ETSI TS 136 213 V8.6.0 (2009-04)

Technical Specification

LTE;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Physical layer procedures
(3GPP TS 36.213 version 8.6.0 Release 8)

Reference
RTS/TSGR-0136213v860

Keywords
LTE

ETSI

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Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Contents

Foreword

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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 TS36.321, "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification"

[9] 3GPP TS36.423, "Evolved Universal Terrestrial Radio Access (E-UTRA); X2 Application Protocol (X2AP)"

[10] 3GPP TS36.133, "Evolved Universal Terrestrial Radio Access (E-UTRA); Requirements for support of radio resource management"

[11] 3GPP TS36.331, "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification"

3 Definitions, symbols, and abbreviations

3.1 Symbols

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

$N_{\mathrm{RB}}^{\mathrm{DL}}$	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 following abbreviations apply.

ACK	Acknowledgement
BCH	Broadcast Channel
CCE	Control Channel Element
CQI	Channel Quality Indicator
CRC	Cyclic Redundancy Check
DAI	Downlink Assignment Index
DL	Downlink
DTX	Discontinuous Transmission
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
PRACH	Physical Random Access Channel
PRB	Physical Resource Block
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
QoS	Quality of Service
RBG	Resource Block Group
RE	Resource Element
RPF	Repetition Factor
RS	Reference Signal
SIR	Signal-to-Interference Ratio
SINR	Signal to Interference plus Noise Ratio
SPS C-RNTI	Semi-Persistent Scheduling C-RNTI
SRS	Sounding Reference Symbol
TA	Time alignment
TTI	Transmission Time Interval
UE	User Equipment
UL	Uplink
UL-SCH	Uplink Shared Channel
VRB	Virtual Resource Block

4 Synchronisation 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.

4.2 Timing synchronisation

4.2.1 Radio link monitoring

The downlink radio link quality of the serving 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].

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 synchronisation

[For example, for cell sites with a multicast physical channel]

4.2.3 Transmission timing adjustments

Upon reception of a timing advance command, the UE shall adjust its uplink transmission timing for PUCCH/PUSCH/SRS. The timing advance command indicates the change of the uplink timing relative to the current uplink timing as multiples of $16\,T_s$. The start timing of the random access preamble is specified in [3].

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

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

For a timing advance command received on subframe *n*, the corresponding adjustment of the timing shall apply from the beginning of subframe *n+6*. 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 transmit complete 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.

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 DFT-SOFDM 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.

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 P_{PUSCH} for the physical uplink shared channel (PUSCH) transmission in subframe *i* is defined by

$$P_{\mathrm{PUSCH}}(i) = \min\{P_{\mathrm{CMAX}}, 10\log_{10}(M_{\mathrm{PUSCH}}(i)) + P_{\mathrm{O\_PUSCH}}(j) + \alpha(j)\cdot PL + \Delta_{\mathrm{TF}}(i) + f(i)\} \text{ [dBm]}$$

where,

- P_{CMAX} is the configured UE transmitted power defined in [6]
- $M_{\mathrm{PUSCH}}(i)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe *i*.
- $P_{\mathrm{O\_PUSCH}}(j)$ is a parameter composed of the sum of a cell specific nominal component $P_{\mathrm{O\_NOMINAL\_PUSCH}}(j)$ provided from higher layers for *j=0* and *1* and a UE specific component $P_{\mathrm{O\_UE\_PUSCH}}(j)$ provided by higher layers for *j=0* and *1*. 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*. $P_{\mathrm{O\_UE\_PUSCH}}(2) = 0$ and $P_{\mathrm{O\_NOMINAL\_PUSCH}}(2) = P_{\mathrm{O\_PRE}} + \Delta_{PREAMBLE\_Msg3}$, where the parameter PREAMBLE_INITIAL_RECEIVED_TARGET_POWER [8], $P_{\mathrm{O\_PRE}}$ and $\Delta_{PREAMBLE\_Msg3}$ are signalled from higher layers.
- For *j* =0 or *1*, $\alpha \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$ is a 3-bit cell specific parameter provided by higher layers. For j=2, $\alpha(j) = 1.$
- *PL* is the downlink pathloss estimate calculated in the UE in dB and PL = referenceSignalPower – higher layer filtered RSRP, where referenceSignalPower is provided by higher layers and RSRP is defined in [5] and the higher layer filter configuration is defined in [11]
- $\Delta_{\mathrm{TF}}(i) = 10\log_{10}((2^{MPR\cdot K_S} - 1)\beta_{offset}^{PUSCH})$ for $K_S = 1.25$ and 0 for $K_S = 0$ where K_S is given by the UE specific parameter *deltaMCS-Enabled* provided by higher layers
  - $MPR = O_{CQI} / N_{RE}$ for control data sent via PUSCH without UL-SCH data and $\sum_{r=0}^{C-1} K_r / N_{RE}$ 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 bits including CRC bits and N_{RE} is the number of resource elements determined as

$N_{RE} = M_{\text{PUSCH}} \cdot N_{\text{sc}}^{\text{RB}} \cdot N_{\text{symb}}^{\text{PUSCH-initial}}$, where C, K_r and $N_{\text{symb}}^{\text{PUSCH-initial}}$ is defined in [4] and C, K_r and M_{PUSCH} are obtained from the initial PDCCH for the same transport block.

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

- δ_{PUSCH} is a UE specific correction value, also referred to as a TPC command and is included in PDCCH with DCI format 0 or jointly coded with other TPC commands in PDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUSCH-RNTI. The current PUSCH power control adjustment state is given by $f(i)$ which is defined by:
  - $f(i) = f(i-1) + \delta_{PUSCH}(i - K_{PUSCH})$ if accumulation is enabled based on the UE-specific parameter *Accumulation-enabled* provided by higher layers or if the TPC command δ_{PUSCH} is included in a PDCCH with DCI format 0 where the CRC is scrambled by the Temporary C-RNTI
    - where $\delta_{\text{PUSCH}}(i - K_{PUSCH})$ was signalled on PDCCH with DCI format 0 or 3/3A on subframe $i - K_{PUSCH}$, and where $f(0)$ is the first value after reset of accumulation.
    - The value of K_{PUSCH} is
      - For FDD, K_{PUSCH} = 4
      - 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 of DCI format 0 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 UE attempts to decode a PDCCH of DCI format 0 with the UE's C-RNTI and a PDCCH of DCI format 3/3A with this UE's TPC-PUSCH-RNTI in every subframe except when in DRX
    - If DCI format 0 and DCI format 3/3A are both detected in the same subframe, then the UE shall use the δ_{PUSCH} provided in DCI format 0.
    - $\delta_{\text{PUSCH}} = 0$ dB for a subframe where no TPC command is decoded or where DRX occurs or *i* is not an uplink subframe in TDD.
    - The δ_{PUSCH} dB accumulated values signalled on PDCCH with DCI format 0 are given in Table 5.1.1.1-2.
    - 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 maximum power, positive TPC commands shall not be accumulated
    - If UE has reached minimum power, negative TPC commands shall not be accumulated
    - UE shall reset accumulation
      - when an absolute TPC command is received
      - when $P_{\text{O\_UE\_PUSCH}}$ is received
      - when the UE receives random access response message
  - $f(i) = \delta_{\text{PUSCH}}(i - K_{\text{PUSCH}})$ if accumulation is not enabled based on the UE-specific parameter *Accumulation-enabled* provided by higher layers

- where $\delta_{\text{PUSCH}}(i - K_{PUSCH})$ was signalled on PDCCH with DCI format 0 on subframe $i - K_{PUSCH}$
- The value of K_{PUSCH} is
  - For FDD, K_{PUSCH} = 4
  - 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 PDCCHof DCI format 0 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 δ_{PUSCH} dB absolute values signalled on PDCCH with DCI format 0 are given in Table 5.1.1.1-2.
- $f(i) = f(i-1)$ for a subframe where no PDCCH with DCI format 0 is decoded or where DRX occurs or *i* is not an uplink subframe in TDD.

- For both types of $f(*)$ (accumulation or current absolute) the first value is set as follows:
  - If $P_{\text{O\_UE\_PUSCH}}$ is received from higher layers,
    - $f(i) = 0$
  - Else
    - $f(0) = \Delta P_{rampup} + \delta_{msg2}$
      - where δ_{msg2} is the TPC command indicated in the random access response, see Section 6.2, and
      - ΔP_{rampup} is provided by higher layers and corresponds to the total power ramp-up from the first to the last preamble

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 to absolute and accumulated δ_{PUSCH} values.

TPC Command Field in DCI format 0/3	Accumulated δ_{PUSCH} [dB]	Absolute δ_{PUSCH} [dB] only DCI format 0
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 δ_{PUSCH} values.

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

5.1.1.2 Power headroom

The UE power headroom PH valid for subframe *i* is defined by

$$PH\ (i) = P_{\text{CMAX}} - \{10\log_{10}(M_{\text{PUSCH}}(i)) + P_{\text{O\_PUSCH}}(j) + \alpha(j)\cdot PL + \Delta_{\text{TF}}(i) + f(i)\}\ \text{[dB]}$$

where, P_{CMAX}, $M_{\text{PUSCH}}(i)$, $P_{\text{O\_PUSCH}}(j)$, $\alpha(j)$, PL, $\Delta_{\text{TF}}(i)$ and $f(i)$ are defined in section 5.1.1.1.

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.

5.1.2 Physical uplink control channel

5.1.2.1 UE behaviour

The setting of the UE Transmit power P_{PUCCH} for the physical uplink control channel (PUCCH) transmission in subframe *i* is defined by

$$P_{\text{PUCCH}}(i) = \min\{P_{\text{CMAX}}, P_{\text{0\_PUCCH}} + PL + h(n_{CQI}, n_{HARQ}) + \Delta_{\text{F\_PUCCH}}(F) + g(i)\}\ \text{[dBm]}$$

where

- P_{CMAX} is the configured UE transmitted power defined in [6]
- The parameter $\Delta_{\text{F\_PUCCH}}(F)$ is provided by higher layers. Each $\Delta_{\text{F\_PUCCH}}(F)$ value corresponds to a PUCCH format (*F*) relative to PUCCH format 1a, where each PUCCH format (*F*) is defined in Table 5.4-1 [3].
- $h(n)$ is a PUCCH format dependent value, where n_{CQI} corresponds to the number information bits for the channel quality information defined in section 5.2.3.3 in [4] and n_{HARQ} is the number of HARQ bits.
    - For PUCCH format 1,1a and 1b $h(n_{CQI}, n_{HARQ}) = 0$

- For PUCCH format 2, 2a, 2b and normal cyclic prefix

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

- For PUCCH format 2 and extended cyclic prefix

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

- $P_{\text{O\_PUCCH}}$ is a parameter composed of the sum of a cell specific parameter $P_{\text{O\_NOMINAL\_PUCCH}}$ provided by higher layers and a UE specific component $P_{\text{O\_UE\_PUCCH}}$ 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 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.
  - 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 with the UE's C-RNTI on every subframe except when in DRX.
  - If the UE decodes a PDCCH with DCI format 1A/1B/1D/1/2A/2 and the corresponding detected RNTI equals the C-RNTI of the UE, the UE shall use the δ_{PUCCH} provided in that PDCCH.

    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 δ_{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.
    - For FDD, $M = 1$ and $k_0 = 4$.
    - For TDD, values of M and k_m are given in Table 10.1-1.
    - The δ_{PUCCH} dB values signalled on PDCCH with DCI format 1A/1B/1D/1/2A/2 are given in Table 5.1.2.1-1.
    - 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.
    - The initial value of $g(i)$ is defined as
      - If $P_{\text{O\_UE\_PUCCH}}$ is received from higher layers,
        - $g(i) = 0$
      - Else
        - $g(0) = \Delta P_{rampup} + \delta_{Msg2}$
          - where δ_{msg2} is the TPC command indicated in the random access response, see Section 6.2 and
          - ΔP_{rampup} is the total power ramp-up from the first to the last preamble provided by higher layers

- If UE has reached maximum power, positive TPC commands shall not be accumulated
- If UE has reached minimum power, negative TPC commands shall not be accumulated
- UE shall reset accumulation
  - at cell-change
  - when entering/leaving RRC active state
  - when $P_{\mathrm{O\_UE\_PUCCH}}$ is received
  - when the UE receives a random access response message
- $g(i) = g(i-1)$ if i is not an uplink subframe in TDD.

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

TPC Command Field in DCI format 1A/1B/1D/1/2A/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

5.1.3.1 UE behaviour

The setting of the UE Transmit power P_{SRS} for the Sounding Reference Symbol transmitted on subframe *i* is defined by

$$P_{\mathrm{SRS}}(i) = \min\{P_{\mathrm{CMAX}},\ P_{\mathrm{SRS\_OFFSET}} + 10\log_{10}(M_{\mathrm{SRS}}) + P_{\mathrm{O\_PUSCH}}(j) + \alpha(j)\cdot PL + f(i)\}\ \text{[dBm]}$$

where

- P_{CMAX} is the configured UE transmitted power defined in [6]
- For $K_S = 1.25$, $P_{\mathrm{SRS\_OFFSET}}$ is a 4-bit UE specific parameter semi-statically configured by higher layers with 1dB step size in the range [-3, 12] dB.
- For $K_S = 0$, $P_{\mathrm{SRS\_OFFSET}}$ is a 4-bit UE specific parameter semi-statically configured by higher layers with 1.5 dB step size in the range [-10.5,12] dB
- M_{SRS} is the bandwidth of the SRS transmission in subframe *i* expressed in number of resource blocks.
- $f(i)$ is the current power control adjustment state for the PUSCH, see Section 5.1.1.1.
- $P_{\mathrm{O\_PUSCH}}(j)$ and $\alpha(j)$ are parameters as defined in Section 5.1.1.1, where $j = 1$.

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 reference-signal EPRE can be derived from the downlink reference-signal transmit power given by the parameter *Reference-signal-power* 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. In addition, ρ_A and ρ_B are UE-specific.

The UE may assume that for 16 QAM, 64 QAM, 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 Section 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.

If UE-specific RSs are present in a PRB, the ratio of PDSCH EPRE to UE-specific RS EPRE for each OFDM symbol is equal. In addition, the UE may assume that for 16QAM or 64QAM, this ratio is 0 dB.

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 or 64QAM, 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 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

5.2.1 eNodeB Relative Narrowband TX Power restrictions

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

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

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, frequency position and preamble format)
2. Parameters for determining the root sequences and their cyclic shifts in the preamble sequence set for the cell (index to 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_{PRACH} = min{ P_{CMAX} , PREAMBLE_RECEIVED_TARGET_POWER + PL}_[dBm], where P_{CMAX} is the configured UE transmitted power defined in [6] and PL is the downlink pathloss estimate calculated in the UE.

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], clause 5.1.4). If detected, the corresponding PDSCH transport block is passed to higher layers. The higher layers parse the transport block and indicate the 20-bit UL-SCH grant to the physical layer, which is processed according to section 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 section 6.2 is set to zero. The UE shall postpone the PUSCH transmission to the next available UL subframe 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 random access procedure is triggered by the PDCCH indicating downlink data arrival in subframe *n*, 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.

6.2 Random Access Response Grant

The higher layers indicate the 20-bit UL Grant to the physical layer, as defined in [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

- CQI request – 1 bit

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, 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 $N_{RB}^{UL} \leq 44$

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

The UL delay applies for both TDD and FDD and this field can be set to 0 or 1 to indicate whether the delay of PUSCH is introduced as shown in section 6.1.1.

7 Physical downlink shared channel related procedures

For FDD, there shall be a maximum of 8 HARQ processes in the downlink.

For TDD, the maximum number of HARQ processes in the downlink shall be determined by the UL/DL configuration (Table 4.2-2 of [3]), as indicated in table 7-1.

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

7.1 UE procedure for receiving the physical downlink shared channel

A UE shall upon detection of a PDCCH with DCI format 1, 1A, 1B, 1C, 1D, 2 or 2A 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 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 is one, Single-antenna port, port 0 is used, otherwise Transmit diversity.
DCI format 1A	Common	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity

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 is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
DCI format 1A	Common	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used, otherwise Transmit diversity

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, UE is not required to decode a PDSCH indicated by a PDCCH with a CRC scrambled by C-RNTI or SPS C-RNTI.

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

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

The UE is semi-statically configured via higher layer signalling to receive PDSCH data transmissions signalled via PDCCH UE specific search spaces, according to one of seven transmission modes, denoted mode 1 to mode 7.

For frame structure type 1, the UE is not expected to receive PDSCH resource blocks transmitted on antenna port 5 in any subframe in which the number of OFDM symbols for PDCCH with normal CP is equal to four, nor 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 synchronisation signals in the same subframe.

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, nor 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.

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.

When a UE configured in transmission mode 3 or 4 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 is by C-RNTI.

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

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common and UE specific by C-RNTI	Single-antenna port, port 0 (see subclause 7.1.1)
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0 (see subclause 7.1.1)
Mode 2	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 1	UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 3	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 2A	UE specific by C-RNTI	Large delay CDD (see subclause 7.1.3) or Transmit diversity (see subclause 7.1.2)
Mode 4	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 2	UE specific by C-RNTI	Closed-loop spatial multiplexing (see subclause 7.1.4)or Transmit diversity (see subclause 7.1.2)
Mode 5	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 1D	UE specific by C-RNTI	Multi-user MIMO (see subclause 7.1.5)
Mode 6	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 1B	UE specific by C-RNTI	Closed-loop spatial multiplexing (see subclause 7.1.4) using a single transmission layer
Mode 7	DCI format 1A	Common and UE specific by C-RNTI	If the number of PBCH antenna ports is one, Single-antenna port, port 0 is used (see subclause 7.1.1), otherwise Transmit diversity (see subclause 7.1.2)
	DCI format 1	UE specific by C-RNTI	Single-antenna port; port 5 (see subclause 7.1.1)

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 and any corresponding PDSCH 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.

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

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

Transmission mode	DCI format	Search Space	Transmission scheme of PDSCH corresponding to PDCCH
Mode 1	DCI format 1A	Common and UE specific by C-RNTI	Single-antenna port, port 0 (see subclause 7.1.1)
	DCI format 1	UE specific by C-RNTI	Single-antenna port, port 0 (see subclause 7.1.1)
Mode 2	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 1	UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 3	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 2A	UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 4	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
	DCI format 2	UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 5	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 6	DCI format 1A	Common and UE specific by C-RNTI	Transmit diversity (see subclause 7.1.2)
Mode 7	DCI format 1A	Common and UE specific by C-RNTI	Single-antenna port; port 5
	DCI format 1	UE specific by C-RNTI	Single-antenna port; port 5

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 specific by Temporary C-RNTI	If the number of PBCH antenna port is one, Single-antenna port, port 0 is used, otherwise Transmit diversity
DCI format 1	UE specific by Temporary C-RNTI	If the number of PBCH antenna port is one, Single-antenna port, port 0 is used, otherwise Transmit diversity

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

7.1.1 Single-antenna port scheme

For the single-antenna port transmission schemes (port 0 and port 5) of the PDSCH, the UE may assume that an eNB transmission on the PDSCH would be performed according to Section 6.3.4.1 of [3]

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 Section 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 Section 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 Section 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 Section 6.3.4.2.1 of [3]. The $\delta_{\text{power-offset}}$ dB value signalled on PDCCH with DCI format 1D using the downlink power offset field is given in Table 7.1.5-1.

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

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

7.1.6 Resource allocation

The UE shall interpret the resource allocation field depending on the PDCCH DCI format detected. A resource allocation field in each PDCCH includes two parts, a resource allocation header field and information consisting of the actual resource block assignment. PDCCH DCI formats 1, 2 and 2A with type 0 and PDCCH DCI formats 1, 2 and 2A 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 (section 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 and 2A 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.

A UE shall discard PDSCH resource allocation in the corresponding PDCCH if consistent control information is not detected.

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 physical resource blocks (PRBs). 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 $N_{\text{RB}}^{\text{DL}}$ PRBs 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 $N_{\mathrm{RB}}^{\mathrm{DL}}$	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 PRBs from the set of PRBs from one of P RBG subsets. 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 PRB in the selected RBG subset in such a way that MSB to LSB of the bitmap are mapped to the PRBs in the increasing frequency order. The PRB is allocated to the UE if the corresponding bit value in the bit field is 1, the PRB is not allocated to the UE otherwise. The portion of the bitmap used to address PRBs in a selected RBG subset has size $N_{\mathrm{RB}}^{\mathrm{TYPE1}}$ and is defined as

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

The addressable PRB numbers of a selected RBG subset start from an offset, $\Delta_{\mathrm{shift}}(p)$ to the smallest PRB number within the selected RBG subset, which is mapped to the MSB of the bitmap. The offset is in terms of the number of PRBs 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 $\Delta_{\mathrm{shift}}(p) = 0$. Otherwise, the offset for RBG subset p is given by $\Delta_{\mathrm{shift}}(p) = N_{\mathrm{RB}}^{\mathrm{RBG\ subset}}(p) - N_{\mathrm{RB}}^{\mathrm{TYPE1}}$, where the LSB of the bitmap is justified with the highest PRB number within the selected RBG subset. $N_{\mathrm{RB}}^{\mathrm{RBG\ subset}}(p)$ is the number of PRBs in RBG subset p and can be calculated by the following equation,

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

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

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

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, 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 $N_{\mathrm{VRB}}^{\mathrm{DL}}$ VRBs, where $N_{\mathrm{VRB}}^{\mathrm{DL}}$ is defined in [3], if the DCI CRC is scrambled by P-RNTI, RA-RNTI, or SI-RNTI. With PDCCH DCI format 1B, 1D, or 1A with a CRC scrambled with C-RNTI, distributed VRB allocations for a UE vary from a single VRB up to $N_{\mathrm{VRB}}^{\mathrm{DL}}$ VRBs if $N_{\mathrm{RB}}^{\mathrm{DL}}$ is 6-49 and vary from a single VRB up to 16 if $N_{\mathrm{RB}}^{\mathrm{DL}}$ is 50-110. With PDCCH DCI format 1C, distributed VRB allocations for a UE vary from $N_{\mathrm{RB}}^{\mathrm{step}}$ VRB(s) up to $\lfloor N_{\mathrm{VRB}}^{\mathrm{DL}} / N_{\mathrm{RB}}^{\mathrm{step}} \rfloor \cdot N_{\mathrm{RB}}^{\mathrm{step}}$ VRBs with an increment step of $N_{\mathrm{RB}}^{\mathrm{step}}$, where $N_{\mathrm{RB}}^{\mathrm{step}}$ value is determined depending on the downlink system bandwidth as shown in Table 7.1.6.3-1.

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

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

For PDCCH 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 $(L_{CRBs} - 1) \le \lfloor N_{RB}^{DL} / 2 \rfloor$ then

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

else

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

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

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

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

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

else

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

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

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

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 $N^{\text{1A}}_{\text{PRB}}$ from Section 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 the Table 7.1.7.2.1-1 column indicator N'_{PRB} to the total number of allocated PRBs based on the procedure defined in Section 7.1.6.

  if the transport block is transmitted in DwPTS of the special subframe in frame structure type 2, then

  set the Table 7.1.7.2.1-1 column indicator $N_{PRB} = \max\left\{\lfloor N'_{\text{PRB}} \times 0.75 \rfloor, \quad 1\right\}$,

  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 0.930, 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 CP or configurations 0 and 4 with extended CP, shown in table 4.2-1 [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, 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	

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:
    - o the UE shall set the TBS index (I_{TBS}) equal to I_{MCS} and determine its TBS by the procedure in Section 7.1.7.2.1.
- for DCI format 1C:
    - o 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

- 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 and 2A as specified below. For a transport block that is not mapped to two-layer spatial multiplexing, the TBS is determined by the procedure in Section 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 Section 7.1.7.2.2.
- for $29 \le I_{\text{MCS}} \le 31$, the TBS is assumed to be as determined from DCI transported in the latest PDCCH for the same transport block using $0 \le I_{\text{MCS}} \le 28$.
- In DCI formats 2 and 2A a transport block is disabled if $I_{\text{MCS}} = 0$ and if rv_{idx} = 1 otherwise the transport block is enabled.

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

7.1.7.2.1 Transport blocks not mapped to two-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 27×110)

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

7.1.7.2.2 Transport blocks mapped to two-layer spatial multiplexing

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

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

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

TBS_L1	TBS_L2	TBS_L1	TBS_L2	TBS_L1	TBS_L2	TBS_L1	TBS_L2
1544	3112	3752	7480	10296	20616	28336	57336
1608	3240	3880	7736	10680	21384	29296	59256
1672	3368	4008	7992	11064	22152	30576	61664
1736	3496	4136	8248	11448	22920	31704	63776
1800	3624	4264	8504	11832	23688	32856	66592

1864	3752	4392	8760	12216	24496	34008	68808
1928	3880	4584	9144	12576	25456	35160	71112
1992	4008	4776	9528	12960	25456	36696	73712
2024	4008	4968	9912	13536	27376	37888	76208
2088	4136	5160	10296	14112	28336	39232	78704
2152	4264	5352	10680	14688	29296	40576	81176
2216	4392	5544	11064	15264	30576	42368	84760
2280	4584	5736	11448	15840	31704	43816	87936
2344	4776	5992	11832	16416	32856	45352	90816
2408	4776	6200	12576	16992	34008	46888	93800
2472	4968	6456	12960	17568	35160	48936	97896
2536	5160	6712	13536	18336	36696	51024	101840
2600	5160	6968	14112	19080	37888	52752	105528
2664	5352	7224	14688	19848	39232	55056	110136
2728	5544	7480	14688	20616	40576	57336	115040
2792	5544	7736	15264	21384	42368	59256	119816
2856	5736	7992	15840	22152	43816	61664	124464
2984	5992	8248	16416	22920	45352	63776	128496
3112	6200	8504	16992	23688	46888	66592	133208
3240	6456	8760	17568	24496	48936	68808	137792
3368	6712	9144	18336	25456	51024	71112	142248
3496	6968	9528	19080	26416	52752	73712	146856
3624	7224	9912	19848	27376	55056	75376	149776

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 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

7.1.7.3 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].

7.2 UE procedure for reporting channel quality indication (CQI), precoding matrix indicator (PMI) and rank indication (RI)

The time and frequency resources that can be used by the UE to report CQI, PMI, and 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.

CQI, PMI, and RI reporting is periodic or aperiodic.

A UE shall transmit periodic CQI/PMI, or RI reporting on PUCCH as defined hereafter in subframes with no PUSCH allocation. A UE shall transmit periodic CQI/PMI or RI reporting on PUSCH as defined hereafter in subframes with PUSCH allocation, where the UE shall use the same PUCCH-based periodic CQI/PMI or RI reporting format on PUSCH.

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

The CQI transmissions on PUCCH and PUSCH for various scheduling modes are summarized in the following table:

Table 7.2-1: Physical Channels for Aperiodic or Periodic CQI reporting

Scheduling Mode	Periodic CQI reporting channels	Aperiodic CQI reporting channel
Frequency non-selective	PUCCH	
Frequency selective	PUCCH	PUSCH

In case both periodic and aperiodic reporting would occur in the same subframe, the UE shall only transmit the aperiodic report in that subframe.

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 mode 4, a UE shall determine a RI from the supported set of RI values for the corresponding eNodeB and UE antenna configuration 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 for the corresponding eNodeB and UE antenna configuration 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 and RI within a precoder codebook subset specified by a bitmap parameter *codebookSubsetRestriction* configured by higher layer signalling. For a specific precoder codebook and associated transmission mode, the bitmap can specify all possible precoder codebook subsets from which the UE can assume the eNB may be using when the UE is configured in the relevant transmission mode. Codebook subset restriction is supported for transmission modes 3, 4, 5 and 6. 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 Section 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 Section 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].

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**
	Transmission mode 3	2	4
	Transmission mode 4	6	64
	Transmission mode 5	4	16
	Transmission mode 6	4	16

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 mode 4 with RI=1, a single 4-bit wideband CQI is reported according to Table 7.2.3-1.
- For transmission modes 3 and 4, CQI is calculated assuming transmission of one codeword for RI=1 and two codewords for RI > 1.
- For RI > 1 with transmission mode 4, PUSCH based triggered reporting includes reporting a wideband CQI which comprises:
  - A 4-bit wideband CQI for codeword 0 according to Table 7.2.3-1
  - A 4-bit wideband CQI for codeword 1 according to Table 7.2.3-1

- For RI > 1 with transmission mode 4, PUCCH based reporting includes reporting a 4-bit wideband CQI for codeword 0 according to Table 7.2.3-1 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 CQI/PMI/RI Reporting using PUSCH

A UE shall perform aperiodic CQI, PMI and RI reporting using the PUSCH in subframe $n+k$, upon receiving in subframe n either:

- a DCI format 0, or
- a Random Access Response Grant,

if the respective CQI request field is set to 1 and is not reserved.

When the CQI request field from a DCI format 0 is set to 1, 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.

When the CQI request field from a Random Access Response Grant is set to 1 and is not reserved, k is equal to k_1 if the UL delay field in section 6.2 is set to zero, where k_1 is given in section 6.1.1. The UE shall postpone aperiodic CQI, PMI and RI 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.

When aperiodic CQI/PMI/RI report with no transport block associated as defined in section 8.6.2 and positive SR is transmitted in the same subframe, the UE shall transmit SR, and, if applicable, ACK/NAK, on PUCCH resources as described in Section 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 reporting modes given in Table 7.2.1-1 and described below.

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

For each of the transmission modes defined in Section 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
Transmission mode 5 : Mode 3-1
Transmission mode 6 : Modes 1-2, 2-2, 3-1
Transmission mode 7 : Modes 2-0, 3-0

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

For $N_{\mathrm{RB}}^{\mathrm{DL}} \leq 7$, PUSCH reporting modes are not supported.
RI is only reported for transmission modes 3 and 4.

A RI report on an aperiodic reporting mode is valid only for CQI/PMI report 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.
    - Subband size is given by Table 7.2.1-3.
    - For transmission mode 4 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 single selected precoding matrix indicator
    - For transmission mode 4 the reported PMI and CQI values are calculated conditioned on the reported RI. For other transmission modes 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.

  - The UE shall also report the selected single precoding matrix indicator preferred 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

  - A UE shall also report the selected single precoding matrix indicator for all set S subbands.
  - For transmission mode 4 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 $\{s_i\}_{i=0}^{M-1}$, $(1 \le s_i \le N, \quad s_i < s_{i+1})$ contains the *M* sorted subband indices and $\left\langle \begin{matrix} x \\ y \end{matrix} \right\rangle = \begin{cases} \binom{x}{y} & x \ge y \\ 0 & x < y \end{cases}$ is the extended binomial coefficient, resulting in unique label $r \in \left\{ 0, \cdots, \binom{N}{M} - 1 \right\}$.

- The CQI value for the *M* selected subbands for each codeword is encoded differentially using 2-bits relative to its respective wideband CQI as defined by

  - Differential CQI offset level = *M* selected subbands CQI index – wideband CQI index

  - The mapping from the 2-bit differential CQI value to the offset level is shown in Table 7.2.1-4.

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

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

- Supported subband size *k* and *M* values include those shown in Table 7.2.1-5. In Table 7.2.1-5 the *k* and *M* values are a function of system bandwidth.

- The number of bits to denote the position of the *M* selected subbands is $L = \left\lceil \log_2 \binom{N}{M} \right\rceil$.

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

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

7.2.2 Periodic CQI/PMI/RI Reporting using PUCCH

A UE is semi-statically configured by higher layers to periodically feed back different CQI, PMI, and RI on the PUCCH using the reporting modes given in Table 7.2.2-1 and described below.

Table 7.2.2-1: CQI and PMI Feedback Types for PUCCH 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 Section 7.1, the following 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

The periodic CQI reporting mode is given by the parameter *cqi-FormatIndicatorPeriodic* which is configured by higher-layer signalling.

For the UE-selected subband CQI, a CQI report in a certain subframe describes the channel quality in a particular part or in particular parts of the bandwidth 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.

- There are a total of *N* subbands for a 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 $N_{\mathrm{RB}}^{\mathrm{DL}}$ as given in Table 7.2.2-2. If $J = 1$ then N_{j} is $\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k / J \rceil$. If *J>1* then N_{j} is either $\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k / J \rceil$ or $\lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k / J \rceil - 1$, depending on $N_{\mathrm{RB}}^{\mathrm{DL}}$, *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 where $L = \lceil \log_2 \lceil N_{\mathrm{RB}}^{\mathrm{DL}} / k / J \rceil \rceil$.

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

Four CQI/PMI and RI reporting types with distinct periods and offsets are supported for each PUCCH reporting mode as given in Table 7.2.2-3:

- Type 1 report supports CQI feedback for the UE selected sub-bands
- Type 2 report supports wideband CQI and PMI feedback.
- Type 3 report supports RI feedback
- Type 4 report supports wideband CQI

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

- The reporting instances for wideband CQI/PMI are subframes satisfying $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}\right) \bmod N_P = 0$, where n_f is the system frame number, and n_s = {0,1,…, 19} is the slot index within the frame, and $N_{OFFSET,CQI}$ is the corresponding wideband CQI/PMI reporting offset (in subframes) and N_{P} is the wideband CQI/PMI period (in subframes).
- In case RI reporting is configured, the reporting interval of the RI reporting is an integer multiple M_{RI} of wideband CQI/PMI period N_{P} (in subframes).
  - The reporting instances for RI are subframes satisfying $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}\right) \bmod (N_P \cdot M_{RI}) = 0$, where n_f is the system frame number, and n_s = {0,1,…, 19} is the slot index within the frame, $N_{OFFSET,CQI}$ is the corresponding wideband CQI/PMI reporting offset (in subframes) and $N_{OFFSET,RI}$ is the corresponding relative RI offset to the wideband CQI/PMI reporting offset (in subframes).
  - The reporting offset for RI $N_{OFFSET,RI}$ takes values from the set {0, −1, …, −(N_{P}−1)}.
  - In case of collision of RI and wideband CQI/PMI the wideband CQI/PMI is dropped.

- The periodicity N_{P} and offset $N_{OFFSET,CQI}$ for wideband CQI/PMI reporting are determined based on the parameter *cqi-pmi-ConfigIndex* given in Table 7.2.2-1A for FDD and table 7.2.2-1C for TDD. The periodicity M_{RI}, and offset $N_{OFFSET,RI}$ for RI reporting are determined based on the parameter *ri-ConfigIndex* given in Table 7.2.2-1B. Both *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* are configured by higher layer signalling.

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 $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}\right) \bmod N_P = 0$, where n_f is the system frame number, and n_s = {0,1,…, 19} is the slot index within the frame, $N_{OFFSET,CQI}$ is the corresponding wideband CQI/PMI reporting offset (in subframes) , and N_{P} is the period of CQI/PMI reporting instance (in subframes).
  - The wideband CQI/PMI report has period H*N_{P}, and is reported on the subframes satisfying $\left(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}\right) \bmod (H \cdot N_P) = 0$, where n_f is the system frame number, and n_s =

{0,1,…, 19} is the slot index within the frame. .The integer H is defined as $H=J*K+1$, where J is the number of bandwidth parts.

- Between every two consecutive wideband CQI/PMI reports, the remaining $J*K$ 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 $J*K$ 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/PMI reports. Each full cycle of bandwidth parts shall be in increasing order starting from bandwidth part 0 to bandwidth part J-1.

- In case RI reporting is configured, the reporting interval of RI is M_{RI} times the wideband CQI/PMI period, 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 $\left(10 \times n_f + \lfloor n_s/2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}\right) \bmod \left(H \cdot N_P \cdot M_{RI}\right) = 0$, where n_f is the system frame number, and n_s = {0,1,…, 19} is the slot index within the frame, $N_{OFFSET,CQI}$ is the corresponding wideband CQI/PMI reporting offset (in subframes) and $N_{OFFSET,RI}$ is the corresponding relative RI offset to the wideband CQI/PMI reporting offset (in subframes).
  - In case of collision between RI and wideband CQI/PMI or subband CQI, the wideband CQI/PMI or subband CQI is dropped.

- The parameter K is selected from the set {1, 2, 3, 4}, and the parameter $N_{OFFSET,RI}$ is selected from the set {0, -1, …,-(N_P -1), - N_P }.

- The periodicity N_P and offset $N_{OFFSET,CQI}$ for CQI reporting are determined based on the parameter *cqi-pmi-ConfigIndex* given in Table 7.2.2-1A for FDD and table 7.2.2-1C for TDD. The periodicity M_{RI}, and offset $N_{OFFSET,RI}$ for RI reporting are determined based on the parameter *ri-ConfigIndex* given in Table 7.2.2-1B. Both *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* are configured by higher layer signalling.

In case of collision between CQI/PMI/RI and ACK/NACK in a same subframe, CQI/PMI/RI is dropped if the parameter *simultaneousAckNackAndCQI* provided by higher layers is set *FALSE*. CQI/PMI/RI is multiplexed with ACK/NAK otherwise.

The following PUCCH formats are used:

- Format 2 as defined in section 5.4.2 in [3] when CQI/PMI or RI report is not multiplexed with ACK/NAK
- Format 2a/2b as defined in section 5.4.2 in [3] when CQI/PMI or RI report is multiplexed with ACK/NAK for normal CP
- Format 2 as defined in section 5.4.2 in [3] when CQI/PMI or RI report is multiplexed with ACK/NAK for extended CP

The CQI/PMI or RI report shall be transmitted on the PUCCH resource $n_{\mathrm{PUCCH}}^{(2)}$ as defined in [3], where $n_{\mathrm{PUCCH}}^{(2)}$ is UE specific and configured by higher layers.

In case of collision between CQI/PMI/RI and positive SR in a same subframe, CQI/PMI/RI is dropped.

Table 7.2.2-1A: Mapping of *cqi-pmi-ConfigIndex* to N_P and $N_{OFFSET,CQI}$ for FDD.

cqi-pmi-ConfigIndex = $I_{CQI/PMI}$	Value of N_P	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 *ri-ConfigIndex* to M_{RI} and $N_{OFFSET,RI}$.

ri-ConfigIndex = 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 *cqi-pmi-ConfigIndex* to N_P and $N_{OFFSET,CQI}$ for TDD.

cqi-pmi-ConfigIndex = $I_{CQI/PMI}$	Value of N_P	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 periodic CQI/PMI reporting, the following periodicity values apply depending on the TDD UL/DL configuration [3]:

- The reporting period of $N_P = 1$ is only applicable to TDD UL/DL configurations 0, 1, 3, 4, and 6, where all UL subframes in a radio frame are used for CQI/PMI reporting.
- The reporting period of $N_P = 5$ is only applicable to TDD UL/DL configurations 0, 1, 2, and 6.
- The reporting periods of $N_P = \{10, 20, 40, 80, 160\}$ are applicable to all TDD UL/DL configurations.

For $N_{\mathrm{RB}}^{\mathrm{DL}} \leq 7$, Mode 2-0 and Mode 2-1 are not supported.

A RI report in a periodic reporting mode is valid only for CQI/PMI report on that periodic reporting mode.

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* .

- 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
  - Mode 1-1 description:
    - In the subframe where RI is reported (only for transmission mode 4):
      - 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/PMI is reported:
      - A single precoding matrix is selected from the codebook subset assuming transmission on set *S* subbands
      - A UE shall report a type 2 report on each respective successive reporting opportunity consisting of
        - A single wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set *S* subbands.
        - The selected single precoding matrix indicator (wideband PMI)
        - When RI>1, a 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
      - For transmission mode 4 the PMI and CQI are calculated conditioned on the last reported periodic RI. For other transmission modes they are calculated conditioned on transmission rank 1.

- 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.

o Mode 2-1 description:

▪ In the subframe where RI is reported (only for transmission mode 4):

- 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/PMI is reported:

- 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 precoding matrix indicator (wideband PMI).
  - o When RI>1, and additional 3-bit wideband spatial differential CQI, which is shown in Table 7.2-2.
- For transmission mode 4 the PMI and CQI values are calculated conditioned on the last reported periodic RI. For other transmission modes they are 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 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 set S subbands.
- The mapping from the 3-bit subband spatial differential CQI value to the offset level is shown in Table 7.2-2.

- For transmission mode 4 the subband selection and CQI values are calculated conditioned on the last reported periodic wideband PMI and RI. For other transmission modes they are calculated conditioned on the last reported PMI and transmission rank 1.

Table 7.2.2-2: Subband Size (*k*) and Bandwidth Parts *(J)* vs. Downlink System Bandwidth

System Bandwidth $N_{\mathrm{RB}}^{\mathrm{DL}}$	Subband Size k (RBs)	Bandwidth Parts (*J*)
6 – 7	NA	NA
8 – 10	4	1
11 – 26	4	2
27 – 63	6	3
64 – 110	8	4

If parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the UE shall drop the periodic CQI report and shall not multiplex periodic CQI/PMI and/or rank indicator in the PUSCH transmission.

Table 7.2.2-3: PUCCH Report Type Payload size per Reporting Mode

PUCCH Report 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
2	Wideband CQI/PMI	2 TX Antennas RI = 1	6	6	NA	NA
		4 TX Antennas RI = 1	8	8	NA	NA
		2 TX Antennas RI > 1	8	8	NA	NA
		4 TX Antennas RI > 1	11	11	NA	NA
3	RI	2-layer spatial multiplexing	1	1	1	1
		4-layer spatial multiplexing	2	2	2	2
4	Wideband CQI	RI = 1 or RI>1	NA	NA	4	4

7.2.3 Channel quality indicator (CQI) definition

The CQI indices and their interpretations are given in Table 7.2.3-1.

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 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 CQI reference resource, could be received with a transport block error probability not exceeding 0.1.

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 CQI 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 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 a 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 CQI reference resource is defined as follows:

- In the frequency domain, the CQI 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, the CQI reference resource is defined by a single downlink subframe $n\text{-}n_{CQI\_ref}$,
    - o where for periodic CQI reporting n_{CQI_ref} is the smallest value greater than or equal to 4, such that it corresponds to a valid downlink subframe;
    - o where for aperiodic CQI reporting n_{CQI_ref} is such that the reference resource is in the same valid downlink subframe as the corresponding CQI request in a DCI format 0.
    - o where for aperiodic CQI reporting n_{CQI_ref} is equal to 4 and downlink subframe $n\text{-}n_{CQI\_ref}$ corresponds to a valid downlink subframe, where downlink subframe $n\text{-}n_{CQI\_ref}$ is received after the subframe with the corresponding CQI request in a Random Access Response Grant.

    A downlink subframe shall be considered to be valid if:

    - ▪ it is configured as a downlink subframe for that UE, and
    - ▪ 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.

    If there is no valid downlink subframe for the CQI reference resource, CQI reporting is omitted in uplink subframe *n*.
- In the layer domain, the CQI reference resource is defined by any RI and PMI on which the CQI is conditioned.

In the CQI reference resource, the UE shall assume the following for the purpose of deriving the CQI index:

- The first 3 OFDM symbols are occupied by control signalling
- No resource elements used by primary or secondary synchronisation signals or PBCH
- CP length of the non-MBSFN subframes
- Redundancy Version 0
- 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).
- The ratio of PDSCH EPRE to cell-specific RS EPRE is as given in Section 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 CQI reference resource

Transmission mode	Transmission scheme of PDSCH
1	Single-antenna port, port 0
2	Transmit diversity
3	Transmit diversity if the associated rank indicator is 1, otherwise large delay CDD
4	Closed-loop spatial multiplexing
5	Multi-user MIMO
6	Closed-loop spatial multiplexing with a single transmission layer
7	If the number of PBCH antenna ports is one, Single-antenna port, port 0; otherwise Transmit diversity

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

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). A UE shall report PMI based on the feedback modes described in 7.2.1 and 7.2.2. Each PMI value corresponds to a codebook index given in Table 6.3.4.2.3-1 or Table 6.3.4.2.3-2 of [3] as follows:

- For 2 antenna ports $\{0,1\}$ 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 $\{0,1\}$ 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 $\{0,1,2,3\}$, 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.

For other transmission modes, PMI reporting is not supported.

7.3 UE procedure for reporting ACK/NACK

For FDD, when both ACK/NACK and SR are transmitted in the same sub-frame a UE shall transmit the ACK/NACK on its assigned ACK/NACK PUCCH resource for a negative SR transmission and transmit the ACK/NACK on its assigned SR PUCCH resource for a positive SR transmission.

For TDD and all UL-DL configurations except configuration 5, two ACK/NACK feedback modes are supported by higher layer configuration.

- ACK/NACK bundling, and
- ACK/NACK multiplexing

For TDD UL-DL configuration 5, only ACK/NACK bundling is supported.

For TDD, the UE shall upon detection of a PDSCH transmission or a PDCCH indicating downlink SPS release (defined in section 9.2) within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1-1 intended for the UE and for which ACK/NACK response shall be provided, transmit the ACK/NACK response in UL subframe *n*.

For TDD UL-DL configurations 1-6, the value of the Downlink Assignment Index (DAI) in DCI format 0, 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 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 within all the subframe(s) $n-k$. In case neither PDSCH transmission, nor PDCCH 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, V_{DAI}^{UL}, if transmitted, is set to 4.

For TDD UL-DL configurations 1-6, the value of the DAI in DCI format 1/1A/1B/1D/2/2A denotes the accumulative number of PDCCH(s) with assigned PDSCH transmission(s) and PDCCH indicating downlink SPS release up to the present subframe within subframe(s) $n-k$, where $k \in K$, and shall be updated from subframe to subframe. Denote V_{DAI}^{DL} as the value of the DAI in PDCCH with DCI format 1/1A/1B/1D/2/2A detected by the UE according to Table 7.3-X in subframe $n-k_m$, where k_m is the smallest value in the set K (defined in Table 10.1-1) such that the UE detects a DCI format 1/1A/1B/1D/2/2A. Denote U_{DAI} as the total number of PDCCH(s) with assigned PDSCH transmission(s) and PDCCH indicating downlink SPS release detected by the UE within the subframe(s) $n-k$, where $k \in K$. Denote N_{SPS}, which can be zero or one, as the number of PDSCH transmissions without a corresponding PDCCH within the subframe(s) $n-k$, where $k \in K$.

For TDD ACK/NACK bundling or ACK/NACK multiplexing and a subframe n with $M=1$, the UE shall generate one or two ACK/NACK bits by performing a logical AND operation per codeword across M DL subframes associated with a single UL subframe, of all the corresponding $U_{DAI}+N_{SPS}$ individual PDSCH transmission ACK/NACKs and individual ACK in response to received PDCCH indicating downlink SPS release, where M is the number of elements in the set K defined in Table 10.1-1. 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 UE detects the PDSCH transmission with or without corresponding PDCCH within the subframe $n-k$, 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 with DCI format 0 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 ACK/NACK 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 with DCI format 0 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 ACK/NACK if $U_{DAI} + N_{SPS} = 0$.

For TDD ACK/NACK bundling, when the UE is configured by transmission mode 3 or 4 defined in Section 7.1 and ACK/NACK bits are transmitted on PUSCH, the UE shall always generate 2 ACK/NACK 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
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	**DL 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	

For TDD ACK/NACK multiplexing and a subframe n with $M > 1$, spatial ACK/NACK bundling across multiple codewords within a DL subframe is performed by a logical AND operation of all the corresponding individual ACK/NACKs. In case the UE is transmitting on PUSCH, the UE shall determine the number of ACK/NAK feedback bits O^{ACK} and the ACK/NACK feedback bits o_n^{ACK} , $n = 0,\ldots,O^{ACK} - 1$ to be transmitted in subframe *n* in case the UE is transmitting on PUSCH.

- If the PUSCH transmission is adjusted based on a detected PDCCH with DCI format 0 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 ACK/NACK. The spatially bundled ACK/NACK for a PDSCH transmission with a corresponding PDCCH or for a PDCCH 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 detected in subframe $n-k$. For the case with $N_{SPS} > 0$, the ACK/NACK associated with a PDSCH transmission without a corresponding PDCCH is mapped to $o_{O^{ACK}-1}^{ACK}$. The ACK/NACK feedback bits without any detected PDSCH transmission or without detected PDCCH indicating downlink SPS release are set to NACK.
- If the PUSCH transmission is not adjusted based on a detected PDCCH with DCI format 0 intended for the UE, $O^{ACK} = M$, and o_i^{ACK} is associated with the spatially bundled ACK/NACK for DL subframe $n-k_i$, where $k_i \in K$. The ACK/NACK feedback bits without any detected PDSCH transmission or without detected PDCCH indicating downlink SPS release are set to NACK.

For TDD when both ACK/NACK and SR are transmitted in the same sub-frame, a UE shall transmit the bundled ACK/NACK or the multiple ACK/NAK responses (according to section 10.1) on its assigned ACK/NACK 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 section 5.4.1 in [3]. The value of $b(0),b(1)$ are generated according to Table 7.3-1 from the $U_{DAI} + N_{SPS}$ ACK/NACK responses including ACK in response to PDCCH indicating downlink SPS release by spatial ACK/NAK bundling across multiple codewords within each PDSCH transmission.

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

Number of ACK among multiple ($U_{DAI} + N_{SPS}$) ACK/NACK responses	$b(0),b(1)$
0 or None (UE detect at least one DL assignment is missed)	0, 0
1	1, 1
2	1, 0
3	0, 1
4	1, 1
5	1, 0
6	0, 1
7	1, 1
8	1, 0
9	0, 1

For TDD when both ACK/NACK and CQI/PMI or RI are configured to be transmitted in the same sub-frame on PUCCH, a UE shall transmit CQI and $b(0),b(1)$ using PUCCH format 2b for normal CP or PUCCH format 2 for extended CP, according to section 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 $U_{DAI} + N_{SPS}$ ACK/NACK responses including ACK in response to PDCCH indicating downlink SPS release by spatial ACK/NACK bundling across multiple codewords within each PDSCH transmission.

When only ACK/NACK or only a SR is transmitted a UE shall use PUCCH Format 1a or 1b for the ACK/NACK resource and PUCCH Format 1 for the SR resource as defined in section 5.4.1 in [3].

8 Physical uplink shared channel related procedures

For FDD, there shall be 8 HARQ processes in the uplink for non-subframe bundling operation, i.e. normal HARQ operation, and 4 HARQ processes in the uplink for subframe bundling operation. The subframe bundling operation is configured by the parameter *ttiBundling* provided by higher layers.

In subframe bundling operation, a bundle of PUSCH transmissions consists of four consecutive uplink subframes in both FDD and TDD.

For FDD and normal HARQ operation, the UE shall upon detection of a PDCCH with DCI format 0 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 and PHICH information.

For FDD and subframe bundling operation, the UE shall upon detection of a PDCCH 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 and PHICH information.

For FDD and TDD, the NDI as signalled on PDCCH, the RV as determined in section 8.6.1, and the TBS as determined in section 8.6.2, shall be delivered to higher layers.

For TDD, the number of HARQ processes shall be determined by the DL/UL configuration (Table 4.2-2 of [3]), as indicated in table 8-1.

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 UL/DL configurations 1-6 and normal HARQ operation, the UE shall upon detection of a PDCCH with DCI format 0 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 and PHICH information

For TDD UL/DL configuration 0 and normal HARQ operation the UE shall upon detection of a PDCCH with DCI format 0 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 DCI format 0 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 Section 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 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 Section 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 DCI format 0 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 UL/DL configurations 1 and 6 and subframe bundling operation, the UE shall upon detection of a PDCCH 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 and PHICH information.

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

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

TDD UL/DL Configuration	DL 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	DL 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

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.

Table 8-3: PDCCH configured by C-RNTI

DCI format	Search Space
DCI format 0	Common and UE specific by C-RNTI

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 PDCCHs for downlink data arrival, the UE shall decode the PDCCH according to the combination defined in table 8-4.

Table 8-4: PDCCH configured for downlink data arrival

DCI format	Search Space
DCI format 1A	Common and UE specific by C-RNTI

If a UE is configured by higher layers to decode PDCCHs with the CRC scrambled by the SPS C-RNTI, 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.

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

DCI format	Search Space
DCI format 0	Common and UE specific by C-RNTI

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 Section 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 Section 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

8.1 Resource Allocation for PDCCH DCI Format 0

The resource allocation information 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 $(L_{\text{CRBs}} - 1) \le \lfloor N_{\text{RB}}^{\text{UL}} / 2 \rfloor$ then

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

else

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

A UE shall discard PUSCH resource allocation in the corresponding PDCCH with DCI format 0 if consistent control information is not detected.

8.2 UE sounding procedure

The following Sounding Reference Symbol (SRS) parameters are UE specific semi-statically configurable by higher layers:

- Transmission comb k_{TC}, as defined in Section 5.5.3.2 of [3]
- Starting physical resource block assignment n_{RRC}, as defined in Section 5.5.3.2 of [3]
- Duration of SRS transmission: single or indefinite (until disabled), as defined in [11]
- SRS configuration index I_{SRS} for SRS periodicity and SRS subframe offset T_{offset}, as defined in Table 8.2-1 and Table 8.2-2
- SRS bandwidth B_{SRS}, as defined in Section 5.5.3.2 of [3]
- Frequency hopping bandwidth, b_{hop}, as defined in Section 5.5.3.2 of [3]
- Cyclic shift n_{SRS}^{cs}, as defined in Section 5.5.3.2 of [3]

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

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

When antenna selection is enabled 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., $b_{hop} \ge B_{SRS}$),

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

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 Section 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.

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

A UE shall not transmit SRS whenever SRS and PUCCH format 2/2a/2b transmissions happen to coincide in the same subframe.

A UE shall not transmit SRS whenever SRS transmission and PUCCH transmission carrying ACK/NACK and/or positive SR happen to coincide in the same subframe if the parameter *Simultaneous-AN-and-SRS* is *FALSE*. A UE shall transmit SRS whenever SRS transmission and PUCCH transmission carrying ACK/NACK and/or positive SR happen to coincide in the same subframe if the parameter *Simultaneous-AN-and-SRS* is *TRUE*.

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 cell, the UE shall not transmit SRS.

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

The UE specific SRS configuration 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, respectively. The periodicity T_{SRS} of the SRS transmission 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, two SRS resources are configured in a half frame containing UL subframe(s).

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

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} , FDD

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

Table 8.2-2: UE Specific SRS Periodicity T_{SRS} and Subframe Offset Configuration T_{offset} , TDD

Configuration Index I_{SRS}	SRS Periodicity T_{SRS} (ms)	SRS Subframe Offset T_{offset}
0	2	0, 1
1	2	0, 2
2	2	1, 2
3	2	0, 3
4	2	1, 3
5	2	0, 4
6	2	1, 4
7	2	2, 3
8	2	2, 4
9	2	3, 4
10 – 14	5	I_{SRS} – 10
15 – 24	10	I_{SRS} – 15
25 – 44	20	I_{SRS} – 25
45 – 84	40	I_{SRS} – 45
85 – 164	80	I_{SRS} – 85
165 – 324	160	I_{SRS} – 165
325 – 644	320	I_{SRS} – 325
645 – 1023	reserved	reserved

Table 8.2-3: k_{SRS} for TDD

	subframe index *n* 0	1: 1st symbol of UpPTS	1: 2nd symbol of UpPTS	2	3	4	5	6: 1st symbol of UpPTS	6: 2nd symbol of UpPTS	7	8	9
k_{SRS} in case UpPTS length of 2 symbols		0	1	2	3	4		5	6	7	8	9
k_{SRS} in case UpPTS length of 1 symbol		1		2	3	4		6		7	8	9

8.3 UE ACK/NACK procedure

For Frame Structure type 1, an ACK/NACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in subframe *i*-4.

For Frame Structure type 2 UL/DL configuration 1-6, an ACK/NACK received on the PHICH assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* as indicated by the following table 8.3-1.

For Frame Structure type 2 UL/DL configuration 0, an ACK/NACK received on the PHICH in the resource corresponding to $I_{PHICH}=0$, as defined in Section 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i-k* as indicated by the following table 8.3-1. If, for Frame Structure type 2 UL/DL configuration 0, an ACK/NACK received on the PHICH in the resource corresponding to $I_{PHICH}=1$, as defined in Section 9.1.2, assigned to a UE in subframe *i* is associated with the PUSCH transmission in the subframe *i*-6.

Table 8.3-1 *k* for TDD configurations 0-6

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

The physical layer in the UE shall deliver indications to the higher layers as follows:

For downlink subframe *i*, if a transport block was transmitted in the associated PUSCH subframe then:

- if ACK is decoded on the PHICH in subframe *i*, ACK shall be delivered to the higher layers;
- else NACK shall be delivered to the higher layers.

8.4 UE PUSCH Hopping procedure

The UE shall perform PUSCH frequency hopping if the single bit frequency hopping (FH) field in a corresponding PDCCH with DCI format 0 is set to 1 otherwise no PUSCH frequency hopping is performed.

A UE performing PUSCH frequency hopping shall determine its PUSCH resource allocation (RA) for the first slot of a subframe (*S1*) including the lowest index PRB ($n_{PRB}^{S1}(n)$) in subframe *n* from the resource allocation field in a corresponding PDCCH with DCI format 0 received on subframe $n\text{-}K_{PUSCH}$. For a non-adaptive retransmission of a packet on a dynamically assigned PUSCH resource a UE shall determine its hopping type based on the last received PDCCH with DCI Format 0 associated with the packet. For a PUSCH transmission on a semi-persistently allocated resource on subframe *n* in the absence of a corresponding PDCCH with a DCI Format 0 in subframe $n\text{-}K_{PUSCH}$, the UE shall determine its hopping type based on the hopping information in the most recent grant that assigns the semi-persistent resource allocation. For FDD, K_{PUSCH} =4; for TDD UL/DL configuration 0, if the PUSCH transmission in subframe 2 or 7 is scheduled with a PDCCH of DCI format 0 in which the LSB of the UL index is set to 1, K_{PUSCH} = 7; for all other PUSCH transmissions in TDD, K_{PUSCH} is given in Table 5.1.1.1-1.

The resource allocation field in DCI format 0 excludes either 1 or 2 bits used for hopping information as indicated by Table 8.4-1 below where the number of PUSCH resource blocks is defined as

$$N_{RB}^{PUSCH} = \begin{cases} N_{RB}^{UL} - \tilde{N}_{RB}^{HO} - \left(N_{RB}^{UL} \bmod 2\right) & \text{Type 1 PUSCH hopping} \\ N_{RB}^{UL} & \text{Type 2 } N_{sb} = 1 \text{ PUSCH hopping} \\ N_{RB}^{UL} - \tilde{N}_{RB}^{HO} & \text{Type 2 } N_{sb} > 1 \text{ PUSCH hopping} \end{cases}$$

For type 1 and type 2 PUSCH hopping, $\tilde{N}_{\text{RB}}^{\text{HO}} = N_{\text{RB}}^{\text{HO}} + 1$ if $N_{\text{RB}}^{\text{HO}}$ is an odd number where $N_{\text{RB}}^{\text{HO}}$ defined in [3]. $\tilde{N}_{\text{RB}}^{\text{HO}} = N_{\text{RB}}^{\text{HO}}$ in other cases. The size of the resource allocation field in DCI format 0 after excluding either 1 or 2 bits shall be $y = \left\lceil \log_2(N_{\text{RB}}^{\text{UL}}(N_{\text{RB}}^{\text{UL}}+1)/2) \right\rceil - N_{UL\_hop}$, where N_{UL_hop} = 1 or 2 bits. The number of contiguous RBs that can be assigned to a type-1 hopping user is limited to $\left\lfloor 2^y / N_{\text{RB}}^{\text{UL}} \right\rfloor$. The number of contiguous RBs that can be assigned to a type-2 hopping user is limited to $\min(\left\lfloor 2^y / N_{\text{RB}}^{\text{UL}} \right\rfloor, \left\lfloor N_{\text{RB}}^{\text{PUSCH}} / N_{sb} \right\rfloor)$,where the number of sub-bands N_{sb} is given by higher layers.

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in section 8.4.1 and type 2 is described in section 8.4.2.

Table 8.4-1: Number of Hopping Bits N_{UL_hop} vs. System Bandwidth

System BW N_{RB}^{UL}	#Hopping bits for 2nd slot RA (N_{UL_hop})
6-49	1
50-110	2

The parameter *Hopping-mode* provided by higher layers determines if PUSCH frequency hopping is "inter-subframe" or "intra and inter-subframe".

8.4.1 Type 1 PUSCH Hopping

For PUSCH hopping type 1 the hopping bit or bits indicated in Table 8.4-1 determine $\tilde{n}_{PRB}(i)$ as defined in Table 8.4-2. The lowest index PRB (n_{PRB}^{S1}) of the 1st slot RA in subframe *i* is defined as $n_{PRB}^{S1}(i) = \tilde{n}_{PRB}^{S1}(i) + \tilde{N}_{\text{RB}}^{\text{HO}}/2$, where $n_{PRB}^{S1}(i) = RB_{START}$, and RB_{START} is obtained from the uplink scheduling grant as in Section 8.4 and Section 8.1.

The lowest index PRB ($n_{PRB}(i)$) of the 2nd slot RA in subframe *i* is defined as $n_{PRB}(i) = \tilde{n}_{PRB}(i) + \tilde{N}_{\text{RB}}^{\text{HO}}/2$.

The set of physical resource blocks to be used for PUSCH transmission are L_{CRBs} contiguously allocated resource blocks from PRB index n_{PRB}^{S1} for the 1st slot, and from PRB index $n_{PRB}(i)$ for the 2nd slot, respectively, where L_{CRBs} is obtained from the uplink scheduling grant as in Section 8.4 and Section 8.1.

If the *Hopping-mo*de is "inter-subframe", the 1st slot RA is applied to even CURRENT_TX_NB, and the 2nd slot RA is applied to odd CURRENT_TX_NB, where CURRENT_TX_NB is defined in [8].

8.4.2 Type 2 PUSCH Hopping

In PUSCH hopping type 2 the set of physical resource blocks to be used for transmission in slot n_s is given by the scheduling grant together with a predefined pattern according to [3] section 5.3.4. If the system frame number is not acquired by the UE yet, the UE shall not transmit PUSCH with type-2 hopping and N_{sb}>1 for TDD, where N_{sb} is defined in [3].

Table 8.4-2: PDCCH DCI Format 0 Hopping Bit Definition

System BW N_{RB}^{UL}	Number of Hopping bits	Information in hopping bits	$\tilde{n}_{PRB}(i)$
6 – 49	1	0	$\left(\left\lfloor N_{RB}^{PUSCH}/2\right\rfloor+\tilde{n}_{PRB}^{S1}(i)\right)\bmod N_{RB}^{PUSCH}$,
		1	Type 2 PUSCH Hopping
50 – 110	2	00	$\left(\left\lfloor N_{RB}^{PUSCH}/4\right\rfloor+\tilde{n}_{PRB}^{S1}(i)\right)\bmod N_{RB}^{PUSCH}$
		01	$\left(-\left\lfloor N_{RB}^{PUSCH}/4\right\rfloor+\tilde{n}_{PRB}^{S1}(i)\right)\bmod N_{RB}^{PUSCH}$
		10	$\left(\left\lfloor N_{RB}^{PUSCH}/2\right\rfloor+\tilde{n}_{PRB}^{S1}(i)\right)\bmod N_{RB}^{PUSCH}$
		11	Type 2 PUSCH Hopping

8.5 UE Reference Symbol procedure

If UL sequence hopping is configured in the cell, it applies to all reference symbols (SRS, PUSCH and PUCCH RS).

8.6 Modulation order, redundancy version and transport block size determination

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

- read the 5-bit “modulation and coding scheme and redundancy version” field (I_{MCS}) in the DCI, and
- check the “CQI request” bit in DCI, and
- compute the total number of allocated PRBs (N_{PRB}) based on the procedure defined in Section 8.1, and
- compute the number of coded symbols for control information..

8.6.1 Modulation order and redundancy version determination

For $0 \le I_{\mathrm{MCS}} \le 28$, the modulation order (Q_m) is determined as follows:

- If the UE is capable of supporting 64QAM in PUSCH and has not been configured by higher layers to transmit only QPSK and 16QAM, the modulation order is given by $Q_m^{'}$ in Table 8.6.1-1.
- If the UE is not capable of supporting 64QAM in PUSCH or has been configured by higher layers to transmit only QPSK and 16QAM, $Q_m^{'}$ is first read from Table 8.6.1-1. The modulation order is set to $Q_m = \min(4, Q_m^{'})$ **.**
- If the parameter *ttiBundling* provided by higher layers is set to *TRUE*, then the resource allocation size is restricted to $N_{\mathrm{PRB}} \le 3$ and the modulation order is set to $Q_m = 2$.

For $29 \le I_{\mathrm{MCS}} \le 31$, the modulation order is assumed to be as determined from DCI transported in the most recent PDCCH for the same transport block using $0 \le I_{\mathrm{MCS}} \le 28$ except for the following case. If $I_{\mathrm{MCS}} = 29$, the “CQI request” bit in DCI format 0 is set to 1 and $N_{\mathrm{PRB}} \le 4$, the modulation order is set to $Q_m = 2$.

The UE shall use I_{MCS} and Table 8.6.1-1 to determine the redundancy version (rv_{idx}) to use in the physical uplink shared channel.

Table 8.6.1-1: Modulation, TBS index and redundancy version table for PUSCH

MCS Index I_{MCS}	**Modulation Order** Q_m'	**TBS Index** I_{TBS}	**Redundancy Version** rv_{idx}
0	2	0	0
1	2	1	0
2	2	2	0
3	2	3	0
4	2	4	0
5	2	5	0
6	2	6	0
7	2	7	0
8	2	8	0
9	2	9	0
10	2	10	0
11	4	10	0
12	4	11	0
13	4	12	0
14	4	13	0
15	4	14	0
16	4	15	0
17	4	16	0
18	4	17	0
19	4	18	0
20	4	19	0
21	6	19	0
22	6	20	0
23	6	21	0
24	6	22	0
25	6	23	0
26	6	24	0
27	6	25	0
28	6	26	0
29	reserved		1
30			2
31			3

8.6.2 Transport block size determination

For $0 \le I_{\text{MCS}} \le 28$, the UE shall first determine the TBS index (I_{TBS}) using I_{MCS} and Table 8.6.1-1. The UE shall then follow the procedure in Section 7.1.7.2.1 to determine the transport block size.

For $29 \le I_{\text{MCS}} \le 31$, the transport block size is assumed to be as determined from DCI transported in the initial PDCCH for the same transport block using $0 \le I_{\text{MCS}} \le 28$ except for the following case. If $I_{\text{MCS}} = 29$, the "CQI request" bit in DCI format 0 is set to 1 and $N_{\text{PRB}} \le 4$, then there is no transport block for the UL-SCH and only the control information feedback for the current PUSCH reporting mode is transmitted by the UE.

8.6.3 Control information MCS offset determination

$\beta_{offset}^{HARQ-ACK}$, β_{offset}^{RI} and β_{offset}^{CQI} shall be configured to values according to Table 8.6.3-1,2,3 with the higher layer signalled indexes $I_{offset}^{HARQ-ACK}$, I_{offset}^{RI}, and I_{offset}^{CQI}, respectively.

Table 8.6.3-1: Mapping of HARQ-ACK offset values and the index signalled by higher layers

$I_{offset}^{HARQ-ACK}$	$\beta_{offset}^{HARQ-ACK}$
0	2.000
1	2.500
2	3.125
3	4.000
4	5.000
5	6.250
6	8.000
7	10.000
8	12.625
9	15.875
10	20.000
11	31.000
12	50.000
13	80.000
14	126.000
15	reserved

Table 8.6.3-2: Mapping of RI offset values and the index signalled by higher layers

I_{offset}^{RI}	β_{offset}^{RI}
0	1.250
1	1.625
2	2.000
3	2.500
4	3.125
5	4.000
6	5.000
7	6.250
8	8.000
9	10.000
10	12.625
11	15.875

12	20.000
13	reserved
14	reserved
15	reserved

Table 8.6.3-3: Mapping of CQI offset values and the index signalled by higher layers

I_{offset}^{CQI}	β_{offset}^{CQI}
0	reserved
1	reserved
2	1.125
3	1.250
4	1.375
5	1.625
6	1.750
7	2.000
8	2.250
9	2.500
10	2.875
11	3.125
12	3.500
13	4.000
14	5.000
15	6.250

8.7 UE Transmit Antenna Selection

UE transmit antenna selection is configured by higher layers.

If UE transmit antenna selection is disabled or not supported by the UE, the UE shall transmit from UE port 0.

If closed-loop UE transmit antenna selection is enabled by higher layers the UE shall perform transmit antenna selection in response to the most recent command received via DCI Format 0 in section 5.3.3.2 [4].

If open-loop UE transmit antenna selection is enabled by higher layers, the transmit antenna to be selected by the UE is not specified.

9 Physical downlink control channel procedures

9.1 UE procedure for determining physical downlink control channel assignment

9.1.1 PDCCH Assignment Procedure

The control region consists of a set of CCEs, numbered from 0 to $N_{\mathrm{CCE},k}-1$ according to Section 6.8.2 in [3], where $N_{\mathrm{CCE},k}$ is the total number of CCEs in the control region of subframe k. The UE shall monitor a set of PDCCH candidates for control information in every non-DRX subframe, where monitoring implies attempting to decode each of the PDCCHs in the set according to all the monitored DCI formats.

The set of PDCCH candidates to monitor are defined in terms of search spaces, where a search space $S_k^{(L)}$ at aggregation level $L \in \{1,2,4,8\}$ is defined by a set of PDCCH candidates. The CCEs corresponding to PDCCH candidate *m* of the search space $S_k^{(L)}$ are given by

$$L \cdot \left\{ (Y_k + m) \bmod \lfloor N_{\mathrm{CCE},k} / L \rfloor \right\} + i$$

where Y_k is defined below, $i = 0,\cdots,L-1$ and $m = 0,\cdots,M^{(L)}-1$. $M^{(L)}$ is the number of PDCCH candidates to monitor in the given search space.

The UE shall monitor one common search space at each of the aggregation levels 4 and 8 and one UE-specific search space at each of the aggregation levels 1, 2, 4, 8. The common and UE-specific search spaces may overlap.

The aggregation levels defining the search spaces are listed in Table 9.1.1-1. The DCI formats that the UE shall monitor depend on the configured transmission mode as defined in Section 7.1.

Table 9.1.1-1: PDCCH candidates monitored by a UE.

Search space $S_k^{(L)}$			Number of PDCCH candidates $M^{(L)}$
Type	**Aggregation level L**	**Size [in CCEs]**	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

For the common search spaces, Y_k is set to 0 for the two aggregation levels $L = 4$ and $L = 8$.

For the UE-specific search space $S_k^{(L)}$ at aggregation level L, the variable Y_k is defined by

$$Y_k = (A \cdot Y_{k-1}) \bmod D$$

where $Y_{-1} = n_{\mathrm{RNTI}} \neq 0$, $A = 39827$, $D = 65537$ and $k = \lfloor n_s / 2 \rfloor$, n_s is the slot number within a radio frame.. The RNTI value used for n_{RNTI} is defined in section 7.1 in downlink and section 8 in uplink.

9.1.2 PHICH Assignment Procedure

For scheduled PUSCH transmissions in subframe n, a UE shall determine the corresponding PHICH resource in subframe $n+ k_{PHICH}$, where k_{PHICH} is always 4 for FDD and is given in table 9.1.2-1 for TDD. For subframe bundling operation, the corresponding PHICH resource is associated with the last subframe in the bundle.

Table 9.1.2-1: k_{PHICH} for TDD

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

The PHICH resource is determined from lowest index PRB of the uplink resource allocation and the 3-bit uplink demodulation reference symbol (DMRS) cyclic shift associated with the PUSCH transmission, both indicated in the PDCCH with DCI format 0 granting the PUSCH transmission.

The PHICH resource is identified by the index pair $(n_{PHICH}^{group}, n_{PHICH}^{seq})$ where n_{PHICH}^{group} is the PHICH group number and n_{PHICH}^{seq} is the orthogonal sequence index within the group as defined by:

$$n_{PHICH}^{group} = (I_{PRB\_RA}^{lowest\_index} + n_{DMRS}) \bmod N_{PHICH}^{group} + I_{PHICH} N_{PHICH}^{group}$$
$$n_{PHICH}^{seq} = (\lfloor I_{PRB\_RA}^{lowest\_index} / N_{PHICH}^{group} \rfloor + n_{DMRS}) \bmod 2N_{SF}^{PHICH}$$

where

- n_{DMRS} is mapped from the cyclic shift for DMRS field (according to Table 9.1.2-2) in the most recent DCI format 0 [4] for the transport block associated with the corresponding PUSCH transmission. For a semi-persistently configured PUSCH transmission on subframe n in the absence of a corresponding PDCCH with a DCI Format 0 in subframe $n - k_{PUSCH}$ or a PUSCH transmission associated with a random access response grant, n_{DMRS} is set to zero where k_{PUSCH} is as defined in section 8.
- N_{SF}^{PHICH} is the spreading factor size used for PHICH modulation as described in section 6.9.1 in [3].
- $I_{PRB\_RA}^{lowest\_index}$ is the lowest PRB index in the first slot of the corresponding PUSCH transmission
- N_{PHICH}^{group} is the number of PHICH groups configured by higher layers as described in section 6.9 of [3],
- $I_{PHICH} = \begin{cases} 1 & \text{for TDD UL/DL configuration 0 with PUSCH transmission in subframe } n = 4 \text{ or } 9 \\ 0 & \text{otherwise} \end{cases}$

Table 9.1.2-2: Mapping between n_{DMRS} and the cyclic shift for DMRS field in DCI format 0 in [4]

Cyclic Shift for DMRS Field in DCI format 0 in [4]	n_{DMRS}
000	0
001	1
010	2
011	3
100	4
101	5
110	6
111	7

9.2 PDCCH validation for semi-persistent scheduling

A UE shall validate a Semi-Persistent Scheduling assignment PDCCH only if all the following conditions are met:

- the CRC parity bits obtained for the PDCCH payload are scrambled with the Semi-Persistent Scheduling C-RNTI
- the new data indicator field, in case of DCI formats 2 and 2A for the enabled transport block, is set to '0'

Validation is achieved if all the fields for the respective used DCI format are set according to Table 9.2-1 or Table 9.2-1A.

If validation is achieved, the UE shall consider the received DCI information accordingly as a valid semi-persistent activation or release.

If validation is not achieved, the received DCI format shall be considered by the UE as having been received with a non-matching CRC.

Table 9.2-1: Special fields for Semi-Persistent Scheduling Activation PDCCH Validation

	DCI format 0	DCI format 1/1A	DCI format 2/2A
TPC command for scheduled PUSCH	set to '00'	N/A	N/A
Cyclic shift DM RS	set to '000'	N/A	N/A
Modulation and coding scheme and redundancy version	MSB is set to '0'	N/A	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	MSB is set to '0'	For the enabled transport block: MSB is set to '0'
Redundancy version	N/A	set to '00'	For the enabled transport block: set to '00'

Table 9.2-1A: Special fields for Semi-Persistent Scheduling Release PDCCH Validation

	DCI format 0	DCI format 1A
TPC command for scheduled PUSCH	set to '00'	N/A
Cyclic shift DM RS	set to '000'	N/A
Modulation and coding scheme and redundancy version	set to '11111'	N/A
Resource block assignment and hopping resource allocation	Set to all '1's	N/A
HARQ process number	N/A	FDD: set to '000' TDD: set to '0000'
Modulation and coding scheme	N/A	set to '11111'
Redundancy version	N/A	set to '00'
Resource block assignment	N/A	Set to all '1's

For the case that the DCI format indicates a semi-persistent downlink scheduling activation, the TPC command for PUCCH field shall be used as an index to one of the four PUCCH resource indices configured by higher layers, with the mapping defined in Table 9.2-2

Table 9.2-2: PUCCH Resource Index for Downlink Semi-Persistent Scheduling

Value of 'TPC command for PUCCH'	$n_{\mathrm{PUCCH}}^{(1)}$
'00'	The first PUCCH resource index configured by the higher layers
'01'	The second PUCCH resource index configured by the higher layers
'10'	The third PUCCH resource index configured by the higher layers
'11'	The fourth PUCCH resource index configured by the higher layers

10 Physical uplink control channel procedures

10.1 UE procedure for determining physical uplink control channel assignment

Uplink control information (UCI) in subframe n shall be transmitted

- on PUCCH using format 1/1a/1b or 2/2a/2b if the UE is not transmitting on PUSCH in subframe n
- on PUSCH if the UE is transmitting on PUSCH in subframe n unless the PUSCH transmission corresponds to a Random Access Response Grant or a retransmission of the same transport block as part of the contention based random access procedure, in which case UCI is not transmitted

Throughout this section, subframes are numbered in monotonically increasing order; if the last subframe of a radio frame is denoted k, the first subframe of the next radio frame is denoted $k+1$.

The following combinations of uplink control information on PUCCH are supported:

- HARQ-ACK using PUCCH format 1a or 1b
- HARQ-ACK using PUCCH format 1b with channel selection

- Scheduling request (SR) using PUCCH format 1
- HARQ-ACK and SR using PUCCH format 1a or 1b
- CQI using PUCCH format 2
- CQI and HARQ-ACK using PUCCH format
  - 2a or 2b for normal cyclic prefix
  - 2 for extended cyclic prefix

The scrambling initialization of PUCCH format 2, 2a and 2b is by C-RNTI.

The parameter *Simultaneous-AN-and-CQI* provided by higher layers determine if a UE can transmit a combination of CQI and HARQ-ACK on PUCCH in the same subframe.

For TDD, two ACK/NACK feedback modes are supported by higher layer configuration.

- ACK/NACK bundling and
- ACK/NACK multiplexing

For TDD UL-DL configuration 5, only ACK/NACK bundling is supported.

TDD ACK/NACK bundling is performed per codeword across M multiple DL subframes associated with a single UL subframe *n*, where M is the number of elements in the set K defined in Table 10.1-1, by a logical AND operation of all the individual PDSCH transmission (with and without corresponding PDCCH) ACK/NACKs and ACK in response to PDCCH indicating downlink SPS release. The bundled 1 or 2 ACK/NACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

For TDD ACK/NACK multiplexing and a subframe *n* with $M > 1$, where M is the number of elements in the set K defined in Table 10.1-1, spatial ACK/NACK bundling across multiple codewords within a DL subframe is performed by a logical AND operation of all the corresponding individual ACK/NACKs and PUCCH format 1b with channel selection is used. For TDD ACK/NACK multiplexing and a subframe *n* with $M = 1$, spatial ACK/NACK bundling across multiple codewords within a DL subframe is not performed, 1 or 2 ACK/NACK bits are transmitted using PUCCH format 1a or PUCCH format 1b, respectively.

For FDD, the UE shall use PUCCH resource $n^{(1)}_{\text{PUCCH}}$ for transmission of HARQ-ACK in subframe n, where

- for a PDSCH transmission indicated by the detection of a corresponding PDCCH in subframe $n-4$, or for a PDCCH indicating downlink SPS release (defined in section 9.2) in subframe $n-4$, the UE shall use $n^{(1)}_{\text{PUCCH}} = n_{\text{CCE}} + N^{(1)}_{\text{PUCCH}}$, where n_{CCE} is the number of the first CCE used for transmission of the corresponding DCI assignment and $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers.
- for a PDSCH transmission where there is not a corresponding PDCCH detected in subframe $n-4$, the value of $n^{(1)}_{\text{PUCCH}}$ is determined according to higher layer configuration and Table 9.2-2.

For TDD ACK/NACK bundling or TDD ACK/NACK multiplexing and a subframe *n* with $M = 1$ where M is the number of elements in the set K defined in Table 10.1-1, the UE shall use PUCCH resource $n^{(1)}_{\text{PUCCH}}$ for transmission of HARQ-ACK in subframe n, where

- If there is PDSCH transmission indicated by the detection of corresponding PDCCH or there is PDCCH indicating downlink SPS release within subframe(s) $n-k$, where $k \in K$ and K (defined in Table 10.1-1) is a set of *M* elements $\{k_0, k_1, \cdots k_{M-1}\}$ depending on the subframe *n* and the UL-DL configuration (defined in Table 4.2-2 in [3]), the UE first selects a p value out of {0, 1, 2, 3} which makes $N_p \le n_{CCE} < N_{p+1}$ and shall use $n^{(1)}_{PUCCH} = (M - m - 1) \times N_p + m \times N_{p+1} + n_{CCE} + N^{(1)}_{PUCCH}$, where $N^{(1)}_{\text{PUCCH}}$ is configured by higher layers, $N_p = \max\{0, \lfloor [N^{\text{DL}}_{\text{RB}} \times (N^{\text{RB}}_{\text{sc}} \times p - 4)] / 36 \rfloor\}$, and n_{CCE} is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_m$ and the corresponding *m*, where k_m is the smallest value in set K such that UE detects a PDCCH in subframe $n-k_m$.

- If there is only a PDSCH transmission where there is not a corresponding PDCCH detected within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1-1, the value of $n^{(1)}_{\mathrm{PUCCH}}$ is determined according to higher layer configuration and Table 9.2-2.

Table 10.1-1: Downlink association set index K: $\{k_0, k_1, \cdots k_{M-1}\}$ for TDD

UL-DL Configuration	Subframe *n*									
	0	1	2	3	4	5	6	7	8	9
0	-	-	6	-	4	-	-	6	-	4
1	-	-	7, 6	4	-	-	-	7, 6	4	-
2	-	-	8, 7, 4, 6	-	-	-	-	8, 7, 4, 6	-	-
3	-	-	7, 6, 11	6, 5	5, 4	-	-	-	-	-
4	-	-	12, 8, 7, 11	6, 5, 4, 7	-	-	-	-	-	-
5	-	-	13, 12, 9, 8, 7, 5, 4, 11, 6	-	-	-	-	-	-	-
6	-	-	7	7	5	-	-	7	7	-

For TDD ACK/NACK multiplexing and sub-frame n with $M > 1$, where M is the number of elements in the set K defined in Table 10.1-1, denote $n^{(1)}_{\mathrm{PUCCH,i}}$ as the ACK/NACK resource derived from sub-frame $n-k_i$ and HARQ-ACK(i) as the ACK/NACK/DTX response from sub-frame $n-k_i$, where $k_i \in K$ (defined in Table 10.1-1) and $0 \le i \le M-1$.

- For a PDSCH transmission or a PDCCH indicating downlink SPS release in sub-frame $n-k_i$ where $k_i \in K$, the ACK/NACK resource $n^{(1)}_{PUCCH,i} = (M-i-1)\times N_p + i \times N_{p+1} + n_{CCE,i} + N^{(1)}_{PUCCH}$, where p is selected from {0, 1, 2, 3} such that $N_p \le n_{CCE} < N_{p+1}$, $N_p = \max\{0, \lfloor [N^{\mathrm{DL}}_{\mathrm{RB}} \times (N^{\mathrm{RB}}_{\mathrm{sc}} \times p - 4)]/36 \rfloor\}$, $n_{\mathrm{CCE,i}}$ is the number of the first CCE used for transmission of the corresponding PDCCH in subframe $n-k_i$, and $N^{(1)}_{\mathrm{PUCCH}}$ is configured by higher layers.
- For a PDSCH transmission where there is not a corresponding PDCCH detected in subframe $n-k_i$, the value of $n^{(1)}_{\mathrm{PUCCH,i}}$ is determined according to higher layer configuration and Table 9.2-2.

The UE shall transmit $b(0), b(1)$ on an ACK/NACK resource $n^{(1)}_{\mathrm{PUCCH}}$ in sub-frame n using PUCCH format 1b according to section 5.4.1 in [3]. The value of $b(0), b(1)$ and the ACK/NACK resource $n^{(1)}_{\mathrm{PUCCH}}$ are generated by channel selection according to Table 10.1-2, 10.1-3, and 10.1-4 for *M* = 2, 3, and 4, respectively. In case $b(0), b(1)$ are mapped to "N/A," then the UE shall not transmit ACK/NACK response in sub-frame n.

Table 10.1-2: Transmission of ACK/NACK multiplexing for *M* = 2

HARQ-ACK(0), HARQ-ACK(1)	$n^{(1)}_{\mathrm{PUCCH}}$	$b(0), b(1)$
ACK, ACK	$n^{(1)}_{\mathrm{PUCCH,1}}$	1, 1
ACK, NACK/DTX	$n^{(1)}_{\mathrm{PUCCH,0}}$	0, 1
NACK/DTX, ACK	$n^{(1)}_{\mathrm{PUCCH,1}}$	0, 0

NACK/DTX, NACK	$n^{(1)}_{\text{PUCCH},1}$	1, 0
NACK, DTX	$n^{(1)}_{\text{PUCCH},0}$	1, 0
DTX, DTX	N/A	N/A

Table 10.1-3: Transmission of ACK/NACK multiplexing for *M* = 3

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n^{(1)}_{\text{PUCCH}}$	$b(0), b(1)$
ACK, ACK, ACK	$n^{(1)}_{\text{PUCCH},2}$	1, 1
ACK, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1, 1
ACK, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},0}$	1, 1
ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	0, 1
NACK/DTX, ACK, ACK	$n^{(1)}_{\text{PUCCH},2}$	1, 0
NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	0, 0
NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},2}$	0, 0
DTX, DTX, NACK	$n^{(1)}_{\text{PUCCH},2}$	0, 1
DTX, NACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1, 0
NACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	1, 0
DTX, DTX, DTX	N/A	N/A

Table 10.1-4: Transmission of ACK/NACK multiplexing for *M* = 4

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n^{(1)}_{\text{PUCCH}}$	$b(0), b(1)$
ACK, ACK, ACK, ACK	$n^{(1)}_{\text{PUCCH},1}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1, 0
NACK/DTX,NACK/DTX,NACK,DTX	$n^{(1)}_{\text{PUCCH},2}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},1}$	1, 0
NACK, DTX, DTX, DTX	$n^{(1)}_{\text{PUCCH},0}$	1, 0

ACK, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 1
NACK/DTX, NACK/DTX, NACK/DTX, NACK	$n^{(1)}_{\text{PUCCH},3}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	0, 1
ACK, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},0}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},0}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 1
NACK/DTX, NACK, DTX, DTX	$n^{(1)}_{\text{PUCCH},1}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	1, 0
NACK/DTX, ACK, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},3}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n^{(1)}_{\text{PUCCH},1}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n^{(1)}_{\text{PUCCH},2}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n^{(1)}_{\text{PUCCH},3}$	0, 0
DTX, DTX, DTX, DTX	N/A	N/A

ACK/NACK repetition is enabled or disabled by a UE specific parameter *ackNackRepetition* configured by higher layers. Once enabled, the UE shall repeat any ACK/NACK transmission with a repetition factor N_{ANRep}, where N_{ANRep} is provided by higher layers and includs the initial ACK/NACK transmission, until ACK/NACK repetition is disabled by higher layers. For a PDSCH transmission without a corresponding PDCCH detected, the UE shall transmit the corresponding ACK/NACK response N_{ANRep} times using PUCCH resource $n^{(1)}_{\text{PUCCH}}$ configured by higher layers. For a PDSCH transmission with a corresponding PDCCH detected, or for a PDCCH indicating downlink SPS release, the UE shall first transmit the corresponding ACK/NACK response once using PUCCH resource derived from the corresponding PDCCH CCE index (as described in Section 10.1), and repeat the transmission of the corresponding ACK/NACK response $N_{\text{ANRep}} - 1$ times always using PUCCH resource $n^{(1)}_{\text{PUCCH, ANRep}}$, where $n^{(1)}_{\text{PUCCH, ANRep}}$ is configured by higher layers.

For TDD, ACK/NACK repetition is only applicable for ACK/NACK bundling and is not applicable for ACK/NACK multiplexing.

The scheduling request (SR) shall be transmitted on the PUCCH resource $n^{(1)}_{\text{PUCCH}} = n^{(1)}_{\text{PUCCH,SRI}}$ as defined in [3], where $n^{(1)}_{\text{PUCCH,SRI}}$ is UE specific and configured by higher layers. The SR configuration for SR transmission periodicity and subframe offset is defined by SR configuration index I_{SR} in Table 10.1-5.

SR transmission instances are the subframes satisfying $\left(10\times n_f + \lfloor n_s/2 \rfloor - N_{OFFSET,SR}\right) \bmod SR_{Periodicity} = 0$, where n_f is the system frame number, and n_s = {0,1,…, 19} is the slot index within the frame, and $N_{OFFSET,SR}$ is the SR subframe offset defined in Table 10.1-5 and $SR_{Periodicity}$ is the SR periodicity defined in Table 10.1-5.

Table 10.1-5: UE-specific SR periodicity and subframe offset configuration

SR configuration Index I_{SR}	SR periodicity (ms)	SR subframe offset
0 – 4	5	I_{SR}
5 – 14	10	$I_{SR}-5$
15 – 34	20	$I_{SR}-15$
35 – 74	40	$I_{SR}-35$
75 – 154	80	$I_{SR}-75$
155	Reserved	

10.2 Uplink ACK/NACK timing

For FDD, the UE shall upon detection of a PDSCH transmission in subframe *n-4* intended for the UE and for which an ACK/NACK shall be provided, transmit the ACK/NACK response in subframe *n*. If ACK/NACK repetition is enabled, upon detection of a PDSCH transmission in subframe *n-4* intended for the UE and for which ACK/NACK response shall be provided, and if the UE is not repeating the transmission of any ACK/NACK in subframe n corresponding to a PDSCH transmission in subframes $n - N_{\mathrm{ANRep}} - 3$, … , $n-5$, the UE:

- shall transmit only the ACK/NACK response (corresponding to the detected PDSCH transmission in subframe $n-4$) on PUCCH in subframes n, $n+1$, …, $n+N_{\mathrm{ANRep}}-1$;
- shall not transmit any other signal in subframes n, $n+1$, …, $n+N_{\mathrm{ANRep}}-1$; and
- shall not transmit any ACK/NACK response repetitions corresponding to any detected PDSCH transmission in subframes $n-3$, …, $n+N_{\mathrm{ANRep}}-5$.

For TDD, the UE shall upon detection of a PDSCH transmission within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1-1 intended for the UE and for which ACK/NACK response shall be provided, transmit the ACK/NACK response in UL subframe *n*. If ACK/NACK repetition is enabled, upon detection of a PDSCH transmission within subframe(s) $n-k$, where $k \in K$ and K is defined in Table 10.1-1 intended for the UE and for which ACK/NACK response shall be provided, and if the UE is not repeating the transmission of any ACK/NACK in suframe n corresponding to a PDSCH transmission in a DL subframe earlier than subframe $n-k$, the UE:

- shall transmit only the ACK/NACK response (corresponding to the detected PDSCH transmission in subframe $n-k$) on PUCCH in UL subframe n and the next $N_{\mathrm{ANRep}}-1$ UL subframes denoted as n_1, …, $n_{N_{\mathrm{ANRep}}-1}$;
- shall not transmit any other signal in UL subframe n, n_1, …, $n_{N_{\mathrm{ANRep}}-1}$; and

- shall not transmit any ACK/NACK response repetitions corresponding to any detected PDSCH transmission in subframes $n_i - k$, where $k \in K_i$, K_i is the set defined in Table 10.1-1 corresponding to UL subframe n_i, and $1 \le i \le N_{\text{ANRep}} - 1$.

For TDD, ACK/NACK bundling, if the UE detects that at least one downlink assignment has been missed as described in Section 7.3, the UE shall not transmit ACK/NACK in case the UE is not transmitting on PUSCH.

The uplink timing for the ACK corresponding to a detected PDCCH indicating downlink SPS release shall be the same as the uplink timing for the ACK/NACK corresponding to a detected PDSCH, as defined above.

Annex A (informative): Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2006-09					Draft version created		0.0.0
2006-10					Endorsed by RAN1	0.0.0	0.1.0
2007-01					Inclusion of decisions from RAN1#46bis and RAN1#47	0.1.0	0.1.1
2007-01					Endorsed by RAN1	0.1.1	0.2.0
2007-02					Inclusion of decisions from RAN1#47bis	0.2.0	0.2.1
2007-02					Endorsed by RAN1	0.2.1	0.3.0
2007-02					Editor's version including decisions from RAN1#48 & RAN1#47bis	0.3.0	0.3.1
2007-03					Updated Editor's version	0.3.1	0.3.2
2007-03	RAN#35	RP-070171			For information at RAN#35	0.3.2	1.0.0
2007-03					Random access text modified to better reflect RAN1 scope	1.0.0	1.0.1
2007-03					Updated Editor's version	1.0.1	1.0.2
2007-03					Endorsed by RAN1	1.0.2	1.1.0
2007-05					Updated Editor's version	1.1.0	1.1.1
2007-05					Updated Editor's version	1.1.1	1.1.2
2007-05					Endorsed by RAN1	1.1.2	1.2.0
2007-08					Updated Editor's version	1.2.0	1.2.1
2007-08					Updated Editor's version – uplink power control from RAN1#49bis	1.2.1	1.2.2
2007-08					Endorsed by RAN1	1.2.2	1.3.0
2007-09					Updated Editor's version reflecting RAN#50 decisions	1.3.0	1.3.1
2007-09					Updated Editor's version reflecting comments	1.3.1	1.3.2
2007-09					Updated Editor's version reflecting further comments	1.3.2	1.3.3
2007-09					Updated Editor's version reflecting further comments	1.3.3	1.3.4
2007-09					Updated Edtior's version reflecting further comments	1.3.4	1.3.5
2007-09	RAN#37	RP-070731			Endorsed by RAN1	1.3.5	2.0.0
2007-09	RAN#37	RP-070737			For approval at RAN#37	2.0.0	2.1.0
12/09/07	RAN_37	RP-070737	-	-	Approved version	2.1.0	8.0.0
28/11/07	RAN_38	RP-070949	0001	2	Update of 36.213	8.0.0	8.1.0
05/03/08	RAN_39	RP-080145	0002	-	Update of TS36.213 according to changes listed in cover sheet	8.1.0	8.2.0
28/05/08	RAN_40	RP-080434	0003	1	PUCCH timing and other formatting and typo corrections	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0006	1	PUCCH power control for non-unicast information	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0008	-	UE ACK/NACK Procedure	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0009	-	UL ACK/NACK timing for TDD	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0010	-	Specification of UL control channel assignment	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0011	-	Precoding Matrix for 2Tx Open-loop SM	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0012	-	Clarifications on UE selected CQI reports	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0013	1	UL HARQ Operation and Timing	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0014	-	SRS power control	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0015	1	Correction of UE PUSCH frequency hopping procedure	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0017	4	Blind PDCCH decoding	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0019	1	Tx Mode vs DCI format is clarified	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0020	-	Resource allocation for distributed VRB	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0021	2	Power Headroom	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0022	-	Clarification for RI reporting in PUCCH and PUSCH reporting modes	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0025	-	Correction of the description of PUSCH power control for TDD	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0026	-	UL ACK/NACK procedure for TDD	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0027	-	Indication of radio problem detection	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0028	-	Definition of Relative Narrowband TX Power Indicator	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0029	-	Calculation of $\Delta_{TF}(i)$ for UL-PC	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0030	-	CQI reference and set S definition, CQI mode removal, and Miscellanious	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0031	-	Modulation order and TBS determination for PDSCH and PUSCH	8.2.0	8.3.0
28/05/08	RAN_40	RP-080434	0032	-	On Sounding RS	8.2.0	8.3.0
28/05/08	RAN_40	RP-080426	0033	-	Multiplexing of rank and CQI/PMI reports on PUCCH	8.2.0	8.3.0
28/05/08	RAN_40	RP-080466	0034	-	Timing advance command responding time	8.2.0	8.3.0
09/09/08	RAN_41	RP-080670	37	2	SRS hopping pattern for closed loop antenna selection	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	39	2	Clarification on uplink power control	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	41	-	Clarification on DCI formats using resource allocation type 2	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	43	2	Clarification on tree structure of CCE aggregations	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	46	2	Correction of the description of PUCCH power control for TDD	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	47	1	Removal of CR0009	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	48	1	Correction of mapping of cyclic shift value to PHICH modifier	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	49	-	TBS disabling for DCI formats 2 and 2A	8.3.0	8.4.0

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
09/09/08	RAN_41	RP-080670	50	-	Correction of maximum TBS sizes	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	51	-	Completion of the table specifying the number of bits for the periodic feedback	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	54	-	Clarification of RNTI for PUSCH/PUCCH power control with DCI formats 3/3A	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	55	1	Clarification on mapping of Differential CQI fields	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	59	1	PUSCH Power Control	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	60	-	RB restriction and modulation order for CQI-only transmission on PUSCH	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	61	-	Modulation order determination for uplink retransmissions	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	62	2	Introducing missing L1 parameters into 36.213	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	63	2	Correcting the range and representation of delta_TF_PUCCH	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	64	1	Adjusting TBS sizes to for VoIP	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	67	-	Correction to the downlink resource allocation	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	68	-	Removal of special handling for PUSCH mapping in PUCCH region	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	69	-	Correction to the formulas for uplink power control	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	70	1	Definition of Bit Mapping for DCI Signalling	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	71	-	Clarification on PUSCH TPC commands	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	72	1	Reference for CQI/PMI Reporting Offset	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	74	-	Correction to the downlink/uplink timing	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	75	-	Correction to the time alignment command	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	77	1	Correction of offset signalling of UL Control information MCS	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	78	2	DCI format1C	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	80	-	Correction to Precoder Cycling for Open-loop Spatial Multiplexing	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	81	1	Clarifying Periodic CQI Reporting using PUCCH	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	84	1	CQI reference measurement period	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	86	-	Correction on downlink multi-user MIMO	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	87	-	PUCCH Reporting	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	88	1	Handling of Uplink Grant in Random Access Response	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	89	-	Correction to UL Hopping operation	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	90	-	DRS EPRE	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	92	-	Uplink ACK/NACK mapping for TDD	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	93	-	UL SRI Parameters Configuration	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	94	-	Miscellaneous updates for 36.213	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	95	-	Clarifying Requirement for Max PDSCH Coding Rate	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	96	-	UE Specific SRS Configuration	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	97	-	DCI Format 1A changes needed for scheduling Broadcast Control	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	98	-	Processing of TPC bits in the random access response	8.3.0	8.4.0
09/09/08	RAN_41	RP-080670	100	1	Support of multi-bit ACK/NAK transmission in TDD	8.3.0	8.4.0
03/12/08	RAN_42	RP-081075	82	3	Corrections to RI for CQI reporting	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	83	2	Moving description of large delay CDD to 36.211	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	102	3	Reception of DCI formats	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	105	8	Alignment of RAN1/RAN2 specification	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	107	1	General correction of reset of power control and random access response message	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	108	2	Final details on codebook subset restrictions	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	109	-	Correction on the definition of Pmax	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	112	2	CQI/PMI reference measurement periods	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	113	-	Correction of introduction of shortened SR	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	114	-	RAN1/2 specification alignment on HARQ operation	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	115	-	Introducing other missing L1 parameters in 36.213	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	116	-	PDCCH blind decoding	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	117	-	PDCCH search space	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	119	-	Delta_TF for PUSCH	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	120	-	Delta_preamble_msg3 parameter values and TPC command in RA response	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	122	1	Correction of offset signaling of uplink control information MCS	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	124	-	Miscellaneous Corrections	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	125	-	Clarification of the uplink index in TDD mode	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	126	-	Clarification of the uplink transmission configurations	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	127	2	Correction to the PHICH index assignment	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	128	-	Clarification of type-2 PDSCH resource allocation for format 1C	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	129	-	Clarification of uplink grant in random access response	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	130	-	UE sounding procedure	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	134	-	Change for determining DCI format 1A TBS table column indicator for broadcast control	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	135	-	Clarifying UL VRB Allocation	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	136	1	Correction for Aperiodic CQI	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	137	1	Correction for Aperiodic CQI Reporting	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	138	1	Correction to PUCCH CQI reporting mode for N^DL_RB <= 7	8.4.0	8.5.0

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Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
03/12/08	RAN_42	RP-081075	140	1	On sounding procedure in TDD	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	141	1	Alignment of RAN1/RAN3 specification	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	143	1	TTI bundling	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	144	1	ACK/NACK transmission on PUSCH for LTE TDD	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	145	1	Timing relationship between PHICH and its associated PUSCH	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	147	1	Definition of parameter for downlink reference signal transmit power	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	148	1	Radio link monitoring	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	149	1	Correction in 36.213 related to TDD downlink HARQ processes	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	151	-	Nominal PDSCH-to-RS EPRE Offset for CQI Reporting	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	152	1	Support of UL ACK/NAK repetition in Rel-8	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	155	-	Clarification of misconfiguration of aperiodic CQI and SR	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	156	1	Correction of control information multiplexing in subframe bundling mode	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	157	-	Correction to the PHICH index assignment	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	158	1	UE transmit antenna selection	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	159	-	Clarification of spatial different CQI for CQI reporting Mode 2-1	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	160	1	Corrections for TDD ACK/NACK bundling and multiplexing	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	161	-	Correction to RI for Open-Loop Spatial Multiplexing	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	162	-	Correction of differential CQI	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	163	-	Inconsistency between PMI definition and codebook index	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	164	-	PDCCH validation for semi-persistent scheduling	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	165	1	Correction to the UE behavior of PUCCH CQI piggybacked on PUSCH	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	166	-	Correction on SRS procedure when shortened PUCCH format is used	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	167	1	Transmission overlapping of physical channels/signals with PDSCH for transmission mode 7	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	169	-	Clarification of SRS and SR transmission	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	171	-	Clarification on UE behavior when skipping decoding	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	172	1	PUSCH Hopping operation corrections	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	173	-	Clarification on message 3 transmission timing	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	174	-	MCS handling for DwPTS	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	175	-	Clarification of UE-specific time domain position for SR transmission	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	176	1	Physical layer parameters for CQI reporting	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	177	-	A-periodic CQI clarification for TDD UL/DL configuration 0	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	179	1	Correction to the definitions of rho_A and rho_B (downlink power allocation)	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	180	-	Clarification of uplink A/N resource indication	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	181	-	PDCCH format 0 for message 3 adaptive retransmission and transmission of control information in message 3 during contention based random access procedure	8.4.0	8.5.0
03/12/08	RAN_42	RP-081075	182	-	To Fix the Discrepancy of Uplink Power Control and Channel Coding of Control Information in PUSCH	8.4.0	8.5.0
03/12/08	RAN_42	RP-081122	183	1	CQI reporting for antenna port 5	8.4.0	8.5.0
03/12/08	RAN_42	RP-081110	168	1	Clarification on path loss definition	8.4.0	8.5.0
04/03/09	RAN_43	RP-090236	184	1	Corrections to Transmitted Rank Indication	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	185	4	Corrections to transmission modes	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	186	2	Delta_TF configuration for control only PUSCH	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	187	1	Correction to concurrent SRS and ACK/NACK transmission	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	191	1	PDCCH release for semi-persistent scheduling	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	192	1	Correction on ACKNACK transmission on PUSCH for LTE TDD	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	193	-	Correction to subband differential CQI value to offset level mapping for aperiodic CQI reporting	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	194	-	Correction for DRS Collision handling	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	196	2	Alignment of RAN1/RAN4 specification on UE maximum output power	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	197	-	Transmission scheme for transmission mode 7 with SPS C-RNTI	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	198	-	Clarifying bandwidth parts for periodic CQI reporting and CQI refererence period	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	199	2	Correction to the ACK/NACK bundling in case of transmission mode 3 and 4	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	200	-	ACK/NAK repetition for TDD ACK/NAK multiplexing	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	201	-	Clarifying UL ACK/NAK transmission in TDD	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	202	-	Corrections to UE Transmit Antenna Selection	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	203	-	Correction to UE PUSCH hopping procedure	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	204	-	Correction to PHICH resource association in TTI bundling	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	205	-	Clarification of the length of resource assignment	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	206	-	Correction on ACK/NACK transmission for downlink SPS resource	8.5.0	8.6.0

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Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
					release		
04/03/09	RAN_43	RP-090236	207	-	Introduction of additional values of wideband CQI/PMI periodicities	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	208	2	Correction to CQI/PMI/RI reporting field	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	209	2	Correction to rho_A definition for CQI calculation	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	210	-	Correction to erroneous cases in PUSCH linear block codes	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	211	1	Removing RL monitoring start and stop	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	214	1	Correction to type-1 and type-2 PUSCH hopping	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	215	-	Contradicting statements on determination of CQI subband size	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	216	-	Corrections to SRS	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	219	2	Miscellaneous corrections on TDD ACKNACK	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	221	1	CR for Redundancy Version mapping function for DCI 1C	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	223	-	Scrambling of PUSCH corresponding to Random Access Response Grant	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	225	-	Removal of SRS with message 3	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	226	3	PRACH retransmission timing	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	227	-	Clarifying error handling of PDSCH and PUSCH assignments	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	228	-	Clarify PHICH index mapping	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	229	-	Correction of CQI timing	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	230	-	Alignment of CQI parameter names with RRC	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	231	1	Removal of 'Off' values for periodic reporting in L1	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	232	-	Default value of RI	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	233	1	Clarification of uplink timing adjustments	8.5.0	8.6.0
04/03/09	RAN_43	RP-090236	234	-	Clarification on ACK/NAK repetition	8.5.0	8.6.0

History

Document history		
V8.3.0	November 2008	Publication
V8.4.0	November 2008	Publication
V8.5.0	February 2009	Publication
V8.6.0	April 2009	Publication