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

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 }_[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 $n+k_1$, $k_1 \geq 6$, if the UL delay field in Subclause 6.2 is set to zero where $n+k_1$ 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:
- where $N_{\mathrm{NB}} = \left\lfloor N_{\mathrm{RB}}^{\mathrm{UL}} / 6 \right\rfloor$ and $N_{\mathrm{NB}}^{index} = \left\lceil \log_2(N_{\mathrm{NB}}) \right\rceil$

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

DCI contents	CEmodeA	CEmodeB
Msg3 PUSCH narrowband index	N_{NB}^{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_{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.
- NB_{RAR} given in Table 6.2-A and Table 6.2-B 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'	$(NB_{RAR}+3) \bmod N_{NB}$

- 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. The number of downlink narrowbands is given by $N_{\mathrm{NB2}} = \lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / 6 \rfloor$.

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'	$(NB_{RAR}+3) \bmod N_{NB2}$

- The repetition number field in the random access response grant configured by higher layers indicates the repetition level 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 $Y_B = 512$.

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}
mod(Preamble Index, 2)=0	First narrowband configured by high layer parameter *mpdcch-NarrowbandsToMonitor-r13*
mod(Preamble Index, 2)=1	Second narrowband configured by high layer parameter *mpdcch-NarrowbandsToMonitor-r13*

- The resource allocation field is interpreted as follows:
  - For CEmodeA, 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 configured with a 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 $N_{\mathrm{RB}}^{\mathrm{UL}} \le 44$

  - Truncate the fixed size resource block assignment to its *b* least significant bits, where $b = \left\lceil \log_2\left(N_{\mathrm{RB}}^{\mathrm{UL}} \cdot \left(N_{\mathrm{RB}}^{\mathrm{UL}}+1\right)/2\right)\right\rceil$, 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_{UL_hop} hopping bits in the fixed size resource block assignment, where the number of hopping bits N_{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 $b = \left(\left\lceil \log_2\left(N_{\mathrm{RB}}^{\mathrm{UL}} \cdot \left(N_{\mathrm{RB}}^{\mathrm{UL}}+1\right)/2\right)\right\rceil - 10\right)$, 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.

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 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;

- 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 8 downlink HARQ processes per serving cell.

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 shall be 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 shall be 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 shall be 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.

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

decode the corresponding PDSCH in the same subframe with the restriction of the number of transport blocks defined in the higher layers.

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 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 according to one of the transmission modes, denoted mode 1 to mode 10.

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 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 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.

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 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, $n_{\mathrm{ID}}^{\mathrm{DMRS},i}$, $i = 0,1$ 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	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	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	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	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
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)
Mode 9	DCI format 1A	Common and UE specific by C-RNTI	• 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 *semiOpenLoop,* 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 *dmrs-tableAlt,* 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	• 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 *semiOpenLoop,* 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 *dmrs-tableAlt*, single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise

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	• 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 *semiOpenLoop,* 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 *dmrs-tableAlt*, single-antenna port, port 7 or 8 (see Subclause 7.1.1) otherwise
Mode 10	DCI format 1A	UE specific by C-RNTI	• 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 *semiOpenLoop,* 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 *dmrs-tableAlt*, 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)

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. 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, or upon detection of a EPDCCH with CRC scrambled by the SPS C-RNTI with DCI format 1A/2C/2D, or for a configured PDSCH without PDCCH 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, $n_{\mathrm{ID}}^{\mathrm{DMRS},i}$, $i = 0,1$ 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 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 $n_{\mathrm{ID}}^{(n_{\mathrm{SCID}})}$ (as defined in Subclause 6.10.3.1 of [3]) derived from the DCI format 2D 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	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	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	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	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)
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	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 *semiOpenLoop,* or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter *dmrs-tableAlt*, 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 *semiOpenLoop,* or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter *dmrs-tableAlt*, 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 *semiOpenLoop,* or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter *dmrs-tableAlt*, 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 *semiOpenLoop,* or single-antenna port, port 7, 8, 11, or 13 (see Subclause 7.1.1) if UE is configured with higher layer parameter *dmrs-tableAlt*, 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.

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} , $n_{\mathrm{ID}}^{(n_{\mathrm{SCID}})}$ 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 *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 *schedulingInfoSIB1-BR*	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].
- $N'^{DL}_{RB}=6\cdot\left\lfloor\frac{N^{DL}_{RB}}{6}\right\rfloor$ and N'^{DL}_{RB} is used in place of N^{DL}_{RB} 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 7.1.6.1-1.

The total number of RBGs (N_{RBG}) for downlink system bandwidth of $N_{\text{RB}}^{\text{DL}}$ is given by $N_{RBG} = \lceil N_{\text{RB}}^{\text{DL}} / P \rceil$ where $\lfloor N_{\text{RB}}^{\text{DL}} / P \rfloor$ of the RBGs are of size P and if $N_{\text{RB}}^{\text{DL}} \bmod P > 0$ then one of the RBGs is of size $N_{\text{RB}}^{\text{DL}} - P \cdot \lfloor N_{\text{RB}}^{\text{DL}} / P \rfloor$. 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 $N_{\text{RBG}}^{\text{UL}}$ with N_{RBG} , 'uplink' with 'downlink' , and $N_{\text{RB}}^{\text{UL}}$ with $N_{\text{RB}}^{\text{DL}}$ (but not $N'^{\text{DL}}_{\text{RB}}$).

otherwise

- The RBGs shall be indexed in the order of increasing frequency and non-increasing 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

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 $0 \le p < P$, 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,

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

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

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

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. 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, distributed VRB allocations for a UE vary from $N_{\text{RB}}^{\text{step}}$ VRB(s) up to $\lfloor N_{\text{VRB}}^{\text{DL}} / N_{\text{RB}}^{\text{step}} \rfloor \cdot N_{\text{RB}}^{\text{step}}$ 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.

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

For PDCCH DCI format 1A, 1B or 1D, or for EPDCCH DCI format 1A, 1B, or 1D, or for MPDCCH DCI format 6-1A, 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 $(L_{CRBs}-1) \le \lfloor N_{RB}^{DL}/2 \rfloor$ then

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

else

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

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

For PDCCH DCI format 1C, a type 2 resource block assignment field consists of a resource indication value (*RIV*) corresponding to a starting resource block ($RB_{start} = 0,\ N_{\mathrm{RB}}^{\mathrm{step}},\ 2N_{\mathrm{RB}}^{\mathrm{step}},\ldots,\ (\lfloor N_{\mathrm{VRB}}^{\mathrm{DL}}/N_{\mathrm{RB}}^{\mathrm{step}} \rfloor - 1)N_{\mathrm{RB}}^{\mathrm{step}}$) and a length in terms of virtually contiguously allocated resource blocks ($L_{CRBs} = N_{\mathrm{RB}}^{\mathrm{step}},\ 2N_{\mathrm{RB}}^{\mathrm{step}},\ldots,\ \lfloor N_{\mathrm{VRB}}^{\mathrm{DL}}/N_{\mathrm{RB}}^{\mathrm{step}} \rfloor \cdot N_{\mathrm{RB}}^{\mathrm{step}}$).
The resource indication value is defined by:

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

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

else

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

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

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

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 $l_{\mathrm{DataStart}}$.

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*
  - $l_{\mathrm{DataStart}}$ is given by the higher-layer parameter *epdcch-StartSymbol-r11*.
- else if PDSCH and the corresponding PDCCH/EPDCCH are received on different serving cells
  - $l_{\mathrm{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received,
- Otherwise
  - $l_{\mathrm{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\mathrm{RB}}^{\mathrm{DL}} > 10$, and $l_{\mathrm{DataStart}}$ is given by the CFI value + 1 in the subframe of the given serving cell when $N_{\mathrm{RB}}^{\mathrm{DL}} \le 10$.

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 $N_{\text{RB}}^{\text{DL}} \le 10$.
- 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 $N_{\text{RB}}^{\text{DL}} \le 10$.
  - 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
- 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 $N_{\text{RB}}^{\text{DL}} \le 10$.
- 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 $N_{\text{RB}}^{\text{DL}} \le 10$ 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
    - $l_{\text{DataStart}} = \min\left(2, l'_{\text{DataStart}}\right)$
  - 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.

Fixed system bandwidth dependent Precoding Resource block Groups (PRGs) of size P' partition the system bandwidth and each PRG consists of consecutive PRBs. If $N_{\mathrm{RB}}^{\mathrm{DL}} \bmod P' > 0$ then one of the PRGs is of size $N_{\mathrm{RB}}^{\mathrm{DL}} - P'\left\lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / P' \right\rfloor$. 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 P' =3 otherwise the PRG size a UE may assume for a given system bandwidth is given by:

Table 7.1.6.5-1

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

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
    - 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 $I_{\mathrm{MCS}}^{1} > 15$
  - 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 $I_{\mathrm{MCS}}^{1} > 7$
  - 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 $I_{\mathrm{TBS}}^{1} = I_{\mathrm{MCS}}^{1}$.
  - 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-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 $N_{\mathrm{PRB}}^{1\mathrm{A}}$ 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 $N_{\mathrm{PRB}}^{1\mathrm{A}}$ 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 ≥5MHz and not configured with higher layer parameter *mpdcch-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:
    - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\mathrm{PRB}} \times 0.375 \right\rfloor, \quad 1\right\}$
  - for other special subframe configurations:
    - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\mathrm{PRB}} \times 0.75 \right\rfloor, \quad 1\right\}$,
  - else set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.
- otherwise
  - set N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Subclause 7.1.6.
  - 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:
      - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\mathrm{PRB}} \times 0.375 \right\rfloor, \quad 1\right\}$
    - for other special subframe configurations:
      - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\mathrm{PRB}} \times 0.75 \right\rfloor, \quad 1\right\}$,
  - else, set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = N'_{PRB}$.

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 with the higher layer parameter *crs-LessDwPTS-r14* set as *true*, 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^{1}_{MCS} 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 carriers *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 *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 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 Q_m	Modulation Order 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 Q_m	Modulation Order 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 Q_m	Modulation Order 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	

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 $\left(n_{\text{abs},1}-\delta\right)\bmod N_{\text{acc}}=0$, 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 non-BL/CE subframes where the PDSCH transmission is postponed. Note that BL/CE subframe(s) refers to either BL/CE DL subframe(s) or BL/CE UL subframe(s). 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 $rv=\left(j+rv_{DCI}\right)\bmod 4$, where $j=0,1,...,J^{\text{PDSCH}}-1$, and $J^{\text{PDSCH}}=\left\lceil\frac{N_{\text{abs}}^{\text{PDSCH}}+((i_0-\delta)\bmod N_{acc})}{N_{\text{acc}}}\right\rceil$. The J^{PDSCH} 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 *rv*	rv_{idx}
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 $0 \le I_{TBS} \le 26$.
- 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 *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 $0 \le I_{MCS} \le 28$, 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 $29 \le I_{MCS} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \le I_{TBS} \le 33$. If there is no PDCCH/EPDCCH for the same transport block using $0 \le I_{TBS} \le 26$, 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 $0 \le I_{MCS} \le 27$, 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 $28 \le I_{MCS} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \le I_{MCS} \le 27$.
  - 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 UE supports *ce-pdsch-pusch-maxBandwidth* with value ≥5MHz

- 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, TBS is determined by the procedure in Subclause 7.1.7.2.8 for $0 \le I_{\text{TBS}} \le 14$
  - For CEModeB, TBS is determined by the procedure in Subclause 7.1.7.2.8 for $0 \le I_{\text{TBS}} \le 9$
- if the UE is configured with higher layer parameter *ce-pdsch-maxBandwidth-config* with value > 5MHz
  - For CEModeA, TBS is determined by the procedure in Subclause 7.1.7.2.1 for $0 \le I_{\text{TBS}} \le 14$
  - For CEModeB, TBS is determined by the procedure in Subclause 7.1.7.2.1 for $0 \le I_{\text{TBS}} \le 9$
- otherwise,
  - TBS is determined by the procedure in Subclause 7.1.7.2.1

else

- for $0 \le I_{\text{MCS}} \le 28$, 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 $I_{\text{MCS}} = 28$, 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 $29 \le I_{\text{MCS}} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \le I_{\text{MCS}} \le 28$. If there is no PDCCH/EPDCCH for the same transport block using $0 \le I_{\text{MCS}} \le 28$, 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, 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 $1 \le N_{\text{PRB}} \le 110$, the TBS is given by the (I_{TBS} , N_{PRB}) entry of Table 7.1.7.2.1-1.

Table 7.1.7.2.1-1: Transport block size table (dimension 39×110)

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	4584	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	22920	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	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	2536	2600	2664	2664
3	2984	2984	3112	3112	3240	3240	3368	3368	3496	3496
4	3624	3752	3752	3880	4008	4008	4136	4136	4264	4264
5	4584	4584	4776	4776	4776	4968	4968	5160	5160	5352
6	5352	5352	5544	5736	5736	5992	5992	5992	6200	6200
7	6200	6456	6456	6712	6712	6712	6968	6968	7224	7224
8	7224	7224	7480	7480	7736	7736	7992	7992	8248	8504
9	7992	8248	8248	8504	8760	8760	9144	9144	9144	9528
10	9144	9144	9144	9528	9528	9912	9912	10296	10296	10680
11	10296	10680	10680	11064	11064	11448	11448	11832	11832	12216
12	11832	11832	12216	12216	12576	12576	12960	12960	13536	13536
13	12960	13536	13536	14112	14112	14688	14688	14688	15264	15264
14	14688	14688	15264	15264	15840	15840	16416	16416	16992	16992
15	15840	15840	16416	16416	16992	16992	17568	17568	18336	18336
16	16416	16992	16992	17568	17568	18336	18336	19080	19080	19848
17	18336	19080	19080	19848	19848	20616	20616	20616	21384	21384
18	19848	20616	21384	21384	22152	22152	22920	22920	23688	23688
19	22152	22152	22920	22920	23688	24496	24496	25456	25456	25456
20	23688	24496	24496	25456	25456	26416	26416	27376	27376	28336
21	25456	26416	26416	27376	27376	28336	28336	29296	29296	30576
22	27376	28336	28336	29296	29296	30576	30576	31704	31704	32856
23	29296	29296	30576	30576	31704	31704	32856	32856	34008	34008
24	31704	31704	32856	32856	34008	34008	35160	35160	36696	36696
25	32856	32856	34008	34008	35160	35160	36696	36696	37888	37888
26	37888	37888	39232	40576	40576	40576	42368	42368	43816	43816
26A	32856	34008	34008	35160	36696	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	3112
3	3624	3624	3624	3752	3752	3880	3880	4008	4008	4136
4	4392	4392	4584	4584	4584	4776	4776	4968	4968	4968
5	5352	5544	5544	5736	5736	5736	5992	5992	5992	6200
6	6456	6456	6456	6712	6712	6968	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	22152	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	29296	30576
20	28336	29296	29296	29296	30576	30576	31704	31704	31704	32856
21	30576	31704	31704	31704	32856	32856	34008	34008	35160	35160
22	32856	34008	34008	34008	35160	35160	36696	36696	36696	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	11832	12216	12216	12576	12576
10	12576	12576	12960	12960	12960	13536	13536	13536	14112	14112
11	14112	14688	14688	14688	15264	15264	15840	15840	15840	16416
12	16416	16416	16416	16992	16992	17568	17568	17568	18336	18336
13	18336	18336	19080	19080	19080	19848	19848	19848	20616	20616
14	20616	20616	20616	21384	21384	22152	22152	22152	22920	22920
15	22152	22152	22152	22920	22920	23688	23688	23688	24496	24496
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	29296	30576	30576	30576	31704	31704
19	30576	30576	31704	31704	32856	32856	32856	34008	34008	34008
20	32856	34008	34008	34008	35160	35160	35160	36696	36696	36696
21	35160	36696	36696	36696	37888	37888	39232	39232	39232	40576
22	37888	39232	39232	40576	40576	40576	42368	42368	42368	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	48936	51024	51024
26	52752	52752	55056	55056	55056	55056	57336	57336	57336	59256
26A	45352	46888	46888	48936	48936	48936	51024	51024	51024	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	28336	29296	29296
17	29296	29296	30576	30576	30576	30576	31704	31704	31704	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	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	31704	32856
17	32856	32856	34008	34008	34008	35160	35160	35160	35160	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	45352	46888	46888
21	45352	46888	46888	46888	46888	48936	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	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	7736	7992
5	8760	9144	9144	9144	9144	9528	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	16992	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	24496	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	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

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

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

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

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

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

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	59256	61664
33B	59256	61664	61664	63776	63776	63776	66592	66592	68808	68808

34	63776	63776	66592	66592	68808	68808	71112	71112	71112	73712

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	52752	55056	55056	55056	57336
29	52752	52752	55056	55056	55056	57336	57336	57336	59256	59256
30	55056	57336	57336	57336	59256	59256	59256	61664	61664	63776
31	59256	59256	59256	61664	61664	63776	63776	63776	66592	66592
32	61664	61664	61664	63776	63776	63776	66592	66592	66592	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	81176	84760

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	61664	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	81176	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

I_{TBS}	N_{PRB}									
	91	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
27	59256	61664	61664	61664	63776	63776	63776	63776	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	84760	87936
33B	90816	90816	90816	93800	93800	93800	93800	97896	97896	100752
34	93800	97896	97896	97896	97896	101840	101840	101840	105528	105528

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	81176	84760	84760	84760	84760	87936
31	84760	84760	84760	84760	87936	87936	87936	87936	90816	90816
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

7.1.7.2.2 Transport blocks mapped to two-layer spatial multiplexing

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

For $56 \le N_{PRB} \le 110$, a baseline TBS_L1 is taken from the (I_{TBS} , N_{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		

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, $0 \le I_{TBS} \le 7$.

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

For $37 \le N_{\mathrm{PRB}} \le 110$, a baseline TBS_L1 is taken from the (I_{TBS}, N_{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

7.1.7.2.5 Transport blocks mapped to four-layer spatial multiplexing

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

For $28 \le N_{\mathrm{PRB}} \le 110$, a baseline TBS_L1 is taken from the (I_{TBS}, N_{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

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 ≥5MHz and not configured with higher layer parameter *mpdcch-PDSCH-MaxBandwidth-SC-MTCH* with

value 24 PRBs shall set $I_{TBS} = I_{TBS}^{1}$ and determine its TBS by the procedure in Subclause 7.1.7.2.1 for $0 \le I_{TBS} \le 9$, and N_{PRB} = 4 or N_{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 $1 \le N_{PRB} \le 14$, and $0 \le I_{TBS} \le 14$ the TBS is given by the (I_{TBS}, N_{PRB}) entry of Table 7.1.7.2.1-1.

For $15 \le N_{PRB} \le 24$, and $0 \le I_{TBS} \le 14$ the TBS is given by the (I_{TBS}, N_{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	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 $K_{\mathrm{MIMO}} \cdot \min\left(M_{\mathrm{DL\_HARQ}}, M_{\mathrm{limit}}\right)$ 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 $w_{k+1}, \ldots, w_{\mathrm{mod}(k+n_{SB}-1, N_{cb})}$, where:

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

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

$M_{\mathrm{DL\_HARQ}}$ 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 $w_{k+1}, \ldots, w_{\mathrm{mod}(k+n_{SB}-1, N_{cb})}$ 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 4 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) in the detected PDCCH/EPDCCH with DCI format 2D 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 quasi co-location type (defined in Subclause 7.1.10). 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 PDSCH RE mapping (defined in Subclause 6.4 of [3]) and PDSCH antenna port quasi co-location (defined in Subclause 7.1.10).

Table 7.1.9-1: PDSCH RE Mapping and Quasi-Co-Location Indicator field in DCI format 2D

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

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:

- *crs-PortsCount-r11.*
- *crs-FreqShift-r11.*
- *mbsfn-SubframeConfigList-r11.*
- *csi-RS-ConfigZPId-r11.*

- *pdsch-Start-r11.*
- *qcl-CSI-RS-ConfigNZPId-r11.*
- *zeroTxPowerCSI-RS2-r12* if the UE is configured with higher layer parameter *eMIMO-Type* for TDD serving cell.

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 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 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 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 quasi co-location type (defined in Subclause 7.1.10).

If the UE is configured in transmission mode 10 and configured with Type B 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 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.

A UE configured with higher layer parameter *csi-RS-ConfigZP-Ap* 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 two 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.

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

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 $i = 0, 1, \ldots, N-1$ 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 $i=0,1,\ldots,N-1$ are N consecutive BL/CE DL subframe(s) where, $x=k_0<k_1<\ldots,k_{N-1}$ and the value of $N \in \{n1, n2, \ldots n_{\max}\}$ is determined by the repetition number field in the corresponding DCI, where $n1, n2, \ldots n_{\max}$ 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 $i = 0, 1, \ldots, N-1$, where

- subframe(s) $n+k_i$ with $i=0,1,\ldots,N-1$ are N consecutive BL/CE DL subframe(s), where $0 \le k_0<k_1<\ldots,k_{N-1}$ and the value of $N \in \{n1, n2, \ldots n_{\max}\}$ is determined by the repetition number field in the activation DCI, where $n1, n2, \ldots n_{\max}$ 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 '*pdsch-maxNumRepetitionCEmodeA*'	$\{n1, n2, n3, n4\}$
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*'	$\{n1, n2, \ldots, n8\}$
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	$\{n1, n2, \ldots, n8\}$
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 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, and if the UE is configured with a serving cell with frame structure 3, 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*.

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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ are configured by higher layers.

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 CSI for activated 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 clause 15.2, is successful to determine whether periodic and aperiodic CSI reporting would occur in the same subframe.

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

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

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

- 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

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

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 a selected CSI-RS resource. For each CRI reporting interval 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 a selected CSI-RS resource. For each CRI reporting interval 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 $N_{\mathrm{RB}}^{\mathrm{DL}}$ 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 within a precoder codebook subset specified by one or more bitmap parameter(s) *codebookSubsetRestriction, codebookSubsetRestriction-1, codebookSubsetRestriction-2, codebookSubsetRestriction-3* configured by higher layer signalling.

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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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', the bitmap parameters *codebookSubsetRestriction-1, codebookSubsetRestriction-2* is configured for the CSI process and each subframe sets (if subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $a_{A_c-1},\ldots,a_3,a_2,a_1,a_0$ 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 $b_{B_c-1},\ldots,b_3,b_2,b_1,b_0$ 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 $a_{\upsilon-1}, \upsilon = 2$ is associated with the precoder in Table 6.3.4.2.3-1 of [3] corresponding to υ 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 $a_{\upsilon-1}, \upsilon = 2,3,4$ is associated with the precoders in Table 6.3.4.2.3-2 of [3] corresponding to υ 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 $a_{16(\upsilon-1)+i_c}$ is associated with the precoder for υ 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 $\upsilon=1$ 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 $\upsilon=1$ 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 $a_{16(\upsilon-1)+i_c}$ is associated with the precoder for υ layers and with codebook index i_c in Table 6.3.4.2.3-2 of [3], $\upsilon=1,2$.

    c. 4 antenna ports with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured: bit $a_{16(\upsilon-1)+i_1}$ is associated with the precoder for υ layers ($\upsilon\in\{1,2\}$) and codebook index i_1 and bit $a_{32+16(\upsilon-1)+i_2}$ is associated with the precoder for υ layers ($\upsilon\in\{1,2\}$) 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 υ=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 $a_{16(\upsilon-1)+i_c}$ is associated with the precoder for υ 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 $a_{16(\upsilon-1)+i_1}$ is associated with the precoder for υ layers ($\upsilon\in\{1,2\}$) and codebook index i_1 and bit $a_{32+16(\upsilon-1)+i_2}$ is associated with the precoder for υ layers ($\upsilon\in\{1,2,3,4\}$) 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 υ=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 $a_{f1(\upsilon-1)+i_1}$ is associated with the precoder for υ layers ($\upsilon \in \{1,2,3,4,5,6,7,8\}$) and codebook index i_1 where $f1(\cdot) = \{0,16,32,36,40,44,48,52\}$ and bit $a_{53+g1(\upsilon-1)+i_2}$ is associated with the precoder for υ layers ($\upsilon \in \{1,2,3,4\}$) 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 υ =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 $a_{N_1O_1N_2O_2+\upsilon-1}$ is associated with the precoder for υ layers ($\upsilon \in \{1,2,3,4,5,6,7,8\}$). The quantity $v_{l,m}$ is defined in Subclause 7.2.4. Bit $b_{g(\upsilon-1)+i_2}$ is associated with the precoder for υ layers ($\upsilon \in \{1,2,3,4\}$) 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 υ =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 $a_{f(\upsilon-1)+i_c}$ is associated with the precoder for υ layers and codebook index i_c where $\upsilon \in \{1,2\}$ and $f(\cdot) = \{0,4\}$ for 2 antenna ports, $\upsilon \in \{1,2,3,4\}$ and $f(\cdot) = \{0,8,16,20\}$ for 4 antenna ports, and $\upsilon \in \{1,2,3,4,5,6,7,8\}$ 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.

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 $a_{A_c-1},...,a_3,a_2,a_1,a_0$ 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 $\upsilon = 1$ 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 $\upsilon = 1$ 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 $\upsilon = 1$ 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 $\upsilon = 1$ 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 *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, otherwise 32	
Transmission modes 9 and 10	6	96 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* 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 υ**	
	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	$N_1O_1N_2O_2 + 8$

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	$\{0,16,32,48\}$

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 $N_{\mathrm{RB}}^{\mathrm{DL}}$. The number of subbands for system bandwidth given by $N_{\mathrm{RB}}^{\mathrm{DL}}$ is defined by $N = \lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k \rceil$. 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 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 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 $n+k$ on serving cell c, upon decoding in subframe 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.

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 clause 15.2.1.

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', '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.

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 before the subframe 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, 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 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 1st set of serving cells configured by higher layers
'11'	Aperiodic CSI report is triggered for a 2nd set of serving cells configured by higher layers

Table 7.2.1-1B: CSI Request field for PDCCH/EPDCCH 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 1st set of CSI process(es) configured by higher layers
'11'	Aperiodic CSI report is triggered for a 2nd set of CSI process(es) configured by higher layers

Table 7.2.1-1C: CSI Request field for PDCCH/EPDCCH/MPDCCH 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 1st 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 2nd 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 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 1st set of CSI process(es) configured by higher layers
'011'	Aperiodic CSI report is triggered for a 2nd set of CSI process(es) configured by higher layers
'100'	Aperiodic CSI report is triggered for a 3rd set of CSI process(es) configured by higher layers
'101'	Aperiodic CSI report is triggered for a 4th set of CSI process(es) configured by higher layers
'110'	Aperiodic CSI report is triggered for a 5th set of CSI process(es) configured by higher layers
'111'	Aperiodic CSI report is triggered for a 6th set of CSI process(es) configured by higher layers

Table 7.2.1-1E: CSI Request field for PDCCH/EPDCCH 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 1st 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 2nd 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 3rd 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 4th 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 5th 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 6th 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 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 1st set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'010'	Aperiodic CSI report is triggered for a 2nd set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'011'	Aperiodic CSI report is triggered for a 3rd set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'100'	Aperiodic CSI report is triggered for a 4th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'101'	Aperiodic CSI report is triggered for a 5th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'110'	Aperiodic CSI report is triggered for a 6th set of {CSI process, CSI-RS resource} configured by higher layers for serving cell c
'111'	Aperiodic CSI report is triggered for a 7th 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 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 1st 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 2nd 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 3rd 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 4th 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 5th 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 6th 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 7th 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 1st set of {CSI process, CSI-RS resource} configured by higher layers
'0011'	Aperiodic CSI report is triggered for a 2nd set of {CSI process, CSI-RS resource} configured by higher layers
'0100'	Aperiodic CSI report is triggered for a 3rd set of {CSI process, CSI-RS resource} configured by higher layers
'0101'	Aperiodic CSI report is triggered for a 4th set of {CSI process, CSI-RS resource} configured by higher layers
'0110'	Aperiodic CSI report is triggered for a 5th set of {CSI process, CSI-RS resource} configured by higher layers
'0111'	Aperiodic CSI report is triggered for a 6th set of {CSI process, CSI-RS resource} configured by higher layers
'1000'	Aperiodic CSI report is triggered for a 7th set of {CSI process, CSI-RS resource} configured by higher layers
'1001'	Aperiodic CSI report is triggered for a 8th set of {CSI process, CSI-RS resource} configured by higher layers
'1010'	Aperiodic CSI report is triggered for a 9th set of {CSI process, CSI-RS resource} configured by higher layers
'1011'	Aperiodic CSI report is triggered for a 10th set of {CSI process, CSI-RS resource} configured by higher layers
'1100'	Aperiodic CSI report is triggered for a 11th set of {CSI process, CSI-RS resource} configured by higher layers
'1101'	Aperiodic CSI report is triggered for a 12th set of {CSI process, CSI-RS resource} configured by higher layers
'1110'	Aperiodic CSI report is triggered for a 13th set of {CSI process, CSI-RS resource} configured by higher layers
'1111'	Aperiodic CSI report is triggered for a 14th 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 1st 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 2nd 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 3rd 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 4th 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 5th 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 6th 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 7th 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 8th 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 9th 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 10th 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 11th 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 12th 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 13th 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 14th 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 1st set of {CSI process, CSI-RS resource} configured by higher layers
'00011'	Aperiodic CSI report is triggered for a 2nd set of {CSI process, CSI-RS resource} configured by higher layers
'00100'	Aperiodic CSI report is triggered for a 3rd set of {CSI process, CSI-RS resource} configured by higher layers
'00101'	Aperiodic CSI report is triggered for a 4th set of {CSI process, CSI-RS resource} configured by higher layers
'00110'	Aperiodic CSI report is triggered for a 5th set of {CSI process, CSI-RS resource} configured by higher layers
'00111'	Aperiodic CSI report is triggered for a 6th set of {CSI process, CSI-RS resource} configured by higher layers
'01000'	Aperiodic CSI report is triggered for a 7th set of {CSI process, CSI-RS resource} configured by higher layers
'01001'	Aperiodic CSI report is triggered for a 8th set of {CSI process, CSI-RS resource} configured by higher layers
'01010'	Aperiodic CSI report is triggered for a 9th set of {CSI process, CSI-RS resource} configured by higher layers
'01011'	Aperiodic CSI report is triggered for a 10th set of {CSI process, CSI-RS resource} configured by higher layers
'01100'	Aperiodic CSI report is triggered for a 11th set of {CSI process, CSI-RS resource} configured by higher layers
'01101'	Aperiodic CSI report is triggered for a 12th set of {CSI process, CSI-RS resource} configured by higher layers
'01110'	Aperiodic CSI report is triggered for a 13th set of {CSI process, CSI-RS resource} configured by higher layers
'01111'	Aperiodic CSI report is triggered for a 14th set of {CSI process, CSI-RS resource} configured by higher layers
'10000'	Aperiodic CSI report is triggered for a 15th set of {CSI process, CSI-RS resource} configured by higher layers
'10001'	Aperiodic CSI report is triggered for a 16th set of {CSI process, CSI-RS resource} configured by higher layers
'10010'	Aperiodic CSI report is triggered for a 17th set of {CSI process, CSI-RS resource} configured by higher layers
'10011'	Aperiodic CSI report is triggered for a 18th set of {CSI process, CSI-RS resource} configured by higher layers
'10100'	Aperiodic CSI report is triggered for a 19th set of {CSI process, CSI-RS resource} configured by higher layers
'10101'	Aperiodic CSI report is triggered for a 20th set of {CSI process, CSI-RS resource} configured by higher layers
'10110'	Aperiodic CSI report is triggered for a 21st set of {CSI process, CSI-RS resource} configured by higher layers
'10111'	Aperiodic CSI report is triggered for a 22nd set of {CSI process, CSI-RS resource} configured by higher layers
'11000'	Aperiodic CSI report is triggered for a 23rd set of {CSI process, CSI-RS resource} configured by higher layers
'11001'	Aperiodic CSI report is triggered for a 24th set of {CSI process, CSI-RS resource} configured by higher layers
'11010'	Aperiodic CSI report is triggered for a 25th set of {CSI process, CSI-RS resource} configured by higher layers
'11011'	Aperiodic CSI report is triggered for a 26th set of {CSI process, CSI-RS resource} configured by higher layers
'11100'	Aperiodic CSI report is triggered for a 27th set of {CSI process, CSI-RS resource} configured by higher layers
'11101'	Aperiodic CSI report is triggered for a 28th set of {CSI process, CSI-RS resource} configured by higher layers
'11110'	Aperiodic CSI report is triggered for a 29th set of {CSI process, CSI-RS resource} configured by higher layers
'11111'	Aperiodic CSI report is triggered for a 30th 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

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} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers for serving cell c
'00010'	Aperiodic CSI report is triggered for a 1st set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'00011'	Aperiodic CSI report is triggered for a 2nd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'00100'	Aperiodic CSI report is triggered for a 3rd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'00101'	Aperiodic CSI report is triggered for a 4th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'00110'	Aperiodic CSI report is triggered for a 5th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'00111'	Aperiodic CSI report is triggered for a 6th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01000'	Aperiodic CSI report is triggered for a 7th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01001'	Aperiodic CSI report is triggered for a 8th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01010'	Aperiodic CSI report is triggered for a 9th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01011'	Aperiodic CSI report is triggered for a 10th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01100'	Aperiodic CSI report is triggered for a 11th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01101'	Aperiodic CSI report is triggered for a 12th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01110'	Aperiodic CSI report is triggered for a 13th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'01111'	Aperiodic CSI report is triggered for a 14th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10000'	Aperiodic CSI report is triggered for a 15th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10001'	Aperiodic CSI report is triggered for a 16th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10010'	Aperiodic CSI report is triggered for a 17th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10011'	Aperiodic CSI report is triggered for a 18th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10100'	Aperiodic CSI report is triggered for a 19th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10101'	Aperiodic CSI report is triggered for a 20th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10110'	Aperiodic CSI report is triggered for a 21st set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'10111'	Aperiodic CSI report is triggered for a 22nd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11000'	Aperiodic CSI report is triggered for a 23rd set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11001'	Aperiodic CSI report is triggered for a 24th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11010'	Aperiodic CSI report is triggered for a 25th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11011'	Aperiodic CSI report is triggered for a 26th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11100'	Aperiodic CSI report is triggered for a 27th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11101'	Aperiodic CSI report is triggered for a 28th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers
'11110'	Aperiodic CSI report is triggered for a 29th set of {CSI process, CSI-RS resource} and/or {CSI process, CSI subframe set, CSI-RS resource} configured by higher layers

'11111'	Aperiodic CSI report is triggered for a 30th 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 with DCI formats used to grant PUSCH transmissions as given by DCI format 0, DCI format 4 and DCI format 6-0A 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 is set to trigger a report, for FDD *k=4*, and 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 8-2; 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 7; or if both MSB and LSB of the UL index is set to 1, *k* is given in Table 8-2.

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, 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 *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 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 $N_{\mathrm{RB}}^{\mathrm{DL}} \leq 7$, 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 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $RI \le 2$, 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 7.2.1-3.

- 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_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, 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.

o 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.

o 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 $RI \le 2$, 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 7.2.1-3.

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

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

- 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.

o 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.

o 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_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 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 $RI \le 2$, 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.

o 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

- $r = \sum_{i=0}^{M-1} \left\langle \begin{matrix} N - s_i \\ M - i \end{matrix} \right\rangle$
- where the set $\{s_i\}_{i=0}^{M-1}$, $(1 \le s_i \le N, \quad s_i < s_{i+1})$ contains the *M* sorted subband indices and $\left\langle \begin{matrix} x \\ y \end{matrix} \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label $r \in \left\{0, \cdots, \binom{N}{M} - 1\right\}$.

- 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 7.2.1-5. 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_{RB}^{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 7.2.1-6: 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 *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'.

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 serving cell is configured by higher-layer signalling.

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.

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 $N_{\mathrm{RB}}^{\mathrm{DL}}$ where $\left\lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / k \right\rfloor$ subbands are of size k. If $\left\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k \right\rceil - \left\lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / k \right\rfloor > 0$ then one of the subbands is of size $N_{\mathrm{RB}}^{\mathrm{DL}} - k \cdot \left\lfloor N_{\mathrm{RB}}^{\mathrm{DL}} / k \right\rfloor$.

- A bandwidth part *j* is frequency-consecutive and consists of N_j subbands where *J* bandwidth parts span *S* or N_{RB}^{DL} as given in Table 7.2.2-2. If $J=1$ then N_j is $\lceil N_{RB}^{DL}/k/J \rceil$. If *J>1* then N_j is either $\lceil N_{RB}^{DL}/k/J \rceil$ or $\lceil N_{RB}^{DL}/k/J \rceil - 1$, depending on N_{RB}^{DL}, *k* and *J*.
- Each bandwidth part *j*, where $0 \le j \le J$-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 $L = \lceil \log_2 \lceil N_{RB}^{DL}/k/J \rceil \rceil$.

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_{pd} (in subframes) and offset $N_{OFFSET,CQI}$ (in subframes) for CQI/PMI reporting are determined based on the parameter *cqi-pmi-ConfigIndex* ($I_{CQI/PMI}$) 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. The periodicity M_{RI} and relative offset $N_{OFFSET,RI}$ for RI reporting are determined based on the parameter *ri-ConfigIndex* (I_{RI}) given in Table 7.2.2-1B. 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-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 more than one, or 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, 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 c*ri-*

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, ri-ConfigIndex , periodicityOffsetIndex,* and *cri-ConfigIndex* are configured by higher layer signalling. The relative reporting offset for RI $N_{OFFSET,RI}$ takes values from the set $\{0,-1,\ldots,-(N_{pd}-1)\}$. 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, ri-ConfigIndex*2, *periodicityOffsetIndex2,* and *cri-ConfigIndex*2 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-ConfigIndex*2, *periodicityOffsetIndex2,* and *cri-ConfigIndex*2 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-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 $N_{pd}\cdot M_{RI}$ (in subframes).

    - The reporting instances for wideband first PMI and RI for *eMIMO-Type* are subframes satisfying $(10\times n_f+\lfloor n_s/2\rfloor-N_{OFFSET,CQI}-N_{OFFSET,RI}-N_{OFFSET,PMI/RI})\bmod(N_{pd}\cdot M_{RI}\cdot M_{PMI/RI})=0$.

- 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-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 $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,CRI}) \bmod (N_{pd} \cdot M_{CRI}) = 0$.
  - 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 $H.N_{pd} \cdot M_{RI}$ (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 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},1}$ is dropped.

For a serving cell and UE configured in transmission mode 10 and configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 $C_{\mathrm{CSI},1}$ 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 $n_{\mathrm{PUCCH}}^{(2,\tilde{p})}$ as defined in [3], where $n_{\mathrm{PUCCH}}^{(2,\tilde{p})}$ 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,
    - the CSI report of a given PUCCH reporting type shall be transmitted on the PUCCH resource $n_{\mathrm{PUCCH}}^{(2,\tilde{p})}$ as defined in [3], where $n_{\mathrm{PUCCH}}^{(2,\tilde{p})}$ is UE specific and configured by higher layers for each serving cell;
    - 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,

  - 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;
  - 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);
  - 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);
  - 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 $\left(O^{SR}+O_{\text{P-CSI}}+O_{CRC}\right)\le \min\left(M_{\text{RB},1}^{\text{PUCCH4}}, M_{\text{RB},2}^{\text{PUCCH4}}\right)\cdot N_{sc}^{RB}\cdot N_{\text{symb}}^{\text{PUCCH4}}\cdot 2\cdot r$, 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;
    - $O^{SR}=0$ if there is no scheduling request bit in the subframe and $O^{SR}=1$ 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;
    - $N_{\text{symb}}^{\text{PUCCH4}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)-1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)$ 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 $\left(O^{SR}+O_{\text{P-CSI}}+O_{CRC}\right)>2\cdot N_{\text{RE}}\cdot r$, the UE shall select the SR (if any) and $N_{\text{CSI,reported}}$ CSI report(s) for transmission in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$, where:

- $O_{\text{P-CSI}}$ is the total number of CSI report bits in the subframe;
- O_{CRC} is the number of CRC bits
- $O^{SR}=0$ if there is no scheduling request bit in the subframe and $O^{SR}=1$ otherwise;
- $N_{\text{RE}}=M_{\text{RB}}^{\text{PUCCH4}}\cdot N_{sc}^{RB}\cdot N_{\text{symb}}^{\text{PUCCH}}$ for PUCCH format 4 and $N_{\text{RE}}=N_{sc}^{RB}\cdot N_{\text{symb}}^{\text{PUCCH}}/2$ for PUCCH format 5, where $N_{\text{symb}}^{\text{PUCCH}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)-1$ if shortened PUCCH format 4 or shortened PUCCH format 5 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH}}=2\cdot\left(N_{\text{symb}}^{\text{UL}}-1\right)$ otherwise;
- r is the code rate given by higher layer parameter *maximumPayloadCoderate-r13* according to Table 10.1.1-1;
- for a CSI report of a serving cell, $\text{Pri}_{CSI}(y,s,c,t)$ for the CSI report is defined as $\text{Pri}_{CSI}(y,s,c,t)=y\cdot 4\cdot 32\cdot 2+s\cdot 32\cdot 2+c\cdot 2+t$, 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ respectively if CSI subframe sets are configured for the serving cell, and $t = 0$ otherwise.

- The value of $N_{\mathrm{CSI,reported}}$ satisfies $\left(O^{SR} + \sum_{n=1}^{N_{\mathrm{CSI,reported}}} O_{P-CSI,n} + O_{CRC} \right) \le 2 \cdot N_{\mathrm{RE}} \cdot r$ and $\left(O^{SR} + \sum_{n=1}^{N_{\mathrm{CSI,reported}}+1} O_{P-CSI,n} + O_{CRC} \right) > 2 \cdot N_{\mathrm{RE}} \cdot r$, where $O^{SR} = 0$ if there no scheduling request bit in the subframe and $O^{SR} = 1$ otherwise. $O_{P-CSI,n}$ is the number of CSI report bits for the *n*th CSI report in ascending order of $\mathrm{Pri}_{CSI}(y,s,c,t)$.

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 $N_{OFFSET,CQI}$
$0 \le I_{CQI/PMI} \le 1$	2	$I_{CQI/PMI}$
$2 \le I_{CQI/PMI} \le 6$	5	$I_{CQI/PMI} - 2$
$7 \le I_{CQI/PMI} \le 16$	10	$I_{CQI/PMI} - 7$
$17 \le I_{CQI/PMI} \le 36$	20	$I_{CQI/PMI} - 17$
$37 \le I_{CQI/PMI} \le 76$	40	$I_{CQI/PMI} - 37$
$77 \le I_{CQI/PMI} \le 156$	80	$I_{CQI/PMI} - 77$
$157 \le I_{CQI/PMI} \le 316$	160	$I_{CQI/PMI} - 157$
$I_{CQI/PMI} = 317$	Reserved	
$318 \le I_{CQI/PMI} \le 349$	32	$I_{CQI/PMI} - 318$
$350 \le I_{CQI/PMI} \le 413$	64	$I_{CQI/PMI} - 350$
$414 \le I_{CQI/PMI} \le 541$	128	$I_{CQI/PMI} - 414$
$542 \le I_{CQI/PMI} \le 601$	60	$I_{CQI/PMI} - 542$
$602 \le I_{CQI/PMI} \le 1023$	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 $N_{OFFSET,RI}$
$0 \le I_{RI} \le 160$	1	$-I_{RI}$
$161 \le I_{RI} \le 321$	2	$-(I_{RI} - 161)$
$322 \le I_{RI} \le 482$	4	$-(I_{RI} - 322)$
$483 \le I_{RI} \le 643$	8	$-(I_{RI} - 483)$
$644 \le I_{RI} \le 804$	16	$-(I_{RI} - 644)$
$805 \le I_{RI} \le 965$	32	$-(I_{RI} - 805)$
$966 \le I_{RI} \le 1023$	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	$I_{CQI/PMI}$
$1 \le I_{CQI/PMI} \le 5$	5	$I_{CQI/PMI} - 1$
$6 \le I_{CQI/PMI} \le 15$	10	$I_{CQI/PMI} - 6$
$16 \le I_{CQI/PMI} \le 35$	20	$I_{CQI/PMI} - 16$
$36 \le I_{CQI/PMI} \le 75$	40	$I_{CQI/PMI} - 36$
$76 \le I_{CQI/PMI} \le 155$	80	$I_{CQI/PMI} - 76$
$156 \le I_{CQI/PMI} \le 315$	160	$I_{CQI/PMI} - 156$
$316 \le I_{CQI/PMI} \le 375$	60	$I_{CQI/PMI} - 316$
$376 \le I_{CQI/PMI} \le 1023$	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
$7 < I_{CRI} \le 1023$	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 $N_{OFFSET,CRI}$
$0 \le I_{CRI} \le 160$	1	$-I_{CRI}$
$161 \le I_{CRI} \le 321$	2	$-(I_{CRI} - 161)$
$322 \le I_{CRI} \le 482$	4	$-(I_{CRI} - 322)$
$483 \le I_{CRI} \le 643$	8	$-(I_{CRI} - 483)$
$644 \le I_{CRI} \le 804$	16	$-(I_{CRI} - 644)$
$805 \le I_{CRI} \le 965$	32	$-(I_{CRI} - 805)$
$966 \le I_{CRI} \le 1023$	*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 $N_{OFFSET,PMI/RI}$
$0 \le I_{PMI/RI} \le 160$	1	$-I_{PMI/RI}$
$161 \le I_{PMI/RI} \le 321$	2	$-(I_{PMI/RI} - 161)$
$322 \le I_{PMI/RI} \le 482$	4	$-(I_{PMI/RI} - 322)$
$483 \le I_{PMI/RI} \le 643$	8	$-(I_{PMI/RI} - 483)$
$644 \le I_{PMI/RI} \le 804$	16	$-(I_{PMI/RI} - 644)$
$805 \le I_{PMI/RI} \le 965$	32	$-(I_{PMI/RI} - 805)$
$966 \le I_{PMI/RI} \le 1023$	*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:

- 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 $N_{\mathrm{RB}}^{\mathrm{DL}} \le 7$, 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	#bits
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

	Relationship between the first PMI value and codebook index i_1		Relationship between the second PMI value and codebook index i_2		total
RI	Value of the first PMI I_{PMI1}	Codebook index i_1	Value of the second PMI I_{PMI2}	Codebook index i_2	#bits
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 $RI\le 2$ 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 $C_{\text{CSI},0}$ 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:

- 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 $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ 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 $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers for both CSI processes, and/or
- set of restricted RIs with precoder codebook subset restriction if subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ 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 $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ 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.

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):
      - 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 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.
  - 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 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 $N_{\mathrm{RB}}^{\mathrm{DL}}$	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 paramter *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 *codebookConfig*={2,3,4}, RI = 1	NA	8+L	NA	NA
		8 antenna ports or 8/12/16/20/24/28/32 antenna ports with *codebookConfig*={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 *codebookConfig*={1,2,3,4} RI > 4	NA	7+L	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=1, RI = 1	NA	6+L	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=1, RI = 2	NA	9+L	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=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 *codebookConfig*=1, 1≤RI≤8	Note[3]	Note[3]	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*={2,3,4}	Note[4]	Note[4]	NA	NA
		4 antenna ports with *advancedCodebookEnabled* =True, 1≤RI≤2	3	NA	NA	NA
		4 antenna ports with *advancedCodebookEnabled* =True, 3≤RI≤4	0	NA	NA	NA
		8 antenna ports with *advancedCodebookEnabled* =True, 1≤RI≤2	6	NA	NA	NA
		8 antenna ports with *advancedCodebookEnabled* =True, 3≤RI≤7	2	NA	NA	NA
		8 antenna ports with *advancedCodebookEnabled* =True, RI=8	0	NA	NA	NA
		8/12/16/20/24/28/32 antenna ports with *advancedCodebookEnabled* =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 *codebookConfig* = {2,3,4}, RI = 1	8	8	NA	NA
		8 antenna ports or 8/12/16/20/24/28/32 antenna ports with *codebookConfig* = {2,3,4}, 1 < RI < 4	11	11	NA	NA
		8 antenna ports or 8/12/16/20/24/28/32 antenna ports with *codebookConfig* = {2,3,4}, RI = 4	10	10	NA	NA

		8 antenna ports or 8/12/16/20/24/28/32 antenna ports with *codebookConfig* = {1,2,3,4}, RI > 4	7	7	NA	NA
		4 antenna ports RI=1	8	8	NA	NA
		4 antenna port 1<RI≤4	11	11	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=1, RI = 1	6	6	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=1, RI = 2	9	9	NA	NA
		8/12/16/20/24/28/32 antenna ports with *codebookConfig*=1, 2<RI<5	8	8	NA	NA
		4/8 antenna ports with *advancedCodebookEnabled* =True or 8/12/16/20/24/28/32 antenna ports with *advancedCodebookEnabled* =True and *eMIMO-Type* is set to 'CLASS A', RI = 1	10	NA	NA	NA
		4/8 antenna ports with *advancedCodebookEnabled* =True or 8/12/16/20/24/28/32 antenna ports with *advancedCodebookEnabled* =True and *eMIMO-Type* 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 < RI ≤ 4	11	NA	NA	NA
		8 antenna ports 4 < RI ≤ 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<RI≤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
4	**Wideband CQI**	RI = 1 or RI>1, without PMI/RI reporting	NA	NA	4	4
		RI = 1 without PMI reporting	NA	NA	4	4
		RI>1 without PMI reporting	NA	NA	7	7
5	**RI/ first PMI**	8 antenna ports, 2-layer spatial multiplexing	4	NA	NA	NA
		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, *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 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
7	**CRI/RI**	2-layer spatial multiplexing	*k*+1	*k*+1	*k*+1	*k*+1
		4-layer spatial multiplexing	*k*+2	*k*+2	*k*+2	*k*+2
		8-layer spatial multiplexing	*k*+3	*k*+3	*k*+3	*k*+3
8	**CRI/RI/first PMI**	2-layer spatial multiplexing	*k*+4	NA	NA	NA
		4 and 8-layer spatial multiplexing	*k*+5	NA	NA	NA
9	**CRI/RI/PTI**	2-layer spatial multiplexing	NA	*k*+2	NA	NA
		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 *: 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 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.

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 *n* the highest CQI index between 1 and 15 in Table 7.2.3-1 or Table 7.2.3-2 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 between 1 and 10 in Table 7.2.3-3 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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ are configured by higher layers, each CSI reference resource belongs to either $C_{\mathrm{CSI},0}$ or $C_{\mathrm{CSI},1}$ but not to both. When CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 *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 *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 *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 $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 or special subframe n-n_{CQI_ref},
    - where for periodic CSI reporting n_{CQI_ref} is the smallest value greater than or equal to 4, 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 4, 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 4, 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 4, 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 or valid 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 4 and subframe n-n_{CQI_ref} corresponds to a valid downlink or valid special subframe, where subframe n-n_{CQI_ref} is received on or after the subframe 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 an 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 or valid special subframe $n-n_{CQI\_ref}$ prior to the subframe with the corresponding CSI request, where subframe $n-n_{CQI\_ref}$ is the lowest indexed valid downlink or valid 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 4, such that it corresponds to a valid downlink or valid 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 or special subframe $n-n_{CQI\_ref}$,

- where for FDD serving cell and periodic or aperiodic CSI reporting n_{CQI_ref} is the smallest value greater than or equal to 5, such that it corresponds to a valid downlink or valid 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, such that it corresponds to a valid downlink or valid 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, such that it corresponds to a valid downlink or valid 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 5, 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 5, 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 5, 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 $\text{ceil}\left(R^{\text{CSI}} / N_{\text{NB,hop}}^{\text{ch,DL}}\right)$ 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 $N_{\text{NB,hop}}^{\text{ch,DL}}$ 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 higher layer parameter *csi-NumRepetitionCE*.

  A subframe in a serving cell shall be considered to be a valid downlink or a valid special subframe if:
  - it is configured as a downlink subframe or 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 in the primary cell is a downlink subframe or a special subframe with the length of DwPTS more than $7680 \cdot T_s$, and
  - except for a non-BL/CE UE in transmission mode 9 or 10, it is not an MBSFN subframe, and
  - it does not contain a DwPTS field in case the length of DwPTS is $7680 \cdot T_s$ and less, 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 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 or no valid special subframe for the CSI reference resource in a serving cell, CSI reporting is omitted for the serving cell in uplink subframe *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:

- 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 $\{7\ldots 6+\upsilon\}$ for υ layers would result in signals equivalent to corresponding symbols transmitted on antenna ports $\{15\ldots 14+P\}$, as given by,

    if the UE is configured with higher layer parameter *semiOpenLoop*,

$$\begin{bmatrix} y^{(15)}(2i) \\ \vdots \\ y^{(14+P)}(2i) \\ y^{(15)}(2i+1) \\ \vdots \\ y^{(14+P)}(2i+1) \end{bmatrix} = \begin{bmatrix} W(i) & 0 \\ 0 & W(i) \end{bmatrix} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \end{bmatrix} \quad \text{for } \upsilon = 1$$

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = \frac{1}{\sqrt{2}} W(i) \begin{bmatrix} 1 & 1 \\ \phi_i & -\phi_i \end{bmatrix} \begin{bmatrix} x^{(0)}(i) \\ x^{(1)}(i) \end{bmatrix}, \quad \phi_i = e^{j\pi(i \bmod 2)/2} \quad \text{for } \upsilon = 2$$

    where $x(i) = \left[x^{(0)}(i) \ \ldots \ x^{(\upsilon-1)}(i)\right]^T$ 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 $\{15\ldots14+P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in subclause 7.2.5,

otherwise,

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix},$$

where $x(i) = \left[x^{(0)}(i) \quad \ldots \quad x^{(\upsilon-1)}(i)\right]^T$ 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 $\{15\ldots14+P\}$ 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 $\{7\ldots6+\upsilon\}$ for υ layers would result in signals equivalent to corresponding symbols transmitted on antenna ports $\{15\ldots14+P\}$, as given by,

if the UE is configured with higher layer parameter *semiOpenLoop*,

$$\begin{bmatrix} y^{(15)}(2i) \\ \vdots \\ y^{(14+P)}(2i) \\ y^{(15)}(2i+1) \\ \vdots \\ y^{(14+P)}(2i+1) \end{bmatrix} = \begin{bmatrix} W(i) & 0 \\ 0 & W(i) \end{bmatrix} \begin{bmatrix} 1 & 0 & j & 0 \\ 0 & -1 & 0 & j \\ 0 & 1 & 0 & j \\ 1 & 0 & -j & 0 \end{bmatrix} \begin{bmatrix} \mathrm{Re}\left(x^{(0)}(i)\right) \\ \mathrm{Re}\left(x^{(1)}(i)\right) \\ \mathrm{Im}\left(x^{(0)}(i)\right) \\ \mathrm{Im}\left(x^{(1)}(i)\right) \end{bmatrix} \quad \text{for } \upsilon = 1$$

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = \frac{1}{\sqrt{2}} W(i) \begin{bmatrix} 1 & 1 \\ \phi_i & -\phi_i \end{bmatrix} \begin{bmatrix} x^{(0)}(i) \\ x^{(1)}(i) \end{bmatrix}, \quad \phi_i = e^{j\pi(i \bmod 2)/2} \text{ for } \upsilon = 2$$

where $x(i) = \left[x^{(0)}(i) \ \ldots \ x^{(\upsilon-1)}(i)\right]^T$ 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 $\{15 \ldots 14+P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in subclause 7.2.5,

otherwise,

$$\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix},$$

where $x(i) = \left[x^{(0)}(i) \ \ldots \ x^{(\upsilon-1)}(i)\right]^T$ 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 $\{15 \ldots 14+P\}$ would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in Subclause 7.2.5

- 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.

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 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 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 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 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
10	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, port7; otherwise transmit diversity 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)

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

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 n given in Table 6.3.4.2.3-1 of [3] with $\upsilon = 1$.
- 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 $\upsilon = 2$.
- 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 $\upsilon = 2$ 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 $\upsilon \le 2$ with υ 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 $n \in \{0,1,\cdots,15\}$ corresponds to the codebook index n given in Table 6.3.4.2.3-2 of [3] with υ 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 $\upsilon = 2$.
- 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

$$\varphi_n = e^{j\pi n/2}$$
$$\varphi'_n = e^{j2\pi n/32}$$
$$v'_m = \begin{bmatrix} 1 & e^{j2\pi m/32} \end{bmatrix}^T$$

- A first PMI value of $i_1 \in \{0,1,\cdots, f(\upsilon)-1\}$ and a second PMI value of $i_2 \in \{0,1,\cdots, g(\upsilon)-1\}$ correspond to the codebook indices i_1 and i_2 respectively given in Table 7.2.4-0*j* with υ equal to the associated RI value and where *j* ={A,B,C,D} respectively when $\upsilon = \{1,2,3,4\}$, $f(\upsilon) = \{16,16,1,1\}$ and $g(\upsilon) = \{16,16,16,16\}$.

- 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,…,15} for 1 layer and in {0,1,2…,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	$W^{(1)}_{i_1,0}$	$W^{(1)}_{i_1,8}$	$W^{(1)}_{i_1,16}$	$W^{(1)}_{i_1,24}$	$W^{(1)}_{i_1+8,2}$	$W^{(1)}_{i_1+8,10}$	$W^{(1)}_{i_1+8,18}$	$W^{(1)}_{i_1+8,26}$
i_1	i_2							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
0 - 15	$W^{(1)}_{i_1+16,4}$	$W^{(1)}_{i_1+16,12}$	$W^{(1)}_{i_1+16,20}$	$W^{(1)}_{i_1+16,28}$	$W^{(1)}_{i_1+24,6}$	$W^{(1)}_{i_1+24,14}$	$W^{(1)}_{i_1+24,22}$	$W^{(1)}_{i_1+24,30}$
where $W^{(1)}_{m,n} = \frac{1}{2}\begin{bmatrix} v'_m \\ \varphi'_n v'_m \end{bmatrix}$								

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	$W^{(2)}_{i_1,i_1,0}$	$W^{(2)}_{i_1,i_1,1}$	$W^{(2)}_{i_1+8,i_1+8,0}$	$W^{(2)}_{i_1+8,i_1+8,1}$
i_1	i_2			
	4	**5**	**6**	**7**
0 – 15	$W^{(2)}_{i_1+16,i_1+16,0}$	$W^{(2)}_{i_1+16,i_1+16,1}$	$W^{(2)}_{i_1+24,i_1+24,0}$	$W^{(2)}_{i_1+24,i_1+24,1}$
i_1	i_2			
	8	**9**	**10**	**11**
0 – 15	$W^{(2)}_{i_1,i_1+8,0}$	$W^{(2)}_{i_1,i_1+8,1}$	$W^{(2)}_{i_1+8,i_1+16,0}$	$W^{(2)}_{i_1+8,i_1+16,1}$
i_1	i_2			
	12	**13**	**14**	**15**

0 – 15	$W^{(2)}_{i_1,i_1+24,0}$	$W^{(2)}_{i_1,i_1+24,1}$	$W^{(2)}_{i_1+8,i_1+24,0}$	$W^{(2)}_{i_1+8,i_1+24,1}$
where $W^{(2)}_{m,m',n} = \frac{1}{\sqrt{8}}\begin{bmatrix} v'_m & v'_{m'} \\ \varphi_n v'_m & -\varphi_n v'_{m'} \end{bmatrix}$				

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 $\upsilon \le 2$ with υ 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

$$\varphi_n = e^{j\pi n/2}$$
$$v_m = \begin{bmatrix} 1 & e^{j2\pi m/32} & e^{j4\pi m/32} & e^{j6\pi m/32} \end{bmatrix}^{\mathrm{T}}$$

- as follows:For 8 antenna ports $\{15,16,17,18,19,20,21,22\}$, a first PMI value of $i_1 \in \{0,1,\cdots, f(\upsilon)-1\}$ and a second PMI value of $i_2 \in \{0,1,\cdots, g(\upsilon)-1\}$ corresponds to the codebook indices i_1 and i_2 given in

Table 7.2.4-*j* with υ equal to the associated RI value and where $j = \upsilon$, $f(\upsilon) = \{16,16,4,4,4,4,4,1\}$ and $g(\upsilon) = \{16,16,16,8,1,1,1,1\}$.

- 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,…,15} for 1 layer and in {0,1,2…,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	$W^{(1)}_{2i_1,0}$	$W^{(1)}_{2i_1,1}$	$W^{(1)}_{2i_1,2}$	$W^{(1)}_{2i_1,3}$	$W^{(1)}_{2i_1+1,0}$	$W^{(1)}_{2i_1+1,1}$	$W^{(1)}_{2i_1+1,2}$	$W^{(1)}_{2i_1+1,3}$
i_1	i_2							
	8	**9**	**10**	**11**	**12**	**13**	**14**	**15**
0 - 15	$W^{(1)}_{2i_1+2,0}$	$W^{(1)}_{2i_1+2,1}$	$W^{(1)}_{2i_1+2,2}$	$W^{(1)}_{2i_1+2,3}$	$W^{(1)}_{2i_1+3,0}$	$W^{(1)}_{2i_1+3,1}$	$W^{(1)}_{2i_1+3,2}$	$W^{(1)}_{2i_1+3,3}$
where $W^{(1)}_{m,n} = \frac{1}{\sqrt{8}}\begin{bmatrix} v_m \\ \varphi_n v_m \end{bmatrix}$								

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	$W^{(2)}_{2i_1,2i_1,0}$	$W^{(2)}_{2i_1,2i_1,1}$	$W^{(2)}_{2i_1+1,2i_1+1,0}$	$W^{(2)}_{2i_1+1,2i_1+1,1}$
i_1	i_2			
	4	**5**	**6**	**7**
0 – 15	$W^{(2)}_{2i_1+2,2i_1+2,0}$	$W^{(2)}_{2i_1+2,2i_1+2,1}$	$W^{(2)}_{2i_1+3,2i_1+3,0}$	$W^{(2)}_{2i_1+3,2i_1+3,1}$
i_1	i_2			
	8	**9**	**10**	**11**
0 – 15	$W^{(2)}_{2i_1,2i_1+1,0}$	$W^{(2)}_{2i_1,2i_1+1,1}$	$W^{(2)}_{2i_1+1,2i_1+2,0}$	$W^{(2)}_{2i_1+1,2i_1+2,1}$
i_1	i_2			
	12	**13**	**14**	**15**
0 – 15	$W^{(2)}_{2i_1,2i_1+3,0}$	$W^{(2)}_{2i_1,2i_1+3,1}$	$W^{(2)}_{2i_1+1,2i_1+3,0}$	$W^{(2)}_{2i_1+1,2i_1+3,1}$
where $W^{(2)}_{m,m',n} = \frac{1}{4}\begin{bmatrix} v_m & v_{m'} \\ \varphi_n v_m & -\varphi_n v_{m'} \end{bmatrix}$				

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	$W^{(3)}_{8i_1,8i_1,8i_1+8}$	$W^{(3)}_{8i_1+8,8i_1,8i_1+8}$	$\tilde{W}^{(3)}_{8i_1,8i_1+8,8i_1+8}$	$\tilde{W}^{(3)}_{8i_1+8,8i_1,8i_1}$
i_1	i_2			
	4	**5**	**6**	**7**
0 - 3	$W^{(3)}_{8i_1+2,8i_1+2,8i_1+10}$	$W^{(3)}_{8i_1+10,8i_1+2,8i_1+10}$	$\tilde{W}^{(3)}_{8i_1+2,8i_1+10,8i_1+10}$	$\tilde{W}^{(3)}_{8i_1+10,8i_1+2,8i_1+2}$
i_1	i_2			
	8	**9**	**10**	**11**
0 - 3	$W^{(3)}_{8i_1+4,8i_1+4,8i_1+12}$	$W^{(3)}_{8i_1+12,8i_1+4,8i_1+12}$	$\tilde{W}^{(3)}_{8i_1+4,8i_1+12,8i_1+12}$	$\tilde{W}^{(3)}_{8i_1+12,8i_1+4,8i_1+4}$
i_1	i_2			
	12	**13**	**14**	**15**
0 - 3	$W^{(3)}_{8i_1+6,8i_1+6,8i_1+14}$	$W^{(3)}_{8i_1+14,8i_1+6,8i_1+14}$	$\tilde{W}^{(3)}_{8i_1+6,8i_1+14,8i_1+14}$	$\tilde{W}^{(3)}_{8i_1+14,8i_1+6,8i_1+6}$
where $W^{(3)}_{m,m',m''} = \frac{1}{\sqrt{24}}\begin{bmatrix} v_m & v_{m'} & v_{m''} \\ v_m & -v_{m'} & -v_{m''} \end{bmatrix}$, $\tilde{W}^{(3)}_{m,m',m''} = \frac{1}{\sqrt{24}}\begin{bmatrix} v_m & v_{m'} & v_{m''} \\ v_m & v_{m'} & -v_{m''} \end{bmatrix}$				

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	$W^{(4)}_{8i_1,8i_1+8,0}$	$W^{(4)}_{8i_1,8i_1+8,1}$	$W^{(4)}_{8i_1+2,8i_1+10,0}$	$W^{(4)}_{8i_1+2,8i_1+10,1}$
i_1	i_2			
	4	**5**	**6**	**7**
0 - 3	$W^{(4)}_{8i_1+4,8i_1+12,0}$	$W^{(4)}_{8i_1+4,8i_1+12,1}$	$W^{(4)}_{8i_1+6,8i_1+14,0}$	$W^{(4)}_{8i_1+6,8i_1+14,1}$
where $W^{(4)}_{m,m',n} = \frac{1}{\sqrt{32}}\begin{bmatrix} v_m & v_{m'} & v_m & v_{m'} \\ \varphi_n v_m & \varphi_n v_{m'} & -\varphi_n v_m & -\varphi_n v_{m'} \end{bmatrix}$				

Table 7.2.4-5: Codebook for 5-layer CSI reporting using antenna ports 15 to 22.

i_1	i_2
	0
0 - 3	$W^{(5)}_{i_1} = \frac{1}{\sqrt{40}}\begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} \end{bmatrix}$

Table 7.2.4-6: Codebook for 6-layer CSI reporting using antenna ports 15 to 22.

i_1	i_2
	0
0 - 3	$W^{(6)}_{i_1} = \frac{1}{\sqrt{48}}\begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} & v_{2i_1+16} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} & -v_{2i_1+16} \end{bmatrix}$

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 $\{15,16,17,\ldots,34\}$, 24 antenna ports $\{15,16,17,\ldots,38\}$, 28 antenna ports $\{15,16,17,\ldots,42\}$, 32 antenna ports $\{15,16,17,\ldots,46\}$, 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 $\upsilon \le 2$ with υ 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

$$\varphi_n = e^{j\pi n/2}$$

$$u_m = \begin{bmatrix} 1 & e^{j\frac{2\pi m}{O_2 N_2}} & \ldots & e^{j\frac{2\pi m(N_2-1)}{O_2 N_2}} \end{bmatrix}$$

$$v_{l,m} = \begin{bmatrix} u_m & e^{j\frac{2\pi l}{O_1 N_1}} u_m & \ldots & e^{j\frac{2\pi l(N_1-1)}{O_1 N_1}} u_m \end{bmatrix}^T$$

- 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 υ equal to the associated RI value and where $j = \upsilon + 9$.
- 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,…,15} for 1 layer and in {0,1,2…,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)
16	(2,4)	(8,4), (8,8)
	(4,2)	(8,4), (4,4)
	(8,1)	(4,-), (8,-)
20	(2,5)	(8,4)
	(5,2)	(4,4)
	(10,1)	(4,-)
24	(2,6)	(8,4)
	(3,4)	(8,4)
	(4,3)	(4,4)
	(6,2)	(4,4)
	(12,1)	(4,-)
28	(2,7)	(8,4)
	(7,2)	(4,4)
	(14,1)	(4,-)
32	(2,8)	(8,4)
	(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	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(1)}_{i_{1,1},i_{1,2},0}$	$W^{(1)}_{i_{1,1},i_{1,2},1}$	$W^{(1)}_{i_{1,1},i_{1,2},2}$	$W^{(1)}_{i_{1,1},i_{1,2},3}$
where $W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$						

Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			0	**1**	**2**	**3**
2	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2i_{1,1},2i_{1,2},0}$	$W^{(1)}_{2i_{1,1},2i_{1,2},1}$	$W^{(1)}_{2i_{1,1},2i_{1,2},2}$	$W^{(1)}_{2i_{1,1},2i_{1,2},3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			4	**5**	**6**	**7**
2	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2},0}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2},1}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2},2}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2},3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			8	**9**	**10**	**11**
2	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2i_{1,1},2i_{1,2}+1,0}$	$W^{(1)}_{2i_{1,1},2i_{1,2}+1,1}$	$W^{(1)}_{2i_{1,1},2i_{1,2}+1,2}$	$W^{(1)}_{2i_{1,1},2i_{1,2}+1,3}$
Value of Codebook-Config	$i_{1,1}$	$i_{1,2}$	i_2			
			12	**13**	**14**	**15**
2	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2}+1,0}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2}+1,1}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2}+1,2}$	$W^{(1)}_{2i_{1,1}+1,2i_{1,2}+1,3}$
where $W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$						

Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			0	**1**	**2**	**3**
3	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x,2y,0}$	$W^{(1)}_{2x,2y,1}$	$W^{(1)}_{2x,2y,2}$	$W^{(1)}_{2x,2y,3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			4	**5**	**6**	**7**
3	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+2,2y,0}$	$W^{(1)}_{2x+2,2y,1}$	$W^{(1)}_{2x+2,2y,2}$	$W^{(1)}_{2x+2,2y,3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			8	**9**	**10**	**11**
3	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+1,2y+1,0}$	$W^{(1)}_{2x+1,2y+1,1}$	$W^{(1)}_{2x+1,2y+1,2}$	$W^{(1)}_{2x+1,2y+1,3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			12	**13**	**14**	**15**
3	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+3,2y+1,0}$	$W^{(1)}_{2x+3,2y+1,1}$	$W^{(1)}_{2x+3,2y+1,2}$	$W^{(1)}_{2x+3,2y+1,3}$
where $x=i_{1,1}$, $y=i_{1,2}$, $W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$, if $N_1 \geq N_2$						
$x=i_{1,2}$, $y=i_{1,1}$, $W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{m,l} \\ \varphi_n v_{m,l} \end{bmatrix}$, if $N_1 < N_2$						

Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			0	**1**	**2**	**3**
4	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x,2y,0}$	$W^{(1)}_{2x,2y,1}$	$W^{(1)}_{2x,2y,2}$	$W^{(1)}_{2x,2y,3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			4	**5**	**6**	**7**
4	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+1,2y,0}$	$W^{(1)}_{2x+1,2y,1}$	$W^{(1)}_{2x+1,2y,2}$	$W^{(1)}_{2x+1,2y,3}$
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	i_2			
			8	**9**	**10**	**11**
4	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+2,2y,0}$	$W^{(1)}_{2x+2,2y,1}$	$W^{(1)}_{2x+2,2y,2}$	$W^{(1)}_{2x+2,2y,3}$
Value of Codebook-Config	$i_{1,1}$	$i_{1,2}$	i_2			
			12	**13**	**14**	**15**
4	$0,1,...,\frac{N_1O_1}{2}-1$	$0,1,...,\frac{N_2O_2}{2}-1$	$W^{(1)}_{2x+3,2y,0}$	$W^{(1)}_{2x+3,2y,1}$	$W^{(1)}_{2x+3,2y,2}$	$W^{(1)}_{2x+3,2y,3}$

where $x=i_{1,1}, \quad y=i_{1,2}, \quad W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{l,m} \\ \varphi_n v_{l,m} \end{bmatrix}$, if $N_1 \geq N_2$

$x=i_{1,2}, \quad y=i_{1,1}, \quad W^{(1)}_{l,m,n}=\frac{1}{\sqrt{P}}\begin{bmatrix} v_{m,l} \\ \varphi_n v_{m,l} \end{bmatrix}$, 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**				
$i_{1,2}=0,\cdots,N_2O_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1O_1-1$	$W^{(2)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},0}$	$W^{(2)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},1}$	$W^{(2)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},2}$	$W^{(2)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2},3}$
where $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$.				

***2 Layers, Codebook-Config* = 2**				
If $N_1 > N_2, p=1$ otherwise $p=O_1$				
$i_{1,2}=0,\cdots,N_2O_2/2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2},0}$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2},1}$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2},0}$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2},1}$
$i_{1,1}$	i_2			
	4	5	6	7
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,1}$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+1,1}$
$i_{1,1}$	i_2			
	8	9	10	11

$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2i_{1,1},2i_{1,1}+p,2i_{1,2},2i_{1,2},0}$	$W^{(2)}_{2i_{1,1},2i_{1,1}+p,2i_{1,2},2i_{1,2},1}$	$W^{(2)}_{2i_{1,1},2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(2)}_{2i_{1,1},2i_{1,1}+p,2i_{1,2}+1,2i_{1,2}+1,1}$
$i_{1,1}$	i_2			
	12	13	14	15
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+1,0}$	$W^{(2)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+1,1}$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2}+1,0}$	$W^{(2)}_{2i_{1,1}+p,2i_{1,1}+p,2i_{1,2},2i_{1,2}+1,1}$.

where $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$.

***2 Layers, Codebook-Config* = 3**				
$i_{1,2}=0,\cdots,N_2O_2/2-1$				
$i_{1,1}$	i_2			
	0	1	2	3
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x,2y,2y,0}$	$W^{(2)}_{2x,2x,2y,2y,1}$	$W^{(2)}_{2x+1,2x+1,2y+1,2y+1,0}$	$W^{(2)}_{2x+1,2x+1,2y+1,2y+1,1}$
$i_{1,1}$	i_2			
	4	5	6	7
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x+2,2x+2,2y,2y,0}$	$W^{(2)}_{2x+2,2x+2,2y,2y,1}$	$W^{(2)}_{2x+3,2x+3,2y+1,2y+1,0}$	$W^{(2)}_{2x+3,2x+3,2y+1,2y+1,1}$
$i_{1,1}$	i_2			
	8	9	10	11
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x+1,2y,2y+1,0}$	$W^{(2)}_{2x,2x+1,2y,2y+1,1}$	$W^{(2)}_{2x+1,2x+2,2y+1,2y,0}$	$W^{(2)}_{2x+1,2x+2,2y+1,2y,1}$
$i_{1,1}$	i_2			
	12	13	14	15
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x+3,2y,2y+1,0}$	$W^{(2)}_{2x,2x+3,2y,2y+1,1}$	$W^{(2)}_{2x+1,2x+3,2y+1,2y+1,0}$	$W^{(2)}_{2x+1,2x+3,2y+1,2y+1,1}$

where $x=i_{1,1}$, $y=i_{1,2}$, $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$ if $N_1 \geq N_2$ and

$x=i_{1,2}$, $y=i_{1,1}$, $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{m,l} & v_{m',l'} \\ \varphi_n v_{m,l} & -\varphi_n v_{m',l'} \end{bmatrix}$, if $N_1 < N_2$

***2 Layers, Codebook-Config* = 4**				
$i_{1,2}=0,\cdots,N_2O_2/2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x,2y,2y,0}$	$W^{(2)}_{2x,2x,2y,2y,1}$	$W^{(2)}_{2x+1,2x+1,2y,2y,0}$	$W^{(2)}_{2x+1,2x+1,2y,2y,1}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**

$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x+2,2x+2,2y,2y,0}$	$W^{(2)}_{2x+2,2x+2,2y,2y,1}$	$W^{(2)}_{2x+3,2x+3,2y,2y,0}$	$W^{(2)}_{2x+3,2x+3,2y,2y,1}$
$i_{1,1}$	i_2			
	8	**9**	**10**	**11**
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x+1,2y,2y,0}$	$W^{(2)}_{2x,2x+1,2y,2y,1}$	$W^{(2)}_{2x+1,2x+2,2y,2y,0}$	$W^{(2)}_{2x+1,2x+2,2y,2y,1}$
$i_{1,1}$	i_2			
	12	**13**	**14**	**15**
$0,\cdots,\frac{N_1O_1}{2}-1$	$W^{(2)}_{2x,2x+3,2y,2y,0}$	$W^{(2)}_{2x,2x+3,2y,2y,1}$	$W^{(2)}_{2x+1,2x+3,2y,2y,0}$	$W^{(2)}_{2x+1,2x+3,2y,2y,1}$

where $x=i_{1,1}$, $y=i_{1,2}$, $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$ if $N_1 \geq N_2$ and

$x=i_{1,2}$, $y=i_{1,1}$, $W^{(2)}_{l,l',m,m',n}=\frac{1}{\sqrt{2P}}\begin{bmatrix} v_{m,l} & v_{m',l'} \\ \varphi_n v_{m,l} & -\varphi_n v_{m',l'} \end{bmatrix}$, if $N_1 < N_2$

Table 7.2.4-12: Codebook for 3-layer CSI reporting using antenna ports 15 to 14+*P*

***3 Layers, Codebook-Config* = 1,** $N_1>1, N_2>1$		
$i_{1,2}=0,1,\cdots,N_2O_2-1$		
$i_{1,1}$	i_2	
	0	**1**
$0,\cdots,O_1N_1-1$	$W^{(3)}_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2}}$
$O_1N_1,\cdots,2O_1N_1-1$	$W^{(3)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2}$	$\tilde{W}^{(3)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2}$

where $W^{(3)}_{l,l',m,m'}=\frac{1}{\sqrt{3P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} \\ v_{l,m} & -v_{l,m} & -v_{l',m'} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'}=\frac{1}{\sqrt{3P}}\begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l',m'} \\ v_{l,m} & v_{l',m'} & -v_{l',m'} \end{bmatrix}$

***3 Layers, Codebook-Config* = 1,** $N_2=1$		
$i_{1,2}=0$		
$i_{1,1}$	i_2	
	0	**1**
$0,\cdots,O_1N_1-1$	$W^{(3)}_{i_{1,1},i_{1,1}+O_1,0,0}$	$\tilde{W}^{(3)}_{i_{1,1},i_{1,1}+O_1,0,0}$
$O_1N_1,\cdots,2O_1N_1-1$	$W^{(3)}_{i_{1,1},i_{1,1}+2O_1,0,0}$	$\tilde{W}^{(3)}_{i_{1,1},i_{1,1}+2O_1,0,0}$
$2O_1N_1,\cdots,3O_1N_1-1$	$W^{(3)}_{i_{1,1},i_{1,1}+3O_1,0,0}$	$\tilde{W}^{(3)}_{i_{1,1},i_{1,1}+3O_1,0,0}$

where $W^{(3)}_{l,l',m,m'}=\frac{1}{\sqrt{3P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} \\ v_{l,m} & -v_{l,m} & -v_{l',m'} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'}=\frac{1}{\sqrt{3P}}\begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l',m'} \\ v_{l,m} & v_{l',m'} & -v_{l',m'} \end{bmatrix}$

***3 Layers, Codebook-Config* = 2**				
$i_{1,2}=0,1,\cdots,2N_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**

$0,\cdots,2N_1-1$	$W^{(3)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2},2i_{1,2}}$	$W^{(3)}_{2i_{1,1}+4,2i_{1,1},2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1}+4,2i_{1,1},2i_{1,2},2i_{1,2}}$
$2N_1,\cdots,4N_1-1$	$W^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+4}$	$W^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+4,2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+4}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+4,2i_{1,2}}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**
$0,\cdots,2N_1-1$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2},2i_{1,2}}$	$W^{(3)}_{2i_{1,1}+5,2i_{1,1}+1,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1}+5,2i_{1,1}+1,2i_{1,2},2i_{1,2}}$
$2N_1,\cdots,4N_1-1$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2},2i_{1,2}+4}$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+4,2i_{1,2}}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2},2i_{1,2}+4}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+4,2i_{1,2}}$
$i_{1,1}$	i_2			
	8	**9**	**10**	**11**
$0,\cdots,2N_1-1$	$W^{(3)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1}$	$W^{(3)}_{2i_{1,1}+4,2i_{1,1},2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1}+4,2i_{1,1},2i_{1,2}+1,2i_{1,2}+1}$
$2N_1,\cdots,4N_1-1$	$W^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+5}$	$W^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+5,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+5}$	$\tilde{W}^{(3)}_{2i_{1,1},2i_{1,1},2i_{1,2}+5,2i_{1,2}+1}$
$i_{1,1}$	i_2			
	12	**13**	**14**	**15**
$0,\cdots,2N_1-1$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1}$	$W^{(3)}_{2i_{1,1}+5,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1}+5,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+1}$
$2N_1,\cdots,4N_1-1$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5}$	$W^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+5,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5}$	$\tilde{W}^{(3)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+5,2i_{1,2}+1}$
where $W^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$			

***3 Layers, Codebook-Config* =3**				
$i_{1,2}=0,1,\cdots,2N_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,2i_{1,2},2i_{1,2}}$	$W^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,2i_{1,2},2i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2},2i_{1,2}+4}$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2}+4,2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2},2i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2}+4,2i_{1,2}}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,2i_{1,2},2i_{1,2}}$	$W^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,2i_{1,2},2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,2i_{1,2},2i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2},2i_{1,2}+4}$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2}+4,2i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2},2i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2}+4,2i_{1,2}}$
$i_{1,1}$	i_2			
	8	**9**	**10**	**11**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1}$	$W^{(3)}_{4i_{1,1}+4,4i_{1,1},2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1}+4,4i_{1,1},2i_{1,2}+1,2i_{1,2}+1}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1},2i_{1,2}+1,2i_{1,2}+5}$	$W^{(3)}_{4i_{1,1},4i_{1,1},2i_{1,2}+5,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1},2i_{1,2}+1,2i_{1,2}+5}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1},2i_{1,2}+5,2i_{1,2}+1}$
$i_{1,1}$	i_2			
	12	**13**	**14**	**15**

$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1}$	$W^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+1}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5}$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+5,2i_{1,2}+1}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+5,2i_{1,2}+1}$

where $W^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m''}{4}} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m''}{4}} \end{bmatrix}$

3 Layers, Codebook-Config =4, $N_1>1, N_2>1$

$i_{1,2}=0,1,\cdots,4N_2-1$

$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1}+4,i_{1,2},i_{1,2}}$	$W^{(3)}_{4i_{1,1}+4,4i_{1,1},i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1}+4,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+4,4i_{1,1},i_{1,2},i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1},i_{1,2},i_{1,2}+4}$	$W^{(3)}_{4i_{1,1},4i_{1,1},i_{1,2}+4,i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1},i_{1,2},i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1},i_{1,2}+4,i_{1,2}}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,i_{1,2},i_{1,2}}$	$W^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,i_{1,2},i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2},i_{1,2}+4}$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2}+4,i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2},i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2}+4,i_{1,2}}$
$i_{1,1}$	i_2			
	8	**9**	**10**	**11**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,i_{1,2},i_{1,2}}$	$W^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,i_{1,2},i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2},i_{1,2}+4}$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2}+4,i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2},i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2}+4,i_{1,2}}$
$i_{1,1}$	i_2			
	12	**13**	**14**	**15**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,i_{1,2},i_{1,2}}$	$W^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,i_{1,2},i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,i_{1,2},i_{1,2}}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2},i_{1,2}+4}$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2}+4,i_{1,2}}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2},i_{1,2}+4}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2}+4,i_{1,2}}$

where $W^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m''}{4}} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m''}{4}} \end{bmatrix}$

3 Layers, Codebook-Config =4, $N_2=1$

$i_{1,2}=0$

$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1}+4,0,0}$	$W^{(3)}_{4i_{1,1}+4,4i_{1,1},0,0}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1}+4,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+4,4i_{1,1},0,0}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1}+8,0,0}$	$W^{(3)}_{4i_{1,1}+8,4i_{1,1},0,0}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1}+8,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+8,4i_{1,1},0,0}$
$2N_1,\cdots,3N_1-1$	$W^{(3)}_{4i_{1,1},4i_{1,1}+12,0,0}$	$W^{(3)}_{4i_{1,1}+12,4i_{1,1},0,0}$	$\tilde{W}^{(3)}_{4i_{1,1},4i_{1,1}+12,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+12,4i_{1,1},0,0}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**

$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,0,0}$	$W^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+5,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+5,4i_{1,1}+1,0,0}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+9,0,0}$	$W^{(3)}_{4i_{1,1}+9,4i_{1,1}+1,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+9,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+9,4i_{1,1}+1,0,0}$
$2N_1,\cdots,3N_1-1$	$W^{(3)}_{4i_{1,1}+1,4i_{1,1}+13,0,0}$	$W^{(3)}_{4i_{1,1}+13,4i_{1,1}+1,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+1,4i_{1,1}+13,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+13,4i_{1,1}+1,0,0}$
$i_{1,1}$	i_2			
	8	**9**	**10**	**11**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,0,0}$	$W^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+6,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+6,4i_{1,1}+2,0,0}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+10,0,0}$	$W^{(3)}_{4i_{1,1}+10,4i_{1,1}+2,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+10,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+10,4i_{1,1}+2,0,0}$
$2N_1,\cdots,3N_1-1$	$W^{(3)}_{4i_{1,1}+2,4i_{1,1}+14,0,0}$	$W^{(3)}_{4i_{1,1}+14,4i_{1,1}+2,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+2,4i_{1,1}+14,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+14,4i_{1,1}+2,0,0}$
$i_{1,1}$	i_2			
	12	**13**	**14**	**15**
$0,\cdots,N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,0,0}$	$W^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+7,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+7,4i_{1,1}+3,0,0}$
$N_1,\cdots,2N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+11,0,0}$	$W^{(3)}_{4i_{1,1}+11,4i_{1,1}+3,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+11,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+11,4i_{1,1}+3,0,0}$
$2N_1,\cdots,3N_1-1$	$W^{(3)}_{4i_{1,1}+3,4i_{1,1}+15,0,0}$	$W^{(3)}_{4i_{1,1}+15,4i_{1,1}+3,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+3,4i_{1,1}+15,0,0}$	$\tilde{W}^{(3)}_{4i_{1,1}+15,4i_{1,1}+3,0,0}$

where $W^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l}{4},\frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \end{bmatrix}$, $\tilde{W}^{(3)}_{l,l',m,m'} = \frac{1}{\sqrt{3P}}\begin{bmatrix} v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l}{4},\frac{O_2 m'}{4}} & v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \\ v_{\frac{O_1 l}{4},\frac{O_2 m}{4}} & v_{\frac{O_1 l}{4},\frac{O_2 m'}{4}} & -v_{\frac{O_1 l'}{4},\frac{O_2 m'}{4}} \end{bmatrix}$

Table 7.2.4-13: Codebook for 4-layer CSI reporting using antenna ports 15 to 14+*P*

***4 Layers, Codebook-Config* = 1,** $N_1>1, N_2>1$		
$i_{1,2}=0,1,\cdots,N_2O_2-1$		
$i_{1,1}$	i_2	
	0	**1**
$0,\cdots,N_1O_1-1$	$W^{(4)}_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2},0}$	$W^{(4)}_{i_{1,1},i_{1,1}+O_1,i_{1,2},i_{1,2},1}$
$O_1N_1,\cdots,2O_1N_1-1$	$W^{(4)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2,0}$	$W^{(4)}_{i_{1,1},i_{1,1},i_{1,2},i_{1,2}+O_2,1}$

where $W^{(4)}_{l,l',m,m',n} = \frac{1}{\sqrt{4P}}\begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & \varphi_n v_{l',m'} & -\varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$

***4 Layers*, *Codebook-Config* = 1,** $N_2 = 1$		
$i_{1,2} = 0$		
$i_{1,1}$	i_2	
	0	1
$0,\cdots,O_1N_1-1$	$W^{(4)}_{i_{1,1},i_{1,1}+O_1,0,0,0}$	$W^{(4)}_{i_{1,1},i_{1,1}+O_1,0,0,1}$
$O_1N_1,\cdots,2O_1N_1-1$	$W^{(4)}_{i_{1,1},i_{1,1}+2O_1,0,0,0}$	$W^{(4)}_{i_{1,1},i_{1,1}+2O_1,0,0,1}$
$2O_1N_1,\cdots,3O_1N_1-1$	$W^{(4)}_{i_{1,1},i_{1,1}+3O_1,0,0,0}$	$W^{(4)}_{i_{1,1},i_{1,1}+3O_1,0,0,1}$
$W^{(4)}_{l,l',m,m',n} = \frac{1}{\sqrt{4P}}\begin{bmatrix} v_{l,m} & v_{l',m'} & v_{l,m} & v_{l',m'} \\ \varphi_n v_{l,m} & \varphi_n v_{l',m'} & -\varphi_n v_{l,m} & -\varphi_n v_{l',m'} \end{bmatrix}$		

***4 Layers, Codebook-Config* = 2**				
$i_{1,2} = 0,1,\cdots,2N_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,2N_1-1$	$W^{(4)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2},2i_{1,2},0}$	$W^{(4)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2},2i_{1,2},1}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2},2i_{1,2},0}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2},2i_{1,2},1}$
$2N_1,\cdots,4N_1-1$	$W^{(4)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+4,0}$	$W^{(4)}_{2i_{1,1},2i_{1,1},2i_{1,2},2i_{1,2}+4,1}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2},2i_{1,2}+4,0}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2},2i_{1,2}+4,1}$
$i_{1,1}$	i_2			
	4	5	6	7
$0,\cdots,2N_1-1$	$W^{(4)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(4)}_{2i_{1,1},2i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1,1}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1,1}$
$2N_1,\cdots,4N_1-1$	$W^{(4)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+5,0}$	$W^{(4)}_{2i_{1,1},2i_{1,1},2i_{1,2}+1,2i_{1,2}+5,1}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5,0}$	$W^{(4)}_{2i_{1,1}+1,2i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5,1}$
$W^{(4)}_{l,l',m,m',n} = \frac{1}{\sqrt{4P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ \varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & \varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -\varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -\varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$				

***4 Layers, Codebook-Config* =3**				
$i_{1,2} = 0,1,\cdots,2N_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,2i_{1,2},2i_{1,2},0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,2i_{1,2},2i_{1,2},1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,2i_{1,2},2i_{1,2},0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,2i_{1,2},2i_{1,2},1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2},2i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+2,2i_{1,2},2i_{1,2}+4,1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2},2i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+3,2i_{1,2},2i_{1,2}+4,1}$
$i_{1,1}$	i_2			
	4	5	6	7

$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,2i_{1,2}+1,2i_{1,2}+1,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,2i_{1,2}+1,2i_{1,2}+1,1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1},2i_{1,2}+1,2i_{1,2}+5,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1},2i_{1,2}+1,2i_{1,2}+5,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+1,2i_{1,2}+1,2i_{1,2}+5,1}$

$$W^{(4)}_{l,l',m,m',n}=\frac{1}{\sqrt{4P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ \varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & \varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -\varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -\varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$$

4 Layers, Codebook-Config =4, $N_1>1,\ N_2>1$				
$i_{1,2}=0,1,\cdots,4N_2-1$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,i_{1,2},i_{1,2},0}$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,i_{1,2},i_{1,2},1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,i_{1,2},i_{1,2},0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,i_{1,2},i_{1,2},1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1},i_{1,2},i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1},i_{1,2},i_{1,2}+4,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2},i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+1,i_{1,2},i_{1,2}+4,1}$
$i_{1,1}$	i_2			
	4	5	6	7
$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,i_{1,2},i_{1,2},0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,i_{1,2},i_{1,2},1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,i_{1,2},i_{1,2},0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,i_{1,2},i_{1,2},1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2},i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+2,i_{1,2},i_{1,2}+4,1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2},i_{1,2}+4,0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+3,i_{1,2},i_{1,2}+4,1}$

$$W^{(4)}_{l,l',m,m',n}=\frac{1}{\sqrt{4P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ \varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & \varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -\varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -\varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$$

4 Layers, Codebook-Config =4, $N_2=1$				
$i_{1,2}=0$				
$i_{1,1}$	i_2			
	0	**1**	**2**	**3**
$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,0,0,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1}+4,0,0,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,0,0,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+5,0,0,1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1}+8,0,0,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1}+8,0,0,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+9,0,0,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+9,0,0,1}$
$2N_1,\cdots,3N_1-1$	$W^{(4)}_{4i_{1,1},4i_{1,1}+12,0,0,0}$	$W^{(4)}_{4i_{1,1},4i_{1,1}+12,0,0,1}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+13,0,0,0}$	$W^{(4)}_{4i_{1,1}+1,4i_{1,1}+13,0,0,1}$
$i_{1,1}$	i_2			
	4	**5**	**6**	**7**
$0,\cdots,N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,0,0,0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+6,0,0,1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,0,0,0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+7,0,0,1}$
$N_1,\cdots,2N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+10,0,0,0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+10,0,0,1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+11,0,0,0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+11,0,0,1}$
$2N_1,\cdots,3N_1-1$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+14,0,0,0}$	$W^{(4)}_{4i_{1,1}+2,4i_{1,1}+14,0,0,1}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+15,0,0,0}$	$W^{(4)}_{4i_{1,1}+3,4i_{1,1}+15,0,0,1}$

$$W^{(4)}_{l,l',m,m',n}=\frac{1}{\sqrt{4P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \\ \varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & \varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -\varphi_n v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -\varphi_n v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} \end{bmatrix}$$

Table 7.2.4-14: Codebook for 5-layer CSI reporting using antenna ports 15 to 14+*P*

5 Layers, $P=8$, $N_1=N_2$			
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	
1	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
2-4	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
$W^{(5)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{5P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4			
$W^{(5)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{5P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} \end{bmatrix}$ for *Codebook-Config* = 1			

5 Layers, $P=12$				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1>1,\ N_2\geq 1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8}$
4	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(5)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8}$
where $W^{(5)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{5P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(5)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{5P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} \end{bmatrix}$ for *Codebook-Config* = 1				

5 Layers, $P \in \{16,20,24,28,32\}$				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1 > 1, N_2 > 1$	$0,1,\cdots,O_1 N_1 - 1$	$0,1,\cdots,O_2 N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
	$N_2 = 1$	$0,1,\cdots,O_1 N_1 - 1$	0	$W^{(5)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,2},i_{1,2},i_{1,2}}$
2	$N_1 > 1,\ N_2 > 1$	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
3	$N_1 \geq N_2$	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1 < N_2$	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8}$
4	$N_1 \geq N_2,\ N_2 > 1$	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_2 = 1$	$0,1,\cdots,4N_1 - 1$	0	$W^{(5)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_1 < N_2$	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(5)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8}$
where $W^{(5)}_{l,l',l'',m,m',m''} = \frac{1}{\sqrt{5P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(5)}_{l,l',l'',m,m',m''} = \frac{1}{\sqrt{5P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} \end{bmatrix}$ for *Codebook-Config* = 1				

Table 7.2.4-15: Codebook for 6-layer CSI reporting using antenna ports 15 to 14+*P*

6 Layers, $P=8, N_1=N_2$			
Value of *Codebook-Config*	$i_{1,1}$	$i_{1,2}$	
1	$0,1,\cdots,O_1 N_1 - 1$	$0,1,\cdots,O_2 N_2 - 1$	$W^{(6)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
2-4	$0,1,\cdots,4N_1 - 1$	$0,1,\cdots,4N_2 - 1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
where $W^{(6)}_{l,l',l'',m,m',m''} = \frac{1}{\sqrt{6P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(6)}_{l,l',l'',m,m',m''} = \frac{1}{\sqrt{6P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix}$ for *Codebook-Config* = 1			

6 Layers, $P=12$				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1>1,\ N_2\geq 1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8}$
4	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8}$
where $W^{(6)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{6P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(6)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{6P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix}$ for *Codebook-Config* = 1				

6 Layers, $P\in\{16,20,24,28,32\}$				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1>1,N_2>1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,2},i_{1,2},i_{1,2}+O_2}$
	$N_2=1$	$0,1,\cdots,O_1N_1-1$	0	$W^{(6)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,2},i_{1,2},i_{1,2}}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8}$
4	$N_1\geq N_2,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_2=1$	$0,1,\cdots,4N_1-1$	0	$W^{(6)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,2},i_{1,2},i_{1,2}}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(6)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8}$
where $W^{(6)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{6P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(6)}_{l,l',l'',m,m',m''}=\frac{1}{\sqrt{6P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} \end{bmatrix}$ 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	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
2-4	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
where $W^{(7)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(7)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} \end{bmatrix}$ for *Codebook-Config* = 1			

7 Layers, $P=12$				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1>1,\ N_2\geq 1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+4}$
4	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1},i_{1,2},i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}}$
where $W^{(7)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(7)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} \end{bmatrix}$ 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	$N_1 > 1, N_2 > 1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
	$N_2 = 1$	$0,1,\cdots,O_1N_1-1$	0	$W^{(7)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,1}+3O_1,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
2	$N_1 > 1, N_2 > 1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
3	$N_1 \geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
	$N_1 < N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+12}$
4	$N_1 \geq N_2$, $N_2 > 1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
	$N_2 = 1$	$0,1,\cdots,4N_1-1$	0	$W^{(7)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
	$N_1 < N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(7)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+12}$

where

$$W^{(7)}_{l,l',l'',l'''m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$$ for *Codebook-Config* = 2-4

$$W^{(7)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{7P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} \end{bmatrix}$$ 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	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
2-4	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$

where $W^{(8)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{8P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & -v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$

for *Codebook-Config* = 2-4

$$W^{(8)}_{l,l',l'',l''',m,m',m'',m'''} = \frac{1}{\sqrt{8P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} & -v_{l''',m'''} \end{bmatrix}$$

for *Codebook-Config* = 1

8 Layers, *P=12*				
Value of *Codebook-Config*	**Configuration**	$i_{1,1}$	$i_{1,2}$	
1	$N_1>1,\ N_2\geq 1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+4,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+4}$
4	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1},i_{1,2},i_{1,2},i_{1,2},i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}}$
where $W^{(8)}_{l,l',l'',l''',m,m',m'',m'''}=\frac{1}{\sqrt{8P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & -v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(8)}_{l,l',l'',l''',m,m',m'',m'''}=\frac{1}{\sqrt{8P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} & -v_{l''',m'''} \end{bmatrix}$ 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	$N_1>1,N_2>1$	$0,1,\cdots,O_1N_1-1$	$0,1,\cdots,O_2N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+O_1,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+O_2,i_{1,2}+O_2}$
	$N_2=1$	$0,1,\cdots,O_1N_1-1$	0	$W^{(8)}_{i_{1,1},i_{1,1}+O_1,i_{1,1}+2O_1,i_{1,1}+3O_1,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
2	$N_1>1,\ N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,1},i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
3	$N_1\geq N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2}+4,i_{1,2}+4}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1},i_{1,1}+4,i_{1,1}+4,i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+12}$
4	$N_1\geq N_2$, $N_2>1$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
	$N_2=1$	$0,1,\cdots,4N_1-1$	0	$W^{(8)}_{i_{1,1},i_{1,1}+4,i_{1,1}+8,i_{1,1}+12,i_{1,2},i_{1,2},i_{1,2},i_{1,2}}$
	$N_1<N_2$	$0,1,\cdots,4N_1-1$	$0,1,\cdots,4N_2-1$	$W^{(8)}_{i_{1,1},i_{1,1},i_{1,1},i_{1,1},i_{1,2},i_{1,2}+4,i_{1,2}+8,i_{1,2}+12}$
where $W^{(8)}_{l,l',l'',l''',m,m',m'',m'''}=\frac{1}{\sqrt{8P}}\begin{bmatrix} v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \\ v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & -v_{\frac{O_1}{4}l,\frac{O_2}{4}m} & v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & -v_{\frac{O_1}{4}l',\frac{O_2}{4}m'} & v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & -v_{\frac{O_1}{4}l'',\frac{O_2}{4}m''} & v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} & -v_{\frac{O_1}{4}l''',\frac{O_2}{4}m'''} \end{bmatrix}$ for *Codebook-Config* = 2-4 $W^{(8)}_{l,l',l'',l''',m,m',m'',m'''}=\frac{1}{\sqrt{8P}}\begin{bmatrix} v_{l,m} & v_{l,m} & v_{l',m'} & v_{l',m'} & v_{l'',m''} & v_{l'',m''} & v_{l''',m'''} & v_{l''',m'''} \\ v_{l,m} & -v_{l,m} & v_{l',m'} & -v_{l',m'} & v_{l'',m''} & -v_{l'',m''} & v_{l''',m'''} & -v_{l''',m'''} \end{bmatrix}$ *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 $\{15,16,17,\ldots,34\}$, 24 antenna ports $\{15,16,17,\ldots,38\}$, 28 antenna ports $\{15,16,17,\ldots,42\}$, 32 antenna ports $\{15,16,17,\ldots,46\}$, and UE configured with higher layer parameter *advancedCodebookEnabled=TRUE*, and $\upsilon \le 2$ with υ 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

$$\varphi_n = e^{j\pi n/2}$$

$$u_m = \begin{bmatrix} 1 & e^{j\frac{2\pi m}{O_2 N_2}} & \ldots & e^{j\frac{2\pi m(N_2-1)}{O_2 N_2}} \end{bmatrix}$$

$$v_{l,m} = \begin{bmatrix} u_m & e^{j\frac{2\pi l}{O_1 N_1}} u_m & \ldots & e^{j\frac{2\pi l(N_1-1)}{O_1 N_1}} u_m \end{bmatrix}^T$$

- The values of N_1, N_2 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 $i_{2,\nu}$ is the index for the ν^{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 $i_{1,3}$	$N_1 \ge N_2$, $N_1 \ge 4$, $N_2 \ne 1$		$N_1 = 3$, $N_2 = 2$		$N_1 = 2$, $N_2 = 2$		$N_2 > N_1$, $N_2 \ge 4$, $N_1 \ne 1$		$N_2 = 3$, $N_1 = 2$		$N_1 \ge 8$ $N_2 = 1$		$N_1 = 2$, $N_2 = 1$		$N_1 = 4$, $N_2 = 1$	
	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				
$\lfloor i_{2,\upsilon}/4 \rfloor$				
$N_1>1, N_2>1$	0	1	2	3
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,0,3,i_{2,\upsilon}}$
$0 \le i_{1,1} \le 4N_1-1$,	4	5	6	7
$0 \le i_{1,2} \le 4N_2-1$,	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,1,3,i_{2,\upsilon}}$
$0 \le i_{2,\upsilon} \le 63$	8	9	10	11
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,2,3,i_{2,\upsilon}}$
	12	13	14	15
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,4d_2,p,3,3,i_{2,\upsilon}}$
$\lfloor i_{2,\upsilon}/4 \rfloor$				
$N_2=1$	0	1	2	3
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,0,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,0,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,0,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,0,3,i_{2,\upsilon}}$
$0 \le i_{1,1} \le 4N_1-1$,	4	5	6	7
$i_{1,2}=0$,	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,1,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,1,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,1,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,1,3,i_{2,\upsilon}}$
$0 \le i_{2,\upsilon} \le 63$	8	9	10	11
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,2,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,2,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},p,4d_1,d_2,2,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},p,4d_1,d_2,2,3,i_{2,\upsilon}}$
	12	13	14	15
	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,3,0,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,3,1,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,3,2,i_{2,\upsilon}}$	$W^{\upsilon}_{i_{1,1},i_{1,2},4d_1,d_2,p,3,3,i_{2,\upsilon}}$

	$W^{\upsilon}_{k_1,k_2,m_1,m_2,p,q_1,q_2,q_3} = \frac{1}{\sqrt{P\left(1+p^2\right)}}\begin{bmatrix} v_{k_1,k_2} + p\varphi_{q_3}v_{k_1+m_1,k_2+m_2} \\ \varphi_{q_1}\left(v_{k_1,k_2} + p\varphi_{q_2}v_{k_1+m_1,k_2+m_2}\right)\end{bmatrix},\ \upsilon = 1,2$ For one layer: $W^{(1)}_{k_1,k_2,m_1,m_2,p,q_1,q_2,q_3} = W^{1}_{k_1,k_2,m_1,m_2,p,q_1,q_2,q_3}$, and for two layers: $W^{(2)}_{k_1,k_2,m_1,m_2,p,q_{1,1},q_{2,1},q_{3,1},q_{1,2},q_{2,2},q_{3,2}} = \frac{1}{\sqrt{2}}\begin{bmatrix} W^{1}_{k_1,k_2,p,m_1,m_2,q_{1,1},q_{2,1},q_{3,1}} & W^{2}_{k_1,k_2,p,m_1,m_2,q_{1,2},q_{2,2},q_{3,2}}\end{bmatrix}$

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_K1=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_K1=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 υ 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 $\upsilon = 2$ 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 υ 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 $\upsilon = 2$ 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 υ 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* ($k,l \in \{0,1,\cdots,N-1\}$), and 0 otherwise.

Table 7.2.4-18: Codebook for υ-layer CSI reporting using antenna ports $\{15,16\}$

Codebook index, *n*	Number of layers υ	
	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 υ-layer CSI reporting using antenna ports $\{15,16,17,18\}$

Codebook index, *n*	Number of layers υ			
	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 υ-layer CSI reporting using antenna ports $\{15,16,17,18,19,20,21,22\}$

Codebook index, *n*	Number of layers υ			
	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 υ	
	5	6
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 υ	
	7	8
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 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, 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 *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 *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 *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-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 *eMIMO-Type* and *eMIMO-Type* is set to 'CLASS B',

- if the UE is configured with higher layer parameter *csi-RS-ConfigNZP-ApList*, the higher layer parameter *csi-RS-NZP-mode* is set to aperiodic, and number of configured CSI-RS resources in *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 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.

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 sub-frame, 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 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 sub-frame 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 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 *n* if the UE does not receive PDSCH or PDCCH indicating downlink SPS release in subframe *n-4*.

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, a UE shall use PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 in [3].

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai*, for FDD and a subframe *n*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of serving cell(s) with PDSCH transmission(s) associated with PDCCH/EPDCCH and serving cell with PDCCH/EPDCCH indicating downlink SPS release, up to the present serving cell in increasing order of serving cell index; the value of the total DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the total number of serving cell(s) with PDSCH transmission(s) associated with PDCCH/EPDCCH(s) and serving cell with PDCCH/EPDCCH indicating downlink SPS release. Denote $V_{C-DAI,c}^{DL}$ as the value of the counter DAI in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D scheduling PDSCH transmission or indicating downlink SPS release for serving cell *c*, according to table 7.3.1-1. Denote V_{T-DAI}^{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 scheduling PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release in a subframe.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe *n*, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the following pseudo-code:

Set *c = 0* – cell index: lower indices correspond to lower RRC indices of corresponding cell

Set *j = 0*

Set $V_{temp} = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

while *c* < N_{cells}^{DL}

if there is a PDSCH on serving cell *c* associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell *c*,

if $V_{C-DAI,c}^{DL} = \varnothing$

$V_{C-DAI,c}^{DL} = \mathrm{mod}\left(V_{temp},4\right)+1$

end if

if $V_{C-DAI,c}^{DL} \le V_{temp}$

$j = j+1$

end if

$V_{temp} = V_{C-DAI,c}^{DL}$

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,

$\tilde{o}_{8j+2\left(V_{C-DAI,c}^{DL}-1\right)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$\tilde{o}_{8j+2\left(V_{C-DAI,c}^{DL}-1\right)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$V_s = V_s \cup \left\{8j+2\left(V_{C-DAI,c}^{DL}-1\right), 8j+2\left(V_{C-DAI,c}^{DL}-1\right)+1\right\}$

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,

$\tilde{o}_{4j+V_{C-DAI,c}^{DL}-1}^{ACK}$ = binary AND operation of the HARQ-ACK bits corresponding to the first and second codewords of this cell

$V_s = V_s \cup \left\{4j+V_{C-DAI,c}^{DL}-1\right\}$

else

$\tilde{o}_{4j+V_{C-DAI,c}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$V_s = V_s \cup \left\{4j+V_{C-DAI,c}^{DL}-1\right\}$

end if

end if

$c = c + 1$

end while

if $V_{T-DAI}^{DL} < V_{temp}$

$j = j+1$

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,

$O^{ACK} = 2 \cdot \left(4 \cdot j + V_{T-DAI}^{DL}\right)$

else

$O^{ACK} = 4 \cdot j + V_{T-DAI}^{DL}$

end if

$\tilde{o}_i^{ACK} = \text{NACK}$ for any $i \in \{0,1,...,O^{ACK}-1\} \setminus V_s$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in subframe *n*-4

$O^{ACK} = O^{ACK} + 1$

$o_{O^{ACK}-1}^{ACK}$ = HARQ-ACK bit associated with the SPS PDSCH transmission

end if

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = dai*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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	$V_{C-DAI,c}^{DL}$ or V_{T-DAI}^{DL}	Number of serving cells with PDSCH transmission associated with PDCCH/EPDCCH and serving cell with PDCCH/EPDCCH 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* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe *n*, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 in [4].

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = cc*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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 parameter *HARQACKDelayType* 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*.

- 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 $1 \le M \le 4$ BL/CE DL subframes for which subframe *n* is the 'HARQ-ACK transmission subframe'.
- if subframe *n-k1* 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-k1* indicates a value 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 $\{n_1...n_L\}, n_i \ge n$, 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 half-duplex FDD operation

'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'*
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 PUCCH Format 1 for the SR resource as defined in Subclause 5.4.1 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 indicating downlink SPS release (defined in Subclause 9.2) 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 TDD, 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 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, V_{DAI}^{UL}, detected by the UE according to Table 7.3-X in subframe $n-k'$, where k' is defined in Table 7.3-Y, represents the total number of subframes with PDSCH transmissions and with PDCCH/EPDCCH indicating downlink SPS release to the corresponding UE within all the subframe(s) $n-k$, where $k \in K$. The value V_{DAI}^{UL} includes all PDSCH transmission with and without corresponding PDCCH/EPDCCH within all the subframe(s) $n-k$. In case neither PDSCH transmission, nor PDCCH/EPDCCH 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, 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 according to Table 7.3-Z in subframe $n-k'$, where k' is defined in Table 7.3-Y. In case neither PDSCH transmission, nor PDCCH/EPDCCH 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 if transmitted.

If a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = 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 denotes the accumulative number of PDCCH/EPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release up to the present subframe within subframe(s) $n-k$ of each configured serving cell, where $k \in K$, and shall be updated from subframe to subframe. Denote $V_{DAI,c}^{DL}$ as the value of the DAI in PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D detected by the UE according to Table 7.3-X in subframe $n-k_m$ in serving cell c, where k_m is the smallest value in the set K (defined in Table 10.1.3.1-1) such that the UE detects a DCI format 1/1A/1B/1D/2/2A/2B/2C/2D. 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 (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release detected by the UE within the subframe(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 within the subframe(s) $n-k$, where $k \in K$.

For TDD HARQ-ACK bundling or HARQ-ACK multiplexing and a subframe n with $M=1$, the UE shall generate one or two HARQ-ACK bits by performing a logical AND operation per codeword across M downlink and special subframes associated with a single UL subframe, of all the corresponding $U_{DAI}+N_{SPS}$ individual PDSCH transmission HARQ-ACKs and individual ACK in response to received PDCCH/EPDCCH indicating downlink SPS release, where M is the number of elements in the set K defined in Table 10.1.3.1-1. 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, or detects PDCCH indicating downlink SPS release within the subframe $n-k$, where $k \in K$. The UE shall not transmit HARQ-ACK on PUSCH if the UE does not receive PDSCH or PDCCH indicating downlink SPS release within the subframe(s) $n-k$, where $k \in K$.
- For the case that the UE is not transmitting on PUSCH in subframe *n* and TDD UL/DL configurations 1-6, if $U_{DAI}>0$ and $V_{DAI}^{DL} \neq (U_{DAI}-1) \bmod 4+1$, 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 with DCI format 0/4 intended for the UE and TDD UL/DL configurations 1-6, if $V_{DAI}^{UL} \neq (U_{DAI}+N_{SPS}-1) \bmod 4+1$ 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 $N_{\text{bundled}}=V_{DAI}^{UL}+2$. If the UE does not detect any downlink assignment missing, N_{bundled} is determined by the UE as $N_{\text{bundled}}=V_{DAI}^{UL}$. UE shall not transmit HARQ-ACK if $U_{DAI}+N_{SPS}=0$ and $V_{DAI}^{UL}=4$.
- For the case that the UE is transmitting on PUSCH, and the PUSCH transmission is not based on a detected PDCCH/EPDCCH with DCI format 0/4 intended for the UE and TDD UL/DL configurations 1-6, if $U_{DAI}>0$ and $V_{DAI}^{DL} \neq (U_{DAI}-1) \bmod 4+1$, the UE detects that at least one downlink assignment has been missed and

the UE shall generate NACK for all codewords. The UE determines $N_{\text{bundled}} = (U_{DAI} + N_{SPS})$ as the number of assigned subframes. The UE shall not transmit HARQ-ACK if $U_{DAI} + N_{SPS} = 0$.

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 $o_{c,0}^{ACK}\, o_{c,1}^{ACK},..., o_{c,O_c^{ACK}-1}^{ACK}$ 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 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 on PUCCH, $B_c^{DL} = M$ 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 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.

- For 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 10.1.3.1-1 associated with subframe *n* and the set K does not include a special subframe of configurations 0 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$. 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, 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 indicating downlink SPS release in subframe(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 with DCI format 0/4, the UE shall assume $B_c^{DL} = W_{DAI}^{UL} + 4\left\lceil \left(U - W_{DAI}^{UL}\right)/4 \right\rceil$, 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 indicating downlink SPS release in subframe(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 indicating downlink SPS release in subframe(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*, the HARQ-ACK feedback bits $o_{c,0}^{ACK}\, o_{c,1}^{ACK},..., o_{c,O_c^{ACK}-1}^{ACK}$ 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 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 on PUCCH, $B_c^{DL} = M$ 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 and 5 with normal downlink CP or of configurations 0 and 4 with extended downlink CP; otherwise $B_c^{DL} = M - 1$.

- For 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 and 5 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 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 TDD UL/DL configurations 1-6, the 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 $o_{c,DAI(k)-1}^{ACK}$ 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 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 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 indicating downlink SPS release in subframe $n-k$ 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 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},...,$o_{O^{ACK}-1}^{ACK}$ on PUSCH are constructed as follows.

- For TDD UL/DL configuration 0, o_j^{ACK} = HARQ-ACK(*j*), $0 \le j \le A-1$ 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, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ 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} = HARQ-ACK(*j*), $0 \le j \le A-1$ 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, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ 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 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.

Table 7.3-X: Value of Downlink Assignment Index

DAI MSB, LSB	V_{DAI}^{UL} or V_{DAI}^{DL}	Number of subframes with PDSCH transmission and with PDCCH/EPDCCH 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-Z: Value of W_{DAI}^{UL} determined by the DAI field in DCI format 0/4

DAI MSB, LSB	W_{DAI}^{UL}
0,0	1
0,1	2
1,0	3
1,1	4

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 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}, $n = 0, \ldots, O^{ACK} - 1$ 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*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe, first in increasing order of serving cell index and then in increasing order of subframe index within subframe(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 denotes the total number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH(s) or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present subframe within subframe(s) $n-k$ where $k \in K$, and shall be updated from subframe to subframe. 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 scheduling PDSCH transmission or indicating downlink SPS release for serving cell *c* in subframe $n-k$ 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 $n-k$ 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 scheduling PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release in a subframe.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe *n*, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, \ldots, \tilde{o}_{O^{ACK}-1}^{ACK}$ 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 index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in K$

Set *j = 0*

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set *M* to the number of subframes within subframe(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 *m* associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell *c* in subframe *m*,

if $V_{C-DAI,c,m}^{DL} \le V_{temp}$

j = j+1

end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

if $V_{T-DAI,m}^{DL} = \varnothing$

$V_{temp2} = V_{C-DAI,c,m}^{DL}$

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,

$\tilde{o}_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$\tilde{o}_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$V_s = V_s \cup \left\{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right), 8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1\right\}$

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

$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$

else

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$

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,

$$O^{ACK} = 2 \cdot \left(4 \cdot j + V_{temp2}\right)$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

$$\tilde{o}_i^{ACK} = \text{NACK} \quad \text{for any} \quad i \in \left\{0,1,...,O^{ACK}-1\right\} \setminus V_s$$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in a subframe $n-k$ 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*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH 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* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe *n*, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 in [4].

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = cc*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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* transmission of HARQ-ACK coincides with a sub-frame 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 one of the following cases

- 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

- 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

- 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* transmission of HARQ-ACK coincides with a sub-frame 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 one of the following cases

- 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

- 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

- 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 sub-frame, 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 in [3]. 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 TDD UL/DL configurations 1-6, if $\sum_{c=0}^{N_{cells}^{DL}-1}U_{DAI,c}>0$ and $V_{DAI,c}^{DL} \neq \left(U_{DAI,c}-1\right) \bmod 4+1$ 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/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}. 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/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
- 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 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,

  - 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 $\left(O^{ACK}+O^{SR}+O_{\text{P-CSI}}+O_{CRC}\right)\le \min\left(M_{\text{RB},1}^{\text{PUCCH4}}, M_{\text{RB},2}^{\text{PUCCH4}}\right)\cdot N_{sc}^{RB}\cdot N_{\text{symb}}^{\text{PUCCH4}}\cdot 2\cdot r$, 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 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 periodic CSI report(s), where

    - O^{ACK} is the total number of HARQ-ACK bits in the subframe;
    - $O^{SR}=0$ if there is no scheduling request bit in the subframe and $O^{SR}=1$ otherwise
    - $O_{\text{P-CSI}}$ 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;

- $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot \left(N_{\text{symb}}^{\text{UL}} - 1 \right) - 1$ if shortened PUCCH format 4 is used in the subframe and $N_{\text{symb}}^{\text{PUCCH4}} = 2 \cdot \left(N_{\text{symb}}^{\text{UL}} - 1 \right)$ otherwise; and
- r is the code rate given by higher layer parameter *maximumPayloadCoderate-r13* according to Table 10.1.1-1.

o 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,

  o 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];

  o 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

  o if $\left(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}} \right) \le 2 \cdot N_{\text{RE}} \cdot r$, 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 $n_{\text{PUCCH}}^{(5)}$;

  o if $\left(O^{ACK} + O^{SR} + O_{\text{P-CSI}} + O_{\text{CRC}} \right) > 2 \cdot N_{\text{RE}} \cdot r$, the UE shall select $N_{\text{CSI,reported}}$ CSI report(s) for transmission together with HARQ-ACK/SR in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$, where $\text{Pri}_{CSI}(y,s,c,t)$, N_{RE} and r are determined according to Subclause 7.2.2; the value of $N_{\text{CSI,reported}}$ satisfies $\left(O^{ACK} + O^{SR} + \sum_{n=1}^{N_{\text{CSI,reported}}} O_{\text{P-CSI},n} + O_{\text{CRC}} \right) \le 2 \cdot N_{\text{RE}} \cdot r$ and $\left(O^{ACK} + O^{SR} + \sum_{n=1}^{N_{\text{CSI,reported}}+1} O_{\text{P-CSI},n} + O_{\text{CRC}} \right) > 2 \cdot N_{\text{RE}} \cdot r$, and $O_{P-CSI,n}$ is the number of CSI report bits for the *n*th CSI report in ascending order of $\text{Pri}_{CSI}(y,s,c,t)$.

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* 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 is not used.

The UE shall upon detection of a PDSCH transmission or a PDCCH/EPDCCH indicating downlink SPS release (defined in Subclause 9.2) 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 downlink 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;* 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.* M_c is the number of elements in set K_c associated with subframe *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.

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 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-Y and the "TDD UL/DL Configuration" in Table 7.3-Y 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 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 if transmitted.

If a UE is not configured with higher layer parameter *codebooksizeDetermination-r13 = 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 denotes the accumulative number of PDCCH/EPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release up to the present subframe within subframe(s) $n-k$ of each configured serving cell, where $k \in K$, and shall be updated from subframe to subframe. Denote $V_{DAI,c}^{DL}$ as the value of the DAI in PDCCH/EPDCCH with DCI format 1/1A/1B/1D/2/2A/2B/2C/2D detected by the UE according to Table 7.3-X in subframe $n-k_m$ 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.

For all TDD UL/DL configurations, denote $U_{DAI,c}$ as the total number of PDCCH/EPDCCH (s) with assigned PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release detected by the UE within the subframe(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 within the subframe(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 $o_{c,0}^{ACK}\, o_{c,1}^{ACK},\ldots, o_{c,O_c^{ACK}-1}^{ACK}$ 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 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 n on PUCCH or a PUSCH transmission not performed based on a detected DCI format 0/4 or a PUSCH transmission performed based on an associated detected DCI format 0/4 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 indicating downlink SPS release in subframe(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 n performed based on a detected PDCCH/EPDCCH with DCI format 0/4 using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min\left(W_{DAI}^{UL}, M_c\right)$. 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 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 with DCI format 0/4 using UL-reference UL/DL configuration belonging to {1,2,3,4,5,6} (defined in Sec 8.0), the UE shall assume $B_c^{DL} = \min\left(W_{DAI}^{UL} + 4\left\lceil \left(U - W_{DAI}^{UL}\right)/4 \right\rceil, M_c\right)$, 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 indicating downlink SPS release in subframe(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 indicating downlink SPS release in subframe(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 = cc* is not configured, the HARQ-ACK feedback bits $o_{c,0}^{ACK}\, o_{c,1}^{ACK},\ldots, o_{c,O_c^{ACK}-1}^{ACK}$ 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 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 *n* on PUCCH or a PUSCH transmission not performed based on a detected DCI format 0/4 or a PUSCH transmission performed based on an associated detected DCI format 0/4, 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 indicating downlink SPS release in subframe(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 = cc*,

- 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 or for a PDCCH/EPDCCH indicating downlink SPS release in subframe $n-k$ 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 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 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 indicating downlink SPS release in subframe $n-k$ 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 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},...,$o_{O^{ACK}-1}^{ACK}$ 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, $o_j^{ACK} = o(j)$, $0 \le j \le 3$ 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} = HARQ-ACK(j), $0 \le j \le A-1$ 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), $o_j^{ACK} = o(j)$, $0 \le j \le 3$ 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 *codebooksizeDetermination-r13 = dai*, the value of the counter Downlink Assignment Indicator (DAI) in DCI format 1/1A/1B/1D/2/2A/2B/2C/2D denotes the accumulative number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present serving cell and present subframe, first in increasing order of serving cell index and then in increasing order of subframe index within subframe(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 denotes the total number of {serving cell, subframe}-pair(s) in which PDSCH transmission(s) associated with PDCCH/EPDCCH(s) or PDCCH/EPDCCH indicating downlink SPS release is present, up to the present subframe within subframe(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 to subframe. 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 scheduling PDSCH transmission or indicating downlink SPS release for serving cell c in subframe $n-k$ 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 $n-k$ 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 scheduling PDSCH transmission(s) and PDCCH/EPDCCH indicating downlink SPS release in a subframe. 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}-pair {c, $n-k$} is excluded when determining the values of counter DAI and total DAI for HARQ-ACK transmission in subframe n.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = dai* and if the UE transmits HARQ-ACK using PUCCH format 3 or PUCCH format 4 or PUCCH format 5 in subframe n, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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 index: lower index corresponds to earlier subframe within subframe(s) $n-k$ where $k \in \bigcup_{i \in C} K_i$

Set $j = 0$

Set $V_{temp} = 0$

Set $V_{temp2} = 0$

Set $V_s = \varnothing$

Set N_{cells}^{DL} to the number of cells configured by higher layers for the UE

Set M to the number of subframes within subframe(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 m associated with PDCCH/EPDCCH or there is a PDCCH/EPDCCH indicating downlink SPS release on serving cell c in subframe m, and if subframe m belongs to the set of subframe(s) $n-k$ where $k \in K_c$,

if $V_{C-DAI,c,m}^{DL} \le V_{temp}$

$j = j+1$

end if

$V_{temp} = V_{C-DAI,c,m}^{DL}$

if $V_{T-DAI,m}^{DL} = \varnothing$

$V_{temp2} = V_{C-DAI,c,m}^{DL}$

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,

$\tilde{o}_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)}^{ACK}$ = HARQ-ACK bit corresponding to the first codeword of this cell

$\tilde{o}_{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1}^{ACK}$ = HARQ-ACK bit corresponding to the second codeword of this cell

$$V_s = V_s \cup \left\{8j+2\left(V_{C-DAI,c,m}^{DL}-1\right), 8j+2\left(V_{C-DAI,c,m}^{DL}-1\right)+1\right\}$$

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

$$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$$

else

$\tilde{o}_{4j+V_{C-DAI,c,m}^{DL}-1}^{ACK}$ = HARQ-ACK bit of this cell

$$V_s = V_s \cup \left\{4j+V_{C-DAI,c,m}^{DL}-1\right\}$$

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,

$$O^{ACK} = 2 \cdot \left(4 \cdot j + V_{temp2}\right)$$

else

$$O^{ACK} = 4 \cdot j + V_{temp2}$$

end if

$$\tilde{o}_i^{ACK} = \text{NACK} \quad \text{for any} \quad i \in \left\{0,1,...,O^{ACK}-1\right\} \setminus V_s$$

if SPS PDSCH transmission is activated for a UE and the UE is configured to receive SPS PDSCH in a subframe $n-k$ 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*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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* and if the UE transmits HARQ-ACK using PUCCH format 4 or PUCCH format 5 in subframe *n*, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ according to the pseudo-code in Subclause 5.2.3.1 in [4].

For a UE configured with higher layer parameter *codebooksizeDetermination-r13 = cc*, if the UE transmits HARQ-ACK on PUSCH in a subframe, the UE shall determine the $\tilde{o}_0^{ACK}, \tilde{o}_1^{ACK}, ..., \tilde{o}_{O^{ACK}-1}^{ACK}$ 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 sub-frame 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 one of the following cases

- 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/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

- 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.

When a PUCCH format 4/5 transmission of HARQ-ACK coincides with a sub-frame 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 $V_{DAI,c}^{DL} \neq \left(U_{DAI,c}-1\right) \bmod 4+1$ 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 i is an uplink or a special subframe of configurations 0 and 5 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 the higher layer parameter *EIMTA-MainConfigServCell-r12* and according to the higher layer parameter *eimta-HARQ-ReferenceConfig-r12* for UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12,*
    - 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.

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 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.

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 sub-frame 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 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 *n* if the UE does not receive PDSCH or PDCCH indicating downlink SPS release in subframe *n-4*.

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].

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 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*.

If a UE is configured with higher layer parameter *codebooksizeDetermination-r13 = 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*.

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].

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, otherwise K is defined in Table 10.1.3.1-1.
- 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, 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 *n* performed based on a detected PDCCH/EPDCCH with DCI format 0/4, 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 corresponding to a PUSCH on the serving cell according to Table 7.3-Z in subframe $n-k'$, 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 in subframe $n-k$ 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 is mapped to $o_{c,O_c^{ACK}-1}^{ACK}$. The HARQ-ACK feedback bits without any detected PDSCH transmission are set to NACK.