 |
| 09/09/08 | RP-41 | RP-080670 | 37 | 2 | SRS hopping pattern for closed loop antenna selection | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 39 | 2 | Clarification on uplink power control | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 41 | - | Clarification on DCI formats using resource allocation type 2 | 8.3.0 | 8.4.0 |

| Change history | | | | | | | |
|----------------|-------|-----------|-----|-----|---|-------|-------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 09/09/08 | RP-41 | RP-080670 | 43 | 2 | Clarification on tree structure of CCE aggregations | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 46 | 2 | Correction of the description of PUCCH power control for TDD | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 47 | 1 | Removal of CR0009 | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 48 | 1 | Correction of mapping of cyclic shift value to PHICH modifier | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 49 | - | TBS disabling for DCI formats 2 and 2A | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 50 | - | Correction of maximum TBS sizes | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 51 | - | Completion of the table specifying the number of bits for the periodic feedback | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 54 | - | Clarification of RNTI for PUSCH/PUCCH power control with DCI formats 3/3A | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 55 | 1 | Clarification on mapping of Differential CQI fields | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 59 | 1 | PUSCH Power Control | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 60 | - | RB restriction and modulation order for CQI-only transmission on PUSCH | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 61 | - | Modulation order determination for uplink retransmissions | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 62 | 2 | Introducing missing L1 parameters into 36.213 | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 63 | 2 | Correcting the range and representation of delta_TF_PUCCH | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 64 | 1 | Adjusting TBS sizes to for VoIP | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 67 | - | Correction to the downlink resource allocation | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 68 | - | Removal of special handling for PUSCH mapping in PUCCH region | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 69 | - | Correction to the formulas for uplink power control | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 70 | 1 | Definition of Bit Mapping for DCI Signalling | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 71 | - | Clarification on PUSCH TPC commands | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 72 | 1 | Reference for CQI/PMI Reporting Offset | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 74 | - | Correction to the downlink/uplink timing | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 75 | - | Correction to the time alignment command | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 77 | 1 | Correction of offset signalling of UL Control information MCS | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 78 | 2 | DCI format1C | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 80 | - | Correction to Precoder Cycling for Open-loop Spatial Multiplexing | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 81 | 1 | Clarifying Periodic CQI Reporting using PUCCH | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 84 | 1 | CQI reference measurement period | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 86 | - | Correction on downlink multi-user MIMO | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 87 | - | PUCCH Reporting | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 88 | 1 | Handling of Uplink Grant in Random Access Response | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 89 | - | Correction to UL Hopping operation | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 90 | - | DRS EPRE | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 92 | - | Uplink ACK/NACK mapping for TDD | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 93 | - | UL SRI Parameters Configuration | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 94 | - | Miscellaneous updates for 36.213 | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 95 | - | Clarifying Requirement for Max PDSCH Coding Rate | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 96 | - | UE Specific SRS Configuration | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 97 | - | DCI Format 1A changes needed for scheduling Broadcast Control | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 98 | - | Processing of TPC bits in the random access response | 8.3.0 | 8.4.0 |
| 09/09/08 | RP-41 | RP-080670 | 100 | 1 | Support of multi-bit ACK/NAK transmission in TDD | 8.3.0 | 8.4.0 |
| 03/12/08 | RP-42 | RP-081075 | 82 | 3 | Corrections to RI for CQI reporting | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 83 | 2 | Moving description of large delay CDD to 36.211 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 102 | 3 | Reception of DCI formats | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 105 | 8 | Alignment of RAN1/RAN2 specification | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 107 | 1 | General correction of reset of power control and random access response message | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 108 | 2 | Final details on codebook subset restrictions | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 109 | - | Correction on the definition of Pmax | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 112 | 2 | CQI/PMI reference measurement periods | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 113 | - | Correction of introduction of shortened SR | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 114 | - | RAN1/2 specification alignment on HARQ operation | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 115 | - | Introducing other missing L1 parameters in 36.213 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 116 | - | PDCCH blind decoding | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 117 | - | PDCCH search space | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 119 | - | Delta_TF for PUSCH | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 120 | - | Delta_preamble_msg3 parameter values and TPC command in RA response | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 122 | 1 | Correction of offset signaling of uplink control information MCS | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 124 | - | Miscellaneous Corrections | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 125 | - | Clarification of the uplink index in TDD mode | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 126 | - | Clarification of the uplink transmission configurations | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 127 | 2 | Correction to the PHICH index assignment | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 128 | - | Clarification of type-2 PDSCH resource allocation for format 1C | 8.4.0 | 8.5.0 |

| Change history | | | | | | | |
|----------------|-------|-----------|-----|-----|---|-------|-------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 03/12/08 | RP-42 | RP-081075 | 129 | - | Clarification of uplink grant in random access response | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 130 | - | UE sounding procedure | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 134 | - | Change for determining DCI format 1A TBS table column indicator for broadcast control | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 135 | - | Clarifying UL VRB Allocation | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 136 | 1 | Correction for Aperiodic CQI | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 137 | 1 | Correction for Aperiodic CQI Reporting | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 138 | 1 | Correction to PUCCH CQI reporting mode for $N^{DL_RB} \leq 7$ | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 140 | 1 | On sounding procedure in TDD | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 141 | 1 | Alignment of RAN1/RAN3 specification | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 143 | 1 | TTI bundling | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 144 | 1 | ACK/NACK transmission on PUSCH for LTE TDD | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 145 | 1 | Timing relationship between PHICH and its associated PUSCH | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 147 | 1 | Definition of parameter for downlink reference signal transmit power | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 148 | 1 | Radio link monitoring | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 149 | 1 | Correction in 36.213 related to TDD downlink HARQ processes | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 151 | - | Nominal PDSCH-to-RS EPRE Offset for CQI Reporting | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 152 | 1 | Support of UL ACK/NAK repetition in Rel-8 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 155 | - | Clarification of misconfiguration of aperiodic CQI and SR | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 156 | 1 | Correction of control information multiplexing in subframe bundling mode | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 157 | - | Correction to the PHICH index assignment | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 158 | 1 | UE transmit antenna selection | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 159 | - | Clarification of spatial different CQI for CQI reporting Mode 2-1 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 160 | 1 | Corrections for TDD ACK/NACK bundling and multiplexing | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 161 | - | Correction to RI for Open-Loop Spatial Multiplexing | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 162 | - | Correction of differential CQI | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 163 | - | Inconsistency between PMI definition and codebook index | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 164 | - | PDCCH validation for semi-persistent scheduling | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 165 | 1 | Correction to the UE behavior of PUCCH CQI piggybacked on PUSCH | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 166 | - | Correction on SRS procedure when shortened PUCCH format is used | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 167 | 1 | Transmission overlapping of physical channels/signals with PDSCH for transmission mode 7 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 169 | - | Clarification of SRS and SR transmission | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 171 | - | Clarification on UE behavior when skipping decoding | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 172 | 1 | PUSCH Hopping operation corrections | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 173 | - | Clarification on message 3 transmission timing | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 174 | - | MCS handling for DwPTS | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 175 | - | Clarification of UE-specific time domain position for SR transmission | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 176 | 1 | Physical layer parameters for CQI reporting | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 177 | - | A-periodic CQI clarification for TDD UL/DL configuration 0 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 179 | 1 | Correction to the definitions of rho_A and rho_B (downlink power allocation) | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 180 | - | Clarification of uplink A/N resource indication | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 181 | - | PDCCH format 0 for message 3 adaptive retransmission and transmission of control information in message 3 during contention based random access procedure | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081075 | 182 | - | To Fix the Discrepancy of Uplink Power Control and Channel Coding of Control Information in PUSCH | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081122 | 183 | 1 | CQI reporting for antenna port 5 | 8.4.0 | 8.5.0 |
| 03/12/08 | RP-42 | RP-081110 | 168 | 1 | Clarification on path loss definition | 8.4.0 | 8.5.0 |
| 04/03/09 | RP-43 | RP-090236 | 184 | 1 | Corrections to Transmitted Rank Indication | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 185 | 4 | Corrections to transmission modes | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 186 | 2 | Delta_TF configuration for control only PUSCH | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 187 | 1 | Correction to concurrent SRS and ACK/NACK transmission | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 191 | 1 | PDCCH release for semi-persistent scheduling | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 192 | 1 | Correction on ACKNACK transmission on PUSCH for LTE TDD | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 193 | - | Correction to subband differential CQI value to offset level mapping for aperiodic CQI reporting | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 194 | - | Correction for DRS Collision handling | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 196 | 2 | Alignment of RAN1/RAN4 specification on UE maximum output power | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 197 | - | Transmission scheme for transmission mode 7 with SPS C-RNTI | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 198 | - | Clarifying bandwidth parts for periodic CQI reporting and CQI reference period | 8.5.0 | 8.6.0 |

| Change history | | | | | | | |
|----------------|-------|-----------|-----|-----|---|-------|-------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 04/03/09 | RP-43 | RP-090236 | 199 | 2 | Correction to the ACK/NACK bundling in case of transmission mode 3 and 4 | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 200 | - | ACK/NAK repetition for TDD ACK/NAK multiplexing | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 201 | - | Clarifying UL ACK/NAK transmission in TDD | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 202 | - | Corrections to UE Transmit Antenna Selection | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 203 | - | Correction to UE PUSCH hopping procedure | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 204 | - | Correction to PHICH resource association in TTI bundling | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 205 | - | Clarification of the length of resource assignment | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 206 | - | Correction on ACK/NACK transmission for downlink SPS resource release | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 207 | - | Introduction of additional values of wideband CQI/PMI periodicities | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 208 | 2 | Correction to CQI/PMI/RI reporting field | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 209 | 2 | Correction to rho_A definition for CQI calculation | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 210 | - | Correction to erroneous cases in PUSCH linear block codes | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 211 | 1 | Removing RL monitoring start and stop | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 214 | 1 | Correction to type-1 and type-2 PUSCH hopping | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 215 | - | Contradicting statements on determination of CQI subband size | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 216 | - | Corrections to SRS | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 219 | 2 | Miscellaneous corrections on TDD ACKNACK | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 221 | 1 | CR for Redundancy Version mapping function for DCI 1C | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 223 | - | Scrambling of PUSCH corresponding to Random Access Response Grant | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 225 | - | Removal of SRS with message 3 | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 226 | 3 | PRACH retransmission timing | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 227 | - | Clarifying error handling of PDSCH and PUSCH assignments | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 228 | - | Clarify PHICH index mapping | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 229 | - | Correction of CQI timing | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 230 | - | Alignment of CQI parameter names with RRC | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 231 | 1 | Removal of 'Off' values for periodic reporting in L1 | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 232 | - | Default value of RI | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 233 | 1 | Clarification of uplink timing adjustments | 8.5.0 | 8.6.0 |
| 04/03/09 | RP-43 | RP-090236 | 234 | - | Clarification on ACK/NAK repetition | 8.5.0 | 8.6.0 |
| 27/05/09 | RP-44 | RP-090529 | 235 | 1 | Correction to the condition of resetting accumulated uplink power correction | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 236 | - | Correction to the random access channel parameters received from higher layer | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 237 | - | Correction on TDD ACKNACK | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 238 | 1 | Correction on CQI reporting | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 239 | - | Correction on the HARQ process number | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 241 | 1 | CR correction of the description on TTI-bundling | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 242 | 1 | Clarify latest and initial PDCCH for PDSCH and PUSCH transmissions, and NDI for SPS activation | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 243 | - | Clarify DRS EPRE | 8.6.0 | 8.7.0 |
| 27/05/09 | RP-44 | RP-090529 | 244 | 1 | Clarification on TPC commands for SPS | 8.6.0 | 8.7.0 |
| 15/09/09 | RP-45 | RP-090888 | 245 | 1 | Correction to PUSCH hopping and PHICH mapping procedures | 8.7.0 | 8.8.0 |
| 15/09/09 | RP-45 | RP-090888 | 246 | - | Clarification on subband indexing in periodic CQI reporting | 8.7.0 | 8.8.0 |
| 15/09/09 | RP-45 | RP-090888 | 247 | 2 | Correction to DVRB operation in TDD transmission mode 7 | 8.7.0 | 8.8.0 |
| 15/09/09 | RP-45 | RP-090888 | 249 | - | Clarification of concurrent ACKNACK and periodic PMI/RI transmission on PUCCH for TDD | 8.7.0 | 8.8.0 |
| 15/09/09 | RP-45 | RP-090888 | 250 | - | Clarify Inter-cell synchronization text | 8.7.0 | 8.8.0 |
| 01/12/09 | RP-46 | RP-091172 | 248 | 1 | Introduction of LTE positioning | 8.8.0 | 9.0.0 |
| 01/12/09 | RP-46 | RP-091172 | 254 | - | Clarification of PDSCH and PRS in combination for LTE positioning | 8.8.0 | 9.0.0 |
| 01/12/09 | RP-46 | RP-091177 | 255 | 5 | Editorial corrections to 36.213 | 8.8.0 | 9.0.0 |
| 01/12/09 | RP-46 | RP-091257 | 256 | 1 | Introduction of enhanced dual layer transmission | 8.8.0 | 9.0.0 |
| 01/12/09 | RP-46 | RP-091177 | 257 | 1 | Add shorter SR periodicity | 8.8.0 | 9.0.0 |
| 01/12/09 | RP-46 | RP-091256 | 258 | - | Introduction of LTE MBMS | 8.8.0 | 9.0.0 |
| 17/12/09 | RP-46 | RP-091257 | 256 | 1 | Correction by MCC due to wrong implementation of CR0256r1 – Sentence is added to Single-antenna port scheme subclause 7.1.1 | 9.0.0 | 9.0.1 |
| 16/03/10 | RP-47 | RP-100211 | 259 | 3 | UE behavior when collision of antenna port 7/8 with PBCH or SCH happened and when distributed VRB is used with antenna port 7 | 9.0.1 | 9.1.0 |
| 16/03/10 | RP-47 | RP-100210 | 260 | 1 | MCCH change notification using DCI format 1C | 9.0.1 | 9.1.0 |
| 16/03/10 | RP-47 | RP-100211 | 263 | - | Correction on PDSCH EPRE and UE-specific RS EPRE for Rel-9 enhanced DL transmissions | 9.0.1 | 9.1.0 |
| 01/06/10 | RP-48 | RP-100589 | 265 | - | Clarification for TDD when multiplexing ACK/NACK with SR of ACK/NACK with CQI/PMI or RI | 9.1.0 | 9.2.0 |
| 01/06/10 | RP-48 | RP-100590 | 268 | 1 | Clarification of PRS EPRE | 9.1.0 | 9.2.0 |

| Change history | | | | | | | |
|----------------|-------|-----------|-----|-----|---|--------|--------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 14/09/10 | RP-49 | RP-100900 | 269 | - | Clarification on Extended CP support with Transmission Mode 8 | 9.2.0 | 9.3.0 |
| 07/12/10 | RP-50 | RP-101320 | 270 | - | Introduction of Rel-10 LTE-Advanced features in 36.213 | 9.3.0 | 10.0.0 |
| 27/12/10 | - | - | - | - | Editorial change to correct a copy/past error in subclause 7.2.2 | 10.0.0 | 10.0.1 |
| 15/03/11 | RP-51 | RP-110255 | 271 | 1 | A clarification for redundancy version of PMCH | 10.0.1 | 10.1.0 |
| 15/03/11 | RP-51 | RP-110258 | 272 | - | RLM Procedure with restricted measurements | 10.0.1 | 10.1.0 |
| 15/03/11 | RP-51 | RP-110256 | 273 | - | Corrections to Rel-10 LTE-Advanced features in 36.213 | 10.0.1 | 10.1.0 |
| 01/06/11 | RP-52 | RP-110819 | 274 | 3 | Correction to HARQ-ACK procedure for TDD mode b with M=2 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 275 | 3 | Determination of PUSCH A/N codebook size for TDD | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110823 | 276 | - | The triggering of aperiodic SRS in DCI formats 2B and 2C | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 278 | 3 | Corrections to power headroom | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 279 | 1 | Removal of square brackets for PUCCH format 3 ACK/NACK | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 281 | 1 | Correction of AN repetition and PUCCH format 3 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 282 | 2 | Correction to timing for secondary cell activation and deactivation | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110823 | 283 | 1 | Correction to MCS offset for multiple TBs | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110820 | 286 | 1 | Miscellaneous Corrections | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 288 | 1 | Corrections on UE procedure for determining PUCCH Assignment | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 289 | 2 | Correction to Multi-cluster flag in DCI format 0 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 290 | 2 | Joint transmission of ACK/NACK and SR with PUCCH format 3 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 291 | 3 | Correction of uplink resource allocation type 1 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 292 | 1 | Correction on CSI-RS configuration | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110818 | 294 | - | ACK/NACK and CQI simultaneous transmission in ACK/NACK bundling in TDD | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110823 | 295 | - | UE specific disabling of UL DMRS sequence hopping | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 296 | - | PDSCH transmission in MBSFN subframes | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 297 | - | Introduction of PCMAX for PUSCH power scaling | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 298 | - | Power control for SR and ACK/NACK with PUCCH format 3 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 299 | 2 | CR on power control for HARQ-ACK transmission on PUCCH | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 300 | 2 | Correction to handling of search space overlap | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 301 | 1 | Correction to simultaneous transmission of SRS and PUCCH format 2/2a/2b | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 302 | 1 | Correction for Simultaneous PUCCH and SRS Transmissions on CA | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 303 | - | Correction on 8Tx Codebook Sub-sampling for PUCCH Mode 1-1 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 304 | 1 | Corrections on CQI type in PUCCH mode 2-1 and clarification on simultaneous PUCCH and PUSCH transmission for UL-SCH subframe bundling | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110818 | 305 | 1 | Correction on UE behaviour upon reporting periodic CSI using PUCCH Mode1-1 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110818 | 306 | - | Clarification for the definition of CQI | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110818 | 307 | - | Clarification for the definition of Precoding Matrix Indicator | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 308 | - | Simultaneous SRS transmissions in more than one cell | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 310 | 1 | Miscellaneous Corrections for TS 36.213 | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 311 | 1 | Configuration of pmi-RI-Report | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 312 | 1 | Correction on the support of PUCCH format 3 and channel selection | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110821 | 313 | - | Correction on UE behaviour during DM-RS transmission on subframes carrying synchronization signals | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110820 | 314 | 1 | 36.213 CR on antenna selection | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110823 | 316 | 1 | Number of HARQ process for UL spatial multiplexing | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 317 | - | PUCCH format 3 Fallback procedure in TDD | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 318 | - | Clarification on CSI reporting under an invalid downlink subframe | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 320 | - | Multiple Aperiodic SRS Triggers for Same Configuration | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110823 | 321 | - | UE antenna switch in UL MIMO | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110819 | 322 | - | UE behaviour for PDSCH reception with limited soft buffer in CA | 10.1.0 | 10.2.0 |
| 01/06/11 | RP-52 | RP-110859 | 323 | - | Joint transmission of ACK/NACK and SR or CSI with PUCCH format 3 and channel selection | 10.1.0 | 10.2.0 |
| 15/09/11 | RP-53 | RP-111229 | 277 | 1 | Correction to reception of PRS in MBSFN subframes | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 325 | 3 | Corrections on UE procedure for reporting HARQ-ACK | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 326 | 2 | Corrections on Physical Uplink Control Channel Procedure | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111231 | 331 | 1 | Correction to uplink transmission scheme usage for random access response and PHICH-triggered retransmissions | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111229 | 336 | - | Corrections on transmission mode 9 | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 339 | - | Corrections on HARQ-ACK codebook size determination | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 340 | - | Corrections on TDD PUCCH format 1b with channel selection and HARQ-ACK transmission on PUSCH | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 341 | - | Corrections on NACK generation | 10.2.0 | 10.3.0 |

| Change history | | | | | | | |
|----------------|-------|-----------|-----|-----|--|--------|--------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 15/09/11 | RP-53 | RP-111230 | 342 | - | Corrections on power headroom reporting | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111229 | 346 | - | Correction on TBS translation table | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111229 | 347 | 2 | Correction to the condition of enabling PMI feedback | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111232 | 348 | - | Miscellaneous corrections to 36.213 | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111229 | 349 | - | Corrections on PUSCH and PUCCH modes | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111231 | 350 | 1 | CR on UL HARQ ACK determination | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111231 | 351 | 1 | Correction on UL DMRS resources for PHICH-triggered retransmission | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 352 | - | Clarification on the common search space description | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111232 | 353 | 1 | Clarification on ambiguous DCI information between UE-specific search space and common search space for DCI formats 0 and 1A | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111229 | 354 | - | Clarification of Reference PDSCH Power for CSI-RS based CSI Feedback | 10.2.0 | 10.3.0 |
| 15/09/11 | RP-53 | RP-111230 | 355 | 2 | Corrections on reporting Channel State Information | 10.2.0 | 10.3.0 |
| 05/12/11 | RP-54 | RP-111669 | 324 | 3 | Accumulation of power control commands from DCI format 3/3A | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 357 | 1 | Miscellaneous corrections on uplink power control | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 358 | - | Corrections on $N_c^{\{received\}}$ | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 359 | - | Corrections on TDD PUCCH format 1b with channel selection and two configured serving cells | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 360 | - | Corrections on the notation of k and k_m | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111668 | 361 | 1 | Corrections on PUCCH mode 2-1 | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111668 | 362 | 3 | A correction to PDSCH transmission assumption for CQI calculation | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 363 | 1 | Corrections on PUCCH Resource Notation | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111667 | 364 | - | Correction on the notation of SRS transmission comb | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 365 | - | Clarification on the HARQ-ACK procedure of TDD UL-DL configuration 5 | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 366 | 2 | Clarification on the determination of resource for PUCCH Format 1b with channel selection in TDD mode | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 367 | 1 | Correction on HARQ-ACK procedure | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 368 | - | Correction for A/N on PUSCH with $W=1,2$ in case of TDD channel selection | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111668 | 369 | - | Clarification of PUCCH 2-1 Operation | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111668 | 370 | 1 | Correction on PMI index | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 371 | 2 | Correction to periodic CSI reports for carrier aggregation | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 373 | 1 | Removal of square bracket in HARQ-ACK procedure | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 374 | 1 | Clarification on UE's capability of supporting PUCCH format 3 | 10.3.0 | 10.4.0 |
| 05/12/11 | RP-54 | RP-111666 | 375 | 1 | Clarifications of UE behavior on PUSCH power control | 10.3.0 | 10.4.0 |
| 28/02/12 | RP-55 | RP-120286 | 376 | 1 | RNTI Configuration associated with DL Resource Allocation Type 2 | 10.4.0 | 10.5.0 |
| 28/02/12 | RP-55 | RP-120283 | 377 | 2 | Correction for ACK/NACK related procedure in case of TDD UL-DL configuration 0 | 10.4.0 | 10.5.0 |
| 13/06/12 | RP-56 | RP-120737 | 378 | 3 | Correction of FDD channel selection HARQ-ACK and SR transmission | 10.5.0 | 10.6.0 |
| 13/06/12 | RP-56 | RP-120738 | 379 | - | Removal of description with square brackets | 10.5.0 | 10.6.0 |
| 13/06/12 | RP-56 | RP-120738 | 381 | - | Correction on transmission mode 9 with a single antenna port transmission | 10.5.0 | 10.6.0 |
| 04/09/12 | RP-57 | RP-121265 | 382 | - | Clarification of codebook subsampling for PUCCH 2-1 | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121266 | 383 | - | Correction to UE transmit antenna selection | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121264 | 384 | - | TDD HARQ-ACK procedure for PUCCH format 1b with channel selection in carrier aggregation | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121265 | 385 | - | Corrections for Handling CSI-RS patterns | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121264 | 386 | 1 | Reference serving cell for pathloss estimation | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121264 | 387 | - | Power control for PUCCH format 3 with single configured cell | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121264 | 388 | - | ACK/NACK resource in case of channel selection | 10.6.0 | 10.7.0 |
| 04/09/12 | RP-57 | RP-121274 | 380 | 4 | Introduction of an additional special subframe configuration | 10.7.0 | 11.0.0 |
| 04/09/12 | RP-57 | RP-121272 | 389 | - | Introduction of Rel-11 features | 10.7.0 | 11.0.0 |
| 04/12/12 | RP-58 | RP-121839 | 393 | - | Correction to the parameter ue-Category-v10xy | 11.0.0 | 11.1.0 |
| 04/12/12 | RP-58 | RP-121837 | 395 | - | Correction of reference signal scrambling sequence initialization for SPS in transmission mode 7 | 11.0.0 | 11.1.0 |
| 04/12/12 | RP-58 | RP-121846 | 396 | - | Finalisation for introducing Rel-11 features | 11.0.0 | 11.1.0 |
| 26/02/13 | RP-59 | RP-130254 | 398 | - | Correction on UE procedure for reporting HARQ-ACK | 11.1.0 | 11.2.0 |
| 26/02/13 | RP-59 | RP-130252 | 400 | - | Corrections for SRS power scaling in UpPTS | 11.1.0 | 11.2.0 |
| 26/02/13 | RP-59 | RP-130252 | 403 | - | CR on UE specific search and Common search space overlap on PDCCH | 11.1.0 | 11.2.0 |
| 26/02/13 | RP-59 | RP-130358 | 404 | - | Additional clarifications/corrections for introducing Rel-11 features | 11.1.0 | 11.2.0 |
| 11/06/13 | RP-60 | RP-130752 | 405 | - | Correction to EPDCCH monitoring in case of cross-carrier scheduling | 11.2.0 | 11.3.0 |

| Change history | | | | | | | Old | New |
|----------------|-------|-----------|-----|-----|--|--|--------|--------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | | | |
| 11/06/13 | RP-60 | RP-130751 | 407 | 1 | Correction on the RI bit width | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 408 | - | Correction on parallel reception of PDSCH and Msg 2 | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130747 | 409 | - | Correction on zero power CSI-RS resource configuration | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 410 | 1 | Corrections on different TDD UL-DL configurations on different bands | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130752 | 411 | - | Correction on EPDCCH PRB pair indication | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130752 | 412 | - | Correction on EPDCCH hashing function | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130752 | 413 | - | Correction on PUCCH resource determination for FDD EPDCCH | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130752 | 414 | 2 | CR on ambiguity in EPDCCH decoding candidates under two overlapped EPDCCH resource sets | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130749 | 415 | - | Removal of the case for spatial domain bundling in TDD UL/DL configuration 0 | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130752 | 416 | - | Corrections to EPDCCH PRB pair indication | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130753 | 417 | 1 | Correction to PUSCH/PUCCH transmit power after PRACH power ramping | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130747 | 418 | - | CR on RI-Reference CSI Process with Subframe Sets | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130747 | 420 | - | Correction on UE-specific RS scrambling for SPS PDSCH in TM10 | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130747 | 421 | - | CR on resolving ambiguous UE capability signaling for CoMP | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 422 | - | Correction of valid downlink subframe | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130749 | 424 | - | Correction on HARQ-ACK transmission for a UE configured with PUCCH format 3 | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 425 | - | Correction of PHICH resource for half duplex TDD UE | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 426 | - | Correction on n_{HARQ} for TDD CA with different UL-DL configurations | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 427 | - | Correction on implicit HARQ-ACK resource determination for PUCCH format 1b with channel selection for TDD CA with different UL-DL configurations | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130750 | 428 | - | Correction on SRS power scaling with multiple TAGs | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130747 | 429 | - | Correction on MBSFN subframe configuration | | 11.2.0 | 11.3.0 |
| 11/06/13 | RP-60 | RP-130749 | 430 | - | CR on SCell activation timing | | 11.2.0 | 11.3.0 |
| 03/09/13 | | | | | MCC clean-up | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131249 | 432 | - | Correction for EPDCCH Search Space | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131250 | 433 | - | Correction to QCL behaviour on CRS | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131250 | 434 | - | Correction on PUCCH power control | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131248 | 435 | - | Correction on the ratio of PDSCH EPRE to CRS EPRE for TM10 | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131249 | 436 | - | CR on EPDCCH Search Space for Cross-Carrier Scheduling | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131249 | 437 | - | Correction to the UE behaviour in case of collision between PRS and EPDCCH in different CP case | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131249 | 438 | - | On correction to higher layer parameter name for EPDCCH resource mapping | | 11.3.0 | 11.4.0 |
| 03/09/13 | RP-61 | RP-131248 | 439 | - | Correction to PDSCH mapping for CoMP | | 11.3.0 | 11.4.0 |
| 03/12/13 | RP-62 | RP-131893 | 440 | 1 | Correction on parameter ue-Category | | 11.4.0 | 11.5.0 |
| 03/12/13 | RP-62 | RP-131892 | 442 | 1 | Correction on determination of modulation order and transport block size | | 11.4.0 | 11.5.0 |
| 03/12/13 | RP-62 | RP-132024 | 445 | 3 | Correction on CSI reporting type and parameters | | 11.4.0 | 11.5.0 |
| 03/12/13 | RP-62 | RP-131894 | 446 | - | Correction on deriving the length of the non-MBSFN region | | 11.4.0 | 11.5.0 |
| 03/12/13 | RP-62 | RP-131896 | 431 | 5 | Introduction of Rel 12 feature for Downlink MIMO Enhancement | | 11.5.0 | 12.0.0 |
| 03/03/14 | RP-63 | RP-140286 | 447 | - | Correction to CSI Reporting | | 12.0.0 | 12.1.0 |
| 03/03/14 | RP-63 | RP-140291 | 448 | - | Clarification on PUCCH Mode 1-1 for 4Tx Dual Codebook | | 12.0.0 | 12.1.0 |
| 03/03/14 | RP-63 | RP-140287 | 450 | 1 | Common search space monitoring for MBMS | | 12.0.0 | 12.1.0 |
| 03/03/14 | RP-63 | RP-140290 | 452 | - | Introduction of new UE categories | | 12.0.0 | 12.1.0 |
| 03/03/14 | RP-63 | RP-140288 | 455 | 1 | Modification to l_SRS = 0 for trigger type 1 SRS and TDD | | 12.0.0 | 12.1.0 |
| 03/03/14 | RP-63 | RP-140289 | 458 | - | Correction to CSI processing in TM10 | | 12.0.0 | 12.1.0 |
| 10/06/14 | RP-64 | RP-140858 | 459 | 1 | Clarification on PUCCH reporting type payload size | | 12.1.0 | 12.2.0 |
| 10/06/14 | RP-64 | RP-140858 | 461 | - | Clarification on SRS colliding with PUCCH in the same cell when the UE is configured with multiple TAGs | | 12.1.0 | 12.2.0 |
| 10/06/14 | RP-64 | RP-140858 | 462 | 1 | Clarification on SRS antenna switching | | 12.1.0 | 12.2.0 |
| 10/06/14 | RP-64 | RP-140862 | 463 | - | Introduction of Rel-12 LTE-Advanced features in 36.213 | | 12.1.0 | 12.2.0 |
| 10/09/14 | RP-65 | RP-141479 | 464 | - | Correction on SRS transmission for TDD-FDD CA | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141478 | 465 | - | Correction on beta_{offset}^{l_HARQ-ACK} determination for a UE configured with two uplink power control subframe sets | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141478 | 466 | - | Corrections for TDD eIMTA | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141479 | 467 | 3 | CR on HARQ-ACK Multiplexing in PUSCH for TDD-FDD CA | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141474 | 469 | - | Correction to UCI embedding in case of a single serving cell and simultaneous PUSCH and PUCCH transmission | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141478 | 470 | - | Corrections on UL-reference UL/DL configuration | | 12.2.0 | 12.3.0 |
| 10/09/14 | RP-65 | RP-141473 | 471 | - | CR for Clarification of special subframe and usage alignment | | 12.2.0 | 12.3.0 |

| Change history | | | | | | | |
|----------------|------------|-----------|-----|-----|---|--------|--------|
| Date | TSG # | TSG Doc. | CR | Rev | Subject/Comment | Old | New |
| 10/09/14 | RP-65 | RP-141485 | 472 | - | Introduction of low-cost MTC and 256QAM features | 12.2.0 | 12.3.0 |
| 08/12/14 | RP-66 | RP-142104 | 482 | 5 | Introduction of Dual Connectivity, Small Cell Enhancements, NAICS, eIMTA, and TDD-FDD CA features | 12.3.0 | 12.4.0 |
| 08/12/14 | RP-66 | RP-142097 | 487 | 1 | Clarification of periodic CSI feedback for subband CQI and PMI | 12.3.0 | 12.4.0 |
| 08/12/14 | RP-66 | RP-142100 | 491 | - | Correction of the parameter CSIProcessIndex | 12.3.0 | 12.4.0 |
| 09/03/15 | RP-67 | RP-150366 | 492 | 2 | Introduction of D2D feature into 36.213 | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150363 | 494 | 1 | Correction to PUCCH procedures in case of FDD Pcell and TDD Scell in TDD-FDD CA | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150364 | 498 | - | Correction on higher layer parameter names for 256QAM | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150359 | 500 | - | TM10 CSI-IM Interference Measurements | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150358 | 502 | - | Clarification on common search reception related to MBMS | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150364 | 503 | - | Correction to Discovery in Small Cell Enhancement feature | 12.4.0 | 12.5.0 |
| 09/03/15 | RP-67 | RP-150365 | 504 | 1 | Corrections to Dual Connectivity feature | 12.4.0 | 12.5.0 |
| 15/06/15 | RP-68 | RP-150931 | 493 | 2 | Clarification on HARQ-ACK repetition | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150932 | 497 | 3 | Clarification on PUCCH Format 3 Resource Derivation for TDD UL/DL Configuration 5 | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 506 | - | Clarification on the PRACH power in subframe i2-1 for PCM2 | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 507 | - | Clarification on the MTA operation in PCM1 | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 512 | - | Correction of higher layer parameter names in dual connectivity | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150935 | 513 | 1 | Correction on UE procedure of determining subframe pool for PSCCH and PSSCH in ProSe | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150935 | 514 | 1 | Correction on UE procedure of transmitting PSCCH in ProSe | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 515 | 1 | Correction on UL Power Control for Synchronous Dual Connectivity | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 516 | 1 | Correction on UL Power Control for Asynchronous Dual Connectivity | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150937 | 517 | - | Correction to Rel-12 UE category signal name | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150936 | 520 | - | Corrections on eIMTA RRC parameter naming | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150933 | 521 | - | Correction on Closed Loop Antenna Selection for Dual Connectivity | 12.5.0 | 12.6.0 |
| 15/06/15 | RP-68 | RP-150935 | 523 | - | Alignment of ProSe parameter names | 12.5.0 | 12.6.0 |
| 14/09/15 | RP-69 | RP-151470 | 525 | - | UE processing time relaxation on Type 2 Power Headroom Reporting | 12.6.0 | 12.7.0 |
| 14/09/15 | RP-69 | RP-151468 | 527 | - | Correction of ProSe parameters | 12.6.0 | 12.7.0 |
| 14/09/15 | RP-69 | RP-151471 | 528 | 2 | Clarification on power control for PCM2 | 12.6.0 | 12.7.0 |
| 07/12/15 | RP-70 | RP-152034 | 530 | 1 | Clarification of PUCCH resource allocation related to EPDCCH SCells | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152037 | 531 | - | Clarification on the parameter notations for eIMTA | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152037 | 534 | - | Correction on aperiodic CSI transmission without UL-SCH according to table 7.2.1-1C | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152038 | 535 | 1 | Introduction of new maximum TBS for TM9/10 | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152034 | 542 | - | Clarification of PHICH resource assignment related to EPDCCH scheduled PUSCH | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152036 | 543 | 1 | Modify max TA for dual connectivity | 12.7.0 | 12.8.0 |
| 07/12/15 | RP-70 | RP-152125 | 533 | 3 | eD2D CR for 36.213 | 12.8.0 | 13.0.0 |
| 07/12/15 | RP-70 | RP-152031 | 536 | - | Introduction of Rel 13 features for SC-PTM | 12.8.0 | 13.0.0 |
| 07/12/15 | RP-70 | RP-152026 | 537 | 2 | Introduction of LAA (PHY layer aspects) | 12.8.0 | 13.0.0 |
| 07/12/15 | RP-70 | RP-152026 | 538 | 5 | Introduction of LAA (eNB Channel Access Procedures) | 12.8.0 | 13.0.0 |
| 07/12/15 | RP-70 | RP-152027 | 539 | 1 | Introduction of Enhanced CA in Release 13 | 12.8.0 | 13.0.0 |
| 07/12/15 | RP-70 | RP-152025 | 541 | 1 | Introduction of EB/FD-MIMO | 12.8.0 | 13.0.0 |
| 26/01/16 | Post RP-70 | | | | MCC update to show correct version of the spec in the headers of all subparts and get all of them aligned with coversheet | 13.0.0 | 13.0.1 |

| Change history | | | | | | | |
|----------------|-------------|-----------|------|---------|-----|---|----------------|
| Date | Meeting | TDoc | CR | R ev | Cat | Subject/Comment | New version |
| 2016-03 | RAN#71 | RP-160359 | 546 | - | F | Alignment eD2D CR for 36.213 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160549 | 548 | 3 | F | Clarification on PDSCH collision with PSS/SSS/PBCH | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 550 | 1 | F | Clarification on number of PRBs for PUCCH format 4 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 554 | 2 | F | Clarification on code rate for periodic CSI transmission on PUCCH format 4 and 5 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 555 | 1 | F | Clarification on Averaging of CSI Measurements in LAA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 559 | - | F | Limit on number of periodic CSI reports | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 560 | 1 | F | Correction on Transmission Code Rate Determination | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 562 | - | F | CR on LAA defer and sensing duration | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 563 | - | F | Correction on aperiodic CSI only PUSCH without UL-SCH | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 564 | - | F | Correction on HARQ-ACK and periodic CSI transmission | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 565 | - | F | Correction on Simultaneous HARQ-ACK and P-CSI Transmission | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 566 | 1 | F | CR on MR support in TM9 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 568 | - | F | Correction on Subsampling of Class A Codebook | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 569 | - | F | CR on definition of LAA idle sensing for periods longer than one CCA slot | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 570 | - | F | Correction on total sensing and transmission time for Japan | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 571 | - | F | Correction on common DCI detection of LAA in 36.213 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 572 | - | F | CR on valid downlink subframe definition for TM9/10 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 573 | - | F | CR on eCCE of EPDCCH for partial subframe | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 576 | - | F | Correction on cross-carrier scheduling in LAA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 577 | - | F | Correction on QCL type B for LAA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 578 | - | F | Correction on Class B CSI reporting | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 579 | - | F | CR on CRI reporting for one CSI-RS ports (36.213) | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 580 | - | F | Correction to the condition of CRI updating restriction | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 581 | - | F | Correction to the additional UpPTS symbols for SRS | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 582 | - | F | Clarification on PUCCH mode 1-1 configuration | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 584 | - | F | Correction on EPDCCH assignment in LAA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 585 | - | F | CR for LAA CW reset per AC in case of K attempts at CWmax | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 586 | - | F | Corrections to RI-inheritance | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 587 | - | F | CR on CSI-RS resource in 36.213 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 588 | - | F | CR on mismatch between 36.213 and 36.331 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 589 | - | F | Correction on CSI transmission for eCA in 36.213 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 590 | - | F | Clarification on joint reports of CRI | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 591 | - | F | Correction to RI reference CSI process | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 592 | - | F | Corrections to Class B CSI reporting on PUCCH | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 594 | - | F | Correction on PUCCH transmission and (E)PDCCH disabling in eCA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 595 | - | F | CSI-RS in DwPTS | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 596 | 1 | F | Correction on shortened PUCCH format for Rel-13 CA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160357 | 598 | - | F | Correction on HARQ-ACK bit concatenation for PUCCH format 4 and 5 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 599 | - | F | Corrections for LAA Energy Detection Threshold | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 0600 | - | F | Correction on channel access procedure for DL LBT | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 0601 | - | F | Correction on CWS adjustment in LAA | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 0602 | - | F | Corrections for Type B Multi-channel access procedure for an LAA SCell | 13.1.0 |
| 2016-03 | RAN#71 | RP-160358 | 0603 | - | F | CR on Class B CQI measurement correction | 13.1.0 |
| 2016-03 | RAN#71 | RP-160360 | 0604 | 1 | F | Corrections for PDCCCH and EPDCCH monitoring on an LAA SCell in 36.213 | 13.1.0 |
| 2016-03 | RAN#71 | RP-160363 | 0605 | - | A | Clarification on T_threshold in dual connectivity | 13.1.0 |
| 2016-03 | RAN#71 | RP-160361 | 0540 | 6 | B | Introduction of further LTE Physical Layer Enhancements for MTC | 13.1.0 |
| 2016-03 | Post RAN#71 | | | | | MCC update to show correct version of the spec in the headers of all subparts and get all of them aligned with coversheet | 13.1.1 |
| 2016-06 | RAN#72 | RP-161062 | 0575 | 2 | F | Correction on SPS HARQ-ACK bit handling in case of dynamic codebook configuration of eCA in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0593 | 1 | F | Correction to the UE's assumption on DMRS ports | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0608 | 1 | F | Correction on HARQ-ACK ordering in case of semi-static codebook configuration of eCA | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0610 | 1 | F | Correction on timing for secondary cell activation/deactivation for eCA in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161068 | 0611 | - | A | Correction on RRC parameter for configuring new TBSs | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0614 | - | F | Correction to rank 5-8 FD-MIMO CSI feedback | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0615 | - | F | Correction on aperiodic CSI reporting mode 1-0 and 1-1 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0616 | - | F | Correction of paging PDSCH transmission for MTC UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0618 | - | F | Update RRC parameter names for MTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0619 | - | F | PUCCH repetition for Msg4 for MTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0620 | - | F | MPDCCH repetition for paging and random access for MTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0621 | 1 | F | MCS field in DCI format 6-2 for paging for MTC | 13.2.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|--|--------|
| 2016-06 | RAN#72 | RP-161062 | 0622 | - | F | Coding of higher layer parameter codebooksizesDetermination-r13 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0623 | 1 | F | Corrections on Simultaneous HARQ-ACK and P-CSI in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161069 | 0624 | - | F | Corrections SRS dropping in CA in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0625 | - | D | Correction to the usage of undefined terminology "channel" | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0626 | - | F | Correction on channel access procedure after an additional defer duration for DL LBT | 13.2.0 |
| 2016-06 | RAN#72 | RP-161284 | 0627 | 1 | F | Clarification for LAA CSI processing | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0628 | - | F | MCS Table for Initial Partial TTI in LAA | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0629 | - | F | Correction on the linkage between CSI-RS and CSI-IM for Class B | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0630 | - | F | Correction for HARQ-ACK Codebook Determination in eCA | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0631 | - | F | Clarification on "special subframe" for frame structure type 3 in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161062 | 0632 | - | F | Corrections on simultaneous transmission of HARQ-ACK and SR in 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0633 | 2 | F | MDPCCCH candidate overflow monitoring correction for eMTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0634 | - | F | Correction to TS 36.213 for eMTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0635 | 1 | F | Correction on M-PDCCH case definition | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0636 | - | F | Correction on CSS for MPDCCH configured by temporary C-RNTI and Type0 MPDCCH CSS resource | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0637 | 2 | F | Correction on collision of dynamically scheduled data and semi-statically scheduled data for Rel-13 eMTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0638 | 1 | F | Correction on PDSCH transmission timing for Rel-13 eMTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0639 | - | F | On the collision between eMTC SIB and MPDCCH/PDSCH in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0639 | - | F | On the collision between eMTC SIB and MPDCCH/PDSCH in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0640 | - | F | Collision between PUCCH format 2 and PDSCH with repetitions | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0641 | - | F | Clarification of TM1/2/6 on MBSFN subframes | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0642 | - | F | Correction of fallback behavior for TM9 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0643 | - | F | Correction on RV and MPDCCH starting position | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0644 | 1 | F | Collision between PSS/SSS/PBCH and PDSCH for MTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0645 | - | F | CR for 36.213 on multi-channel access procedure Type A2 in LAA | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0646 | - | F | CR for TS36.213 related to 2+4 PRB set | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0647 | - | F | CR on CSI-RS ID configuration for TM9 in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0649 | - | F | Initial CCA Behaviour in the Channel Access Procedure | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0650 | - | F | CR on clarification for channel sensing | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0651 | - | F | CR for the contention window adjustment procedure in LAA downlink channel access | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0653 | 1 | F | eMTC MPDCCH corrections for 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161064 | 0654 | - | F | Correction on search space to decode the PDCCH configured by the SC-N-RNTI | 13.2.0 |
| 2016-06 | RAN#72 | RP-161067 | 0656 | 1 | B | Introduction of NB-IoT | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0657 | - | F | Starting OFDM symbol for SIB1-BR for BL/CE UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0658 | - | F | Collision between SIB1-BR and SI message for BL/CE UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0660 | 3 | F | MPDCCH search space for random access in connected mode for BL/CE UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0662 | - | F | Definition of number of MPDCCH repetitions for BL/CE UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0663 | - | F | PRB locations for Type0 MPDCCH search space for BL/CE UE | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0666 | - | F | CR on FD-MIMO codebooks (36.213) | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0667 | - | F | CR on CSI-Reporting-Type in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161070 | 0668 | - | B | Introduction of 60ms periodicity for wideband CQI/PMI reporting | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0669 | - | F | Introduction of 60ms periodicity for wideband CQI/PMI reporting | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0670 | - | F | On MPDCCH AL and search space for 8 EREGs per ECCE in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0671 | - | F | CR on MPDCCH quasi co-location | 13.2.0 |
| 2016-06 | RAN#72 | RP-161063 | 0672 | - | F | Correction on UE assumption on DMRS ports | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0673 | - | F | A-CSI Reporting for TM6 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0674 | - | F | Corrections on CSI Reporting | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0675 | - | F | Correction on RV determination for PUSCH in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0677 | - | F | Clarification on Msg3 PUSCH repetition level in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0678 | - | F | Correction on SRS frequency location in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0679 | - | F | Correction on PDSCH reception timing for eMTC | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0680 | 1 | F | Correcting configuration parameter for number of PRB-pairs | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0681 | - | F | Clarification on starting subframe for MPDCCH | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0682 | - | F | MCS for Random Access Response Grant | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0683 | 2 | F | Correction on UCI multiplexing on PUSCH | 13.2.0 |
| 2016-06 | RAN#72 | RP-161061 | 0684 | - | F | Correction on RLM for PSCell in dual connectivity | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0685 | - | F | Correction on PDSCH transmission scheme assumed for TM9 CSI reference resource in TS 36.213 | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0686 | - | F | CR on clarification for channel sensing | 13.2.0 |
| 2016-06 | RAN#72 | RP-161065 | 0687 | - | F | CR on CWp adjustment | 13.2.0 |
| 2016-06 | RAN#72 | RP-161066 | 0688 | - | F | Clarification of CSI measurements | 13.2.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|---|--------|
| 2016-09 | RAN#73 | RP-161563 | 0689 | 1 | F | Correction on random access procedure for NB-IoT on TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0690 | - | F | Correction on NPDCCH related procedure on TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0691 | - | F | Corrections to RRC parameter names for NB-IoT in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0692 | 1 | F | Corrections on NPDSCH related procedure in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161560 | 0693 | - | F | Correction on FD-MIMO codebook in 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161560 | 0694 | - | F | Correction on RRC parameters for SRS enhancement in 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0695 | - | F | Transport block size determination for Msg2 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0696 | - | F | Correction on NPUSCH related procedure on TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0698 | - | F | Correction on the reference of narrowband definition in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0699 | - | F | Correction on the relationship between IMCS and ITBS for DCI format 6-1A in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0700 | 1 | F | Correction on the scrambling initialization for SIB1-BR and SI for eMTC in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0701 | - | F | Corrections on NPDCCH search space for random access in connected mode in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161558 | 0706 | 1 | A | Correction on storing soft channel bits for different UE categories in Rel-13 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161560 | 0708 | - | F | Correction on the citation of table indexs for mapping of ICRI to MCRI | 13.3.0 |
| 2016-09 | RAN#73 | RP-161560 | 0710 | - | F | Corrections on Codebooks in 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0711 | - | F | Default max number of PUSCH repetitions for Msg3 for BL/CE UE | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0714 | 1 | F | PDSCH start subframe in TDD for BL/CE UE | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0715 | - | F | Repetition with aperiodic CSI for BL/CE UE | 13.3.0 |
| 2016-09 | RAN#73 | RP-161561 | 0718 | - | F | Correction on "special subframe" for frame structure type 3 in 36.213 for Rel-13 LAA | 13.3.0 |
| 2016-09 | RAN#73 | RP-161559 | 0719 | - | F | Clarification on HARQ-ACK transmission | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0720 | 1 | F | Correction for UL grant size in RAR | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0721 | 2 | F | MBSFN subframes and SIB2 decoding | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0722 | 1 | F | Overriding of invalid subframe for msg3 PUSCH when R=1 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0723 | - | F | On the mapping of TPC command field to power correction values in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0724 | - | F | Correction on the MPDCCH scheduling Paging in special subframe in TS 36.213 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0725 | 1 | F | Clarification of valid subframe in eMTC | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0726 | - | F | Quasi-colocation of NB-IoT antenna ports | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0728 | 1 | F | PUCCH resource allocation | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0729 | 1 | F | RV version for PDSCH carrying paging | 13.3.0 |
| 2016-09 | RAN#73 | RP-161735 | 0730 | 1 | F | Missing definition of higher layer parameter eutra-CRS-SequencelInfo | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0731 | - | F | PUSCH timing delay for NB-IoT | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0732 | - | F | RV Cycling for PUSCH and PDSCH | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0734 | - | F | Clarification of scheduling delay | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0736 | - | F | Clarification on MPDCCH monitoring on SFN rollover and search space overlap | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0737 | - | F | PUCCH transmission and invalid subframes | 13.3.0 |
| 2016-09 | RAN#73 | RP-161562 | 0738 | - | F | SRS bit in DCI | 13.3.0 |
| 2016-09 | RAN#73 | RP-161563 | 0739 | - | F | Clarification of NB-IoT DL subframe configuration | 13.3.0 |
| 2016-09 | RAN#73 | RP-161560 | 0740 | - | F | Correction on FD-MIMO codebooks | 13.3.0 |
| 2016-09 | RAN#73 | RP-161561 | 0741 | 1 | F | CR on LAA post transmission backoff | 13.3.0 |
| 2016-09 | RAN#73 | RP-161797 | 0745 | 1 | F | CR to remove the incorrect implementation of LAA defer and sensing duration introduced by the unapproved CR R1-161166 | 13.3.0 |
| 2016-09 | RAN#73 | RP-161572 | 0709 | 2 | B | Addition of LTE_LATRED_L2-Core | 14.0.0 |
| 2016-09 | RAN#73 | RP-161571 | 0742 | - | B | Introduction of eLAA (PHY layer aspects) in 36.213 | 14.0.0 |
| 2016-09 | RAN#73 | RP-161803 | 0743 | 1 | B | Introduction of eLAA (UL Channel Access Procedure) in 36.213 | 14.0.0 |
| 2016-09 | RAN#73 | RP-161570 | 0744 | - | B | Introduction of V2V into TS36.213 | 14.0.0 |
| 2016-12 | RAN#74 | RP-162359 | 0747 | - | A | Correction on the determination of NPDCCH candidates | 14.1.0 |
| 2016-12 | RAN#74 | RP-162362 | 0748 | - | B | Introduction of RACHless handover for Further mobility enhancement in LTE | 14.1.0 |
| 2016-12 | RAN#74 | RP-162356 | 0757 | - | A | Correction to PUCCH reporting mode 2-1 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162356 | 0758 | - | A | Correction to PUCCH reporting mode 1-1 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0759 | - | F | Correction on UL grant reception in ending partial subframe | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0760 | - | F | Correction on UL burst scheduling | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0761 | - | F | CR on PHICH operation for eLAA in 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0762 | - | F | Correction on handling UL LBT procedure under UE power limited case | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0765 | - | A | Clarification on spectral efficiency | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0766 | 2 | A | Aperiodic CSI without MPDCCH frequency hopping | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0768 | 1 | A | Correction on equation for MPDCCH search space and starting subframe position | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0771 | - | A | Clarification of number of repetitions of PUCCH | 14.1.0 |
| 2016-12 | RAN#74 | RP-162359 | 0772 | - | A | Clarification on nrs-Power related description | 14.1.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|--|--------|
| 2016-12 | RAN#74 | RP-162368 | 0773 | - | F | Removal of LAA DRS channel access from UL Type 2 Channel Access description | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0774 | - | D | CR on UL duration and offset field in TS 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0775 | - | F | Correction on channel access priority class according to UL LBT type indication in eLAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0776 | 1 | F | Correction on periodic CSI transmission | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0778 | - | F | CR on UL CWS adjustment for eLAA in 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0779 | 1 | F | CR on trigger monitoring timeline for triggered grants in eLAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0781 | 2 | F | CR on aperiodic CSI reporting for triggered UL grants in LAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0783 | - | F | Correction on CSI measurement in LAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0784 | - | F | Correction on PDCCH candidate configuration | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0786 | - | F | Correction on the UL Type 1 channel access description | 14.1.0 |
| 2016-12 | RAN#74 | RP-162361 | 0787 | - | A | Correction on downlink power allocation for SC-PTM | 14.1.0 |
| 2016-12 | RAN#74 | RP-162359 | 0790 | - | A | Corrections on the description of carrier for NB-IoT in TS 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162359 | 0792 | 2 | A | Corrections on the Table 16.6-2: Type 1- NPDCCH common search space candidates for NB-IoT in TS 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162359 | 0797 | - | A | Control information inconsistent handling for NB-IoT in 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0802 | 1 | F | CR on Multi-carrier LBT for Uplink Transmission | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0803 | - | F | Corrections to EPDCCH candidate derivation procedure for eLAA in TS36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162357 | 0804 | - | A | Correction on DL CWS adjustment for LAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0805 | - | F | Correction on aperiodic CSI only transmission for LAA SCell | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0807 | - | A | CR on RV Cycling for PDSCH | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0809 | 1 | F | CR on UE assumption of LBT success for determining periodic CSI reporting | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0810 | - | F | Correction on continuous transmission after the successful LBT | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0811 | - | A | CR on MCOT limits for carriers on which eNB performs Type B LBT | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0813 | - | F | CR on the UE assumption on multiple UL grants indicating a same subframe | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0814 | - | A | PDSCH transmission on special subframe for eMTC | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0815 | - | F | CR on using 25us LBT for UEs on carriers without eNB Cat 4 LBT | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0816 | - | F | CR on UL resource allocation for 10MHz LAA SCell | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0818 | - | A | DCI for SPS | 14.1.0 |
| 2016-12 | RAN#74 | RP-162358 | 0820 | - | A | Number of MPDCCH-PRB sets | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0821 | - | F | Correction on EPDCCH candidate configuration | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0822 | - | F | CR on applying TPC commands for UL grants in LAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0823 | - | F | CR on PHR reporting for triggered UL grants in LAA | 14.1.0 |
| 2016-12 | RAN#74 | RP-162368 | 0824 | - | F | Correction on PDCCH candidate adjustments | 14.1.0 |
| 2016-12 | RAN#74 | RP-162359 | 0826 | - | A | Correction on NPDCCH and NPD SCH start symbol | 14.1.0 |
| 2016-12 | RAN#74 | RP-162364 | 0827 | - | B | Introduction of SRS switching into 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162365 | 0828 | - | B | Introduction of Multiuser Superposition Transmission (MUST) in 36.213 | 14.1.0 |
| 2016-12 | RAN#74 | RP-162366 | 0829 | - | F | Corrections to 36.213 on V2V | 14.1.0 |
| 2017-03 | RAN#75 | RP-170605 | 0830 | 1 | B | Introduction of Uplink Capacity Enhancements for LTE to 36.213 sections 00-05 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170605 | 0831 | 1 | B | Introduction of Uplink Capacity Enhancements for LTE to 36.213 sections 06-09 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170608 | 0832 | 1 | B | Introduction of eMBMS enhancements for LTE to 36.213 sections 06-09 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170608 | 0833 | 1 | B | Introduction of eMBMS enhancements for LTE to 36.213 sections 10-13 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170610 | 0835 | - | A | Correction on NPDCCH start subframe | 14.2.0 |
| 2017-03 | RAN#75 | RP-170610 | 0837 | - | A | Correction on NRS power in-band with non-integer nrs-CRS-PowerOffset | 14.2.0 |
| 2017-03 | RAN#75 | RP-170606 | 0839 | - | A | Correction on NRS power in-band with non-integer nrs-CRS-PowerOffset | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0841 | - | A | PDSCH dropping rules in special subframes in eMTC | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0843 | - | A | I_0 definition for RV cycling | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0845 | - | A | PUCCH resource determination for M greater than 1 in eMTC | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0847 | - | A | Correction on aperiodic CQI reporting for BL/CE UEs in 1.4MHz system bandwidth | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0849 | - | A | Clarification on Msg 3/4 MPDCCH narrowband index | 14.2.0 |
| 2017-03 | RAN#75 | RP-170618 | 0850 | - | F | CR on two-stage scheduling for eLAA in 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170618 | 0851 | - | F | CR on DCI blind decodes for eLAA in 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170616 | 0852 | - | F | Correction on downlink power allocation for UE with QPSK modulation for MUST in TS 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170618 | 0853 | - | F | Correction on PHR for LAA | 14.2.0 |
| 2017-03 | RAN#75 | RP-170610 | 0855 | - | A | Correction on the description of UE procedure for receiving ACK/NACK | 14.2.0 |
| 2017-03 | RAN#75 | RP-170609 | 0857 | - | A | PUCCH collision in eMTC | 14.2.0 |
| 2017-03 | RAN#75 | RP-170618 | 0858 | - | F | Clarification on channel access procedure for SRS transmission | 14.2.0 |
| 2017-03 | RAN#75 | RP-170610 | 0860 | - | A | NPDCCH starting subframe determination in NB-IoT | 14.2.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|--|--------|
| 2017-03 | RAN#75 | RP-170615 | 0861 | 1 | F | CR for SRS switching in 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170622 | 0863 | - | B | Introduction of V2X | 14.2.0 |
| 2017-03 | RAN#75 | RP-170623 | 0864 | - | B | Introduction of Further Enhanced MTC into 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170624 | 0865 | - | B | Introduction of NB-IoT enhancements for LTE | 14.2.0 |
| 2017-03 | RAN#75 | RP-170625 | 0866 | - | B | Introduction of Voice and Video enhancement for LTE to 36.213 | 14.2.0 |
| 2017-03 | RAN#75 | RP-170607 | 0867 | - | B | Introduction of eFD-MIMO into 36.213 | 14.2.0 |
| 2017-06 | RAN#76 | RP-171196 | 0869 | - | A | Correction on Msg3 PUSCH Repetition for CE mode B | 14.3.0 |
| 2017-06 | RAN#76 | RP-171195 | 0872 | - | F | Correction on UE procedure for receiving PDSCH on FeMBMS/Unicast-mixed carrier in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171205 | 0873 | - | F | Correction on TBS values | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0875 | - | A | Candidate determination for MPDCCH starting in unsupported special subframe for eMTC | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0877 | - | A | PUCCH resource determination in TDD for eMTC | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0879 | - | A | Corrections on UL resource allocation type 0 in TS 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171197 | 0881 | - | A | Timing relationship for RAR monitoring in NB-IoT | 14.3.0 |
| 2017-06 | RAN#76 | RP-171201 | 0882 | - | F | CR on two stage grant DCI field definition | 14.3.0 |
| 2017-06 | RAN#76 | RP-171201 | 0883 | - | F | Correction to SRS Triggering for LAA SCells | 14.3.0 |
| 2017-06 | RAN#76 | RP-171201 | 0884 | - | F | Correction for MCOT value on channel access priority class for UL | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0885 | - | F | Correction on tables used for SCI format 1 in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0886 | - | F | Alignment with 36.212 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0887 | - | F | Mapping of wideband combination index to allocated widebands in FeMTC | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0888 | - | F | Clarification of TBS table for PDSCH with maximum 5 MHz channel bandwidth | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0889 | - | F | UL Type 4 resource allocation | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0890 | - | F | Corrections on PUCCH reporting type payload size in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0891 | - | F | Correction on CSI relaxation for aperiodic CSI-RS | 14.3.0 |
| 2017-06 | RAN#76 | RP-171210 | 0892 | - | B | Introduction of new maximum TBS for DL 256QAM | 14.3.0 |
| 2017-06 | RAN#76 | RP-171192 | 0893 | 1 | F | Removal of Table 8.6.1-4 in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171206 | 0894 | - | F | Modulation overriding in video-voice enhancements | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0895 | - | F | CR on CSI-RS resource activation | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0898 | 1 | F | Corrections on UE partial sensing behaviour in TS 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0899 | - | F | Corrections to 36.213 for Rel-14 eFD-MIMO | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0900 | - | F | Corrections to 36.213 for Rel-14 eFD-MIMO CSI collision handling | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0901 | - | F | Corrections on QCL indication in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0902 | - | F | Corrections on CRI reporting for multi-shot CSI-RS in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171210 | 0903 | - | F | CR on Higher-Layer Parameters for 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0904 | - | F | Clarification of resource allocation for PDSCH in CE mode A | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0905 | - | F | Corrections on the UL resource allocation type 4 in TS 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0906 | - | A | PUCCH format 2 collision with PDSCH with repetitions | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0907 | - | F | CR on subframe indexing in resource reselection | 14.3.0 |
| 2017-06 | RAN#76 | RP-171193 | 0909 | - | A | Determination of PUCCH format selection depending on number of HARQ-ACK, CSI and SR bits | 14.3.0 |
| 2017-06 | RAN#76 | RP-171199 | 0910 | 2 | F | Miscellaneous corrections to 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171197 | 0913 | - | A | Correction on 3.75 kHz NPUSCH format 2 transmission | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0916 | - | F | CR for skipped subframe handling for shorter periodicity in PC5-based V2V | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0918 | - | A | Clarification of the #repetitions used for msg3 retransmissions | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0919 | - | A | CR on MPDCCH PRB Sets – Rel-14 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0921 | 1 | A | Correction of RAR window definition in CE mode B | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0925 | - | F | Correction of UE behavior to meet Crlimit | 14.3.0 |
| 2017-06 | RAN#76 | RP-171204 | 0926 | - | F | Correction on HARQ-ACK bundling and dynamic HARQ-ACK timing in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171200 | 0927 | - | F | Corrections on Power Control for SRS Switching | 14.3.0 |
| 2017-06 | RAN#76 | RP-171210 | 0929 | - | F | Corrections on the numbering of the tables in 8.0 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171192 | 0930 | 1 | F | Corrections on PRB scaling for PUSCH in UpPTS | 14.3.0 |
| 2017-06 | RAN#76 | RP-171194 | 0931 | - | F | CR on CSR for CSI feedback for semi-OL transmission | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0933 | - | A | Clarification of RV Cycling in the presence of invalid SFs | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0935 | - | A | Correction of the calculation of the #RV-blocks for a given PDSCH | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0937 | - | A | Clarification for the overlap of UL TA update and retuning gaps for BL/CE UEs | 14.3.0 |
| 2017-06 | RAN#76 | RP-171196 | 0939 | - | A | Correction on starting OFDM symbol for MPDCCH and PDSCH in special subframe | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0941 | - | F | Correction on abbreviation of Uplink SPS RNTI and Sidelink SPS RNTI in 36.213 | 14.3.0 |
| 2017-06 | RAN#76 | RP-171205 | 0942 | - | F | Timing relationships for 2 HARQ processes | 14.3.0 |
| 2017-06 | RAN#76 | RP-171203 | 0940 | - | F | CR on skipped subframe handling for partial sensing | 14.3.0 |
| 2017-09 | RAN#77 | RP-171646 | 0945 | 1 | F | Clarification of Type1A-CSS candidates | 14.4.0 |
| 2017-09 | RAN#77 | RP-171642 | 0950 | 1 | F | Correction for UCI transmission on LAA sCell | 14.4.0 |
| 2017-09 | RAN#77 | RP-171639 | 0953 | - | A | Correction on MPDCCH search space with CRC scrambled by the C-RNTI outside the random access procedure | 14.4.0 |
| 2017-09 | RAN#77 | RP-171644 | 0955 | - | F | Corrections to Mode-3 scheduling | 14.4.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|---|--------|
| 2017-09 | RAN#77 | RP-171638 | 0956 | - | F | CSI periodicity relationship between eMIMO-Types in hybrid CSI | 14.4.0 |
| 2017-09 | RAN#77 | RP-171637 | 0958 | - | A | Correction on PUCCH format 3 information for eCA | 14.4.0 |
| 2017-09 | RAN#77 | RP-171642 | 0959 | - | F | Correction on periodic CSI reporting for LAA SCell | 14.4.0 |
| 2017-09 | RAN#77 | RP-171649 | 0961 | - | A | Corrections on Class A Codebook in 36.213 | 14.4.0 |
| 2017-09 | RAN#77 | RP-171644 | 0962 | - | F | CR on definition of sensing window | 14.4.0 |
| 2017-09 | RAN#77 | RP-171644 | 0963 | 1 | F | CR on subframe index for PSCCH re-transmission in mode 3 | 14.4.0 |
| 2017-09 | RAN#77 | RP-171636 | 0964 | - | F | Correct RRC parameter for UL 256QAM | 14.4.0 |
| 2017-09 | RAN#77 | RP-171637 | 0966 | - | A | Maximum Code Rate applicability for UCI reporting over PUSCH | 14.4.0 |
| 2017-09 | RAN#77 | RP-171649 | 0968 | - | A | PUCCH priority for CSI report types 7-8-9-10 | 14.4.0 |
| 2017-09 | RAN#77 | RP-171645 | 0969 | - | F | Correction on TBS determination for PDSCH in CE mode B | 14.4.0 |
| 2017-09 | RAN#77 | RP-171650 | 0973 | - | A | SRS dropping for simultaneous SRS and PUSCH in intraband CA | 14.4.0 |
| 2017-09 | RAN#77 | RP-171637 | 0975 | - | A | PUCCH Format 4-5 collision with SRS | 14.4.0 |
| 2017-09 | RAN#77 | RP-171646 | 0976 | - | F | Search space monitoring | 14.4.0 |
| 2017-09 | RAN#77 | RP-171646 | 0977 | - | F | Clarification on NPDCCH monitoring for Rel-14 2-HARQ process UE | 14.4.0 |
| 2017-09 | RAN#77 | RP-171646 | 0978 | - | F | Correction of RAR window timing definition in NB-IoT | 14.4.0 |
| 2017-12 | RAN#78 | RP-172677 | 0979 | 1 | F | PUSCH and SRS Transmission in UpPTS | 14.5.0 |
| 2017-12 | RAN#78 | RP-172682 | 0981 | - | F | CR on CSI report reference subframe for an LAA SCell | 14.5.0 |
| 2017-12 | RAN#78 | RP-172679 | 0983 | - | D | Renaming of duplicated table 7.2.1-1A | 14.5.0 |
| 2017-12 | RAN#78 | RP-172681 | 0985 | 1 | A | Corrections of parameter names for NB-IoT | 14.5.0 |
| 2017-12 | RAN#78 | RP-172686 | 0986 | 1 | F | Clarification on timing relationships of 2 HARQ process | 14.5.0 |
| 2017-12 | RAN#78 | RP-172680 | 0987 | - | A | TBS for TDD special subframe for BL/CE UE without repetition | 14.5.0 |
| 2017-12 | RAN#78 | RP-172680 | 0989 | - | A | Non-repeated PUCCH SR transmissions on invalid UL subframes | 14.5.0 |
| 2017-12 | RAN#78 | RP-172679 | 0990 | - | F | Clarification on supporting lower frequency domain density for Class A NZP CSI-RS | 14.5.0 |
| 2017-12 | RAN#78 | RP-172685 | 0991 | - | F | Corrections on HARQ-ACK bundling | 14.5.0 |
| 2017-12 | RAN#78 | RP-172681 | 0997 | - | A | Typo correction for table 16.5.1.2.1-1 | 14.5.0 |
| 2017-12 | RAN#78 | RP-172678 | 0999 | - | A | Usage of PUCCH format 3 for with more than 5 CC | 14.5.0 |
| 2017-12 | RAN#78 | RP-172684 | 1000 | - | F | Correction on sidelink index field name in DCI format 5A for V2V in 36.213 | 14.5.0 |
| 2017-12 | RAN#78 | RP-172685 | 1001 | - | F | Correction for modulation determination under larger TBS for random access response grant | 14.5.0 |
| 2017-12 | RAN#78 | RP-172692 | 1002 | - | F | Correction on higher layer parameter for eVoLTE | 14.5.0 |
| 2017-12 | RAN#78 | RP-172691 | 1003 | - | F | Correction for dropping rules in intra-band SRS carrier switching | 14.5.0 |
| 2017-12 | RAN#78 | RP-172677 | 1004 | - | F | Change request for UE behaviour under special subframe configuration 10 | 14.5.0 |
| 2017-12 | RAN#78 | RP-172679 | 1005 | - | F | Correction on the scale factor for semi-OL rank-1 | 14.5.0 |
| 2017-12 | RAN#78 | RP-172686 | 1008 | - | F | Correction of NRS-CRS power offset configuration for NB-IoT | 14.5.0 |
| 2017-12 | RAN#78 | RP-172686 | 1009 | - | F | Clarification of carrier indication in DCI format N1 in NB-IoT | 14.5.0 |
| 2017-12 | RAN#78 | RP-172686 | 1010 | - | F | Clarification on 2 HARQ process applicability to UE-specific search space | 14.5.0 |
| 2017-12 | RAN#78 | RP-172686 | 1011 | - | F | Correction of interference in NB-IoT RACH procedure | 14.5.0 |
| 2017-12 | RAN#78 | RP-172693 | 0992 | 1 | B | Introduction of shortened processing time and shortened TTI into 36.213, s00-s05 | 15.0.0 |
| 2017-12 | RAN#78 | RP-172693 | 0993 | 1 | B | Introduction of shortened processing time and shortened TTI into 36.213, s06-s09 | 15.0.0 |
| 2017-12 | RAN#78 | RP-172693 | 0994 | 1 | B | Introduction of shortened processing time and shortened TTI into 36.213, s10-s13 | 15.0.0 |
| 2018-03 | RAN#79 | RP-180195 | 0995 | 2 | B | Introduction of feCoMP into 36.213 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180201 | 1013 | 2 | B | Introducing support for EN-DC Coexistence into TS36.213 s00-s05 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180201 | 1014 | 2 | B | Introducing support for EN-DC Coexistence into TS36.213 s06-s09 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180201 | 1015 | 3 | B | Introducing support for EN-DC Coexistence into TS36.213 s10-s13 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180194 | 1030 | - | A | Correction on CSI reporting for Class B K>1 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180191 | 1032 | - | A | Clarification on UL power control for NB-IoT | 15.1.0 |
| 2018-03 | RAN#79 | RP-180188 | 1035 | - | A | Multiple CSI reports for eCA | 15.1.0 |
| 2018-03 | RAN#79 | RP-180194 | 1036 | - | A | Correction on CSI reporting for Class B K=1 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180190 | 1037 | - | A | Correction to determination of number of PUCCH repetitions for BL/CE UE | 15.1.0 |
| 2018-03 | RAN#79 | RP-180192 | 1038 | - | A | Correction on PUCCH resource determination in HARQ-ACK bundling | 15.1.0 |
| 2018-03 | RAN#79 | RP-180192 | 1039 | - | A | Correction on higher layer parameter <i>schedulingInfoSIB1-BR-r13</i> | 15.1.0 |
| 2018-03 | RAN#79 | RP-180187 | 1040 | - | A | Correction on DwPTS usage in special subframe configuration 10 | 15.1.0 |
| 2018-03 | RAN#79 | RP-180196 | 1041 | - | A | UCI multiplexing for eVoLTE | 15.1.0 |
| 2018-03 | RAN#79 | RP-180198 | 1042 | - | A | Corrections for antenna switching | 15.1.0 |
| 2018-03 | RAN#79 | RP-180193 | 1043 | - | A | Correction on Msg3 power control | 15.1.0 |
| 2018-03 | RAN#79 | RP-180190 | 1048 | - | A | SPS for eMTC | 15.1.0 |
| 2018-06 | RAN#80 | RP-181171 | 1045 | 1 | A | Support of early contention resolution | 15.2.0 |
| 2018-06 | RAN#80 | RP-181170 | 1049 | 2 | F | Corrections for shortened processing time and shortened TTI in 36.213, s00-s05 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181170 | 1050 | 2 | F | Corrections for shortened processing time and shortened TTI in 36.213, s06-s07 | 15.2.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|--|--------|
| 2018-06 | RAN#80 | RP-181170 | 1051 | 2 | F | Corrections for shortened processing time and shortened TTI in 36.213, s10-s13 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181170 | 1052 | 1 | F | Corrections for shortened processing time and shortened TTI in 36.213, s14-xx | 15.2.0 |
| 2018-06 | RAN#80 | RP-181173 | 1053 | 1 | B | Introduction of enhancements for high capacity stationary wireless link and introduction of 1024 QAM for LTE to 36.213 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181180 | 1054 | 1 | B | Introduction of Enhancements to LTE operation in unlicensed spectrum into 36.213 s00-s05 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181180 | 1055 | 2 | B | Introduction of Enhancements to LTE operation in unlicensed spectrum into 36.213 s06-s09 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181180 | 1057 | - | B | Introduction of Enhancements to LTE operation in unlicensed spectrum into 36.213 s14-xx | 15.2.0 |
| 2018-06 | RAN#80 | RP-181162 | 1060 | - | A | Correction on number of subframes for semistatic codebook determination and transmission over PUSCH | 15.2.0 |
| 2018-06 | RAN#80 | RP-181165 | 1063 | - | A | Correction on TBS determination for msg 3 retransmission and CSS for fallback | 15.2.0 |
| 2018-06 | RAN#80 | RP-181181 | 1065 | - | A | Clarification of Msg3 power control in NB-IoT | 15.2.0 |
| 2018-06 | RAN#80 | RP-181161 | 1067 | - | A | On the configuration of UL 256QAM | 15.2.0 |
| 2018-06 | RAN#80 | RP-181179 | 1069 | - | A | Correction on look-ahead for SRS carrier switching | 15.2.0 |
| 2018-06 | RAN#80 | RP-181175 | 1070 | - | B | Introduction of Enhancing CA Utilization into 36.213 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181181 | 1072 | - | A | Clarification of NPUSCH uplink compensation gaps for 2 HARQ processes | 15.2.0 |
| 2018-06 | RAN#80 | RP-181182 | 1073 | - | B | Introduction of reduced control plane latency | 15.2.0 |
| 2018-06 | RAN#80 | RP-181170 | 1074 | 1 | F | Corrections for shortened processing time and shortened TTI in 36.213, s08-s09 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181182 | 1075 | 1 | B | Introduction of SRS antenna switching for 4 ports in TS36.213 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181162 | 1078 | - | A | Correction of a typo further to CR0594 faulty implementation | 15.2.0 |
| 2018-06 | RAN#80 | RP-181162 | 1081 | - | A | Clarification on beta offset for more than 22 HARQ-ACK bits | 15.2.0 |
| 2018-06 | RAN#80 | RP-181162 | 1084 | - | A | Clarification on simultaneousAckNackAndCQI for format 4-5 and format 3 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181162 | 1087 | - | A | Clarification on PUCCH formats | 15.2.0 |
| 2018-06 | RAN#80 | RP-181164 | 1090 | - | A | Correction on PUCCH configuration with CEModeA or CEModeB | 15.2.0 |
| 2018-06 | RAN#80 | RP-181178 | 1092 | - | A | Correction to timing advance | 15.2.0 |
| 2018-06 | RAN#80 | RP-181169 | 1094 | - | A | Correction on RV determination for eVoLTE | 15.2.0 |
| 2018-06 | RAN#80 | RP-181165 | 1096 | - | A | Corrections in Physical Resource Block numbering to RA Type0 for FeMTC UEs | 15.2.0 |
| 2018-06 | RAN#80 | RP-181182 | 1097 | - | B | Introduction of advanced CSI CBSR in TS 36.213 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181181 | 1099 | - | A | Clarification of NPUSCH reception in 2 NB-IoT HARQ processes | 15.2.0 |
| 2018-06 | RAN#80 | RP-181175 | 1100 | - | B | Short CQI Reporting for EuCA | 15.2.0 |
| 2018-06 | RAN#80 | RP-181174 | 1101 | 1 | B | Introduction of even further enhanced MTC for LTE in 36.213, s00-s05 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181174 | 1102 | 1 | B | Introduction of even further enhanced MTC for LTE in 36.213, s06-s07 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181174 | 1103 | 1 | B | Introduction of even further enhanced MTC for LTE in 36.213, s08-s09 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181166 | 1104 | 1 | B | Introduction of Rel-15 Further NB-IoT enhancements in 36.213, s14 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181182 | 1105 | - | B | Introduction of modulation enhancements | 15.2.0 |
| 2018-06 | RAN#80 | RP-181168 | 1106 | - | F | Corrections to feCoMP in 36.213, s06-s07 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181176 | 1107 | - | B | Addition of V2X Phase 2 based on LTE in 36.213, s14 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181177 | 1108 | - | B | Introduction of HRLLC for LTE in 36.213, s07-1 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181177 | 1109 | - | B | Introduction of HRLLC for LTE in 36.213, s07-3 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181177 | 1110 | - | B | Introduction of HRLLC in 36.213, s08 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181177 | 1111 | - | B | Introduction of HRLLC in 36.213, s09 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181177 | 1112 | - | B | Introduction of HRLLC in 36.213, s10 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181277 | 1113 | - | B | Introduction of Aerial for LTE in 36.213, s00-s05 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181172 | 1114 | - | F | Correction for EN-DC Coexistence into TS36.213 s06-s07 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181172 | 1115 | - | F | Correction for EN-DC Coexistence into TS36.213 s08-s09 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181172 | 1116 | - | F | Correction for EN-DC Coexistence into TS36.213 s00-s05 | 15.2.0 |
| 2018-06 | RAN#80 | RP-181172 | 1117 | - | F | Correction for EN-DC Coexistence into TS36.213 s00-s05 | 15.2.0 |
| 2018-09 | RAN#81 | RP-181785 | 1118 | - | F | Correction on CRI definition in 36.213 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181781 | 1123 | - | A | PRG for eMTC | 15.3.0 |
| 2018-09 | RAN#81 | RP-181779 | 1126 | - | A | Correction on TDD HARQ-ACK reporting procedure for different UL/DL configurations | 15.3.0 |
| 2018-09 | RAN#81 | RP-181779 | 1128 | - | A | Correction on PUCCH format 4 HARQ-ACK procedure without adaptive codebook | 15.3.0 |
| 2018-09 | RAN#81 | RP-181784 | 1131 | - | A | Correction to PDSCH RE mapping in TM10 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181780 | 1133 | - | A | Correction on advanced CSI codebook | 15.3.0 |
| 2018-09 | RAN#81 | RP-181794 | 1137 | - | A | Corrections related to capabilities for SRS Carrier Switching | 15.3.0 |
| 2018-09 | RAN#81 | RP-181788 | 1139 | - | A | Capability for FeMBMS | 15.3.0 |
| 2018-09 | RAN#81 | RP-181778 | 1141 | - | A | SRS transmission in UpPTS for special subframe configuration 10 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181778 | 1143 | - | A | HARQ-ACK payload size determination for crs-less special subframe configuration 10 | 15.3.0 |

| | | | | | | | |
|---------|--------|-----------|------|---|---|--|--------|
| 2018-09 | RAN#81 | RP-181785 | 1144 | - | F | Correction on aperiodic CSI triggering for feCoMP in 36.213 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181797 | 1145 | 1 | F | Corrections related to modulation enhancements | 15.3.0 |
| 2018-09 | RAN#81 | RP-181790 | 1146 | - | F | Applicability of 1024QAM to SPS C-RNTI | 15.3.0 |
| 2018-09 | RAN#81 | RP-181790 | 1147 | - | F | Removal of R_CSI from 1024QAM CQI table | 15.3.0 |
| 2018-09 | RAN#81 | RP-181786 | 1149 | - | A | Clarification for antenna selection | 15.3.0 |
| 2018-09 | RAN#81 | RP-181800 | 1153 | - | A | Change request on UE transmit antenna selection | 15.3.0 |
| 2018-09 | RAN#81 | RP-181797 | 1154 | - | B | Change request on 1T2R antenna switching of SRS | 15.3.0 |
| 2018-09 | RAN#81 | RP-181795 | 1155 | - | F | Correction to AUL-UCI resource allocation in 36.213 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181782 | 1157 | - | A | Correction for HARQ-ACK delay in eMTC | 15.3.0 |
| 2018-09 | RAN#81 | RP-181787 | 1158 | - | F | Corrections for shortened processing time and shortened TTI in 36.213, s00-s05 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181787 | 1159 | - | F | Corrections for shortened processing time and shortened TTI in 36.213, s06-s07 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181787 | 1160 | - | F | Corrections for shortened processing time and shortened TTI in 36.213, s08-s09 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181787 | 1161 | - | F | Corrections for shortened processing time and shortened TTI in 36.213, s10-s13 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181792 | 1162 | - | F | Correction to V2X Phase 2 based on LTE in 36.213, s14 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181791 | 1163 | - | D | Corrections to even further enhanced MTC for LTE in 36.213, s00-s05 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181791 | 1164 | - | F | Corrections to even further enhanced MTC for LTE in 36.213, s06-s07 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181791 | 1165 | - | F | Corrections to even further enhanced MTC for LTE in 36.213, s08-s09 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181783 | 1166 | - | D | Editorial corrections to Rel-15 Further NB-IoT enhancements in 36.213, s2 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181783 | 1167 | - | F | Corrections to Rel-15 Further NB-IoT enhancements in 36.213, s14 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181793 | 1168 | - | F | Corrections to HRLLC in 36.213, s00-s05 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181793 | 1169 | - | F | Corrections to HRLLC in 36.213, s06-s07 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181793 | 1170 | - | F | Corrections to HRLLC in 36.213, s08-s09 | 15.3.0 |
| 2018-09 | RAN#81 | RP-181791 | 1171 | - | F | Corrections to even further enhanced MTC for LTE in 36.213, s14-xx | 15.3.0 |
| 2018-12 | RAN#82 | RP-182520 | 1174 | - | A | Correction for Type 6 report for FD-MIMO | 15.4.0 |
| 2018-12 | RAN#82 | RP-182518 | 1176 | - | A | Correction on PDSCH RE mapping around aperiodic zero power CSI-RS | 15.4.0 |
| 2018-12 | RAN#82 | RP-182528 | 1178 | - | A | Correction on NB-IoT DL subframe definition on non-anchor carriers | 15.4.0 |
| 2018-12 | RAN#82 | RP-182527 | 1180 | - | A | HARQ reference configuration for SRS carrier switching | 15.4.0 |
| 2018-12 | RAN#82 | RP-182517 | 1182 | - | A | Aperiodic CSI report for PUSCH in UpPTS | 15.4.0 |
| 2018-12 | RAN#82 | RP-182522 | 1183 | - | F | Correction on subslot-SPUCCH resource for formats 1a and 1b | 15.4.0 |
| 2018-12 | RAN#82 | RP-182522 | 1184 | - | F | Corrections related to CSI update capability for sTTI | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1185 | - | F | UL SPS repetition counting | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1186 | - | F | Validation of SPS for one UL SPS configuration | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1187 | - | F | On activation of UL SPS configuration | 15.4.0 |
| 2018-12 | RAN#82 | RP-182517 | 1189 | - | A | CSI reference resource with crs-less-ssp10 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1190 | - | F | Corrections on subframe-PDSCH repetition with eIMTA | 15.4.0 |
| 2018-12 | RAN#82 | RP-182524 | 1191 | 2 | F | Corrections to even further enhanced MTC for LTE in 36.213, s06-s07 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182524 | 1192 | 2 | F | Corrections to even further enhanced MTC for LTE in 36.213, s08-s09 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182519 | 1193 | 2 | F | Corrections to Rel-15 Further NB-IoT enhancements in 36.213, s14-xx | 15.4.0 |
| 2018-12 | RAN#82 | RP-182527 | 1195 | - | A | Correction for SRS triggering for SRS carrier switching | 15.4.0 |
| 2018-12 | RAN#82 | RP-182527 | 1197 | - | A | Applicability of 1 and 2 bit field for DCI format 3B | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1198 | - | F | Correction on slot-PDSCH repetition for TDD | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1199 | - | F | Correction on DCI validation for UL SPS | 15.4.0 |
| 2018-12 | RAN#82 | RP-182529 | 1200 | - | F | Correction on references to MCS table | 15.4.0 |
| 2018-12 | RAN#82 | RP-182526 | 1201 | - | F | Corrections on UL SPS repetition | 15.4.0 |
| 2018-12 | RAN#82 | RP-182521 | 1202 | - | F | Correction on CQI definition for feCoMP in 36.213 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182527 | 1204 | 1 | A | Correction on look-ahead for PHR determination in SRS carrier switching | 15.4.0 |
| 2018-12 | RAN#82 | RP-182525 | 1205 | - | F | Correction on resource exclusion procedure for V2X Phase 2 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182524 | 1206 | 1 | F | Corrections to even further enhanced MTC for LTE in 36.213, s00-s05 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182524 | 1207 | 1 | F | Corrections to even further enhanced MTC for LTE in 36.213, s10-s13 | 15.4.0 |
| 2018-12 | RAN#82 | RP-182525 | 1208 | - | F | CR on sensing and reporting for mode 3 in Rel-15 eV2X | 15.4.0 |
| 2019-03 | RAN#83 | RP-190434 | 1210 | - | A | Correction of higher layer signalling for special subframe configuration 10 | 15.5.0 |
| 2019-03 | RAN#83 | RP-190439 | 1212 | - | A | Priority rules for SRS carrier switching | 15.5.0 |
| 2019-03 | RAN#83 | RP-190439 | 1214 | - | A | Support of 6-symbol SRS in UpPTS | 15.5.0 |
| 2019-03 | RAN#83 | RP-190445 | 1216 | - | A | Corrections for VoLTE enhancements | 15.5.0 |

| | | | | | | | |
|---------|----------|-----------|------|---|---|--|--------|
| 2019-03 | RAN#83 | RP-190443 | 1219 | - | A | Correction for TDD UL/DL configuration 0 and PUSCH with repetitions | 15.5.0 |
| 2019-03 | RAN#83 | RP-190445 | 1221 | - | A | Power control for PUSCH enhancements | 15.5.0 |
| 2019-03 | RAN#83 | RP-190437 | 1222 | - | F | Correction on the MCS index range for DCI format 6-1A | 15.5.0 |
| 2019-03 | RAN#83 | RP-190437 | 1223 | - | F | Edge PRB restriction for flexible starting PUSCH PRB for LTE-MTC | 15.5.0 |
| 2019-03 | RAN#83 | RP-190438 | 1225 | - | A | Correction on PSSCH resource pool determination in 36.213 | 15.5.0 |
| 2019-03 | RAN#83 | RP-190443 | 1228 | - | A | UL Delay for CE Mode B | 15.5.0 |
| 2019-03 | RAN#83 | RP-190446 | 1229 | - | F | Introduction of SUO Case 1 for NE-DC as Rel-15 late drop | 15.5.0 |
| 2019-03 | RAN#83 | RP-190436 | 1230 | - | F | Corrections on CSI update capability for sTTI | 15.5.0 |
| 2019-03 | RAN#83 | RP-190436 | 1231 | - | F | Correction on type 2 power headroom | 15.5.0 |
| 2019-03 | RAN#83 | RP-190436 | 1232 | - | F | Correction on the 1ms HARQ-ACK transmission for the collision between sPUSCH and PUCCH/PUSCH | 15.5.0 |
| 2019-03 | RAN#83 | RP-190435 | 1233 | - | F | Correction on NPRACH format 2 configuration presence | 15.5.0 |
| 2019-03 | RAN#83 | RP-190441 | 1235 | - | A | Power control for RACH-less HO | 15.5.0 |
| 2019-03 | RAN#83 | RP-190445 | 1237 | - | A | Correction for DCI 0C and special subframe configuration 10 | 15.5.0 |
| 2019-03 | RAN#83 | RP-190445 | 1239 | - | A | HARQ ID for asynchronous HARQ with DCI format 0 | 15.5.0 |
| 2019-03 | RAN#83 | RP-190442 | 1241 | - | A | On MPDCCH USS/CSS differentiation | 15.5.0 |
| 2019-03 | RAN#83 | RP-190437 | 1242 | - | F | EPRF for RSS | 15.5.0 |
| 2019-03 | RAN#83 | RP-190446 | 1243 | - | F | Correction on UL HARQ for EN-DC with SUO Case 1 | 15.5.0 |
| 2019-06 | RAN#84 | RP-191271 | 1244 | - | F | DCI formats for alternative TBS in 1024QAM | 15.6.0 |
| 2019-06 | RAN#84 | RP-191279 | 1245 | - | F | (Late drop) Correction on UL HARQ for NE-DC with SUO Case 1 | 15.6.0 |
| 2019-06 | RAN#84 | RP-191268 | 1247 | - | A | Dropping rule for PUSCH in UpPTS + aperiodic SRS + periodic SRS | 15.6.0 |
| 2019-06 | RAN#84 | RP-191270 | 1248 | - | F | Corrections related to CSI feedback with 64-QAM | 15.6.0 |
| 2019-06 | RAN#84 | RP-191269 | 1249 | - | F | Correction on NB-IoT SPS power control | 15.6.0 |
| 2019-06 | RAN#84 | RP-191272 | 1252 | - | A | Correction for overlapping MPDCCH search spaces | 15.6.0 |
| 2019-06 | RAN#84 | RP-191272 | 1255 | 1 | A | On set of candidates for different ALs for MPDCCH in USS | 15.6.0 |
| 2019-06 | RAN#84 | RP-191270 | 1256 | - | F | EPRF for MWUS | 15.6.0 |
| 2019-06 | RAN#84 | RP-191269 | 1257 | 1 | F | Parameter Correction in NPUSCH power control equation and Enhanced power headroom set for NB-IoT | 15.6.0 |
| 2019-06 | RAN#84 | RP-191276 | 1260 | - | A | Clarification on Class A periodic CSI reporting using PUCCH | 15.6.0 |
| 2019-06 | RAN#84 | RP-191269 | 1261 | - | F | Correction on timing relationship for UE configured with EDT | 15.6.0 |
| 2019-06 | RAN#84 | RP-191279 | 1262 | - | F | Correction on calculation of Multiple Entry PHR for EN-DC and NE-DC | 15.6.0 |
| 2019-09 | RAN#85 | RP-191938 | 1263 | - | F | Correction on maximum number of HARQ processes for Case 1 HARQ timing | 15.7.0 |
| 2019-09 | RAN#85 | RP-191945 | 1264 | - | F | TBS scaling with configuration of different modulation orders | 15.7.0 |
| 2019-09 | RAN#85 | RP-191935 | 1266 | - | A | Support of MPDCCH in CRS-less ssp10 | 15.7.0 |
| 2019-09 | RAN#85 | RP-191945 | 1267 | 1 | F | Correction on higher layer parameter configuring short TTI length in 36.213 | 15.7.0 |
| 2019-09 | RAN#85 | RP-191936 | 1268 | - | F | Correction on high layer parameters related to EDT and SR | 15.7.0 |
| 2019-09 | RAN#85 | RP-191947 | 1270 | - | A | Correction on UE procedure for transmitting PSCCH in mode 3 | 15.7.0 |
| 2019-09 | RAN#85 | RP-191938 | 1271 | - | F | Correction on calculation of Multiple Entry PHR for EN-DC and NE-DC | 15.7.0 |
| 2019-12 | RAN#86 | RP-192620 | 1274 | - | A | Clarification to postponing in subframes that are not BL/CE subframes | 15.8.0 |
| 2019-12 | RAN#86 | RP-192619 | 1276 | - | A | Correction on repetition number of MPDCCH with HARQ-ACK bundling | 15.8.0 |
| 2019-12 | RAN#86 | RP-192619 | 1278 | - | A | Correction to HARQ-ACK delay | 15.8.0 |
| 2019-12 | RAN#86 | RP-192621 | 1279 | - | F | Correction on antenna switching parameter in UE sounding procedure in 36.213 | 15.8.0 |
| 2019-12 | RAN#86 | RP-192630 | 1280 | - | F | Correction on SPDCCH monitoring for TS 36.213 | 15.8.0 |
| 2019-12 | RAN#86 | RP-192633 | 1281 | - | F | NPDCCH start position for special subframe | 15.8.0 |
| 2019-12 | RAN#86 | RP-192622 | 1282 | - | F | Correction on PUSCH scheduling with CSS for Case 1 HARQ timing | 15.8.0 |
| 2019-12 | RAN#86 | RP-192618 | 1283 | - | F | Correction to 64-QAM TBS determination for eMTC | 15.8.0 |
| 2019-12 | RAN#86 | RP-192619 | 1285 | - | A | Clarification for PUCCH resource determination with HARQ-ACK bundling | 15.8.0 |
| 2019-12 | RAN#86 | RP-192630 | 1286 | - | F | Correction on TPC accumulation reset for short TTI | 15.8.0 |
| 2020-03 | RAN#87-e | RP-200201 | 1301 | - | A | Correction on priority value in LTE V2X | 15.9.0 |
| 2020-03 | RAN#87-e | RP-200182 | 1302 | - | F | Correction on Msg3 NPUSCH for NB-IoT EDT | 15.9.0 |

| | | | | | | | |
|---------|----------|-----------|------|---|---|--|---------|
| 2020-03 | RAN#87-e | RP-200179 | 1305 | - | A | Corrections on the indication value for the transport blocks in a bundle for HD-FDD eMTC UEs | 15.9.0 |
| 2020-03 | RAN#87-e | RP-200180 | 1310 | - | A | Clarification on MPDCCH monitoring during UL gaps | 15.9.0 |
| 2020-06 | RAN#88-e | RP-200683 | 1318 | - | F | Correction on PUSCH and PDSCH scheduling with CSS | 15.10.0 |
| 2020-06 | RAN#88-e | RP-200682 | 1320 | - | A | Clarification on set of values for HARQ delay | 15.10.0 |
| 2020-06 | RAN#88-e | RP-200682 | 1322 | - | A | Clarification on PUCCH collision for HARQ-ACK bundling | 15.10.0 |
| 2020-06 | RAN#88-e | RP-200684 | 1324 | - | F | Correction on Msg3 NPUSCH retransmission for NB-IoT EDT | 15.10.0 |
| 2020-06 | RAN#88-e | RP-200681 | 1326 | - | F | CR on excluding TDD special subframes for MWUS maximum and actual duration | 15.10.0 |
| 2020-06 | RAN#88-e | RP-200704 | 1329 | - | A | Correction on NPDCCCH monitoring for NB-IoT | 15.10.0 |