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Contents

Foreword

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document specifies and establishes the characteristics of the physicals layer procedures in the FDD and TDD modes of E-UTRA.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 36.201: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Layer – General Description".

[3] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".

[4] 3GPP TS 36.212: "Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding".

[5] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer – Measurements".

[6] 3GPP TS 36.101: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[7] 3GPP TS 36.104: "Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception".

[8] 3GPP TS 36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[9] 3GPP TS 36.423, "Evolved Universal Terrestrial Radio Access (E-UTRA); X2 Application Protocol (X2AP)".

[10] 3GPP TS 36.133, "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management".

[11] 3GPP TS 36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[12] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

n_f	System frame number as defined in [3]
n_s	Slot number within a radio frame as defined in [3]
N_{cells}^{DL}	Number of configured cells
$N_{\mathrm{RB}}^{\mathrm{DL}}$	Downlink bandwidth configuration, expressed in units of $N_{\mathrm{sc}}^{\mathrm{RB}}$ as defined in [3]
$N_{\mathrm{RB}}^{\mathrm{UL}}$	Uplink bandwidth configuration, expressed in units of $N_{\mathrm{sc}}^{\mathrm{RB}}$ as defined in [3]
$N_{\mathrm{symb}}^{\mathrm{UL}}$	Number of SC-FDMA symbols in an uplink slot as defined in [3]
$N_{\mathrm{sc}}^{\mathrm{RB}}$	Resource block size in the frequency domain, expressed as a number of subcarriers as defined in [3]
T_s	Basic time unit as defined in [3]

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply.
An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

ACK	Acknowledgement
BCH	Broadcast Channel
CCE	Control Channel Element
CDD	Cyclic Delay Diversity
CIF	Carrier Indicator Field
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
CSI	Channel State Information
CSI-IM	CSI-interference measurement
DAI	Downlink Assignment Index
DCI	Downlink Control Information
DL	Downlink
DL-SCH	Downlink Shared Channel
DTX	Discontinuous Transmission
EPDCCH	Enhanced Physical Downlink Control Channel
EPRE	Energy Per Resource Element
MCS	Modulation and Coding Scheme
NACK	Negative Acknowledgement
PBCH	Physical Broadcast Channel
PCFICH	Physical Control Format Indicator Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PHICH	Physical Hybrid ARQ Indicator Channel
PMCH	Physical Multicast Channel
PMI	Precoding Matrix Indicator
PRACH	Physical Random Access Channel
PRS	Positioning Reference Signal
PRB	Physical Resource Block
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
PTI	Precoding Type Indicator
RBG	Resource Block Group

RE	Resource Element
RI	Rank Indication
RS	Reference Signal
SINR	Signal to Interference plus Noise Ratio
SPS C-RNTI	Semi-Persistent Scheduling C-RNTI
SR	Scheduling Request
SRS	Sounding Reference Symbol
TAG	Timing Advance Group
TBS	Transport Block Size
UCI	Uplink Control Information
UE	User Equipment
UL	Uplink
UL-SCH	Uplink Shared Channel
VRB	Virtual Resource Block

4 Synchronization procedures

4.1 Cell search

Cell search is the procedure by which a UE acquires time and frequency synchronization with a cell and detects the physical layer Cell ID of that cell. E-UTRA cell search supports a scalable overall transmission bandwidth corresponding to 6 resource blocks and upwards.

The following signals are transmitted in the downlink to facilitate cell search: the primary and secondary synchronization signals.

A UE may assume the antenna ports 0 – 3 and the antenna port for the primary/secondary synchronization signals of a serving cell are quasi co-located (as defined in [3]) with respect to Doppler shift and average delay.

4.2 Timing synchronization

4.2.1 Radio link monitoring

The downlink radio link quality of the primary cell shall be monitored by the UE for the purpose of indicating out-of-sync/in-sync status to higher layers.

In non-DRX mode operation, the physical layer in the UE shall every radio frame assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

In DRX mode operation, the physical layer in the UE shall at least once every DRX period assess the radio link quality, evaluated over the previous time period defined in [10], against thresholds (Q_{out} and Q_{in}) defined by relevant tests in [10].

If higher-layer signalling indicates certain subframes for restricted radio link monitoring, the radio link quality shall not be monitored in any subframe other than those indicated.

The physical layer in the UE shall in radio frames where the radio link quality is assessed indicate out-of-sync to higher layers when the radio link quality is worse than the threshold Q_{out}. When the radio link quality is better than the threshold Q_{in}, the physical layer in the UE shall in radio frames where the radio link quality is assessed indicate in-sync to higher layers.

4.2.2 Inter-cell synchronization

No functionality is specified in this subclause in this release.

4.2.3 Transmission timing adjustments

Upon reception of a timing advance command for a TAG containing the primary cell, the UE shall adjust uplink transmission timing for PUCCH/PUSCH/SRS of the primary cell based on the received timing advance command. The UL transmission timing for PUSCH/SRS of a secondary cell is the same as the primary cell if the secondary cell and the primary cell belong to the same TAG.

Upon reception of a timing advance command for a TAG not containing the primary cell, if all the serving cells in the TAG have the same frame structure type, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG based on the received timing advance command where the UL transmission timing for PUSCH /SRS is the same for all the secondary cells in the TAG.

Upon reception of a timing advance command for a TAG not containing the primary cell, if a serving cell in the TAG has a different frame structure type compared to the frame structure type of another serving cell in the same TAG, the UE shall adjust uplink transmission timing for PUSCH/SRS of all the secondary cells in the TAG by using $N_{TAoffset} = 624$ regardless of the frame structure type of the serving cells and based on the received timing advance command where the UL transmission timing for PUSCH /SRS is the same for all the secondary cells in the TAG. $N_{TAoffset}$ is described in [3].

The timing advance command for a TAG indicates the change of the uplink timing relative to the current uplink timing for the TAG as multiples of $16\,T_s$. The start timing of the random access preamble is specified in [3].

In case of random access response, an 11-bit timing advance command [8], T_A, for a TAG indicates N_{TA} values by index values of $T_A = 0, 1, 2, ..., 1282$, where an amount of the time alignment for the TAG is given by $N_{TA} = T_A \times 16$. N_{TA} is defined in [3].

In other cases, a 6-bit timing advance command [8], T_A, for a TAG indicates adjustment of the current N_{TA} value, $N_{TA,old}$, to the new N_{TA} value, $N_{TA,new}$, by index values of $T_A = 0, 1, 2,..., 63$, where $N_{TA,new} = N_{TA,old} + (T_A - 31) \times 16$. Here, adjustment of N_{TA} value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing for the TAG by a given amount respectively.

For a timing advance command received on subframe *n*, the corresponding adjustment of the uplink transmission timing shall apply from the beginning of subframe *n+6.* For serving cells in the same TAG, when the UE's uplink PUCCH/PUSCH/SRS transmissions in subframe *n* and subframe *n*+1 are overlapped due to the timing adjustment, the UE shall complete transmission of subframe *n* and not transmit the overlapped part of subframe *n*+1.

If the received downlink timing changes and is not compensated or is only partly compensated by the uplink timing adjustment without timing advance command as specified in [10], the UE changes N_{TA} accordingly.

4.3 Timing for Secondary Cell Activation / Deactivation

When a UE receives an activation command [8] for a secondary cell in subframe *n*, the corresponding actions in [8] shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe n+8, except for the following:

- the actions related to CSI reporting
- the actions related to the *sCellDeactivationTimer* associated with the secondary cell [8]

which shall be applied in subframe *n+8*.

When a UE receives a deactivation command [8] for a secondary cell or the *sCellDeactivationTimer* associated with the secondary cell expires in subframe *n*, the corresponding actions in [8] shall apply no later than the minimum requirement defined in [10], except for the actions related to CSI reporting which shall be applied in subframe *n+8.*

5 Power control

Downlink power control determines the Energy Per Resource Element (EPRE). The term Resource Element Energy denotes the energy prior to CP insertion. The term resource element energy also denotes the average energy taken over all constellation points for the modulation scheme applied. Uplink power control determines the average power over a SC-FDMA symbol in which the physical channel is transmitted.

5.1 Uplink power control

Uplink power control controls the transmit power of the different uplink physical channels.

For PUSCH, the transmit power $\hat{P}_{\mathrm{PUSCH},c}(i)$ defined in subclause 5.1.1, is first scaled by the ratio of the number of antennas ports with a non-zero PUSCH transmission to the number of configured antenna ports for the transmission scheme. The resulting scaled power is then split equally across the antenna ports on which the non-zero PUSCH is transmitted.

For PUCCH or SRS, the transmit power $\hat{P}_{\mathrm{PUCCH}}(i)$, defined in subclause 5.1.1.1, or $\hat{P}_{\mathrm{SRS,c}}(i)$ is split equally across the configured antenna ports for PUCCH or SRS. $\hat{P}_{\mathrm{SRS,c}}(i)$ is the linear value of $P_{\mathrm{SRS,c}}(i)$ defined in subclause 5.1.3.

A cell wide overload indicator (OI) and a High Interference Indicator (HII) to control UL interference are defined in [9].

5.1.1 Physical uplink shared channel

5.1.1.1 UE behaviour

The setting of the UE Transmit power for a Physical Uplink Shared Channel (PUSCH) transmission is defined as follows.

If the UE transmits PUSCH without a simultaneous PUCCH for the serving cell c, then the UE transmit power $P_{\mathrm{PUSCH},c}(i)$ for PUSCH transmission in subframe i for the serving cell c is given by

$$P_{\mathrm{PUSCH,c}}(i) = \min\left\{\begin{array}{l} P_{\mathrm{CMAX},c}(i), \\ 10\log_{10}(M_{\mathrm{PUSCH,c}}(i)) + P_{\mathrm{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\mathrm{TF,c}}(i) + f_c(i) \end{array}\right\} \quad [\mathrm{dBm}]$$

If the UE transmits PUSCH simultaneous with PUCCH for the serving cell c, then the UE transmit power $P_{\mathrm{PUSCH},c}(i)$ for the PUSCH transmission in subframe i for the serving cell c is given by

$$P_{\mathrm{PUSCH,c}}(i) = \min\left\{\begin{array}{l} 10\log_{10}\left(\hat{P}_{\mathrm{CMAX},c}(i) - \hat{P}_{\mathrm{PUCCH}}(i)\right), \\ 10\log_{10}(M_{\mathrm{PUSCH,c}}(i)) + P_{\mathrm{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\mathrm{TF,c}}(i) + f_c(i) \end{array}\right\} \quad [\mathrm{dBm}]$$

If the UE is not transmitting PUSCH for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall assume that the UE transmit power $P_{\mathrm{PUSCH},c}(i)$ for the PUSCH transmission in subframe i for the serving cell c is computed by

$$P_{\mathrm{PUSCH,c}}(i) = \min\left\{P_{\mathrm{CMAX,c}}(i), P_{\mathrm{O\_PUSCH,c}}(1) + \alpha_c(1)\cdot PL_c + f_c(i)\right\} \quad [\mathrm{dBm}]$$

where,

- $P_{\mathrm{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] in subframe i for serving cell c and $\hat{P}_{\mathrm{CMAX,c}}(i)$ is the linear value of $P_{\mathrm{CMAX,c}}(i)$. If the UE transmits PUCCH without PUSCH in subframe i for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall assume $P_{\mathrm{CMAX,c}}(i)$ as given by subclause 5.1.2.1. If the UE does not transmit PUCCH and PUSCH in subframe i for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for

PUSCH, the UE shall compute $P_{\text{CMAX,c}}(i)$ assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR, A-MPR, P-MPR and ΔT_C are defined in [6].

- $\hat{P}_{\text{PUCCH}}(i)$ is the linear value of $P_{\text{PUCCH}}(i)$ defined in subclause 5.1.2.1
- $M_{\text{PUSCH,c}}(i)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe *i* and serving cell c.
- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*,
  - when j=0, $P_{\text{O\_PUSCH,c}}(0) = P_{\text{O\_UE\_PUSCH,c,2}}(0) + P_{\text{O\_NOMINAL\_PUSCH,c,2}}(0)$, where j=0 is used for PUSCH (re)transmissions corresponding to a semi-persistent grant. $P_{\text{O\_UE\_PUSCH,c,2}}(0)$ and $P_{\text{O\_NOMINAL\_PUSCH,c,2}}(0)$ are the parameters *p0-UE-PUSCH-Persistent-SubframeSet2-r12 and p0-NominalPUSCH-Persistent -SubframeSet2-r12* respectively provided by higher layers, for each serving cell c.
  - when j=1, $P_{\text{O\_PUSCH,c}}(1) = P_{\text{O\_UE\_PUSCH,c,2}}(1) + P_{\text{O\_NOMINAL\_PUSCH,c,2}}(1)$, where j=1 is used for PUSCH (re)transmissions corresponding to a dynamic scheduled grant. $P_{\text{O\_UE\_PUSCH,c,2}}(1)$ and $P_{\text{O\_NOMINAL\_PUSCH,c,2}}(1)$ are the parameters *p0-UE-PUSCH-SubframeSet2-r12 and p0-NominalPUSCH-SubframeSet2-r12* respectively, provided by higher layers for serving cell c.
  - when j=2, $P_{\text{O\_PUSCH,c}}(2) = P_{\text{O\_UE\_PUSCH,c}}(2) + P_{\text{O\_NOMINAL\_PUSCH,c}}(2)$ where $P_{\text{O\_UE\_PUSCH,c}}(2) = 0$ and $P_{\text{O\_NOMINAL\_PUSCH,c}}(2) = P_{\text{O\_PRE}} + \Delta_{PREAMBLE\_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* [8] ($P_{\text{O\_PRE}}$) and $\Delta_{PREAMBLE\_Msg3}$ are signalled from higher layers for serving cell c, where j=2 is used for PUSCH (re)transmissions corresponding to the random access response grant.

  Otherwise

  - $P_{\text{O\_PUSCH,c}}(j)$ is a parameter composed of the sum of a component $P_{\text{O\_NOMINAL\_PUSCH,c}}(j)$ provided from higher layers for *j=0* and *1* and a component $P_{\text{O\_UE\_PUSCH,c}}(j)$ provided by higher layers for *j=0* and *1* for serving cell c. For PUSCH (re)transmissions corresponding to a semi-persistent grant then *j=0* , for PUSCH (re)transmissions corresponding to a dynamic scheduled grant then *j=1* and for PUSCH (re)transmissions corresponding to the random access response grant then *j=2*. $P_{\text{O\_UE\_PUSCH,c}}(2) = 0$ and $P_{\text{O\_NOMINAL\_PUSCH,c}}(2) = P_{\text{O\_PRE}} + \Delta_{PREAMBLE\_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* [8] ($P_{\text{O\_PRE}}$) and $\Delta_{PREAMBLE\_Msg3}$ are signalled from higher layers for serving cell c.
- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*,
  - For *j*=0 or 1, $\alpha_c(j) = \alpha_{c,2} \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$. $\alpha_{c,2}$ is the parameter *alpha-SubframeSet2-r12* provided by higher layers for each serving cell c.
  - For *j*=2, $\alpha_c(j) = 1$.

  Otherwise

  - For *j* =0 or *1*, $\alpha_c \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ is a 3-bit parameter provided by higher layers for serving cell c. For j=2, $\alpha_c(j) = 1$.

- PL_c is the downlink pathloss estimate calculated in the UE for serving cell c in dB and PL_c = *referenceSignalPower* – higher layer filtered RSRP, where *referenceSignalPower* is provided by higher layers and RSRP is defined in [5] for the reference serving cell and the higher layer filter configuration is defined in [11] for the reference serving cell. If serving cell c belongs to a TAG containing the primary cell then, for the uplink of the primary cell, the primary cell is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP. For the uplink of the secondary cell, the serving cell configured by the higher layer parameter *pathlossReferenceLinking* defined in [11] is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP. If serving cell c belongs to a TAG not containing the primary cell then serving cell c is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

- $\Delta_{TF,c}(i) = 10\log_{10}\left(\left(2^{BPRE \cdot K_s} - 1\right) \cdot \beta_{offset}^{PUSCH}\right)$ for $K_S = 1.25$ and 0 for $K_S = 0$ where K_S is given by the parameter *deltaMCS-Enabled* provided by higher layers for each serving cell c. $BPRE$ and β_{offset}^{PUSCH}, for each serving cell c, are computed as below. $K_S = 0$ for transmission mode 2.

  - $BPRE = O_{\mathrm{CQI}} / N_{\mathrm{RE}}$ for control data sent via PUSCH without UL-SCH data and $\sum_{r=0}^{C-1} K_r / N_{\mathrm{RE}}$ for other cases.

    - where C is the number of code blocks, K_r is the size for code block r, O_{CQI} is the number of CQI/PMI bits including CRC bits and N_{RE} is the number of resource elements determined as $N_{\mathrm{RE}} = M_{sc}^{PUSCH-initial} \cdot N_{\mathrm{symb}}^{\mathrm{PUSCH\text{-}initial}}$, where C, K_r, $M_{sc}^{PUSCH-initial}$ and $N_{\mathrm{symb}}^{\mathrm{PUSCH\text{-}initial}}$ are defined in [4].

  - $\beta_{offset}^{PUSCH} = \beta_{offset}^{CQI}$ for control data sent via PUSCH without UL-SCH data and 1 for other cases.

- $\delta_{\mathrm{PUSCH,c}}$ is a correction value, also referred to as a TPC command and is included in PDCCH/EPDCCH with DCI format 0/4 for serving cell c or jointly coded with other TPC commands in PDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUSCH-RNTI. If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the current PUSCH power control adjustment state for serving cell c is given by $f_{c,2}(i)$, and the UE shall use $f_{c,2}(i)$ instead of $f_c(i)$ to determine $P_{\mathrm{PUSCH},c}(i)$. Otherwise, the current PUSCH power control adjustment state for serving cell c is given by $f_c(i)$. $f_{c,2}(i)$ and $f_c(i)$ are defined by:

  - $f_c(i) = f_c(i-1) + \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ and $f_{c,2}(i) = f_{c,2}(i-1) + \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ if accumulation is enabled based on the parameter *Accumulation-enabled* provided by higher layers or if the TPC command $\delta_{\mathrm{PUSCH,c}}$ is included in a PDCCH/EPDCCH with DCI format 0 for serving cell c where the CRC is scrambled by the Temporary C-RNTI

    - where $\delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ was signalled on PDCCH/EPDCCH with DCI format 0/4 or PDCCH with DCI format 3/3A on subframe $i - K_{PUSCH}$, and where $f_c(0)$ is the first value after reset of accumulation.

    - The value of K_{PUSCH} is

      - For FDD or FDD-TDD and serving cell frame structure type 1, K_{PUSCH} = 4

      - For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with 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" refers to the UL-reference UL/DL configuration (defined in subclause 8.0) for serving cell c.

- For TDD UL/DL configurations 1-6, K_{PUSCH} is given in Table 5.1.1.1-1
- For TDD UL/DL configuration 0
  - If the PUSCH transmission in subframe *2* or *7* is scheduled with a PDCCH/EPDCCH of DCI format 0/4 in which the LSB of the UL index is set to 1, $K_{PUSCH} = 7$
  - For all other PUSCH transmissions, K_{PUSCH} is given in Table 5.1.1.1-1.

- For serving cell c the UE attempts to decode a PDCCH/EPDCCH of DCI format 0/4 with the UE's C-RNTI or DCI format 0 for SPS C-RNTI and a PDCCH of DCI format 3/3A with this UE's TPC-PUSCH-RNTI in every subframe except when in DRX or where serving cell c is deactivated.
- If DCI format 0/4 for serving cell c and DCI format 3/3A are both detected in the same subframe, then the UE shall use the $\delta_{\mathrm{PUSCH,c}}$ provided in DCI format 0/4.
- $\delta_{\mathrm{PUSCH,c}} = 0\,\mathrm{dB}$ for a subframe where no TPC command is decoded for serving cell c or where DRX occurs or *i* is not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.
- The $\delta_{\mathrm{PUSCH,c}}$ dB accumulated values signalled on PDCCH/EPDCCH with DCI format 0/4 are given in Table 5.1.1.1-2. If the PDCCH/EPDCCH with DCI format 0 is validated as a SPS activation or release PDCCH/EPDCCH, then $\delta_{\mathrm{PUSCH,c}}$ is 0dB.
- The δ_{PUSCH} dB accumulated values signalled on PDCCH with DCI format 3/3A are one of SET1 given in Table 5.1.1.1-2 or SET2 given in Table 5.1.1.1-3 as determined by the parameter *TPC-Index* provided by higher layers.
- If UE has reached $P_{\mathrm{CMAX,c}}(i)$ for serving cell c, positive TPC commands for serving cell c shall not be accumulated
- If UE has reached minimum power, negative TPC commands shall not be accumulated
- If the UE is not configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c, the UE shall reset accumulation
  - For serving cell c, when $P_{\mathrm{O\_UE\_PUSCH,c}}$ value is changed by higher layers
  - For serving cell c, when the UE receives random access response message for serving cell c
- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c,
  - the UE shall reset accumulation corresponding to $f_c(*)$ for serving cell c
    - when $P_{\mathrm{O\_UE\_PUSCH,c}}$ value is changed by higher layers
    - when the UE receives random access response message for serving cell c
  - the UE shall reset accumulation corresponding to $f_{c,2}(*)$ for serving cell c
    - when $P_{\mathrm{O\_UE\_PUSCH,c,2}}$ value is changed by higher layers
- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and
  - if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_c(i) = f_c(i-1)$

- if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_{c,2}(i) = f_{c,2}(i-1)$

- $f_c(i) = \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ and $f_{c,2}(i) = \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ if accumulation is not enabled for serving cell c based on the parameter *Accumulation-enabled* provided by higher layers
  - where $\delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ was signalled on PDCCH/EPDCCH with DCI format 0/4 for serving cell c on subframe $i - K_{PUSCH}$
  - The value of K_{PUSCH} is
    - For FDD or FDD-TDD and serving cell frame structure type 1, $K_{PUSCH} = 4$
    - For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration (defined in subclause 8.0) for serving cell c.
    - For TDD UL/DL configurations 1-6, K_{PUSCH} is given in Table 5.1.1.1-1.
    - For TDD UL/DL configuration 0
      - If the PUSCH transmission in subframe *2* or *7* is scheduled with a PDCCH/EPDCCH of DCI format 0/4 in which the LSB of the UL index is set to 1, $K_{PUSCH} = 7$
      - For all other PUSCH transmissions, K_{PUSCH} is given in Table 5.1.1.1-1.
  - The $\delta_{\mathrm{PUSCH,c}}$ dB absolute values signalled on PDCCH/EPDCCH with DCI format 0/4 are given in Table 5.1.1.1-2. If the PDCCH/EPDCCH with DCI format 0 is validated as a SPS activation or release PDCCH/EPDCCH, then $\delta_{\mathrm{PUSCH,c}}$ is 0dB.
  - $f_c(i) = f_c(i-1)$ and $f_{c,2}(i) = f_{c,2}(i-1)$ for a subframe where no PDCCH/EPDCCH with DCI format 0/4 is decoded for serving cell c or where DRX occurs or *i* is not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.
  - If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and
    - if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_c(i) = f_c(i-1)$
    - if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_{c,2}(i) = f_{c,2}(i-1)$

- For both types of $f_c(*)$ (accumulation or current absolute) the first value is set as follows:
  - If $P_{\mathrm{O\_UE\_PUSCH,c}}$ value is changed by higher layers and serving cell c is the primary cell or, if $P_{\mathrm{O\_UE\_PUSCH,c}}$ value is received by higher layers and serving cell c is a Secondary cell
    - $f_c(0) = 0$
  - Else
    - If the UE receives the random access response message for a serving cell c

- $f_c(0) = \Delta P_{rampup,c} + \delta_{msg2,c}$, where
  - $\delta_{msg2,c}$ is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell c, see subclause 6.2, and

$$\Delta P_{rampup,c} = \min\left[\left\{\max\left(0, P_{CMAX,c} - \left(\begin{array}{l} 10\log_{10}(M_{PUSCH,c}(0)) \\ + P_{O\_PUSCH,c}(2) + \delta_{msg2} \\ + \alpha_c(2)\cdot PL + \Delta_{TF,c}(0) \end{array}\right)\right)\right\}, \Delta P_{rampuprequested,c}\right]$$

and $\Delta P_{rampuprequested,c}$ is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the serving cell c, $M_{\mathrm{PUSCH,c}}(0)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for the subframe of first PUSCH transmission in the serving cell c, and $\Delta_{TF,c}(0)$ is the power adjustment of first PUSCH transmission in the serving cell c.

- If $P_{\mathrm{O\_UE\_PUSCH,c,2}}$ value is received by higher layers for a serving cell c.
  - $f_{c,2}(0) = 0$

Table 5.1.1.1-1: K_{PUSCH} for TDD configuration 0-6

TDD UL/DL Configuration	subframe number *i*									
	0	1	2	3	4	5	6	7	8	9
0	-	-	6	7	4	-	-	6	7	4
1	-	-	6	4	-	-	-	6	4	-
2	-	-	4	-	-	-	-	4	-	-
3	-	-	4	4	4	-	-	-	-	-
4	-	-	4	4	-	-	-	-	-	-
5	-	-	4	-	-	-	-	-	-	-
6	-	-	7	7	5	-	-	7	7	-

Table 5.1.1.1-2: Mapping of TPC Command Field in DCI format 0/3/4 to absolute and accumulated $\delta_{\mathrm{PUSCH,c}}$ values

TPC Command Field in DCI format 0/3/4	Accumulated $\delta_{\mathrm{PUSCH,c}}$ [dB]	Absolute $\delta_{\mathrm{PUSCH,c}}$ [dB] only DCI format 0/4
0	-1	-4
1	0	-1
2	1	1
3	3	4

Table 5.1.1.1-3: Mapping of TPC Command Field in DCI format 3A to accumulated $\delta_{\mathrm{PUSCH,c}}$ values

TPC Command Field in DCI format 3A	Accumulated $\delta_{\mathrm{PUSCH,c}}$ [dB]
0	-1
1	1

If the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\text{PUSCH},c}(i)$ for the serving cell c in subframe i such that the condition

$$\sum_{c} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) \le \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUCCH}}(i)\right)$$

is satisfied where $\hat{P}_{\text{PUCCH}}(i)$ is the linear value of $P_{\text{PUCCH}}(i)$, $\hat{P}_{\text{PUSCH},c}(i)$ is the linear value of $P_{\text{PUSCH},c}(i)$, $\hat{P}_{CMAX}(i)$ is the linear value of the UE total configured maximum output power P_{CMAX} defined in [6] in subframe i and $w(i)$ is a scaling factor of $\hat{P}_{\text{PUSCH},c}(i)$ for serving cell c where $0 \le w(i) \le 1$. In case there is no PUCCH transmission in subframe i $\hat{P}_{\text{PUCCH}}(i) = 0$.

If the UE has PUSCH transmission with UCI on serving cell j and PUSCH without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\text{PUSCH},c}(i)$ for the serving cells without UCI in subframe i such that the condition

$$\sum_{c \ne j} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) \le \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUSCH},j}(i)\right)$$

is satisfied where $\hat{P}_{\text{PUSCH},j}(i)$ is the PUSCH transmit power for the cell with UCI and $w(i)$ is a scaling factor of $\hat{P}_{\text{PUSCH},c}(i)$ for serving cell c without UCI. In this case, no power scaling is applied to $\hat{P}_{\text{PUSCH},j}(i)$ unless $\sum_{c \ne j} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) = 0$ and the total transmit power of the UE still would exceed $\hat{P}_{CMAX}(i)$.

Note that $w(i)$ values are the same across serving cells when $w(i) > 0$ but for certain serving cells $w(i)$ may be zero.

If the UE has simultaneous PUCCH and PUSCH transmission with UCI on serving cell j and PUSCH transmission without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE obtains $\hat{P}_{\text{PUSCH},c}(i)$ according to

$$\hat{P}_{\text{PUSCH},j}(i) = \min\left(\hat{P}_{\text{PUSCH},j}(i), \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUCCH}}(i)\right)\right)$$

and

$$\sum_{c \ne j} w(i) \cdot \hat{P}_{\text{PUSCH},c}(i) \le \left(\hat{P}_{\text{CMAX}}(i) - \hat{P}_{\text{PUCCH}}(i) - \hat{P}_{\text{PUSCH},j}(i)\right)$$

If the UE is configured with multiple TAGs, and if the PUCCH/PUSCH transmission of the UE on subframe i for a given serving cell in a TAG overlaps some portion of the first symbol of the PUSCH transmission on subframe $i+1$ for a different serving cell in another TAG the UE shall adjust its total transmission power to not exceed P_{CMAX} on any overlapped portion.

If the UE is configured with multiple TAGs, and if the PUSCH transmission of the UE on subframe i for a given serving cell in a TAG overlaps some portion of the first symbol of the PUCCH transmission on subframe $i+1$ for a different serving cell in another TAG the UE shall adjust its total transmission power to not exceed P_{CMAX} on any overlapped portion.

If the UE is configured with multiple TAGs, and if the SRS transmission of the UE in a symbol on subframe i for a given serving cell in a TAG overlaps with the PUCCH/PUSCH transmission on subframe i or subframe $i+1$ for a different serving cell in the same or another TAG the UE shall drop SRS if its total transmission power exceeds P_{CMAX} on any overlapped portion of the symbol.

If the UE is configured with multiple TAGs and more than 2 serving cells, and if the SRS transmission of the UE in a symbol on subframe i for a given serving cell overlaps with the SRS transmission on subframe i for a different serving cell(s) and with PUSCH/PUCCH transmission on subframe i or subframe $i+1$ for another serving cell(s) the UE shall drop the SRS transmissions if the total transmission power exceeds P_{CMAX} on any overlapped portion of the symbol.

If the UE is configured with multiple TAGs, the UE shall, when requested by higher layers, to transmit PRACH in a secondary serving cell in parallel with SRS transmission in a symbol on a subframe of a different serving cell belonging to a different TAG, drop SRS if the total transmission power exceeds P_{CMAX} on any overlapped portion in the symbol.

If the UE is configured with multiple TAGs, the UE shall, when requested by higher layers, to transmit PRACH in a secondary serving cell in parallel with PUSCH/PUCCH in a different serving cell belonging to a different TAG, adjust the transmission power of PUSCH/PUCCH so that its total transmission power does not exceed P_{CMAX} on the overlapped portion.

5.1.1.2 Power headroom

There are two types of UE power headroom reports defined. A UE power headroom PH is valid for subframe *i* for serving cell c.

Type 1:

If the UE transmits PUSCH without PUCCH in subframe i for serving cell c, power headroom for a Type 1 report is computed using

$$PH_{\text{type1,c}}(i) = P_{\text{CMAX},c}(i) - \left\{10\log_{10}(M_{\text{PUSCH,c}}(i)) + P_{\text{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF,c}}(i) + f_c(i)\right\} \quad \text{[dB]}$$

where, $P_{\text{CMAX},c}(i)$, $M_{\text{PUSCH,c}}(i)$, $P_{\text{O\_PUSCH,c}}(j)$, $\alpha_c(j)$, PL_c, $\Delta_{\text{TF},c}(i)$ and $f_c(i)$ are defined in subclause 5.1.1.1.

If the UE transmits PUSCH with PUCCH in subframe i for serving cell c, power headroom for a Type 1 report is computed using

$$PH_{\text{type1,c}}(i) = \tilde{P}_{\text{CMAX},c}(i) - \left\{10\log_{10}(M_{\text{PUSCH,c}}(i)) + P_{\text{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF,c}}(i) + f_c(i)\right\} \quad \text{[dB]}$$

where, $M_{\text{PUSCH,c}}(i)$, $P_{\text{O\_PUSCH,c}}(j)$, $\alpha_c(j)$, PL_c, $\Delta_{\text{TF},c}(i)$ and $f_c(i)$ are defined in subclause 5.1.1.1. $\tilde{P}_{\text{CMAX},c}(i)$ is computed based on the requirements in [6] assuming a PUSCH only transmission in subframe i. For this case, the physical layer delivers $\tilde{P}_{\text{CMAX},c}(i)$ instead of $P_{\text{CMAX},c}(i)$ to higher layers.

If the UE does not transmit PUSCH in subframe i for serving cell c, power headroom for a Type 1 report is computed using

$$PH_{\text{type1,c}}(i) = \tilde{P}_{\text{CMAX},c}(i) - \left\{P_{\text{O\_PUSCH,c}}(1) + \alpha_c(1)\cdot PL_c + f_c(i)\right\} \quad \text{[dB]}$$

where, $\tilde{P}_{\text{CMAX,c}}(i)$ is computed assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR , A-MPR, P-MPR and ΔT_C are defined in [6]. $P_{\text{O\_PUSCH,c}}(1)$, $\alpha_c(1)$, PL_c, and $f_c(i)$ are defined in subclause 5.1.1.1.

Type 2:

If the UE transmits PUSCH simultaneous with PUCCH in subframe i for the primary cell, power headroom for a Type 2 report is computed using

$$PH_{\text{type2}}(i) = P_{\text{CMAX},c}(i) - 10\log_{10}\left(\begin{array}{l} 10^{\left(10\log_{10}(M_{\text{PUSCH,c}}(i)) + P_{\text{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF,c}}(i) + f_c(i)\right)/10} \\ +\ 10^{\left(P_{0\_\text{PUCCH}} + PL_c + h\left(n_{CQI}, n_{HARQ}, n_{SR}\right) + \Delta_{\text{F\_PUCCH}}(F) + \Delta_{TxD}(F') + g(i)\right)/10} \end{array} \right) \text{ [dB]}$$

where, $P_{\text{CMAX,c}}$, $M_{\text{PUSCH,c}}(i)$, $P_{\text{O\_PUSCH,c}}(j)$, $\alpha_c(j)$, $\Delta_{\text{TF},c}(i)$ and $f_c(i)$ are the primary cell parameters as defined in subclause 5.1.1.1 and $P_{\text{O\_PUCCH}}$, PL_c, $h(n_{CQI}, n_{HARQ}, n_{SR})$, $\Delta_{\text{F\_PUCCH}}(F)$, $\Delta_{TxD}(F')$ and $g(i)$ are defined in subclause 5.1.2.1

If the UE transmits PUSCH without PUCCH in subframe i for the primary cell, power headroom for a Type 2 report is computed using

$$PH_{\text{type2}}(i) = P_{\text{CMAX},c}(i) - 10\log_{10}\left(\begin{array}{l} 10^{\left(10\log_{10}(M_{\text{PUSCH,c}}(i)) + P_{\text{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + \Delta_{\text{TF,c}}(i) + f_c(i)\right)/10} \\ +\ 10^{\left(P_{0\_\text{PUCCH}} + PL_c + g(i)\right)/10} \end{array} \right) \text{ [dB]}$$

where, $P_{\text{CMAX,c}}(i)$, $M_{\text{PUSCH,c}}(i)$, $P_{\text{O\_PUSCH,c}}(j)$, $\alpha_c(j)$, $\Delta_{\text{TF},c}(i)$ and $f_c(i)$ are the primary cell parameters as defined in subclause 5.1.1.1 and $P_{\text{O\_PUCCH}}$, PL_c and $g(i)$ are defined in subclause 5.1.2.1.

If the UE transmits PUCCH without PUSCH in subframe i for the primary cell, power headroom for a Type 2 report is computed using

$$PH_{\text{type2}}(i) = P_{\text{CMAX},c}(i) - 10\log_{10}\left(\begin{array}{l} 10^{\left(P_{\text{O\_PUSCH,c}}(1) + \alpha_c(1)\cdot PL_c + f_c(i)\right)/10} \\ +\ 10^{\left(P_{0\_\text{PUCCH}} + PL_c + h\left(n_{CQI}, n_{HARQ}, n_{SR}\right) + \Delta_{\text{F\_PUCCH}}(F) + \Delta_{TxD}(F') + g(i)\right)/10} \end{array} \right) \text{ [dB]}$$

where, $P_{\text{O\_PUSCH,c}}(1)$, $\alpha_c(1)$ and $f_c(i)$ are the primary cell parameters as defined in subclause 5.1.1.1, $P_{\text{CMAX,c}}(i)$, $P_{\text{O\_PUCCH}}$, PL_c, $h(n_{CQI}, n_{HARQ}, n_{SR})$, $\Delta_{\text{F\_PUCCH}}(F)$, $\Delta_{TxD}(F')$ and $g(i)$ are also defined in subclause 5.1.2.1.

If the UE does not transmit PUCCH or PUSCH in subframe i for the primary cell, power headroom for a Type 2 report is computed using

$$PH_{\text{type2}}(i) = \widetilde{P}_{\text{CMAX},c}(i) - 10\log_{10}\left(\begin{array}{l} 10^{\left(P_{\text{O\_PUSCH,c}}(1) + \alpha_c(1)\cdot PL_c + f_c(i)\right)/10} \\ +\ 10^{\left(P_{0\_\text{PUCCH}} + PL_c + g(i)\right)/10} \end{array} \right) \text{ [dB]}$$

where, $\widetilde{P}_{CMAX,c}(i)$ is computed assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR , A-MPR, P-MPR and ΔT_C are defined in [6], $P_{\text{O\_PUSCH,c}}(1)$, $\alpha_c(1)$ and $f_c(i)$ are the primary cell parameters as defined in subclause 5.1.1.1 and $P_{\text{O\_PUCCH}}$, PL_c and $g(i)$ are defined in subclause 5.1.2.1.

The power headroom shall be rounded to the closest value in the range [40; -23] dB with steps of 1 dB and is delivered by the physical layer to higher layers.

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the UE shall use $f_{c,2}(i)$ instead of $f_c(i)$ to compute $PH_{\text{type1,c}}(i)$ and $PH_{\text{type2,c}}(i)$ for subframe *i* and serving cell c, where $f_{c,2}(i)$ is defined in subclause 5.1.1.1.

5.1.2 Physical uplink control channel

5.1.2.1 UE behaviour

If serving cell c is the primary cell, the setting of the UE Transmit power P_{PUCCH} for the physical uplink control channel (PUCCH) transmission in subframe i is defined by

$$P_{\mathrm{PUCCH}}(i) = \min\left\{ \begin{array}{l} P_{\mathrm{CMAX,c}}(i), \\ P_{0\_\mathrm{PUCCH}} + PL_c + h(n_{CQI}, n_{HARQ}, n_{SR}) + \Delta_{\mathrm{F\_PUCCH}}(F) + \Delta_{TxD}(F') + g(i) \end{array} \right\} \quad [\mathrm{dBm}]$$

If the UE is not transmitting PUCCH for the primary cell, for the accumulation of TPC command for PUCCH, the UE shall assume that the UE transmit power P_{PUCCH} for PUCCH in subframe i is computed by

$$P_{\mathrm{PUCCH}}(i) = \min\{P_{\mathrm{CMAX,c}}(i), P_{0\_\mathrm{PUCCH}} + PL_c + g(i)\} \quad [\mathrm{dBm}]$$

where

- $P_{\mathrm{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] in subframe i for serving cell c. If the UE transmits PUSCH without PUCCH in subframe i for the serving cell c, for the accumulation of TPC command for PUCCH, the UE shall assume $P_{\mathrm{CMAX,c}}(i)$ as given by subclause 5.1.1.1. If the UE does not transmit PUCCH and PUSCH in subframe i for the serving cell c, for the accumulation of TPC command for PUCCH, the UE shall compute $P_{\mathrm{CMAX,c}}(i)$ assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR, A-MPR, P-MPR and ΔT_C are defined in [6].
- The parameter $\Delta_{\mathrm{F\_PUCCH}}(F)$ is provided by higher layers. Each $\Delta_{\mathrm{F\_PUCCH}}(F)$ value corresponds to a PUCCH format (*F*) relative to PUCCH format 1a, where each PUCCH format (F) is defined in Table 5.4-1 of [3].
- If the UE is configured by higher layers to transmit PUCCH on two antenna ports, the value of $\Delta_{TxD}(F')$ is provided by higher layers where each PUCCH format F' is defined in Table 5.4-1 of [3] ; otherwise, $\Delta_{TxD}(F') = 0$.
- $h(n_{CQI}, n_{HARQ}, n_{SR})$ is a PUCCH format dependent value, where n_{CQI} corresponds to the number of information bits for the channel quality information defined in subclause 5.2.3.3 in [4]. n_{SR} = 1 if subframe i is configured for SR for the UE not having any associated transport block for UL-SCH, otherwise n_{SR} =0. If the UE is configured with more than one serving cell, or the UE is configured with one serving cell and transmitting using PUCCH format 3, the value of n_{HARQ} is defined in subclause 10.1; otherwise, n_{HARQ} is the number of HARQ-ACK bits sent in subframe i.
  - For PUCCH format 1,1a and 1b $h(n_{CQI}, n_{HARQ}, n_{SR}) = 0$
  - For PUCCH format 1b with channel selection, if the UE is configured with more than one serving cell, $h(n_{CQI}, n_{HARQ}, n_{SR}) = \frac{(n_{HARQ} - 1)}{2}$, otherwise, $h(n_{CQI}, n_{HARQ}, n_{SR}) = 0$
  - For PUCCH format 2, 2a, 2b and normal cyclic prefix

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \begin{cases} 10\log_{10}\left(\frac{n_{CQI}}{4}\right) & \text{if } n_{CQI} \ge 4 \\ 0 & \text{otherwise} \end{cases}$$

  - For PUCCH format 2 and extended cyclic prefix

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \begin{cases} 10\log_{10}\left(\frac{n_{CQI} + n_{HARQ}}{4}\right) & \text{if } n_{CQI} + n_{HARQ} \ge 4 \\ 0 & \text{otherwise} \end{cases}$$

- For PUCCH format 3 and when UE transmits HARQ-ACK/SR without periodic CSI,
  - If the UE is configured by higher layers to transmit PUCCH format 3 on two antenna ports, or if the UE transmits more than 11 bits of HARQ-ACK/SR

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \frac{n_{HARQ} + n_{SR} - 1}{3}$$

  - Otherwise

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \frac{n_{HARQ} + n_{SR} - 1}{2}$$

- For PUCCH format 3 and when UE transmits HARQ-ACK/SR and periodic CSI,
  - If the UE is configured by higher layers to transmit PUCCH format 3 on two antenna ports, or if the UE transmits more than 11 bits of HARQ-ACK/SR and CSI

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \frac{n_{HARQ} + n_{SR} + n_{CQI} - 1}{3}$$

  - Otherwise

$$h(n_{CQI}, n_{HARQ}, n_{SR}) = \frac{n_{HARQ} + n_{SR} + n_{CQI} - 1}{2}$$

- $P_{\text{O\_PUCCH}}$ is a parameter composed of the sum of a parameter $P_{\text{O\_NOMINAL\_PUCCH}}$ provided by higher layers and a parameter $P_{\text{O\_UE\_PUCCH}}$ provided by higher layers.

- δ_{PUCCH} is a UE specific correction value, also referred to as a TPC command, included in a PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D for the primary cell, or included in an EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D for the primary cell, or sent jointly coded with other UE specific PUCCH correction values on a PDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUCCH-RNTI.
  - If a UE is not configured for EPDCCH monitoring, the UE attempts to decode a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and one or several PDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI on every subframe except when in DRX.
  - If a UE is configured for EPDCCH monitoring, the UE attempts to decode
    - a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and one or several PDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI as described in subclause 9.1.1, and
    - one or several EPDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI, as described in subclause 9.1.4.
  - If the UE decodes
    - a PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or
    - an EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D

    for the primary cell and the corresponding detected RNTI equals the C-RNTI or SPS C-RNTI of the UE and the TPC field in the DCI format is not used to determine the PUCCH resource as in subclause 10.1, the UE shall use the δ_{PUCCH} provided in that PDCCH/EPDCCH.

  Else

    - if the UE decodes a PDCCH with DCI format 3/3A, the UE shall use the δ_{PUCCH} provided in that PDCCH else the UE shall set $\delta_{\mathrm{PUCCH}} = 0$ dB.

- $g(i) = g(i-1) + \sum_{m=0}^{M-1} \delta_{PUCCH}(i - k_m)$ where $g(i)$ is the current PUCCH power control adjustment state and where $g(0)$ is the first value after reset.
  - For FDD or FDD-TDD and primary cell frame structure type 1, $M = 1$ and $k_0 = 4$.
  - For TDD, values of M and k_m are given in Table 10.1.3.1-1, where the "UL/DL configuration" in Table 10.1.3.1-1 corresponds to the *eimta-HarqReferenceConfig-r12* for the primary cell when the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for the primary cell.
  - The δ_{PUCCH} dB values signalled on PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D are given in Table 5.1.2.1-1. If the PDCCH with DCI format 1/1A/2/2A/2B/2C/2D or EPDCCH with DCI format 1/1A/2A/2/2B/2C/2D is validated as an SPS activation PDCCH/EPDCCH, or the PDCCH/EPDCCH with DCI format 1A is validated as an SPS release PDCCH/EPDCCH, then δ_{PUCCH} is 0dB.
  - The δ_{PUCCH} dB values signalled on PDCCH with DCI format 3/3A are given in Table 5.1.2.1-1 or in Table 5.1.2.1-2 as semi-statically configured by higher layers.
  - If $P_{\mathrm{O\_UE\_PUCCH}}$ value is changed by higher layers,
    - $g(0) = 0$
  - Else
    - $g(0) = \Delta P_{rampup} + \delta_{msg2}$, where
      - δ_{msg2} is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the primary cell, see subclause 6.2 and
      - if UE is transmitting PUCCH in subframe *i*,

$$\Delta P_{rampup} = \min\left[\left\{\max\left(0, P_{CMAX,c} - \left(\begin{array}{c} P_{0\_PUCCH} \\ + PL_c + h(n_{CQI}, n_{HARQ}, n_{SR}) \\ + \Delta_{F\_PUCCH}(F) + \Delta_{TxD}(F') \end{array}\right)\right)\right\}, \Delta P_{rampuprequested}\right].$$

Otherwise,

$\Delta P_{rampup} = \min\left[\left\{\max\left(0, P_{CMAX,c} - \left(P_{0\_PUCCH} + PL_c\right)\right)\right\}, \Delta P_{rampuprequested}\right]$ and $\Delta P_{rampuprequested}$ is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the primary cell.

  - If UE has reached $P_{\mathrm{CMAX,c}}(i)$ for the primary cell, positive TPC commands for the primary cell shall not be accumulated.
  - If UE has reached minimum power, negative TPC commands shall not be accumulated.

- UE shall reset accumulation
  - when $P_{\text{O\_UE\_PUCCH}}$ value is changed by higher layers
  - when the UE receives a random access response message for the primary cell
  - $g(i) = g(i-1)$ if i is not an uplink subframe in TDD or FDD-TDD and primary cell frame structure type 2.

Table 5.1.2.1-1: Mapping of TPC Command Field in DCI format 1A/1B/1D/1/2A/2B/2C/2D/2/3 to δ_{PUCCH} values

TPC Command Field in DCI format 1A/1B/1D/1/2A/2B/2C/2D/2/3	δ_{PUCCH} [dB]
0	-1
1	0
2	1
3	3

Table 5.1.2.1-2: Mapping of TPC Command Field in DCI format 3A to δ_{PUCCH} values

TPC Command Field in DCI format 3A	δ_{PUCCH} [dB]
0	-1
1	1

5.1.3 Sounding Reference Symbol (SRS)

5.1.3.1 UE behaviour

The setting of the UE Transmit power P_{SRS} for the SRS transmitted on subframe i for serving cell c is defined by

$$P_{\text{SRS,c}}(i) = \min\left\{ P_{\text{CMAX,c}}(i),\ P_{\text{SRS\_OFFSET,c}}(m) + 10\log_{10}(M_{\text{SRS,c}}) + P_{\text{O\_PUSCH,c}}(j) + \alpha_c(j)\cdot PL_c + f_c(i) \right\} \ \text{[dBm]}$$

where

- $P_{\text{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] in subframe i for serving cell c.
- $P_{\text{SRS\_OFFSET,c}}(m)$ is semi-statically configured by higher layers for $m=0$ and $m=1$ for serving cell c. For SRS transmission given trigger type 0 then $m=0$ and for SRS transmission given trigger type 1 then $m=1$.
- $M_{\text{SRS,c}}$ is the bandwidth of the SRS transmission in subframe i for serving cell c expressed in number of resource blocks.
- $f_c(i)$ is the current PUSCH power control adjustment state for serving cell c, see subclause 5.1.1.1.
- $P_{\text{O\_PUSCH,c}}(j)$ and $\alpha_c(j)$ are parameters as defined in subclause 5.1.1.1 for subframe i, where $j=1$.

If the total transmit power of the UE for the Sounding Reference Symbol in an SC-FDMA symbol would exceed $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\text{SRS},c}(i)$ for the serving cell c and the SC-FDMA symbol in subframe i such that the condition

$$\sum_c w(i)\cdot \hat{P}_{\text{SRS},c}(i) \le \hat{P}_{CMAX}(i)$$

is satisfied where $\hat{P}_{\mathrm{SRS},c}(i)$ is the linear value of $P_{\mathrm{SRS},c}(i)$, $\hat{P}_{CMAX}(i)$ is the linear value of P_{CMAX} defined in [6] in subframe i and $w(i)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c}(i)$ for serving cell c where $0 < w(i) \le 1$. Note that $w(i)$ values are the same across serving cells.

If the UE is configured with multiple TAGs and the SRS transmission of the UE in an SC-FDMA symbol for a serving cell in subframe i in a TAG overlaps with the SRS transmission in another SC-FDMA symbol in subframe i for a serving cell in another TAG, and if the total transmit power of the UE for the Sounding Reference Symbol in the overlapped portion would exceed $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\mathrm{SRS},c}(i)$ for the serving cell c and each of the overlapped SRS SC-FDMA symbols in subframe i such that the condition

$$\sum_{c} w(i) \cdot \hat{P}_{\mathrm{SRS},c}(i) \le \hat{P}_{CMAX}(i)$$

is satisfied where $\hat{P}_{\mathrm{SRS},c}(i)$ is the linear value of $P_{\mathrm{SRS},c}(i)$, $\hat{P}_{CMAX}(i)$ is the linear value of P_{CMAX} defined in [6] in subframe i and $w(i)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c}(i)$ for serving cell c where $0 < w(i) \le 1$. Note that $w(i)$ values are the same across serving cells.

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the UE shall use $f_{c,2}(i)$ instead of $f_c(i)$ to determine $P_{\mathrm{SRS},c}(i)$ for subframe i and serving cell c, where $f_{c,2}(i)$ is defined in subclause 5.1.1.1.

5.2 Downlink power allocation

The eNodeB determines the downlink transmit energy per resource element.

A UE may assume downlink cell-specific RS EPRE is constant across the downlink system bandwidth and constant across all subframes until different cell-specific RS power information is received. The downlink cell-specific reference-signal EPRE can be derived from the downlink reference-signal transmit power given by the parameter *referenceSignalPower* provided by higher layers. The downlink reference-signal transmit power is defined as the linear average over the power contributions (in [W]) of all resource elements that carry cell-specific reference signals within the operating system bandwidth.

The ratio of PDSCH EPRE to cell-specific RS EPRE among PDSCH REs (not applicable to PDSCH REs with zero EPRE) for each OFDM symbol is denoted by either ρ_A or ρ_B according to the OFDM symbol index as given by Table 5.2-2 and Table 5.2-3. In addition, ρ_A and ρ_B are UE-specific.

For a UE in transmission mode 8 - 10 when UE-specific RSs are not present in the PRBs upon which the corresponding PDSCH is mapped or in transmission modes 1 – 7, the UE may assume that for 16 QAM, 64 QAM, or 256QAM, spatial multiplexing with more than one layer or for PDSCH transmissions associated with the multi-user MIMO transmission scheme,

- ρ_A is equal to $\delta_{\text{power-offset}} + P_A + 10\log_{10}(2)$ [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to subclause 6.3.4.3 of [3];
- ρ_A is equal to $\delta_{\text{power-offset}} + P_A$ [dB] otherwise

where $\delta_{\text{power-offset}}$ is 0 dB for all PDSCH transmission schemes except multi-user MIMO and where P_A is a UE specific parameter provided by higher layers.

For transmission mode 7, if UE-specific RSs are present in the PRBs upon which the corresponding PDSCH is mapped, the ratio of PDSCH EPRE to UE-specific RS EPRE within each OFDM symbol containing UE-specific RSs shall be a constant, and that constant shall be maintained over all the OFDM symbols containing the UE-specific RSs in the corresponding PRBs. In addition, the UE may assume that for 16QAM, 64QAM, or 256QAM, this ratio is 0 dB.

For transmission mode 8, if UE-specific RSs are present in the PRBs upon which the corresponding PDSCH is mapped, the UE may assume the ratio of PDSCH EPRE to UE-specific RS EPRE within each OFDM symbol containing UE-specific RSs is 0 dB.

For transmission mode 9 or 10, if UE-specific RSs are present in the PRBs upon which the corresponding PDSCH is mapped, the UE may assume the ratio of PDSCH EPRE to UE-specific RS EPRE within each OFDM symbol containing UE-specific RS is 0 dB for number of transmission layers less than or equal to two and -3 dB otherwise.

A UE may assume that downlink positioning reference signal EPRE is constant across the positioning reference signal bandwidth and across all OFDM symbols that contain positioning reference signals in a given positioning reference signal occasion [10].

If CSI-RS is configured in a serving cell then a UE shall assume downlink CSI-RS EPRE is constant across the downlink system bandwidth and constant across all subframes for each CSI-RS resource.

The cell-specific ratio ρ_B / ρ_A is given by Table 5.2-1 according to cell-specific parameter P_B signalled by higher layers and the number of configured eNodeB cell specific antenna ports.

Table 5.2-1: The cell-specific ratio ρ_B / ρ_A for 1, 2, or 4 cell specific antenna ports

P_B	ρ_B / ρ_A	
	One Antenna Port	Two and Four Antenna Ports
0	1	5/4
1	4/5	1
2	3/5	3/4
3	2/5	1/2

For PMCH with 16QAM, 64QAM, or 256QAM, the UE may assume that the ratio of PMCH EPRE to MBSFN RS EPRE is equal to 0 dB.

Table 5.2-2: OFDM symbol indices within a slot of a non-MBSFN subframe where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A or ρ_B

Number of antenna ports	OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A		OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_B	
	Normal cyclic prefix	Extended cyclic prefix	Normal cyclic prefix	Extended cyclic prefix
One or two	1, 2, 3, 5, 6	1, 2, 4, 5	0, 4	0, 3
Four	2, 3, 5, 6	2, 4, 5	0, 1, 4	0, 1, 3

Table 5.2-3: OFDM symbol indices within a slot of an MBSFN subframe where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A or ρ_B

Number of antenna ports	OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A				OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_B			
	Normal cyclic prefix		Extended cyclic prefix		Normal cyclic prefix		Extended cyclic prefix	
	$n_s \bmod 2 = 0$	$n_s \bmod 2 = 1$	$n_s \bmod 2 = 0$	$n_s \bmod 2 = 1$	$n_s \bmod 2 = 0$	$n_s \bmod 2 = 1$	$n_s \bmod 2 = 0$	$n_s \bmod 2 = 1$
One or two	1, 2, 3, 4, 5, 6	0, 1, 2, 3, 4, 5, 6	1, 2, 3, 4, 5	0, 1, 2, 3, 4, 5	0	-	0	-
Four	2, 3, 4, 5, 6	0, 1, 2, 3, 4, 5, 6	2, 4, 3, 5	0, 1, 2, 3, 4, 5	0, 1	-	0, 1	-

5.2.1 eNodeB Relative Narrowband TX Power (RNTP) restrictions

The determination of reported Relative Narrowband TX Power indication $RNTP(n_{PRB})$ is defined as follows:

$$RNTP(n_{PRB}) = \begin{cases} 0 & \text{if} \quad \dfrac{E_A(n_{PRB})}{E_{\max\_nom}^{(p)}} \le RNTP_{threshold} \\ 1 & \text{if} \quad \text{no promise about the upper limit of } \dfrac{E_A(n_{PRB})}{E_{\max\_nom}^{(p)}} \text{ is made} \end{cases}$$

where $E_A(n_{PRB})$ is the maximum intended EPRE of UE-specific PDSCH REs in OFDM symbols not containing RS in this physical resource block on antenna port *p* in the considered future time interval; n_{PRB} is the physical resource block number $n_{PRB} = 0,...,N_{RB}^{DL} - 1$; $RNTP_{threshold}$ takes on one of the following values $RNTP_{threshold} \in \{-\infty,-11,-10,-9,-8,-7,-6,-5,-4,-3,-2,-1,0,+1,+2,+3\}$ [dB] and

$$E_{\max\_nom}^{(p)} = \frac{P_{\max}^{(p)} \cdot \dfrac{1}{\Delta f}}{N_{RB}^{DL} \cdot N_{SC}^{RB}}$$

where $P_{\max}^{(p)}$ is the base station maximum output power described in [7], and Δf, N_{RB}^{DL} and N_{SC}^{RB} are defined in [3].

6 Random access procedure

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

1. Random access channel parameters (PRACH configuration and frequency position)
2. 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.

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

1. Layer 1 procedure is triggered upon request of a preamble transmission by higher layers.
2. 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.
3. A preamble transmission power P_{PRACH} is determined as
   $P_{\mathrm{PRACH}} = \min\{P_{\mathrm{CMAX,c}}(i)$, PREAMBLE_RECEIVED_TARGET_POWER + PL_c }_[dBm], where $P_{\mathrm{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] for subframe *i* of serving cell c and PL_c is the downlink pathloss estimate calculated in the UE for serving cell c.
4. A preamble sequence is selected from the preamble sequence set using the preamble index.
5. A single preamble is transmitted using the selected preamble sequence with transmission power P_{PRACH} on the indicated PRACH resource.
6. 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.

6.1.1 Timing

For the L1 random access procedure, 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 $n+4$.

In case a random access procedure is initiated by a "PDCCH order" in subframe *n*, 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 20-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.
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
- - 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 $N_{\mathrm{RB}}^{\mathrm{UL}} \leq 44$

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.

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, and RI 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

For FDD, 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.

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

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-v12x0* 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.

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.

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.

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 s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2).
DCI format 1A	Common	If the number of PBCH antenna ports s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 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.

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 s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
DCI format 1A	Common	If the number of PBCH antenna ports s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 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.

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 s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
DCI format 1A	Common	If the number of PBCH antenna ports s one, S ng e-antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 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 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;
- the 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. 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;
- the 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.
- The UE may skip decoding the transport block(s) if it does not receive all assigned PDSCH resource blocks. If the UE skips decoding, the physical layer indicates to higher layer that the transport block(s) are not successfully decoded.

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 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-v12x0* 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 spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
Mode 2	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 3	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2A	UE spec f c by C RNTI	Large de ay CDD (see subc ause 7.1.3) or Transm t d vers ty (see subc ause 7.1.2)
Mode 4	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2	UE spec f c by C RNTI	C osed oop spat a mu t p ex ng (see subc ause 7.1.4)or Transm t d vers ty (see subc ause 7.1.2)
Mode 5	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1D	UE spec f c by C RNTI	Mu t user MIMO (see subc ause 7.1.5)
Mode 6	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1B	UE spec f c by C RNTI	C osed oop spat a mu t p ex ng (see subc ause 7.1.4) us ng a s ng e transm ss on ayer
Mode 7	DCI format 1A	Common and UE spec f c by C RNTI	If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
Mode 8	DCI format 1A	Common and UE spec f c by C RNTI	If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2B	UE spec f c by C RNTI	Dua ayer transm ss on, port 7 and 8 (see subc ause 7.1.5A) or s ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 9	DCI format 1A	Common andUE spec f c by C RNTI	• Non MBSFN subframe: If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2) • MBSFN subframe: S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2C	UE spec f c by C RNTI	Up to 8 ayer transm ss on, ports 7 14 (see subc ause 7.1.5B) or s ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 10	DCI format 1A	Common andUE spec f c by C RNTI	• Non MBSFN subframe: If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2) • MBSFN subframe: S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2D	UE spec f c by C RNTI	Up to 8 ayer transm ss on, ports 7 14 (see subc ause 7.1.5B) or s ng e antenna port, port 7 or 8 (see subc ause 7.1.1)

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 spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
Mode 2	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 3	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2A	UE spec f c by C RNTI	Large de ay CDD (see subc ause 7.1.3) or Transm t d vers ty (see subc ause 7.1.2)
Mode 4	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2	UE spec f c by C RNTI	C osed oop spat a mu t p ex ng (see subc ause 7.1.4)or Transm t d vers ty (see subc ause 7.1.2)
Mode 5	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1D	UE spec f c by C RNTI	Mu t user MIMO (see subc ause 7.1.5)
Mode 6	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1B	UE spec f c by C RNTI	C osed oop spat a mu t p ex ng (see subc ause 7.1.4) us ng a s ng e transm ss on ayer
Mode 7	DCI format 1A	UE spec f c by C RNTI	If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
Mode 8	DCI format 1A	UE spec f c by C RNTI	If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2B	UE spec f c by C RNTI	Dua ayer transm ss on, port 7 and 8 (see subc ause 7.1.5A) or s ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 9	DCI format 1A	UE spec f c by C RNTI	• Non MBSFN subframe: If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2) • MBSFN subframe: S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2C	UE spec f c by C RNTI	Up to 8 ayer transm ss on, ports 7 14 (see subc ause 7.1.5B) or s ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 10	DCI format 1A	UE spec f c by C RNTI	• Non MBSFN subframe: If the number of PBCH antenna ports s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2) • MBSFN subframe: S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2D	UE spec f c by C RNTI	Up to 8 ayer transm ss on, ports 7 14 (see subc ause 7.1.5B) or s ng e antenna port, port 7 or 8 (see subc ause 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.

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-v12x0* 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 spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
Mode 2	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 3	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 4	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 5	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 6	DCI format 1A	Common and UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 7	DCI format 1A	Common and UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
Mode 8	DCI format 1A	Common and UE spec f c by C RNTI	S ng e antenna port, port 7(see subc ause 7.1.1)
	DCI format 2B	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 9	DCI format 1A	Common and UE spec f c by C RNTI	S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2C	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8, (see subc ause 7.1.1)
Mode 10	DCI format 1A	Common and UE spec f c by C RNTI	S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2D	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8, (see subc ause 7.1.1)

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 spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 0 (see subc ause 7.1.1)
Mode 2	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 1	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 3	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 4	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
	DCI format 2	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 5	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 6	DCI format 1A	UE spec f c by C RNTI	Transm t d vers ty (see subc ause 7.1.2)
Mode 7	DCI format 1A	UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
	DCI format 1	UE spec f c by C RNTI	S ng e antenna port, port 5 (see subc ause 7.1.1)
Mode 8	DCI format 1A	UE spec f c by C RNTI	S ng e antenna port, port 7(see subc ause 7.1.1)
	DCI format 2B	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8 (see subc ause 7.1.1)
Mode 9	DCI format 1A	UE spec f c by C RNTI	S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2C	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8, (see subc ause 7.1.1)
Mode 10	DCI format 1A	UE spec f c by C RNTI	S ng e antenna port, port 7 (see subc ause 7.1.1)
	DCI format 2D	UE spec f c by C RNTI	S ng e antenna port, port 7 or 8, (see subc ause 7.1.1)

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.

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 spec f c by Temporary C RNTI	If the number of PBCH antenna port s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)
DCI format 1	UE spec f c by Temporary C RNTI	If the number of PBCH antenna port s one, S ng e antenna port, port 0 s used (see subc ause 7.1.1), otherw se Transm t d vers ty (see subc ause 7.1.2)

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, port 5, port 7 or port 8) 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].

In case an antenna port $p \in \{7,8\}$ 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.

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	$-10\,og_{10}(2)$
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].

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.

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]. 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. 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 in such way 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,

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

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

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

7.1.6.3 Resource allocation type 2

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_{VRB}^{DL} VRBs, where N_{VRB}^{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_{VRB}^{DL} VRBs if N_{RB}^{DL} is 6-49 and vary from a single VRB up to 16 if N_{RB}^{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_{VRB}^{DL} VRBs if N_{RB}^{DL} is 6-49 and vary from a single VRB up to 16 if N_{RB}^{DL} is 50-110. With PDCCH DCI format 1C, distributed VRB allocations for a UE vary from N_{RB}^{step} VRB(s) up to $\left\lfloor N_{VRB}^{DL}/N_{RB}^{step}\right\rfloor\cdot N_{RB}^{step}$ VRBs with an increment step of N_{RB}^{step}, where N_{RB}^{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_{RB}^{step} values vs. Downlink System Bandwidth

System BW (N_{RB}^{DL})	N_{RB}^{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, 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 $(L_{CRBs}-1)\le\left\lfloor N_{RB}^{DL}/2\right\rfloor$ 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 $L_{CRBs} \geq 1$ 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_{RB}^{step}, $2N_{RB}^{step}, \ldots$, $(\lfloor N_{VRB}^{DL} / N_{RB}^{step} \rfloor - 1) N_{RB}^{step}$) and a length in terms of virtually contiguously allocated resource blocks ($L_{CRBs} = N_{RB}^{step}$, $2N_{RB}^{step}, \ldots$, $\lfloor N_{VRB}^{DL} / N_{RB}^{step} \rfloor \cdot N_{RB}^{step}$).
The resource indication value is defined by:

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

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

7.1.6.4 PDSCH starting position

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

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

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

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

- if the PDSCH is assigned by a PDCCH with DCI format 1C or by a PDCCH with DCI format 1A and with CRC scrambled with P-RNTI/RA-RNTI/SI-RNTI/Temporary C-RNTI
  - $l_{\text{DataStart}}$ is given by the span of the DCI given by the CFI value in the subframe of the given serving cell according to subclause 5.3.4 of [4].
- if the PDSCH is assigned by a PDCCH/EPDCCH with DCI format 1A and with CRC scrambled with C-RNTI and if the PDSCH transmission is on antenna ports 0 - 3
  - if the PDSCH is assigned by EPDCCH received in the same serving cell

- $l_{\mathrm{DataStart}}$ is given by $l_{\mathrm{EPDCCHStart}}$ for the EPDCCH-PRB-set where EPDCCH with the DCI format 1A was received ($l_{\mathrm{EPDCCHStart}}$ as defined in subclause 9.1.4.1),

- 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 $N_{\mathrm{RB}}^{\mathrm{DL}} \le 10$.

- 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},

    - $l'_{\mathrm{DataStart}}$ 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,

      - $l'_{\mathrm{DataStart}}$ 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 $N_{\mathrm{RB}}^{\mathrm{DL}} \le 10$.

  - 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,

    - $l_{\mathrm{DataStart}} = \min(2, l'_{\mathrm{DataStart}})$,

  - otherwise

    - $l_{\mathrm{DataStart}} = l'_{\mathrm{DataStart}}$.

- 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},

    - $l'_{\mathrm{DataStart}}$ 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,

      - $l'_{\mathrm{DataStart}}$ is given by the higher-layer parameter *pdsch-Start-r10* for the serving cell on which PDSCH is received

- Otherwise
  - $l'_{\text{DataStart}}$ is given by the CFI value in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} > 10$, and $l_{\text{DataStart}}$ is given by the CFI value+1 in the subframe of the given serving cell when $N_{\text{RB}}^{\text{DL}} \leq 10$.
- if the subframe on which PDSCH is received is indicated by the higher layer parameter *mbsfn-SubframeConfigList-r11* determined from the DCI (according to subclause 7.1.9) for the serving cell on which PDSCH is received, or if the PDSCH is received on subframe 1 or 6 for frame structure type 2,
  - $l_{\text{DataStart}} = \min(2, l'_{\text{DataStart}})$,
- otherwise
  - $l_{\text{DataStart}} = l'_{\text{DataStart}}$.

7.1.6.5 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 $N_{\text{RB}}^{\text{DL}} \bmod P' > 0$ then one of the PRGs is of size $N_{\text{RB}}^{\text{DL}} - P'\lfloor N_{\text{RB}}^{\text{DL}} / P' \rfloor$. The PRG size is non-increasing starting at the lowest frequency. The UE may assume that the same precoder applies on all scheduled PRBs within a PRG.

The PRG size a UE may assume for a given system bandwidth is given by:

Table 7.1.6.5-1

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

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

- read the 5-bit "modulation and coding scheme" field (I_{MCS}) in the DCI

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

- for DCI format 1A:
  - set the Table 7.1.7.2.1-1 column indicator N_{PRB} to $N_{\text{PRB}}^{\text{1A}}$ 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

- 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, then

  - for special subframe configuration 9 with normal cyclic prefix or special subframe configuration 7 with extended cyclic prefix:
    - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\text{PRB}} \times 0.375 \right\rfloor, \quad 1\right\}$
  - for other special subframe configurations:
    - set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\left\lfloor N'_{\text{PRB}} \times 0.75 \right\rfloor, \quad 1\right\}$,

  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 0.931, 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, shown in Table 4.2-1 of [3], there shall be no PDSCH transmission in DwPTS of the special subframe.

7.1.7.1 Modulation order determination

The UE shall use Q_m = 2 if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI, otherwise,

- if the higher layer parameter *enableHOM-r12* is set to *TRUE* or if the higher layer parameter *csi-enableHOM-r12* is set to *TRUE* for at least one CSI subframe set, 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,
  - 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
  - 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	TBS Index I_{TBS}
0	2	0
1	2	1
2	2	2
3	2	3
4	2	4
5	2	5
6	2	6
7	2	7
8	2	8
9	2	9
10	4	9
11	4	10
12	4	11
13	4	12
14	4	13
15	4	14
16	4	15
17	6	15
18	6	16
19	6	17
20	6	18
21	6	19
22	6	20
23	6	21
24	6	22
25	6	23
26	6	24
27	6	25
28	6	26
29	2	reserved
30	4	
31	6	

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

MCS Index I_{MCS}	Modulation Order Q_m	TBS Index I_{TBS}
0	2	0
1	2	2
2	2	4
3	2	6
4	2	8
5	4	10
6	4	11
7	4	12
8	4	13
9	4	14
10	4	15
11	6	16
12	6	17
13	6	18
14	6	19
15	6	20

16	6	21
17	6	22
18	6	23
19	6	24
20	8	25
21	8	27
22	8	28
23	8	29
24	8	30
25	8	31
26	8	32
27	8	33
28	2	reserved
29	4	
30	6	
31	8	

7.1.7.2 Transport block size determination

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

- for DCI format 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 $0 \le I_{\text{TBS}} \le 26$.
- for DCI format 1C:
  - 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 *enableHOM-r12* is set to *TRUE* or if higher layer parameter *csi-enableHOM-r12* is set to *TRUE* for at least one CSI subframe set, 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 $0 \le I_{\text{MCS}} \le 28$, 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. 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 $29 \le I_{\text{MCS}} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \le I_{\text{TBS}} \le 33$. If there is no PDCCH/EPDCCH for the same transport block using $0 \le I_{\text{TBS}} \le 26$, 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 $I_{\text{MCS}} = 0$ 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 $0 \le I_{\text{MCS}} \le 27$, 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. 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 $0 \le I_{TBS} \le 33$.
- 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

- 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 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 $29 \le I_{MCS} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH/EPDCCH for the same transport block using $0 \le I_{MCS} \le 28$. If there is no PDCCH/EPDCCH for the same transport block using $0 \le I_{MCS} \le 28$, 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 $I_{MCS} = 0$ and if $rv_{idx} = 1$ otherwise the transport block is enabled.

The NDI and HARQ process ID, as signalled on PDCCH/EPDCCH, 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 $1 \le N_{PRB} \le 110$, 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 34×110)

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

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

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

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

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

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

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

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

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

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

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

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
33	968	1992	2984	4008	4968	5992	6968	7992	8760	9912

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
33	10680	11832	12960	13536	14688	15840	16992	17568	19080	19848

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
33	20616	21384	22920	23688	24496	25456	26416	27376	28336	29296

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
33	30576	31704	32856	34008	35160	35160	36696	37888	39232	39232

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
33	40576	40576	42368	43816	43816	45352	46888	46888	48936	48936

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
33	51024	51024	52752	52752	55056	55056	57336	57336	59256	59256

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
33	59256	61664	61664	63776	63776	63776	66592	66592	68808	68808

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
33	71112	71112	71112	73712	75376	76208	76208	76208	78704	78704

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
33	81176	81176	81176	81176	84760	84760	84760	87936	87936	87936

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
33	90816	90816	90816	93800	93800	93800	93800	97896	97896	97896

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
33	97896	97896	97896	97896	97896	97896	97896	97896	97896	97896

7.1.7.2.2 Transport blocks mapped to two-layer spatial multiplexing

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

For $56 \le N_{\mathrm{PRB}} \le 110$, 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_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

7.1.7.2.3 Transport blocks mapped for DCI Format 1C

The TBS is given by the I_{TBS} entry of Table 7.1.7.2.3-1.

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

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

7.1.7.2.4 Transport blocks mapped to three-layer spatial multiplexing

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

For $37 \leq N_{PRB} \leq 110$, 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 $1 \le N_{PRB} \le 27$, the TBS is given by the (I_{TBS}, $4 \cdot N_{PRB}$) entry of Table 7.1.7.2.1-1.

For $28 \le N_{PRB} \le 110$, 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_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

7.1.7.3 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, then for each serving cell, for at least $K_{\text{MIMO}} \cdot \min(M_{\text{DL\_HARQ}}, M_{\text{limit}})$ transport blocks, upon decoding failure of a code block of a transport block, the UE shall store received soft channel bits corresponding to a range of at least $w_k\ w_{k+1}, \ldots, w_{\text{mod}(k+n_{SB}-1, N_{cb})}$, where:

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

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

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

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

If the UE signals *ue-Category-v12x y*, N'_{soft} is the total number of soft channel bits [12] according to the UE category indicated by *ue-Category-v12xy* [11]. Else if the UE signals *ue-Category-v1170* and not *ue-Category-v12xy*, N'_{soft} is the total number of soft channel bits [12] according to the UE category indicated by *ue-Category-v1170* [11]. Else if the UE signals *ue-Category-v1020* and not *ue-Category-v1170* and not *ue-Category-v12xy*, N'_{soft} is the total number of soft channel bits [12] according to the UE category indicated by *ue-Category-v1020* [11]. Otherwise, N'_{soft} is the total number of soft channel bits [12] according to the UE category indicated by *ue-Category* (without suffix) [11].

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 $w_k\ w_{k+1}, \ldots, w_{\text{mod}(k+n_{SB}-1, N_{cb})}$ may include subsets not containing received soft channel bits.

7.1.9 PDSCH resource mapping parameters

A UE configured in transmission mode 10 for a given serving cell can be configured with up to 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 conf gured by h gher ayers
'01'	Parameter set 2 conf gured by h gher ayers
'10'	Parameter set 3 conf gured by h gher ayers
'11'	Parameter set 4 conf gured by h gher ayers

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.

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).

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.

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 – 22 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 – 22 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 – 22 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.

7.2 UE procedure for reporting Channel State Information (CSI)

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), 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 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. 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 configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for a serving cell can be configured with up to two CSI-IM resources for a CSI process if the UE is configured with CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ for the CSI process. 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.

A UE is configured with resource-restricted CSI measurements if the subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers.

CSI reporting is periodic or aperiodic.

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 higher layer parameter *enableHOM-r12* is set to *TRUE*,

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

Else if the higher layer parameter *csi-enableHOM-r12* for at least one CSI subframe set is set to *TRUE*,

- if the parameter *csi-enableHOM-r12* for a given CSI subframe set is set to *TRUE*,
  - the UE shall report CQI for the given CSI subframe set according to Table 7.2.3-2.
- else
  - the UE shall report CQI for the given CSI subframe set according to Table 7.2.3-1.

Else

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

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.

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 a bitmap parameter *codebookSubsetRestriction* configured by higher layer signalling. For a UE configured in transmission mode 10, 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 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. 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 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: 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].

   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 ($\upsilon \in \{1,2,3,4\}$) 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: 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.

Table 7.2-1b: Number of bits in codebook subset restriction 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 w th *alternativeCodeBookEnabledFor4TX-r12=TRUE* conf gured, otherw se 32	
Transmission modes 9 and 10	6	96 w th *alternativeCodeBookEnabledFor4TX-r12=TRUE* conf gured, otherw se 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	-

The set of subbands (S) a UE shall evaluate for CQI reporting spans the entire downlink system bandwidth. A subband is a set of k contiguous PRBs where k is a function of system bandwidth. Note the last subband in set S may have fewer than k contiguous PRBs depending on N_{RB}^{DL}. The number of subbands for system bandwidth given by N_{RB}^{DL} is defined by $N=\lceil N_{RB}^{DL}/k \rceil$. 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, and transmission modes 8, 9 and 10 with PMI/RI 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, 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, 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, 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 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.

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 *EIMTA-MainConfigServCell-r12* for any serving cell, a report is triggered for serving cell c, if the CSI request field is set to '1'. If the CSI request field is 1 bit and the UE is configured in transmission mode 10 and the UE is not configured with *EIMTA-MainConfigServCell-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 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 *EIMTA-MainConfigServCell-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 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 *EIMTA-*

MainConfigServCell-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 a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell,

- If CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured for any of the at least one serving cell,
  - If the CSI request field is 1 bit, 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 CSI request field size is 2 bits, a report is triggered according to the value in Table 7.2.1-1C corresponding to aperiodic CSI reporting.
- Otherwise,
  - If the CSI request field is 1 bit and the UE is configured in transmission mode 1-9, a report is triggered for serving cell c, if the CSI request field is set to '1'.
  - If the CSI request field is 1 bit and the UE is configured in transmission mode 10, 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 CSI request field size is 2 bits and the UE is configured in transmission mode 1-9 for all serving cells, a report is triggered according to the value in Table 7.2.1-1A corresponding to aperiodic CSI reporting.
  - If the CSI request field size is 2 bits and the UE is configured in transmission mode 10 for at least one serving cell, a report is triggered according to the value in Table 7.2.1-1B corresponding to aperiodic CSI reporting.

For a given serving cell, if the UE is configured in transmission modes 1-9, the "CSI process" in Table 7.2.1-1B and Table 7.2.1-1C 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 receive more than one aperiodic CSI report request for a given subframe.

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.

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 aper od c CSI report s tr ggered
'01'	Aper od c CSI report s tr ggered for serv ng ce c
'10'	Aper od c CSI report s tr ggered for a 1st set of serv ng ce s conf gured by h gher ayers
'11'	Aper od c CSI report s tr ggered for a 2nd set of serv ng ce s conf gured by h gher ayers

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 aper od c CSI report s tr ggered
'01'	Aper od c CSI report s tr ggered for a set of CSI process(es) conf gured by h gher ayers for serv ng ce c
'10'	Aper od c CSI report s tr ggered for a 1st set of CSI process(es) conf gured by h gher ayers
'11'	Aper od c CSI report s tr ggered for a 2nd set of CSI process(es) conf gured by h gher ayers

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

Value of CSI request field	Description
'00'	No aper od c CSI report s tr ggered
'01'	Aper od c CSI report s tr ggered for a set of CSI process(es) and/or {CSI process, CSI subframe set}-pa r(s) conf gured by h gher ayers for serv ng ce c
'10'	Aper od c CSI report s tr ggered for a 1st set of CSI process(es) and/or {CSI process, CSI subframe set}-pa r(s) conf gured by h gher ayers
'11'	Aper od c CSI report s tr ggered for a 2nd set of CSI process(es) and/or {CSI process, CSI subframe set}-pa r(s) conf gured by h gher ayers

NOTE: PDCCH/EPDCCH with DCI formats used to grant PUSCH transmissions as given by DCI format 0 and DCI format 4 are herein referred to as uplink DCI format when common behaviour is addressed.

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).

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.

The minimum reporting interval for aperiodic reporting of CQI and PMI and RI 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 on the same PUSCH using one of the following CSI reporting modes given in Table 7.2.1-1 and described below.

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 1-2
	UE Selected (subband CQI)	Mode 2-0		Mode 2-2
	Higher Layer-configured (subband CQI)	Mode 3-0	Mode 3-1	Mode 3-2

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
Transmission mode 2 : Modes 2-0, 3-0
Transmission mode 3 : Modes 2-0, 3-0
Transmission mode 4 : Modes 1-2, 2-2, 3-1, 3-2
Transmission mode 5 : Mode 3-1
Transmission mode 6 : Modes 1-2, 2-2, 3-1, 3-2
Transmission mode 7 : Modes 2-0, 3-0
Transmission mode 8 : Modes 1-2, 2-2, 3-1, 3-2 if the UE is configured with PMI/RI reporting; modes 2-0, 3-0 if the UE is configured without PMI/RI reporting
Transmission mode 9 : 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; modes 2-0, 3-0 if the UE is configured without PMI/RI reporting or number of CSI-RS ports=1
Transmission mode 10 : 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; modes 2-0, 3-0 if the UE is configured without PMI/RI reporting or number of CSI-RS ports=1.

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

For a serving cell with $N_{\mathrm{RB}}^{\mathrm{DL}} \leq 7$, PUSCH reporting modes are not supported for that serving cell.
RI is only reported for transmission modes 3 and 4, as well as transmission modes 8, 9 and 10 with PMI/RI reporting.

For serving cell c, a UE configured in transmission mode 10 with PMI/RI 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 $C_{\text{CSI},0}$ 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.

A RI report for a serving cell on an aperiodic reporting mode is valid only for CQI/PMI report for that serving cell on that aperiodic reporting mode

- Wideband feedback
  - Mode 1-2 description:
    - 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.
    - Subband size is given by Table 7.2.1-3.
    - 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.

- Higher Layer-configured subband feedback
  - Mode 3-0 description:
    - 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.
  - Mode 3-1 description:
    - 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.

- 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.

- Mode 3-2 description:
  - 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.
  - 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 are calculated conditioned on the reported RI. For transmission mode 6 they are reported conditioned on rank 1.
- 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_{RB}^{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:
  - 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.
- Mode 2-2 description:
  - 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.
  - 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, the UE shall also report the selected single precoding matrix indicator preferred for the M selected subbands. A UE shall also report the selected single precoding matrix indicator for all set S subbands.
  - For transmission modes 9 and 10 with 8 CSI-RS ports configured and for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured, a UE shall report a first precoding matrix indicator for all set S subbands. A UE shall also report a second precoding matrix indicator for all set S subbands and another second precoding matrix indicator for the M selected 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
  - 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.
- 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 $\{s_i\}_{i=0}^{M-1}$, ($1 \le s_i \le N$, $s_i < s_{i+1}$) 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 $L = \left\lceil \log_2 \binom{N}{M} \right\rceil$.

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

System Bandwidth $N_{\mathrm{RB}}^{\mathrm{DL}}$	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

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, 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.

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 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; modes 1-0, 2-0 if the UE is configured without PMI/RI reporting or number of CSI-RS ports=1.
Transmission mode 10 : Modes 1-1, 2-1 if the UE is configured with PMI/RI reporting and number of CSI-RS ports>1; modes 1-0, 2-0 if the UE is configured without PMI/RI reporting or number of CSI-RS ports=1.

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 a UE configured with transmission mode 9 or 10, and 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, 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 $\lfloor N_{\mathrm{RB}}^{\mathrm{DL}}/k \rfloor$ subbands are of size k. If $\lceil N_{\mathrm{RB}}^{\mathrm{DL}}/k \rceil - \lfloor N_{\mathrm{RB}}^{\mathrm{DL}}/k \rfloor > 0$ then one of the subbands is of size $N_{\mathrm{RB}}^{\mathrm{DL}} - k \cdot \lfloor N_{\mathrm{RB}}^{\mathrm{DL}}/k \rfloor$.

- 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

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 TDD-FDD 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. Both *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* are configured by higher layer signalling. The relative reporting offset for RI $N_{OFFSET,RI}$ takes values from the set $\{0,-1,...,-(N_{pd}-1)\}$. If a UE is configured to report for more than one CSI subframe set then parameter *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* respectively correspond to the CQI/PMI and RI periodicity and relative reporting offset for subframe set 1 and *cqi-pmi-ConfigIndex2* and *ri-ConfigIndex*2 respectively correspond to the CQI/PMI and RI periodicity and relative reporting offset for subframe set 2. For a UE configured with transmission mode 10, the parameters *cqi-pmi-ConfigIndex* , *ri-ConfigIndex*, *cqi-pmi-ConfigIndex2* and *ri-ConfigIndex*2 can be configured for each CSI process.

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

- The reporting instances for wideband CQI/PMI are subframes satisfying $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}\right) \bmod \left(N_{pd}\right) = 0$.

- In case RI reporting is configured, the reporting interval of the RI reporting is an integer multiple M_{RI} of period N_{pd} (in subframes).

  - The reporting instances for RI are subframes satisfying $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}\right) \bmod \left(N_{pd} \cdot M_{RI}\right) = 0$.

In the case where both wideband CQI/PMI and subband CQI reporting are configured:

- The reporting instances for wideband CQI/PMI and subband CQI are subframes satisfying $\left(10 \times n_f + \lfloor n_s/2 \rfloor - N_{OFFSET,CQI}\right) \bmod N_{pd} = 0$.

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

In case of collision of a CSI report with PUCCH reporting type 3, 5, or 6 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) has lower priority and is dropped.

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 *CSIProcessIndex* are dropped.

For a serving cell and UE configured in transmission mode 1-9 and UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for the serving cell, and the UE configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 UE configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* for the serving cell, and the UE configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 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 3, 5, 6, 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 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.

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.

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.

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.

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.

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 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.

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	$I_{CQI/PMI} - 414$
$542 \le I_{CQI/PMI} \le 1023$	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	$I_{CQI/PMI} - 156$
$316 \le I_{CQI/PMI} \le 1023$	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-HarqReferenceConfig-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 $N_{\mathrm{RB}}^{\mathrm{DL}} \leq 7$, Mode 2-0 and Mode 2-1 are not supported for that serving cell.

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

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

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

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

An 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 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.

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.

- Wideband feedback
  - Mode 1-0 description:
    - In the subframe where RI is reported (only for transmission mode 3):
      - A 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 CQI is reported:

- 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.

o Mode 1-1 description:

▪ In the subframe where RI is reported (only 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, 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 a first PMI are reported for transmission modes 9 and 10 configured with submode 1 and 8 CSI-RS ports, and for transmission modes 8, 9 and 10 configured with submode 1 and *alternativeCodeBookEnabledFor4TX-r12=TRUE*:

- 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 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 CQI/PMI is reported for all transmission modes 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:

- 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
  - o 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.
  - o The selected single PMI (wideband PMI).
  - o When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- For transmission modes 4, 8, 9 and 10,
  - o 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 configured and for transmission modes 8, 9 and 10 with submode 1 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured:

- 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
  - o 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.
  - o The wideband second PMI corresponding to the selected single precoding matrix.
  - o When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- 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,
  - o 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.
  - o 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,
  - o The wideband second PMI value is calculated conditioned on the last reported periodic RI and the wideband first PMI.
  - o 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 8 CSI-RS ports and submode 2 configured, and for transmission modes 8, 9 and 10 with submode 2 and *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured:

- 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
  - o 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.
  - o The wideband first PMI and the wideband second PMI corresponding to the selected single precoding matrix as defined in subclause 7.2.4.
  - o When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- 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):
            - A 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 wideband CQI is reported:
            - 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.
        - In the subframe where CQI for the selected subbands is reported:
            - 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.
    - 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:
            - Ifa 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 is reported for transmission modes 9 and 10 with 8 CSI-RS ports configured and for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured then:

    - 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 wideband CQI/PMI is reported for all transmission modes 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:
    - 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:
        - o A wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set *S* subbands.
        - o The selected single PMI (wideband PMI).
        - o When RI>1, an additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
    - For transmission modes 4, 8, 9 and 10,
        - o 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 for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured:
    - 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 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 for transmission modes 8,9, and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured:
  - 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 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 8 CSI-RS ports configured for transmission modes 9 and 10, or with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured for transmission modes 8, 9 and 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.
  - 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.

- 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 for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=TRUE* configured:
  - 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 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 for transmission modes 8, 9 and 10 with *alternativeCodeBookEnabledFor4TX-r12=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 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 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_{RB}^{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

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.

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
1a	Sub-band CQI / second PMI	8 antenna ports RI = 1	NA	8+L	NA	NA
		8 antenna ports 1 < RI < 5	NA	9+L	NA	NA
		8 antenna ports RI > 4	NA	7+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	8	8	NA	NA
		2 antenna ports RI > 1	8	8	NA	NA
		4 antenna ports RI > 1	11	11	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
2b	Wideband CQI / second PMI	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
		4 antenna ports RI=1	8	8	NA	NA
		4 antenna port 1<RI≤4	11	11	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 ayer spat a mu t p ex ng	1	1	1	1
		8 antenna ports, 2 ayer spat a mu t p ex ng	1	NA	NA	NA
		4 antenna ports, 4 ayer spat a mu t p ex ng	2	2	2	2
		8 antenna ports, 4 ayer spat a mu t p ex ng	2	NA	NA	NA
		8 ayer spat a mu t p ex ng	3	NA	NA	NA
4	Wideband CQI	RI = 1 or RI>1	NA	NA	4	4
5	RI/ first PMI	8 antenna ports, 2 ayer spat a mu t p ex ng	4	NA	NA	NA
		8 antenna ports, 4 and 8 ayer spat a mu t p ex ng	5			
		4 antenna ports, 2 ayer spat a mu t p ex ng	4			
		4 antenna ports, 4 ayer spat a mu t p ex ng	5			
6	RI/PTI	8 antenna ports, 2 ayer spat a mu t p ex ng	NA	2	NA	NA
		8 antenna ports, 4 ayer spat a mu t p ex ng	NA	3	NA	NA
		8 antenna ports, 8 ayer spat a mu t p ex ng	NA	4	NA	NA
		4 antenna ports, 2 ayer spat a mu t p ex ng	NA	2	NA	NA
		4 antenna ports, 4 ayer spat a mu t p ex ng	NA	3	NA	NA

NOTE *: For w deband CQI report ng types, the stated pay oad s ze app es to the fu bandw dth.

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.

Based on an unrestricted observation interval in time and 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.

If CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ are configured by higher layers, each CSI reference resource belongs to either $C_{\text{CSI},0}$ or $C_{\text{CSI},1}$ but not to both. When CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ 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.

For a UE in transmission mode 9 when parameter *pmi-RI-Report* is 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 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 UE in transmission mode 10, 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 10 , 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 zero power CSI-RS (defined in [3]) within the configured CSI-IM resource associated with the CSI process. If the UE in transmission mode 10 is configured by higher layers for CSI subframe sets $C_{\text{CSI},0}$ and $C_{\text{CSI},1}$ 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.

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:

- 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.
- In the time domain,
  - 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 $n\text{-}n_{CQI\_ref}$,

- 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 *EIMTA-MainConfigServCell-r12*, or if the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12* and the UE is not configured with CSI subframe sets.
  - 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 *EIMTA-MainConfigServCell-r12*, and the UE configured with CSI subframe sets,
  - 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.

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 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 *EIMTA-MainConfigServCell-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 and the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-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 for the CSI process and the UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*.

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:
  - CRS REs are as in non-MBSFN subframes;
  - If the UE is configured for PMI/RI 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 $\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$, where $x(i) = \begin{bmatrix} x^{(0)}(i) & \ldots & x^{(\upsilon-1)}(i) \end{bmatrix}^T$ is a vector of symbols from the layer mapping in subclause 6.3.3.2 of [3], $P \in \{1,2,4,8\}$ is the number of CSI-RS ports configured, and if only one CSI-RS port is configured, $W(i)$ is 1, otherwise $W(i)$ is the precoding matrix corresponding to the reported PMI 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.

- 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:
  - 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 $\{7\ldots 6+\upsilon\}$ for υ layers would result in signals equivalent to corresponding symbols transmitted on antenna ports $\{15\ldots 14+P\}$, as given by $\begin{bmatrix} y^{(15)}(i) \\ \vdots \\ y^{(14+P)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$, where $x(i) = \begin{bmatrix} x^{(0)}(i) & \ldots & x^{(\upsilon-1)}(i) \end{bmatrix}^T$ is a vector of symbols from the layer mapping in subclause 6.3.3.2 of [3], $P \in \{1,2,4,8\}$ is the number of antenna ports of the associated CSI-RS resource, and if P=1, $W(i)$ is 1, otherwise $W(i)$ is the precoding matrix corresponding to the

reported PMI 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	S ng e-antenna port, port 0
2	Transm t d vers ty
3	Transm t d vers ty f the assoc ated rank nd cator s 1, otherw se arge de ay CDD
4	C osed- oop spat a mu t p ex ng
5	Mu t-user MIMO
6	C osed- oop spat a mu t p ex ng w th a s ng e transm ss on ayer
7	If the number of PBCH antenna ports s one, S ng e-antenna port, port 0; otherw se Transm t d vers ty
8	If the UE s conf gured w thout PMI/RI report ng: f the number of PBCH antenna ports s one, s ng e-antenna port, port 0; otherw se transm t d vers ty If the UE s conf gured w th PMI/RI report ng: c osed- oop spat a mu t p ex ng
9	If the UE s conf gured w thout PMI/RI report ng: f the number of PBCH antenna ports s one, s ng e-antenna port, port 0; otherw se transm t d vers ty If the UE s conf gured w th PMI/RI report ng: f the number of CSI-RS ports s one, s ng e-antenna port, port 7; otherw se up to 8 ayer transm ss on, ports 7-14 (see subc ause 7.1.5B)
10	If a CSI process of the UE s conf gured w thout PMI/RI report ng: f the number of CSI-RS ports s one, s ng e-antenna port, port7; otherw se transm t d vers ty If a CSI process of the UE s conf gured w th PMI/RI report ng: f the number of CSI-RS ports s one, s ng e-antenna port, port 7; otherw se up to 8 ayer transm ss on, ports 7-14 (see subc ause 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

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 UE shall report PMI if configured with PMI/RI reporting and the number of CSI-RS ports is larger than 1. 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, 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 4 antenna ports $\{0,1,2,3\}$ or $\{15,16,17,18\}$, 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 *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.

Table 7.2.4-0A: Codebook for 1-layer CSI reporting using antenna ports 0 to 3 or 15 to 18

i_1	i_2							
	0	1	2	3	4	5	6	7
0 – 15	$W_{i_1,0}^{(1)}$	$W_{i_1,8}^{(1)}$	$W_{i_1,16}^{(1)}$	$W_{i_1,24}^{(1)}$	$W_{i_1+8,2}^{(1)}$	$W_{i_1+8,10}^{(1)}$	$W_{i_1+8,18}^{(1)}$	$W_{i_1+8,26}^{(1)}$
i_1	i_2							
	8	9	10	11	12	13	14	15
0 - 15	$W_{i_1+16,4}^{(1)}$	$W_{i_1+16,12}^{(1)}$	$W_{i_1+16,20}^{(1)}$	$W_{i_1+16,28}^{(1)}$	$W_{i_1+24,6}^{(1)}$	$W_{i_1+24,14}^{(1)}$	$W_{i_1+24,22}^{(1)}$	$W_{i_1+24,30}^{(1)}$
where $W_{m,n}^{(1)} = \frac{1}{2}\begin{bmatrix} v'_m \\ \varphi'_n v'_m \end{bmatrix}$								

Table 7.2.4-0B: Codebook for 2-layer CSI reporting using antenna ports 0 to 3 or 15 to 18

i_1	i_2			
	0	1	2	3
0 – 15	$W_{i_1,i_1,0}^{(2)}$	$W_{i_1,i_1,1}^{(2)}$	$W_{i_1+8,i_1+8,0}^{(2)}$	$W_{i_1+8,i_1+8,1}^{(2)}$
i_1	i_2			
	4	5	6	7
0 – 15	$W_{i_1+16,i_1+16,0}^{(2)}$	$W_{i_1+16,i_1+16,1}^{(2)}$	$W_{i_1+24,i_1+24,0}^{(2)}$	$W_{i_1+24,i_1+24,1}^{(2)}$
i_1	i_2			
	8	9	10	11
0 – 15	$W_{i_1,i_1+8,0}^{(2)}$	$W_{i_1,i_1+8,1}^{(2)}$	$W_{i_1+8,i_1+16,0}^{(2)}$	$W_{i_1+8,i_1+16,1}^{(2)}$
i_1	i_2			
	12	13	14	15
0 – 15	$W_{i_1,i_1+24,0}^{(2)}$	$W_{i_1,i_1+24,1}^{(2)}$	$W_{i_1+8,i_1+24,0}^{(2)}$	$W_{i_1+8,i_1+24,1}^{(2)}$
where $W_{m,m',n}^{(2)} = \frac{1}{\sqrt{8}}\begin{bmatrix} v'_m & v'_{m'} \\ \varphi_n v'_m & -\varphi_n v'_{m'} \end{bmatrix}$				

Table 7.2.4-0C: Codebook for 3-layer CSI reporting using antenna ports 15 to 18

i_1	i_2							
	0	1	2	3	4	5	6	7
0	$W_0^{\{124\}}/\sqrt{3}$	$W_1^{\{123\}}/\sqrt{3}$	$W_2^{\{123\}}/\sqrt{3}$	$W_3^{\{123\}}/\sqrt{3}$	$W_4^{\{124\}}/\sqrt{3}$	$W_5^{\{124\}}/\sqrt{3}$	$W_6^{\{134\}}/\sqrt{3}$	$W_7^{\{134\}}/\sqrt{3}$
i_1	i_2							
	8	9	10	11	12	13	14	15
0	$W_8^{\{124\}}/\sqrt{3}$	$W_9^{\{134\}}/\sqrt{3}$	$W_{10}^{\{123\}}/\sqrt{3}$	$W_{11}^{\{134\}}/\sqrt{3}$	$W_{12}^{\{123\}}/\sqrt{3}$	$W_{13}^{\{123\}}/\sqrt{3}$	$W_{14}^{\{123\}}/\sqrt{3}$	$W_{15}^{\{123\}}/\sqrt{3}$

Table 7.2.4-0D: Codebook for 4-layer CSI reporting using antenna ports 15 to 18

i_1	i_2							
	0	1	2	3	4	5	6	7
0	$W_0^{\{1234\}}/2$	$W_1^{\{1234\}}/2$	$W_2^{\{3214\}}/2$	$W_3^{\{3214\}}/2$	$W_4^{\{1234\}}/2$	$W_5^{\{1234\}}/2$	$W_6^{\{1324\}}/2$	$W_7^{\{1324\}}/2$
i_1	i_2							
	8	9	10	11	12	13	14	15
0	$W_8^{\{1234\}}/2$	$W_9^{\{1234\}}/2$	$W_{10}^{\{1324\}}/2$	$W_{11}^{\{1324\}}/2$	$W_{12}^{\{1234\}}/2$	$W_{13}^{\{1324\}}/2$	$W_{14}^{\{3214\}}/2$	$W_{15}^{\{1234\}}/2$

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 8 antenna ports, 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

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

- 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.

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

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	$W_{i_1}^{(8)} = \frac{1}{8} \begin{bmatrix} v_{2i_1} & v_{2i_1} & v_{2i_1+8} & v_{2i_1+8} & v_{2i_1+16} & v_{2i_1+16} & v_{2i_1+24} & v_{2i_1+24} \\ v_{2i_1} & -v_{2i_1} & v_{2i_1+8} & -v_{2i_1+8} & v_{2i_1+16} & -v_{2i_1+16} & v_{2i_1+24} & -v_{2i_1+24} \end{bmatrix}$

7.2.5 Channel-State Information – Reference Signal (CSI-RS) definition

For a serving cell and UE configured in transmission mode 9, 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 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 $I_{\text{CSI-RS}}$. 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].
- 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 – 22 corresponding to the CSI-RS resource configuration are quasi co-located (as defined in [3]) with respect to Doppler shift, and Doppler spread.

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 $I_{\mathrm{CSI-RS}}$. 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 *EIMTA-MainConfigServCell-r12*, or if a UE is configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*and the UE is not configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ for any CSI process, 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 configured with the higher layer parameter *EIMTA-MainConfigServCell-r12*, and the UE is not configured with CSI subframe sets $C_{\mathrm{CSI},0}$ and $C_{\mathrm{CSI},1}$ 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 *EIMTA-MainConfigServCell-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 *EIMTA-MainConfigServCell-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).
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 $I_{\mathrm{CSI-RS}}$. *T*he 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.

7.3 UE procedure for reporting HARQ-ACK

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 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 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*.

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 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

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 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.

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 adjusted 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, 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*≥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 adjusted 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 adjusted 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 adjusted 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 3 is configured for transmission of HARQ-ACK,

- 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 adjusted 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 adjusted 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 adjusted 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 adjusted 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
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 adjusted 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 $o^{ACK}_{O^{ACK}-1}$. 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 adjusted 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 $U_{DAI} + N_{SPS} = 0$.

For TDD 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 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 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 $V_{DAI,c}^{DL} \neq (U_{DAI,c} - 1) \bmod 4 + 1$ for a serving cell c, the UE detects that at least one downlink assignment has been missed.

Table 7.3-1: Mapping between multiple HARQ-ACK responses and $b(0), b(1)$

Number of ACK among multiple ($N_{SPS} + \sum_{c=0}^{N_{cells}^{DL}-1} U_{DAI,c}$) HARQ-ACK responses	$b(0), b(1)$
0 or None (UE detect at east one DL ass gnment s m ssed)	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

- o 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.

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 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*, 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 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 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, 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 in subframe n on PUCCH or a PUSCH transmission not adjusted based on a detected DCI format 0/4 or a PUSCH transmission adjusted 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 adjusted 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 adjusted 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 $W_{DAI}^{UL} = 4$.

When PUCCH format 3 is configured for transmission of HARQ-ACK,

- 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 adjusted 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 adjusted 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 adjusted 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 adjusted 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 $k \in K$.

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.

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,

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
    - o 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
    - o 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.

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 subframe for the secondary cell
    - 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 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 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].

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 where 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, with the exception that 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}..

8 Physical uplink shared channel related procedures

For FDD and transmission mode 1, there shall be 8 uplink HARQ processes per serving cell for non-subframe bundling operation, i.e. normal HARQ operation, and 3 uplink HARQ processes for subframe bundling operation when parameter *e-HARQ-Pattern-r12* is set to *TRUE* and 4 uplink HARQ processes for subframe bundling operation otherwise. For FDD and transmission mode 2, there shall be 16 uplink HARQ processes per serving cell for non-subframe bundling operation and there are two HARQ processes associated with a given subframe as described in [8]. The subframe bundling operation is configured by the parameter *ttiBundling* provided by higher layers.

In case higher layers configure the use of subframe bundling for FDD and TDD, the subframe bundling operation is only applied to UL-SCH, such that four consecutive uplink subframes are used.

8.0 UE procedure for transmitting the physical uplink shared channel

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

For FDD and normal HARQ operation, the UE shall upon detection on a given serving cell of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For FDD-TDD and normal HARQ operation and a PUSCH for serving cell c with frame structure type 1, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0/4 and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission for serving cell c in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, the UE shall adjust the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, and using the number of transmission layers and precoding matrix according to the most recent PDCCH/EPDCCH, if the number of negatively acknowledged transport blocks is equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH.

For normal HARQ operation, if the UE detects a PHICH transmission and if the most recent PUSCH transmission for the same transport block was using spatial multiplexing according to subclause 8.0.2 and the UE does not detect a PDCCH/EPDCCH with DCI format 4 in subframe n intended for the UE, and if the number of negatively acknowledged transport blocks is not equal to the number of transport blocks indicated in the most recent PDCCH/EPDCCH associated with the corresponding PUSCH then the UE shall adjust the corresponding PUSCH retransmission in the associated subframe according to the PHICH information, using the precoding matrix with codebook index 0 and the number of transmission layers equal to number of layers corresponding to the negatively acknowledged transport block from the most recent PDCCH/EPDCCH. In this case, the UL DMRS resources are calculated according to the cyclic shift field for DMRS [3] in the most recent PDCCH/EPDCCH with DCI format 4 associated with the corresponding PUSCH transmission and number of layers corresponding to the negatively acknowledged transport block.

If a UE is configured with the carrier indicator field for a given serving cell, the UE shall use the carrier indicator field value from the detected PDCCH/EPDCCH with uplink DCI format to determine the serving cell for the corresponding PUSCH transmission.

For FDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+4$ UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For FDD-TDD and normal HARQ operation, for a serving cell with frame structure type 1, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+4$ UCI is mapped on the corresponding PUSCH transmission, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For TDD, if a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, if the UE is configured with one serving cell or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same, then for a given serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different, if the serving cell is a primary cell or if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration.

For TDD, if a UE is configured with more than one serving cell and if the UL/DL configurations of at least two serving cells are different and if the serving cell is a secondary cell and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

For FDD-TDD and primary cell frame structure type 2, if a serving cell is a primary cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD if the UE is not configured to monitor PDCCH/EPDCCH in another serving cell for scheduling a secondary serving cell with frame structure type 2, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, and for secondary serving cell *c* with frame structure type 2, if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 1 for scheduling the serving cell, the serving cell UL/DL configuration is the UL-reference UL/DL configuration for the serving cell.

For FDD-TDD, if a UE is configured with more than one serving cell with frame structure type 2, and if the serving cell is a secondary cell with frame structure type 2 and if the UE is configured to monitor PDCCH/EPDCCH in another serving cell with frame structure type 2 for scheduling the serving cell, then for the serving cell, the UL reference UL/DL configuration is given in Table 8-0A corresponding to the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration).

Table 8-0A: UL-reference UL/DL Configuration for serving cell based on the pair formed by (other serving cell UL/DL configuration, serving cell UL/DL configuration)

Set #	(other serving cell UL/DL configuration, serving cell UL/DL configuration)	UL-reference UL/DL configuration
Set 1	(1,1),(1,2),(1,4),(1,5)	1
	(2,2),(2,5)	2
	(3,3),(3,4),(3,5)	3
	(4,4),(4,5)	4
	(5,5)	5
Set 2	(1,0),(2,0),(3,0),(4,0),(5,0)	0
	(2,1),(4,1),(5,1)	1
	(5,2)	2
	(4,3),(5,3)	3
	(5,4)	4
	(1,6),(2,6),(3,6),(4,6),(5,6)	6
Set 3	(3,1)	1
	(3,2),(4,2)	2
	(1,3),(2,3)	3
	(2,4)	4
Set 4	(0,0),(6,0)	0
	(0,1),(0,2),(0,4),(0,5),(6,1),(6,2),(6,5)	1
	(0,3),(6,3)	3
	(6,4)	4
	(0,6),(6,6)	6

If a UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for a serving cell, for a radio frame of the serving cell, PUSCH transmissions can occur only in subframes that are indicated by eIMTA-UL/DL-configuration as uplink subframe(s) for the serving cell unless specified otherwise.

For TDD and normal HARQ operation, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by Table 8-2, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

For FDD-TDD normal HARQ operation, for a serving cell with frame structure type 2, if a PDCCH/EPDCCH with CSI request field set to trigger an aperiodic CSI report on the serving cell, as described in subclause 7.2.1, is detected by a UE on subframe n, then on subframe $n+k$ UCI is mapped on the corresponding PUSCH transmission where k is given by Table 8-2 and the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration for the serving cell, when simultaneous PUSCH and PUCCH transmission is not configured for the UE.

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *FALSE* or not configured, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe n-5 intended for the UE, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

When a UE is configured with higher layer parameter *ttiBundling* and configured with higher layer parameter *e-HARQ-Pattern-r12* set to *TRUE*, for FDD and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe n intended for the UE, and/or a PHICH transmission in subframe n-1 intended for the UE, adjust the corresponding first PUSCH transmission in the bundle in subframe $n+4$ according to the PDCCH/EPDCCH and PHICH information.

For both FDD and TDD serving cells, the NDI as signalled on PDCCH/EPDCCH, the RV as determined in subclause 8.6.1, and the TBS as determined in subclause 8.6.2, shall be delivered to higher layers.

For TDD and transmission mode 1, the number of HARQ processes per serving cell shall be determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in Table 8-1. For TDD and transmission mode 2, the number of HARQ processes per serving cell for non-subframe bundling operation shall be twice the number determined by the UL/DL configuration (Table 4.2-2 of [3]) as indicated in Table 8-1 and there are two HARQ processes associated with a given subframe as described in [8]. For TDD and both transmission mode 1 and transmission mode 2, the "TDD UL/DL configuration" in Table 8-1 refers to the UL-reference UL/DL configuration for the serving cell if UL-reference UL/DL configuration is defined for the serving cell and refers to the serving cell UL/DL configuration otherwise.

Table 8-1: Number of synchronous UL HARQ processes for TDD

TDD UL/DL configuration	Number of HARQ processes for normal HARQ operation	Number of HARQ processes for subframe bundling operation
0	7	3
1	4	2
2	2	N/A
3	3	N/A
4	2	N/A
5	1	N/A
6	6	3

For TDD, if the UE is not configured with *EIMTA-MainConfigServCell-r12* for any serving cell, and if a UE is configured with one serving cell, or if the UE is configured with more than one serving cell and the TDD UL/DL configuration of all the configured serving cells is the same,

- For TDD UL/DL configurations 1-6 and normal HARQ operation, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$, with k given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information.

- For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe n intended for the UE, adjust the corresponding PUSCH transmission in subframe $n+k$ if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe n=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, with *k* given in Table 8-2. If, for TDD UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n* or a PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6, the UE shall adjust the corresponding PUSCH transmission in subframe *n+7*. If, for TDD UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall adjust the corresponding PUSCH transmission in both subframes *n+ k* and *n+7*, with *k* given in Table 8-2.

For TDD, if a UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same or if the UE is configured with *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD,

- For a serving cell with an UL-reference UL/DL configurations belonging to {1,2,3,4,5,6} and normal HARQ operation, the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, adjust the corresponding PUSCH transmission in subframe *n+k* for the serving cell, with *k* given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information, where the "TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.
- For a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH/EPDCCH with uplink DCI format and/or a PHICH transmission in subframe *n* intended for the UE, adjust the corresponding PUSCH transmission in subframe *n+k* for the serving cell if the MSB of the UL index in the PDCCH/EPDCCH with uplink DCI format is set to 1 or PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 0$, as defined in subclause 9.1.2, with *k* given in Table 8-2. If, for a serving cell with UL-reference UL/DL configuration 0 and normal HARQ operation, the LSB of the UL index in the DCI format 0/4 is set to 1 in subframe *n* or a PHICH is received in subframe *n*=0 or 5 in the resource corresponding to $I_{PHICH} = 1$, as defined in subclause 9.1.2, or PHICH is received in subframe *n*=1 or 6, the UE shall adjust the corresponding PUSCH transmission in subframe *n+7* for the serving cell. If, for a serving cell with UL-reference UL/DL configuration 0, both the MSB and LSB of the UL index in the PDCCH/EPDCCH with uplink DCI format are set in subframe *n*, the UE shall adjust the corresponding PUSCH transmission in both subframes *n+ k* and *n+7* for the serving cell, with *k* given in Table 8-2, where the TDD UL/DL Configuration" given in Table 8-2 refers to the UL-reference UL/DL configuration.

For TDD UL/DL configurations 1 and 6 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n-l* with *l* given in Table 8-2a, adjust the corresponding first PUSCH transmission in the bundle in subframe *n+k*, with *k* given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information.

For TDD UL/DL configuration 0 and subframe bundling operation, the UE shall upon detection of a PDCCH/EPDCCH with DCI format 0 in subframe *n* intended for the UE, and/or a PHICH transmission intended for the UE in subframe *n-l* with *l* given in Table 8-2a, adjust the corresponding first PUSCH transmission in the bundle in subframe *n+k*, if the MSB of the UL index in the DCI format 0 is set to 1 or if $I_{PHICH} = 0$, as defined in subclause 9.1.2, with *k* given in Table 8-2, according to the PDCCH/EPDCCH and PHICH information. If, for TDD UL/DL configuration 0 and subframe bundling operation, the LSB of the UL index in the PDCCH/EPDCCH with DCI format 0 is set to 1 in subframe *n* or if $I_{PHICH} = 1$, as defined in subclause 9.1.2, the UE shall adjust the corresponding first PUSCH transmission in the bundle in subframe *n+7*, according to the PDCCH/EPDCCH and PHICH information.

Table 8-2 *k* for TDD configurations 0-6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	4	6				4	6			
1		6			4		6			4
2				4					4	
3	4								4	4
4									4	4
5									4	
6	7	7				7	7			5

Table 8-2a *l* for TDD configurations 0, 1 and 6

TDD UL/DL Configuration	subframe number *n*									
	0	1	2	3	4	5	6	7	8	9
0	9	6				9	6			
1		2			3		2			3
6	5	5				6	6			8

A UE is semi-statically configured via higher layer signalling to transmit PUSCH transmissions signalled via PDCCH/EPDCCH according to one of two uplink transmission modes, denoted mode 1 - 2.

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-3 and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these PDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-3A and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and the PUSCH retransmission for the same transport block is by C-RNTI.

Transmission mode 1 is the default uplink transmission mode for a UE until the UE is assigned an uplink transmission mode by higher layer signalling.

When a UE configured in transmission mode 2 receives a DCI Format 0 uplink scheduling grant, it shall assume that the PUSCH transmission is associated with transport block 1 and that transport block 2 is disabled.

Table 8-3: PDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE spec f c by C-RNTI	S ng e-antenna port, port 10 (see subc ause 8.0.1)
Mode 2	DCI format 0	Common and UE spec f c by C-RNTI	S ng e-antenna port, port 10 (see subc ause 8.0.1)
	DCI format 4	UE spec f c by C-RNTI	C osed- oop spat a mu t p ex ng (see subc ause 8.0.2)

Table 8-3A: EPDCCH and PUSCH configured by C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to EPDCCH
Mode 1	DCI format 0	UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)
Mode 2	DCI format 0	UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)
	DCI format 4	UE spec f c by C RNTI	C osed oop spat a mu t p ex ng (see subc ause 8.0.2)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the PDCCH according to the combination defined in Table 8-4.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the C-RNTI and is also configured to receive random access procedures initiated by "PDCCH orders", the UE shall decode the EPDCCH according to the combination defined in Table 8-4A.

Table 8-4: PDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	Common and UE spec f c by C RNTI

Table 8-4A: EPDCCH configured as "PDCCH order" to initiate random access procedure

DCI format	Search Space
DCI format 1A	UE spec f c by C RNTI

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-5 and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these PDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding PDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

If a UE is configured by higher layers to decode EPDCCHs with the CRC scrambled by the SPS C-RNTI, the UE shall decode the EPDCCH according to the combination defined in Table 8-5A and transmit the corresponding PUSCH. The scrambling initialization of this PUSCH corresponding to these EPDCCHs and PUSCH retransmission for the same transport block is by SPS C-RNTI. The scrambling initialization of initial transmission of this PUSCH without a corresponding EPDCCH and the PUSCH retransmission for the same transport block is by SPS C-RNTI.

Table 8-5: PDCCH and PUSCH configured by SPS C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	Common and UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)
Mode 2	DCI format 0	Common and UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)

Table 8-5A: EPDCCH and PUSCH configured by SPS C-RNTI

Transmission mode	DCI format	Search Space	Transmission scheme of PUSCH corresponding to PDCCH
Mode 1	DCI format 0	UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)
Mode 2	DCI format 0	UE spec f c by C RNTI	S ng e antenna port, port 10 (see subc ause 8.0.1)

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the Temporary C-RNTI regardless of whether UE is configured or not configured to decode PDCCHs with the CRC scrambled by the C-RNTI, the UE shall decode the PDCCH according to the combination defined in Table 8-6 and transmit the corresponding PUSCH. The scrambling initialization of PUSCH corresponding to these PDCCH is by Temporary C-RNTI.

If a Temporary C-RNTI is set by higher layers, the scrambling of PUSCH corresponding to the Random Access Response Grant in subclause 6.2 and the PUSCH retransmission for the same transport block is by Temporary C-RNTI. Else, the scrambling of PUSCH corresponding to the Random Access Response Grant in subclause 6.2 and the PUSCH retransmission for the same transport block is by C-RNTI.

Table 8-6: PDCCH configured by Temporary C-RNTI

DCI format	Search Space
DCI format 0	Common

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUCCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8-7. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-7: PDCCH configured by TPC-PUCCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the TPC-PUSCH-RNTI, the UE shall decode the PDCCH according to the combination defined in table 8.8. The notation 3/3A implies that the UE shall receive either DCI format 3 or DCI format 3A depending on the configuration.

Table 8-8: PDCCH configured by TPC-PUSCH-RNTI

DCI format	Search Space
DCI format 3/3A	Common

8.0.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 10) of the PUSCH, the UE transmission on the PUSCH is performed according to subclause 5.3.2A.1 of [3].

8.0.2 Closed-loop spatial multiplexing scheme

For the closed-loop spatial multiplexing transmission scheme of the PUSCH, the UE transmission on the PUSCH is performed according to the applicable number of transmission layers as defined in subclause 5.3.2A.2 of [3].

8.1 Resource allocation for PDCCH/EPDCCH with uplink DCI format

Two resource allocation schemes Type 0 and Type 1 are supported for PDCCH/EPDCCH with uplink DCI format.

If the resource allocation type bit is not present in the uplink DCI format, only resource allocation type 0 is supported.

If the resource allocation type bit is present in the uplink DCI format, the selected resource allocation type for a decoded PDCCH/EPDCCH is indicated by a resource allocation type bit where type 0 is indicated by 0 value and type 1 is indicated otherwise. The UE shall interpret the resource allocation field depending on the resource allocation type bit in the PDCCH/EPDCCH with uplink DCI format detected.

8.1.1 Uplink resource allocation type 0

The resource allocation information for uplink resource allocation type 0 indicates to a scheduled UE a set of contiguously allocated virtual resource block indices denoted by n_{VRB}. A resource allocation field in the scheduling grant consists of a resource indication value (*RIV*) corresponding to a starting resource block (RB_{START}) and a length in terms of contiguously allocated resource blocks ($L_{\mathrm{CRBs}} \geq 1$). The resource indication value is defined by

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

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (L_{\mathrm{CRBs}} - 1) + RB_{\mathrm{START}}$$

else

$$RIV = N_{\mathrm{RB}}^{\mathrm{UL}} (N_{\mathrm{RB}}^{\mathrm{UL}} - L_{\mathrm{CRBs}} + 1) + (N_{\mathrm{RB}}^{\mathrm{UL}} - 1 - RB_{\mathrm{START}})$$

8.1.2 Uplink resource allocation type 1

The resource allocation information for uplink resource allocation type 1 indicates to a scheduled UE two sets of resource blocks with each set including one or more consecutive resource block groups of size *P* as given in table 7.1.6.1-1 assuming $N_{\mathrm{RB}}^{\mathrm{UL}}$ as the system bandwidth. A combinatorial index *r* consists of $\left\lceil \log_2 \left(\binom{\lceil N_{RB}^{UL} / P + 1 \rceil}{4} \right) \right\rceil$ bits.

The bits from the resource allocation field in the scheduling grant represent *r* unless the number of bits in the resource allocation field in the scheduling grant is

- smaller than required to fully represent *r*, in which case the bits in the resource allocation field in the scheduling grant occupy the LSBs of *r* and the value of the remaining bits of *r* shall be assumed to be 0; or

- larger than required to fully represent *r*, in which case *r* occupies the LSBs of the resource allocation field in the scheduling grant.

The combinatorial index *r* corresponds to a starting and ending RBG index of resource block set 1, s_0 and $s_1 - 1$, and resource block set 2, s_2 and $s_3 - 1$ respectively, where *r* is given by equation $r = \sum_{i=0}^{M-1} \left\langle \begin{matrix} N - s_i \\ M - i \end{matrix} \right\rangle$ defined in subclause 7.2.1 with *M*=4 and $N = \lceil N_{\mathrm{RB}}^{\mathrm{UL}} / P \rceil + 1$. subclause 7.2.1 also defines ordering properties and range of values that s_i (RBG indices) map to. Only a single RBG is allocated for a set at the starting RBG index if the corresponding ending RBG index equals the starting RBG index.

8.2 UE sounding procedure

A UE shall transmit Sounding Reference Symbol (SRS) on per serving cell SRS resources based on two trigger types:

- trigger type 0: higher layer signalling

- trigger type 1: DCI formats 0/4/1A for FDD and TDD and DCI formats 2B/2C/2D for TDD.

In case both trigger type 0 and trigger type 1 SRS transmissions would occur in the same subframe in the same serving cell, the UE shall only transmit the trigger type 1 SRS transmission.

A UE may be configured with SRS parameters for trigger type 0 and trigger type 1 on each serving cell. The following SRS parameters are serving cell specific and semi-statically configurable by higher layers for trigger type 0 and for trigger type 1.

- Transmission comb $\bar{k}_{TC}$, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Starting physical resource block assignment n_{RRC}, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- *duration*: single or indefinite (until disabled), as defined in [11] for trigger type 0
- *srs-ConfigIndex* I_{SRS} for SRS periodicity T_{SRS} and SRS subframe offset T_{offset}, as defined in Table 8.2-1 and Table 8.2-2 for trigger type 0 and SRS periodicity $T_{SRS,1}$ and SRS subframe offset $T_{offset,1}$, as defined in Table 8.2-4 and Table 8.2-5 trigger type 1
- SRS bandwidth B_{SRS}, as defined in subclause 5.5.3.2 of [3] for trigger type 0 and each configuration of trigger type 1
- Frequency hopping bandwidth, b_{hop}, as defined in subclause 5.5.3.2 of [3] for trigger type 0
- Cyclic shift n_{SRS}^{cs}, as defined in subclause 5.5.3.1 of [3] for trigger type 0 and each configuration of trigger type 1
- Number of antenna ports N_p for trigger type 0 and each configuration of trigger type 1

For trigger type 1 and DCI format 4 three sets of SRS parameters, *srs-ConfigApDCI-Format4*, are configured by higher layer signalling. The 2-bit SRS request field [4] in DCI format 4 indicates the SRS parameter set given in Table 8.1-1. For trigger type 1 and DCI format 0, a single set of SRS parameters, *srs-ConfigApDCI-Format0*, is configured by higher layer signalling. For trigger type 1 and DCI formats 1A/2B/2C/2D, a single common set of SRS parameters, *srs-ConfigApDCI-Format1a2b2c*, is configured by higher layer signalling. The SRS request field is 1 bit [4] for DCI formats 0/1A/2B/2C/2D, with a type 1 SRS triggered if the value of the SRS request field is set to '1'.
A 1-bit SRS request field shall be included in DCI formats 0/1A for frame structure type 1 and 0/1A/2B/2C/2D for frame structure type 2 if the UE is configured with SRS parameters for DCI formats 0/1A/2B/2C/2D by higher-layer signalling.

Table 8.1-1: SRS request value for trigger type 1 in DCI format 4

Value of SRS request field	Description
'00'	No type 1 SRS tr gger
'01'	The 1st SRS parameter set conf gured by h gher ayers
'10'	The 2nd SRS parameter set conf gured by h gher ayers
'11'	The 3rd SRS parameter set conf gured by h gher ayers

The serving cell specific SRS transmission bandwidths C_{SRS} are configured by higher layers. The allowable values are given in subclause 5.5.3.2 of [3].

The serving cell specific SRS transmission sub-frames are configured by higher layers. The allowable values are given in subclause 5.5.3.3 of [3].

For a TDD serving cell, SRS transmissions can occur in UpPTS and uplink subframes of the UL/DL configuration indicated by the higher layer parameter *subframeAssignment* for the serving cell.

When closed-loop UE transmit antenna selection is enabled for a given serving cell for a UE that supports transmit antenna selection, the index $a(n_{SRS})$, of the UE antenna that transmits the SRS at time n_{SRS} is given by

$a(n_{SRS}) = n_{SRS} \bmod 2$, for both partial and full sounding bandwidth, and when frequency hopping is disabled (i.e., $b_{hop} \geq B_{SRS}$),

$$a(n_{SRS}) = \begin{cases} \left(n_{SRS} + \lfloor n_{SRS}/2 \rfloor + \beta \cdot \lfloor n_{SRS}/K \rfloor\right) \bmod 2 & \text{when } K \text{ is even} \\ n_{SRS} \bmod 2 & \text{when } K \text{ is odd} \end{cases}, \quad \beta = \begin{cases} 1 & \text{where } K \bmod 4 = 0 \\ 0 & \text{otherwise} \end{cases}$$

when frequency hopping is enabled (i.e., $b_{hop} < B_{SRS}$),

where values B_{SRS}, b_{hop}, N_b, and n_{SRS} are given in subclause 5.5.3.2 of [3], and $K = \prod_{b'=b_{hop}}^{B_{SRS}} N_{b'}$ (where $N_{b_{hop}} = 1$ regardless of the N_b value), except when a single SRS transmission is configured for the UE. If a UE is configured with more than one serving cell, the UE is not expected to transmit SRS on different antenna ports simultaneously.

A UE may be configured to transmit SRS on N_p antenna ports of a serving cell where N_p may be configured by higher layer signalling. For PUSCH transmission mode 1 $N_p \in \{0,1,2,4\}$ and for PUSCH transmission mode 2 $N_p \in \{0,1,2\}$ with two antenna ports configured for PUSCH and $N_p \in \{0,1,4\}$ with 4 antenna ports configured for PUSCH. A UE configured for SRS transmission on multiple antenna ports of a serving cell shall transmit SRS for all the configured transmit antenna ports within one SC-FDMA symbol of the same subframe of the serving cell.
The SRS transmission bandwidth and starting physical resource block assignment are the same for all the configured antenna ports of a given serving cell.

A UE not configured with multiple TAGs shall not transmit SRS in a symbol whenever SRS and PUSCH transmissions happen to overlap in the same symbol.

For TDD serving cell, when one SC-FDMA symbol exists in UpPTS of the given serving cell, it can be used for SRS transmission. When two SC-FDMA symbols exist in UpPTS of the given serving cell, both can be used for SRS transmission and for trigger type 0 SRS both can be assigned to the same UE.

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and SRS and PUCCH format 2/2a/2b happen to coincide in the same subframe in the same serving cell,

- The UE shall not transmit type 0 triggered SRS whenever type 0 triggered SRS and PUCCH format 2/2a/2b transmissions happen to coincide in the same subframe;

- The UE shall not transmit type 1 triggered SRS whenever type 1 triggered SRS and PUCCH format 2a/2b or format 2 with HARQ-ACK transmissions happen to coincide in the same subframe;

- The UE shall not transmit PUCCH format 2 without HARQ-ACK whenever type 1 triggered SRS and PUCCH format 2 without HARQ-ACK transmissions happen to coincide in the same subframe.

If a UE is not configured with multiple TAGs, or if a UE is configured with multiple TAGs and SRS and PUCCH happen to coincide in the same subframe in the same serving cell,

- The UE shall not transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *FALSE*;

- For FDD-TDD and primary cell frame structure 1, the UE shall not transmit SRS in a symbol whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in subclauses 5.4.1 and 5.4.2A of [3] happen to overlap in the same symbol if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE.*
- Unless otherwise prohibited, the UE shall transmit SRS whenever SRS transmission and PUCCH transmission carrying HARQ-ACK and/or positive SR using shortened format as defined in subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe if the parameter *ackNackSRS-SimultaneousTransmission* is *TRUE*.

A UE not configured with multiple TAGs shall not transmit SRS whenever SRS transmission on any serving cells and PUCCH transmission carrying HARQ-ACK and/or positive SR using normal PUCCH format as defined in subclauses 5.4.1 and 5.4.2A of [3] happen to coincide in the same subframe.

In UpPTS, whenever SRS transmission instance overlaps with the PRACH region for preamble format 4 or exceeds the range of uplink system bandwidth configured in the serving cell, the UE shall not transmit SRS.

The parameter *ackNackSRS-SimultaneousTransmission* provided by higher layers determines if a UE is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe. If it is configured to support the transmission of HARQ-ACK on PUCCH and SRS in one subframe, then in the cell specific SRS subframes of the primary cell UE shall transmit HARQ-ACK and SR using the shortened PUCCH format as defined in subclauses 5.4.1 and 5.4.2A of [3], where the HARQ-ACK or the SR symbol corresponding to the SRS location is punctured.
This shortened PUCCH format shall be used in a cell specific SRS subframe of the primary cell even if the UE does not transmit SRS in that subframe. The cell specific SRS subframes are defined in subclause 5.5.3.3 of [3]. Otherwise, the UE shall use the normal PUCCH format 1/1a/1b as defined in subclause 5.4.1 of [3] or normal PUCCH format 3 as defined in subclause 5.4.2A of [3] for the transmission of HARQ-ACK and SR.

Trigger type 0 SRS configuration of a UE in a serving cell for SRS periodicity, T_{SRS}, and SRS subframe offset, T_{offset} , is defined in Table 8.2-1 and Table 8.2-2, for FDD and TDD serving cell, respectively. The periodicity T_{SRS} of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10, 20, 40, 80, 160, 320} ms or subframes.
For the SRS periodicity T_{SRS} of 2 ms in TDD serving cell, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

Type 0 triggered SRS transmission instances in a given serving cell for TDD serving cell with $T_{\mathrm{SRS}} > 2$ and for FDD serving cell are the subframes satisfying $(10 \cdot n_f + k_{\mathrm{SRS}} - T_{offset}) \bmod T_{\mathrm{SRS}} = 0$, where for FDD $k_{\mathrm{SRS}} = \{0,1,...,9\}$ is the subframe index within the frame, for TDD serving cell k_{SRS} is defined in Table 8.2-3. The SRS transmission instances for TDD serving cell with $T_{\mathrm{SRS}} = 2$ are the subframes satisfying $(k_{\mathrm{SRS}} - T_{offset}) \bmod 5 = 0$.

For TDD serving cell, and a UE configured for type 0 triggered SRS transmission in serving cell *c*, and the UE configured with the parameter *EIMTA-MainConfigServCell-r12* for serving cell *c*, if the UE does not detect an UL/DL configuration indication for radio frame *m* (as described in section 13.1), the UE shall not transmit trigger type 0 SRS in a subframe of radio frame *m* that is indicated by the parameter *eimta-HarqReferenceConfig-r12* as a downlink subframe unless the UE transmits PUSCH in the same subframe.

Trigger type 1 SRS configuration of a UE in a serving cell for SRS periodicity, $T_{\mathrm{SRS},1}$, and SRS subframe offset, $T_{offset,1}$, is defined in Table 8.2-4 and Table 8.2-5, for FDD and TDD serving cell, respectively. The periodicity $T_{\mathrm{SRS},1}$ of the SRS transmission is serving cell specific and is selected from the set {2, 5, 10} ms or subframes.
For the SRS periodicity $T_{\mathrm{SRS},1}$ of 2 ms in TDD serving cell, two SRS resources are configured in a half frame containing UL subframe(s) of the given serving cell.

A UE configured for type 1 triggered SRS transmission in serving cell *c* and not configured with a carrier indicator field shall transmit SRS on serving cell *c* upon detection of a positive SRS request in PDCCH/EPDCCH scheduling PUSCH/PDSCH on serving cell *c*.

A UE configured for type 1 triggered SRS transmission in serving cell *c* and configured with a carrier indicator field shall transmit SRS on serving cell *c* upon detection of a positive SRS request in PDCCH/EPDCCH scheduling PUSCH/PDSCH with the value of carrier indicator field corresponding to serving cell *c*.

A UE configured for type 1 triggered SRS transmission on serving cell *c* upon detection of a positive SRS request in subframe *n* of serving cell *c* shall commence SRS transmission in the first subframe satisfying $n+k, k \geq 4$ and

$(10 \cdot n_f + k_{\mathrm{SRS}} - T_{offset,1}) \bmod T_{\mathrm{SRS},1} = 0$ for TDD serving cell *c* with $T_{\mathrm{SRS},1} > 2$ and for FDD serving cell *c*,

$(k_{\mathrm{SRS}} - T_{offset,1}) \bmod 5 = 0$ for TDD serving cell *c* with $T_{\mathrm{SRS},1} = 2$

where for FDD serving cell *c* $k_{\mathrm{SRS}} = \{0,1,...,9\}$ is the subframe index within the frame n_f, for TDD serving cell *c* k_{SRS} is defined in Table 8.2-3.

A UE configured for type 1 triggered SRS transmission is not expected to receive type 1 SRS triggering events associated with different values of trigger type 1 SRS transmission parameters, as configured by higher layer signalling, for the same subframe and the same serving cell.

For TDD serving cell *c*, and a UE configured with *EIMTA-MainConfigServCell-r12* for a serving cell *c*, the UE shall not transmit SRS in a subframe of a radio frame that is indicated by the corresponding eIMTA-UL/DL-configuration as a downlink subframe.

A UE shall not transmit SRS whenever SRS and a PUSCH transmission corresponding to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure coincide in the same subframe.

Table 8.2-1: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} for trigger type 0, FDD

SRS Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0 – 1	2	I_{SRS}
2 – 6	5	I_{SRS} – 2
7 – 16	10	I_{SRS} – 7
17 – 36	20	I_{SRS} – 17
37 – 76	40	I_{SRS} – 37
77 – 156	80	I_{SRS} – 77
157 – 316	160	I_{SRS} – 157
317 – 636	320	I_{SRS} – 317
637 – 1023	reserved	reserved