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*Technical Specification*

**LTE;  
Evolved Universal Terrestrial Radio Access (E-UTRA);  
Physical layer procedures  
(3GPP TS 36.213 version 8.8.0 Release 8)**

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# 1 Scope

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

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# 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.
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- [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:

|                 |                                                                                                     |
|-----------------|-----------------------------------------------------------------------------------------------------|
| $N_{RB}^{DL}$   | Downlink bandwidth configuration, expressed in units of $N_{sc}^{RB}$ as defined in [3]             |
| $N_{RB}^{UL}$   | Uplink bandwidth configuration, expressed in units of $N_{sc}^{RB}$ as defined in [3]               |
| $N_{symb}^{UL}$ | Number of SC-FDMA symbols in an uplink slot as defined in [3]                                       |
| $N_{sc}^{RB}$   | 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

No functionality is specified in this section in this release.

#### 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  $T_A = 0, 1, 2, \dots, 1282$ , 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  $T_A = 0, 1, 2, \dots, 63$ , where  $N_{TA,new} = N_{TA,old} + (T_A - 31) \times 16$ . Here, adjustment of  $N_{TA}$  value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing by a given amount respectively.

For a timing advance command 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 SC-FDMA symbol in which the physical channel is transmitted.

### 5.1 Uplink power control

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

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

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

where,

- $P_{\text{CMAX}}$  is the configured UE transmitted power defined in [6]
- $M_{\text{PUSCH}}(i)$  is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe  $i$ .
- $P_{\text{O\_PUSCH}}(j)$  is a parameter composed of the sum of a cell specific nominal component  $P_{\text{O\_NOMINAL\_PUSCH}}(j)$  provided from higher layers for  $j=0$  and  $1$  and a UE specific component  $P_{\text{O\_UE\_PUSCH}}(j)$  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  $j=2$ .  $P_{\text{O\_UE\_PUSCH}}(2) = 0$  and  $P_{\text{O\_NOMINAL\_PUSCH}}(2) = P_{\text{O\_PRE}} + \Delta_{\text{PREAMBLE\_Msg3}}$ , where the parameter  $P_{\text{O\_PRE}}$  and  $\Delta_{\text{PREAMBLE\_Msg3}}$  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  $PL = \text{referenceSignalPower} - \text{higher layer filtered RSRP}$ , where referenceSignalPower is provided by higher layers and RSRP is defined in [5] and the higher layer filter configuration is defined in [11]
- $\Delta_{\text{TF}}(i) = 10\log_{10}((2^{MPR \cdot K_S} - 1)\beta_{\text{offset}}^{\text{PUSCH}})$  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
  - $MPR = O_{\text{CQI}} / N_{\text{RE}}$  for control data sent via PUSCH without UL-SCH data and  $\sum_{r=0}^{C-1} K_r / N_{\text{RE}}$  for other cases.
    - where  $C$  is the number of code blocks,  $K_r$  is the size for code block  $r$ ,  $O_{\text{CQI}}$  is the number of CQI bits including CRC bits and  $N_{\text{RE}}$  is the number of resource elements

determined as  $N_{RE} = M_{sc}^{PUSCH-initial} \cdot N_{symbol}^{PUSCH-initial}$ , where  $C$ ,  $K_r$ ,  $M_{sc}^{PUSCH-initial}$  and  $N_{symbol}^{PUSCH-initial}$  are defined in [4].

- $\beta_{offset}^{PUSCH} = \beta_{offset}^{CQI}$  for control data sent via PUSCH without UL-SCH data and 1 for other cases.
- $\delta_{PUSCH}$  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  $\delta_{PUSCH}$  is included in a PDCCH with DCI format 0 where the CRC is scrambled by the Temporary C-RNTI
    - where  $\delta_{PUSCH}(i - K_{PUSCH})$  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 or SPS C-RNTI and a PDCCH of DCI format 3/3A with this UE's TPC-PUSCH-RNTI in every subframe except when in DRX
    - If DCI format 0 and DCI format 3/3A are both detected in the same subframe, then the UE shall use the  $\delta_{PUSCH}$  provided in DCI format 0.
    - $\delta_{PUSCH} = 0$  dB for a subframe where no TPC command is decoded or where DRX occurs or  $i$  is not an uplink subframe in TDD.
    - The  $\delta_{PUSCH}$  dB accumulated values signalled on PDCCH with DCI format 0 are given in Table 5.1.1.1-2. If the PDCCH with DCI format 0 is validated as a SPS activation or release PDCCH, then  $\delta_{PUSCH}$  is 0dB.
    - The  $\delta_{PUSCH}$  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  $P_{O\_UE\_PUSCH}$  value is changed by higher layers
      - when the UE receives random access response message
  - $f(i) = \delta_{PUSCH}(i - K_{PUSCH})$  if accumulation is not enabled based on the UE-specific parameter *Accumulation-enabled* provided by higher layers

- where  $\delta_{PUSCH}(i - K_{PUSCH})$  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 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  $\delta_{PUSCH}$  dB absolute values signalled on PDCCH with DCI format 0 are given in Table 5.1.1.1-2. If the PDCCH with DCI format 0 is validated as a SPS activation or release PDCCH, then  $\delta_{PUSCH}$  is 0dB.
- $f(i) = f(i-1)$  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  $P_{O\_UE\_PUSCH}$  value is changed by higher layers,
    - $f(i) = 0$
  - Else
    - $f(0) = \Delta P_{rampup} + \delta_{msg2}$ 
      - where  $\delta_{msg2}$  is the TPC command indicated in the random access response, see Section 6.2, and
      - $\Delta P_{rampup}$  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  $\delta_{\text{PUSCH}}$  values.**

| TPC Command Field in DCI format 0/3 | Accumulated $\delta_{\text{PUSCH}}$ [dB] | Absolute $\delta_{\text{PUSCH}}$ [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  $\delta_{\text{PUSCH}}$  values.**

| TPC Command Field in DCI format 3A | $\delta_{\text{PUSCH}}$ [dB] |
|------------------------------------|------------------------------|
| 0                                  | -1                           |
| 1                                  | 1                            |

### 5.1.1.2 Power headroom

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

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

where,  $P_{\text{CMAX}}$ ,  $M_{\text{PUSCH}}(i)$ ,  $P_{\text{O\_PUSCH}}(j)$ ,  $\alpha(j)$ ,  $PL$ ,  $\Delta_{\text{TF}}(i)$  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  $P_{\text{PUCCH}}$  for the physical uplink control channel (PUCCH) transmission in subframe  $i$  is defined by

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

where

- $P_{\text{CMAX}}$  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  $n_{\text{CQI}}$  corresponds to the number information bits for the channel quality information defined in section 5.2.3.3 in [4] and  $n_{\text{HARQ}}$  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
 
$$h(n_{CQI}, n_{HARQ}) = \begin{cases} 10 \log_{10} \left( \frac{n_{CQI} + n_{HARQ}}{4} \right) & \text{if } n_{CQI} + n_{HARQ} \geq 4 \\ 0 & \text{otherwise} \end{cases}$$
- $P_{O\_PUCCH}$  is a parameter composed of the sum of a cell specific parameter  $P_{O\_NOMINAL\_PUCCH}$  provided by higher layers and a UE specific component  $P_{O\_UE\_PUCCH}$  provided by higher layers.
- $\delta_{PUCCH}$  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 or SPS 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 or SPS C-RNTI of the UE, the UE shall use the  $\delta_{PUCCH}$  provided in that PDCCH.

else

  - if the UE decodes a PDCCH with DCI format 3/3A, the UE shall use the  $\delta_{PUCCH}$  provided in that PDCCH
  - else the UE shall set  $\delta_{PUCCH} = 0$  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  $\delta_{PUCCH}$  dB values signalled on PDCCH with DCI format 1A/1B/1D/1/2A/2 are given in Table 5.1.2.1-1. If the PDCCH with DCI format 1/1A/2/2A is validated as an SPS activation PDCCH, or the PDCCH with DCI format 1A is validated as an SPS release PDCCH, then  $\delta_{PUCCH}$  is 0dB.
  - The  $\delta_{PUCCH}$  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  $P_{O\_UE\_PUCCH}$  value is changed by higher layers,
      - $g(i) = 0$
    - Else
      - $g(0) = \Delta P_{rampup} + \delta_{Msg2}$

- where  $\delta_{msg2}$  is the TPC command indicated in the random access response, see Section 6.2 and
- $\Delta P_{rampup}$  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  $P_{O\_UE\_PUCCH}$  value is changed by higher layers
  - 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  $\delta_{PUCCH}$  values.**

| TPC Command Field in DCI format 1A/1B/1D/1/2A/2/3 | $\delta_{PUCCH}$ [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  $\delta_{PUCCH}$  values.**

| TPC Command Field in DCI format 3A | $\delta_{PUCCH}$ [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

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

where

- $P_{CMAX}$  is the configured UE transmitted power defined in [6]
- For  $K_S = 1.25$ ,  $P_{SRS\_OFFSET}$  is a 4-bit UE specific parameter semi-statically configured by higher layers with 1dB step size in the range [-3, 12] dB.
- For  $K_S = 0$ ,  $P_{SRS\_OFFSET}$  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.
- $P_{O\_PUSCH}(j)$  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  $\rho_A$  or  $\rho_B$  according to the OFDM symbol index as given by Table 5.2-2. In addition,  $\rho_A$  and  $\rho_B$  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,

- $\rho_A$  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];
- $\rho_A$  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 the PRBs upon which the corresponding PDSCH is mapped, the ratio of PDSCH EPRE to UE-specific RS EPRE within each OFDM symbol containing UE-specific RSs shall be a constant, and that constant shall be maintained over all the OFDM symbols containing the UE-specific RSs in the corresponding PRBs. In addition, the UE may assume that for 16QAM or 64QAM, this ratio is 0 dB.

The cell-specific ratio  $\rho_B / \rho_A$  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  $\rho_B / \rho_A$  for 1, 2, or 4 cell specific antenna ports**

| $P_B$ | $\rho_B / \rho_A$ |                            |
|-------|-------------------|----------------------------|
|       | 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  $\rho_A$  or  $\rho_B$**

| Number of antenna | OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is | OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is |
|-------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|
|-------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|

| ports             | denoted by $\rho_A$  |                        | denoted by $\rho_B$  |                        |
|-------------------|----------------------|------------------------|----------------------|------------------------|
|                   | Normal cyclic prefix | Extended cyclic prefix | Normal cyclic prefix | Extended cyclic prefix |
| <b>One or two</b> | 1, 2, 3, 5, 6        | 1, 2, 4, 5             | 0, 4                 | 0, 3                   |
| <b>Four</b>       | 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:

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

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  $n_{PRB} = 0, \dots, N_{RB}^{DL} - 1$ ;  $RNTP_{threshold}$  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

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

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

# 6 Random access procedure

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

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

## 6.1 Physical non-synchronized random access procedure

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

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

1. Layer 1 procedure is triggered upon request of a preamble transmission by higher layers.
2. A preamble index, a target preamble received power (PREAMBLE\_RECEIVED\_TARGET\_POWER), a corresponding RA-RNTI and a PRACH resource are indicated by higher layers as part of the request.
3. A preamble transmission power  $P_{\text{PRACH}}$  is determined as  

$$P_{\text{PRACH}} = \min\{P_{\text{CMAX}}, \text{PREAMBLE\_RECEIVED\_TARGET\_POWER} + \text{PL}\} [\text{dBm}]$$
, where  $P_{\text{CMAX}}$  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  $P_{\text{PRACH}}$  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

$b = \left\lceil \log_2 \left( N_{RB}^{UL} \cdot (N_{RB}^{UL} + 1) / 2 \right) \right\rceil$ , 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  $b = \left( \left\lceil \log_2 \left( N_{RB}^{UL} \cdot (N_{RB}^{UL} + 1) / 2 \right) \right\rceil - 10 \right)$ , 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  $\delta_{msg2}$  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  $\delta_{msg2}$  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.

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

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

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

## 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 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. For frame structure type 2 with normal CP, in the special subframe with configuration #1 or #6 the UE is not expected to receive PDSCH on antenna port 5 for which distributed VRB resource allocation is assigned.

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 ( $N_{\text{RBG}}$ ) for downlink system bandwidth of  $N_{\text{RB}}^{\text{DL}}$  PRBs is given by  $N_{\text{RBG}} = \lceil N_{\text{RB}}^{\text{DL}} / P \rceil$  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  $N_{\text{RBG}}$  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<br>$N_{RB}^{DL}$ | RBG Size<br>( $P$ ) |
|-----------------------------------|---------------------|
| $\leq 10$                         | 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  $0 \leq p < P$ , consists of every  $P$ th RBG starting from RBG  $p$ . The resource block assignment information consists of three fields [4].

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

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

The third field includes a bitmap, where each bit of the bitmap addresses a single 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  $N_{RB}^{TYPE1}$  and is defined as

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

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

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

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

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

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

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

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

For PDCCH DCI format 1A, 1B or 1D, a type 2 resource allocation field consists of a resource indication value ( $RIV$ ) corresponding to a starting resource block ( $RB_{\text{start}}$ ) and a length in terms of virtually contiguously allocated resource blocks  $L_{\text{CRBs}}$ . The resource indication value is defined by

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

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

else

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

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

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

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

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

else

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

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  $N^{1A}_{PRB}$  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

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

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<br>$I_{MCS}$ | Modulation Order<br>$Q_m$ | TBS Index<br>$I_{TBS}$ |
|------------------------|---------------------------|------------------------|
| 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:
  - the UE shall set the TBS index ( $I_{\text{TBS}}$ ) equal to  $I_{\text{MCS}}$  and determine its TBS by the procedure in Section 7.1.7.2.1.
- for DCI format 1C:
  - the UE shall set the TBS index ( $I_{\text{TBS}}$ ) equal to  $I_{\text{MCS}}$  and determine its TBS from Table 7.1.7.2.3-1.

else

- for  $0 \leq I_{\text{MCS}} \leq 28$ , the UE shall first determine the TBS index ( $I_{\text{TBS}}$ ) using  $I_{\text{MCS}}$  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  $29 \leq I_{\text{MCS}} \leq 31$ , the TBS is assumed to be as determined from DCI transported in the latest PDCCH for the same transport block using  $0 \leq I_{\text{MCS}} \leq 28$ . If there is no PDCCH for the same transport block using  $0 \leq I_{\text{MCS}} \leq 28$ , and if the initial PDSCH for the same transport block is semi-persistently scheduled, the TBS shall be determined from the most recent semi-persistent scheduling assignment PDCCH.
- In DCI formats 2 and 2A a transport block is disabled if  $I_{\text{MCS}} = 0$  and if  $rv_{\text{idx}} = 1$  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  $1 \leq N_{\text{PRB}} \leq 110$ , the TBS is given by the  $(I_{\text{TBS}}, N_{\text{PRB}})$  entry of Table 7.1.7.2.1-1.

**Table 7.1.7.2.1-1: Transport block size table (dimension 27×110)**

| $I_{\text{TBS}}$ | $N_{\text{PRB}}$ |      |      |      |      |      |      |      |      |      |
|------------------|------------------|------|------|------|------|------|------|------|------|------|
|                  | 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 |

  

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

For  $56 \leq N_{PRB} \leq 110$ , a baseline TBS\_L1 is taken from the  $(I_{TBS}, N_{PRB})$  entry of Table 7.1.7.2.1-1, which is then translated into TBS\_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  $I_{\text{TBS}}$  entry of Table 7.1.7.2.3-1.

**Table 7.1.7.2.3-1: Transport Block Size Table for DCI format 1C**

| $I_{\text{TBS}}$ | 0   | 1   | 2   | 3   | 4   | 5   | 6   | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   | 15   |
|------------------|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|
| <b>TBS</b>       | 40  | 56  | 72  | 120 | 136 | 144 | 176 | 208  | 224  | 256  | 280  | 296  | 328  | 336  | 392  | 488  |
| $I_{\text{TBS}}$ | 16  | 17  | 18  | 19  | 20  | 21  | 22  | 23   | 24   | 25   | 26   | 27   | 28   | 29   | 30   | 31   |
| <b>TBS</b>       | 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  $N_{RB}^{DL}$  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  $a_{A_c-1}, \dots, a_3, a_2, a_1, a_0$  where  $a_0$  is the LSB and  $a_{A_c-1}$  is the MSB and where a bit value of zero indicates that the PMI and RI reporting is not allowed to correspond to precoder(s) associated with the bit. The association of bits to precoders for the relevant transmission modes are given as follows:

1. Transmission mode 3
  - a. 2 antenna ports: bit  $a_{v-1}$ ,  $v = 2$  is associated with the precoder in Table 6.3.4.2.3-1 of [3] corresponding to  $v$  layers and codebook index 0 while bit  $a_0$  is associated with the precoder for 2 antenna ports in Section 6.3.4.3 of [3].
  - b. 4 antenna ports: bit  $a_{v-1}$ ,  $v = 2, 3, 4$  is associated with the precoders in Table 6.3.4.2.3-2 of [3] corresponding to  $v$  layers and codebook indices 12, 13, 14, and 15 while bit  $a_0$  is associated with the precoder for 4 antenna ports in 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  $a_{16(v-1)+i_c}$  is associated with the precoder for  $v$  layers and with codebook index  $i_c$  in Table 6.3.4.2.3-2 of [3].

## 3. Transmission modes 5 and 6

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

**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 $v$ |       |
|----------------------|----------------------|-------|
|                      | 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                              | $\geq 3$     |
| 4                              | $\leq -4$    |
| 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  $N_{RB}^{DL} \leq 7$ , 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                              | $\geq 2$     |
| 3                              | $\leq -1$    |

- 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<br>$N_{RB}^{DL}$ | Subband Size<br>( $k$ ) |
|-----------------------------------|-------------------------|
| 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
- $$r = \sum_{i=0}^{M-1} \binom{N-s_i}{M-i}$$
  - where the set  $\{s_i\}_{i=0}^{M-1}$ ,  $(1 \leq s_i \leq N, s_i < s_{i+1})$  contains the  $M$  sorted subband indices
- and  $\binom{x}{y} = \begin{cases} \binom{x}{y} & x \geq y \\ 0 & x < y \end{cases}$  is the extended binomial coefficient, resulting in unique label
- $$r \in \left\{ 0, \dots, \binom{N}{M} - 1 \right\}.$$
- The CQI value for the  $M$  selected subbands for each codeword is encoded differentially using 2-bits relative to its respective wideband CQI as defined by
- Differential CQI offset level =  $M$  selected subbands CQI index – wideband CQI index
  - The mapping from the 2-bit differential CQI value to the offset level is shown in Table 7.2.1-4.

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

| Differential CQI value | Offset level |
|------------------------|--------------|
| 0                      | $\leq 1$     |
| 1                      | 2            |
| 2                      | 3            |
| 3                      | $\geq 4$     |

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

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  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod N_P = 0$ , where  $n_f$  is the system frame number, and  $n_s = \{0, 1, \dots, 19\}$  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  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI} - N_{OFFSET,RI}) \bmod (N_P \cdot M_{RI}) = 0$ , where  $n_f$  is the system frame number, and  $n_s = \{0, 1, \dots, 19\}$  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  $\{0, -1, \dots, -(N_P-1)\}$ .
  - 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  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod N_P = 0$ , where  $n_f$  is the system frame number, and  $n_s = \{0, 1, \dots, 19\}$  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  $H \cdot N_P$ , and is reported on the subframes satisfying  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET,CQI}) \bmod (H \cdot N_P) = 0$ , where  $n_f$  is the system frame number, and  $n_s$

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

- Between every two consecutive wideband CQI/PMI reports, the remaining  $J \cdot K$  reporting instances are used in sequence for subband CQI reports on  $K$  full cycles of bandwidth parts except when the gap between two consecutive wideband CQI/PMI reports contains less than  $J \cdot K$  reporting instances due to a system frame number transition to 0, in which case the UE shall not transmit the remainder of the subband CQI reports which have not been transmitted before the second of the two wideband CQI/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  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{OFFSET, CQI} - N_{OFFSET, RI}) \bmod (H \cdot N_P \cdot M_{RI}) = 0$ , where  $n_f$  is the system frame number, and  $n_s = \{0, 1, \dots, 19\}$  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 configured by higher-layer and the parameter  $N_{OFFSET, RI}$  is selected from the set  $\{0, -1, \dots, -(N_P - 1)\}$ .
- 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  $n_{PUCCH}^{(2)}$  as defined in [3], where  $n_{PUCCH}^{(2)}$  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 $N_{OFFSET, CQI}$ |
|-------------------------------------|----------------|----------------------------|
| $0 \leq I_{CQI/PMI} \leq 1$         | 2              | $I_{CQI/PMI}$              |
| $2 \leq I_{CQI/PMI} \leq 6$         | 5              | $I_{CQI/PMI} - 2$          |

|                                  |          |                     |
|----------------------------------|----------|---------------------|
| $7 \leq I_{CQI/PMI} \leq 16$     | 10       | $I_{CQI/PMI} - 7$   |
| $17 \leq I_{CQI/PMI} \leq 36$    | 20       | $I_{CQI/PMI} - 17$  |
| $37 \leq I_{CQI/PMI} \leq 76$    | 40       | $I_{CQI/PMI} - 37$  |
| $77 \leq I_{CQI/PMI} \leq 156$   | 80       | $I_{CQI/PMI} - 77$  |
| $157 \leq I_{CQI/PMI} \leq 316$  | 160      | $I_{CQI/PMI} - 157$ |
| $I_{CQI/PMI} = 317$              | Reserved |                     |
| $318 \leq I_{CQI/PMI} \leq 349$  | 32       | $I_{CQI/PMI} - 318$ |
| $350 \leq I_{CQI/PMI} \leq 413$  | 64       | $I_{CQI/PMI} - 350$ |
| $414 \leq I_{CQI/PMI} \leq 541$  | 128      | $I_{CQI/PMI} - 414$ |
| $542 \leq I_{CQI/PMI} \leq 1023$ | Reserved |                     |

**Table 7.2.2-1B: Mapping of  $ri\text{-}ConfigIndex$  to  $M_{RI}$  and  $N_{OFFSET,RI}$** 

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

**Table 7.2.2-1C: Mapping of  $cqi\text{-}pmi\text{-}ConfigIndex$  to  $N_P$  and  $N_{OFFSET,CQI}$  for TDD.**

| $cqi\text{-}pmi\text{-}ConfigIndex = I_{CQI/PMI}$ | Value of $N_P$ | Value of $N_{OFFSET,CQI}$ |
|---------------------------------------------------|----------------|---------------------------|
| $I_{CQI/PMI} = 0$                                 | 1              | $I_{CQI/PMI}$             |
| $1 \leq I_{CQI/PMI} \leq 5$                       | 5              | $I_{CQI/PMI} - 1$         |
| $6 \leq I_{CQI/PMI} \leq 15$                      | 10             | $I_{CQI/PMI} - 6$         |
| $16 \leq I_{CQI/PMI} \leq 35$                     | 20             | $I_{CQI/PMI} - 16$        |
| $36 \leq I_{CQI/PMI} \leq 75$                     | 40             | $I_{CQI/PMI} - 36$        |
| $76 \leq I_{CQI/PMI} \leq 155$                    | 80             | $I_{CQI/PMI} - 76$        |
| $156 \leq I_{CQI/PMI} \leq 315$                   | 160            | $I_{CQI/PMI} - 156$       |
| $316 \leq I_{CQI/PMI} \leq 1023$                  | 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  $N_{RB}^{DL} \leq 7$ , 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.
- 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:
      - A wideband CQI value which is calculated assuming the use of a single precoding matrix in all subbands and transmission on set  $S$  subbands.
      - The selected single precoding matrix indicator (wideband PMI).
      - 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<br>$N_{RB}^{DL}$ | Subband Size $k$<br>(RBs) | Bandwidth Parts<br>( $J$ ) |
|-----------------------------------|---------------------------|----------------------------|
| 6 – 7                             | NA                        | NA                         |
| 8 – 10                            | 4                         | 1                          |
| 11 – 26                           | 4                         | 2                          |
| 27 – 63                           | 6                         | 3                          |
| 64 – 110                          | 8                         | 4                          |

If parameter *ttiBundling* provided by higher layers is set to *TRUE* and if an UL-SCH in subframe bundling operation collides with a periodic CQI/PMI/RI reporting instance, then the UE shall drop the periodic CQI/PMI/RI report in that subframe and shall not multiplex periodic CQI/PMI and/or rank indicator in the PUSCH transmission in that subframe.

**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<br>(bits/BP) | Mode 2-1<br>(bits/BP) | Mode 1-0<br>(bits/BP) | Mode 2-0<br>(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  $n - n_{CQI\_ref}$ 
  - 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  $n - n_{CQI\_ref}$  corresponds to a valid downlink subframe, where downlink subframe  $n - n_{CQI\_ref}$  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  $\rho_A$  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  $\Delta_{offset}$  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  $v = 1$ .

- 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  $v=2$ .
- For 4 antenna ports  $\{0,1,2,3\}$ , a PMI value of  $n \in \{0,1,\dots,15\}$  corresponds to the codebook index  $n$  given in Table 6.3.4.2.3-2 of [3] with  $v$  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  $N_{\text{bundled}}$  is determined by the UE as  $N_{\text{bundled}} = V_{DAI}^{UL} + 2$ . If the UE does not detect any downlink assignment missing,  $N_{\text{bundled}}$  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<br>MSB, LSB | $V_{DAI}^{UL}$ or $V_{DAI}^{DL}$ | Number of subframes with<br>PDSCH transmission and with<br>PDCCH indicating DL SPS<br>release |
|-----------------|----------------------------------|-----------------------------------------------------------------------------------------------|
| 0,0             | 1                                | 1 or 5 or 9                                                                                   |
| 0,1             | 2                                | 2 or 6                                                                                        |
| 1,0             | 3                                | 3 or 7                                                                                        |
| 1,1             | 4                                | 0 or 4 or 8                                                                                   |

**Table 7.3-Y: Uplink association index  $k'$  for TDD**

| TDD UL/DL<br>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  $o_n^{ACK}$ ,  $n = 0, \dots, O^{ACK} - 1$  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/PMI or RI 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 case higher layers configure the use of subframe bundling for FDD and TDD, the subframe bundling operation is only applied to UL-SCH, such that four consecutive uplink subframes are used.

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<br>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<br>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<br>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  $n_{\text{VRB}}$ . A resource allocation field in the scheduling grant consists of a resource indication value ( $RIV$ ) corresponding to a starting resource block ( $RB_{\text{START}}$ ) and a length in terms of contiguously allocated resource blocks ( $L_{\text{CRBs}} \geq 1$ ). The resource indication value is defined by

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

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

else

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

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  $k_{\text{TC}}$ , as defined in Section 5.5.3.2 of [3]
- Starting physical resource block assignment  $n_{\text{RRC}}$ , 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  $I_{\text{SRS}}$  for SRS periodicity and SRS subframe offset  $T_{\text{offset}}$ , as defined in Table 8.2-1 and Table 8.2-2
- SRS bandwidth  $B_{\text{SRS}}$ , as defined in Section 5.5.3.2 of [3]
- Frequency hopping bandwidth,  $b_{\text{hop}}$ , as defined in Section 5.5.3.2 of [3]
- Cyclic shift  $n_{\text{SRS}}^{\text{cs}}$ , as defined in Section 5.5.3.2 of [3]

The cell specific SRS transmission bandwidths  $C_{\text{SRS}}$  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  $a(n_{\text{SRS}})$ , of the UE antenna that transmits the SRS at time  $n_{\text{SRS}}$  is given by

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

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

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  $T_{SRS} > 2$  and for FDD are the subframes satisfying  $(10 \cdot n_f + k_{SRS} - T_{offset}) \bmod T_{SRS} = 0$ , where  $n_f$  is the system frame number, for FDD  $k_{SRS} = \{0, 1, \dots, 9\}$  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  $T_{SRS} = 2$  are the subframes satisfying  $(k_{SRS} - T_{offset}) \bmod 5 = 0$ .

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       | $I_{\text{SRS}} - 7$   |
| 17 – 36    | 20       | $I_{\text{SRS}} - 17$  |
| 37 – 76    | 40       | $I_{\text{SRS}} - 37$  |
| 77 – 156   | 80       | $I_{\text{SRS}} - 77$  |
| 157 – 316  | 160      | $I_{\text{SRS}} - 157$ |
| 317 – 636  | 320      | $I_{\text{SRS}} - 317$ |
| 637 – 1023 | reserved | reserved               |

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

| Configuration Index $I_{\text{SRS}}$ | SRS Periodicity $T_{\text{SRS}}$ (ms) | SRS Subframe Offset $T_{\text{offset}}$ |
|--------------------------------------|---------------------------------------|-----------------------------------------|
| 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                                     | $I_{\text{SRS}} - 10$                   |
| 15 – 24                              | 10                                    | $I_{\text{SRS}} - 15$                   |
| 25 – 44                              | 20                                    | $I_{\text{SRS}} - 25$                   |
| 45 – 84                              | 40                                    | $I_{\text{SRS}} - 45$                   |
| 85 – 164                             | 80                                    | $I_{\text{SRS}} - 85$                   |
| 165 – 324                            | 160                                   | $I_{\text{SRS}} - 165$                  |
| 325 – 644                            | 320                                   | $I_{\text{SRS}} - 325$                  |
| 645 – 1023                           | reserved                              | reserved                                |

**Table 8.2-3:  $k_{\text{SRS}}$  for TDD**

|  | subframe index $n$ |            |            |   |   |   |   |            |     |   |   |   |
|--|--------------------|------------|------------|---|---|---|---|------------|-----|---|---|---|
|  | 0                  | 1          |            | 2 | 3 | 4 | 5 | 6          |     | 7 | 8 | 9 |
|  |                    | 1st symbol | 2nd symbol |   |   |   |   | 1st symbol | 2nd |   |   |   |

|                                                    | of UpPTS | of UpPTS |   |   |   |  | of UpPTS | symbol of UpPTS |   |   |   |
|----------------------------------------------------|----------|----------|---|---|---|--|----------|-----------------|---|---|---|
| $k_{\text{SRS}}$ in case UpPTS length of 2 symbols | 0        | 1        | 2 | 3 | 4 |  | 5        | 6               | 7 | 8 | 9 |
| $k_{\text{SRS}}$ 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  $I_{\text{PHICH}} = 0$ , 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  $I_{\text{PHICH}} = 1$ , 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 ( $SI$ ) including the lowest index PRB ( $n_{PRB}^{S1}(n)$ ) in subframe  $n$  from the resource allocation field in the latest PDCCH with DCI format 0 for the same transport block. If there is no PDCCH for the same transport block, the UE shall determine its hopping type based on

- the hopping information in the most recent semi-persistent scheduling assignment PDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled or
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

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

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

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

A UE performing PUSCH frequency hopping shall use one of two possible PUSCH frequency hopping types based on the hopping information. PUSCH hopping type 1 is described in 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<br>$N_{RB}^{UL}$ | #Hopping bits for<br>2nd slot RA<br>( $N_{UL\_hop}$ ) |
|----------------------------|-------------------------------------------------------|
| 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 1<sup>st</sup> slot RA in subframe  $i$  is defined as  $n_{PRB}^{S1}(i) = \tilde{n}_{PRB}^{S1}(i) + \tilde{N}_{RB}^{HO} / 2$ , 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 2<sup>nd</sup> slot RA in subframe  $i$  is defined as  $n_{PRB}(i) = \tilde{n}_{PRB}(i) + \tilde{N}_{RB}^{HO} / 2$ .

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 1<sup>st</sup> slot, and from PRB index  $n_{PRB}(i)$  for the 2<sup>nd</sup> slot, respectively, where  $L_{CRBs}$  is obtained from the uplink scheduling grant as in Section 8.4 and Section 8.1.

If the *Hopping-mode* is "inter-subframe", the 1<sup>st</sup> slot RA is applied to even CURRENT\_TX\_NB, and the 2<sup>nd</sup> 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<br>$N_{RB}^{UL}$ | Number of<br>Hopping bits | Information in<br>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  $0 \leq I_{MCS} \leq 28$ , 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  $N_{PRB} \leq 3$  and the modulation order is set to  $Q_m = 2$ .

For  $29 \leq I_{MCS} \leq 31$ , if  $I_{MCS} = 29$ , the “CQI request” bit in DCI format 0 is set to 1 and  $N_{PRB} \leq 4$ , the modulation order is set to  $Q_m = 2$ . Otherwise, the modulation order shall be determined from the DCI transported in the latest PDCCH with DCI format 0 for the same transport block using  $0 \leq I_{MCS} \leq 28$ . If there is no PDCCH with DCI format 0 for the same transport block using  $0 \leq I_{MCS} \leq 28$ , the modulation order shall be determined from

- the most recent semi-persistent scheduling assignment PDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

The 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<br>$I_{MCS}$ | Modulation Order<br>$Q_m'$ | TBS Index<br>$I_{TBS}$ | Redundancy Version<br>$rv_{idx}$ |
|------------------------|----------------------------|------------------------|----------------------------------|
| 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  $0 \leq I_{\text{MCS}} \leq 28$ , the UE shall first determine the TBS index ( $I_{\text{TBS}}$ ) using  $I_{\text{MCS}}$  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  $29 \leq I_{\text{MCS}} \leq 31$ , if  $I_{\text{MCS}} = 29$ , the “CQI request” bit in DCI format 0 is set to 1 and  $N_{\text{PRB}} \leq 4$ , 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. Otherwise, the transport block size shall be determined from the initial PDCCH for the same transport block using  $0 \leq I_{\text{MCS}} \leq 28$ . If there is no initial PDCCH with DCI format 0 for the same transport block using  $0 \leq I_{\text{MCS}} \leq 28$ , the transport block size shall be determined from

- the most recent semi-persistent scheduling assignment PDCCH, when the initial PUSCH for the same transport block is semi-persistently scheduled, or,
- the random access response grant for the same transport block, when the PUSCH is initiated by the random access response grant.

## 8.6.3 Control information MCS offset determination

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

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

| $I_{\text{offset}}^{\text{HARQ-ACK}}$ | $\beta_{\text{offset}}^{\text{HARQ-ACK}}$ |
|---------------------------------------|-------------------------------------------|
| 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**

| $I_{offset}^{RI}$ | $\beta_{offset}^{RI}$ |
|-------------------|-----------------------|
| 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**

| $I_{offset}^{CQI}$ | $\beta_{offset}^{CQI}$ |
|--------------------|------------------------|
| 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.

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# 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  $N_{\text{CCE},k} - 1$  according to Section 6.8.2 in [3], where  $N_{\text{CCE},k}$  is the total number of CCEs in the control region of subframe  $k$ . The UE shall monitor a set of PDCCH candidates 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

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

where  $Y_k$  is defined below,  $i = 0, \dots, L - 1$  and  $m = 0, \dots, M^{(L)} - 1$ .  $M^{(L)}$  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.**

| Type        | Search space $S_k^{(L)}$ |                | Number of PDCCH candidates $M^{(L)}$ |
|-------------|--------------------------|----------------|--------------------------------------|
|             | 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  $Y_{-1} = n_{\text{RNTI}} \neq 0$ ,  $A = 39827$ ,  $D = 65537$  and  $k = \lfloor n_s/2 \rfloor$ ,  $n_s$  is the slot number within a radio frame.. The RNTI value used for  $n_{\text{RNTI}}$  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  $n + k_{\text{PHICH}}$ , where  $k_{\text{PHICH}}$  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:  $k_{\text{PHICH}}$  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  $(n_{\text{PHICH}}^{\text{group}}, n_{\text{PHICH}}^{\text{seq}})$  where  $n_{\text{PHICH}}^{\text{group}}$  is the PHICH group number and  $n_{\text{PHICH}}^{\text{seq}}$  is the orthogonal sequence index within the group as defined by:

$$n_{PHICH}^{group} = (I_{PRB\_RA}^{lowest\_index} + n_{DMRS}) \bmod N_{PHICH}^{group} + I_{PHICH} N_{PHICH}^{group}$$

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

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.  $n_{DMRS}$  shall be set to zero, if there is no PDCCH with DCI format 0 for the same transport block, and
  - if the initial PUSCH for the same transport block is semi-persistently scheduled, or
  - if the initial PUSCH for the same transport block is scheduled by the random access response grant.
- $N_{SF}^{PHICH}$  is the spreading factor size used for PHICH modulation as described in 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 is set to '0'. In case of DCI formats 2 and 2A, the new data indicator field refers to the one for the enabled transport block.

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'<br>TDD: set to '0000' | FDD: set to '000'<br>TDD: set to '0000'               |
| Modulation and coding scheme                        | N/A               | MSB is set to '0'                       | For the enabled transport block:<br>MSB is set to '0' |
| Redundancy version                                  | N/A               | set to '00'                             | For the enabled transport block:<br>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'<br>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' | $n_{\text{PUCCH}}^{(1)}$                                        |
|----------------------------------|-----------------------------------------------------------------|
| '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  $n_{\text{PUCCH}}^{(1)}$  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  $n_{\text{PUCCH}}^{(1)} = n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ , where  $n_{\text{CCE}}$  is the number of the first CCE used for transmission of the corresponding DCI assignment and  $N_{\text{PUCCH}}^{(1)}$  is configured by higher layers.
- for a PDSCH transmission where there is not a corresponding PDCCH detected in subframe  $n-4$ , the value of  $n_{\text{PUCCH}}^{(1)}$  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  $n_{\text{PUCCH}}^{(1)}$  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  $\{k_0, k_1, \dots, k_{M-1}\}$  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  $N_p \leq n_{\text{CCE}} < N_{p+1}$  and shall use  $n_{\text{PUCCH}}^{(1)} = (M - m - 1) \times N_p + m \times N_{p+1} + n_{\text{CCE}} + N_{\text{PUCCH}}^{(1)}$ , where  $N_{\text{PUCCH}}^{(1)}$  is configured by higher layers,  $N_p = \max\{0, \lfloor N_{\text{RB}}^{\text{DL}} \times (N_{\text{sc}}^{\text{RB}} \times p - 4) / 36 \rfloor\}$ , and  $n_{\text{CCE}}$  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  $n_{\text{PUCCH}}^{(1)}$  is determined according to higher layer configuration and Table 9.2-2.

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

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

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  $n_{\text{PUCCH},i}^{(1)}$  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  $0 \leq i \leq M - 1$ .

- 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  $n_{\text{PUCCH},i}^{(1)} = (M - i - 1) \times N_p + i \times N_{p+1} + n_{\text{CCE},i} + N_{\text{PUCCH}}^{(1)}$ , where  $p$  is selected from  $\{0, 1, 2, 3\}$  such that  $N_p \leq n_{\text{CCE}} < N_{p+1}$ ,  $N_p = \max\{0, \lfloor N_{\text{RB}}^{\text{DL}} \times (N_{\text{sc}}^{\text{RB}} \times p - 4) / 36 \rfloor\}$ ,  $n_{\text{CCE},i}$  is the number of the first CCE used for transmission of the corresponding PDCCH in subframe  $n - k_i$ , and  $N_{\text{PUCCH}}^{(1)}$  is configured by higher layers.
- For a PDSCH transmission where there is not a corresponding PDCCH detected in subframe  $n - k_i$ , the value of  $n_{\text{PUCCH},i}^{(1)}$  is determined according to higher layer configuration and Table 9.2-2.

The UE shall transmit  $b(0), b(1)$  on an ACK/NACK resource  $n_{\text{PUCCH}}^{(1)}$  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  $n_{\text{PUCCH}}^{(1)}$  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) | $n_{\text{PUCCH}}^{(1)}$   | $b(0), b(1)$ |
|--------------------------|----------------------------|--------------|
| ACK, ACK                 | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1         |
| ACK, NACK/DTX            | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1         |
| NACK/DTX, ACK            | $n_{\text{PUCCH},1}^{(1)}$ | 0, 0         |
| NACK/DTX, NACK           | $n_{\text{PUCCH},1}^{(1)}$ | 1, 0         |
| NACK, DTX                | $n_{\text{PUCCH},0}^{(1)}$ | 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) | $n_{\text{PUCCH}}^{(1)}$   | $b(0), b(1)$ |
|---------------------------------------|----------------------------|--------------|
| ACK, ACK, ACK                         | $n_{\text{PUCCH},2}^{(1)}$ | 1, 1         |
| ACK, ACK, NACK/DTX                    | $n_{\text{PUCCH},1}^{(1)}$ | 1, 1         |
| ACK, NACK/DTX, ACK                    | $n_{\text{PUCCH},0}^{(1)}$ | 1, 1         |
| ACK, NACK/DTX, NACK/DTX               | $n_{\text{PUCCH},0}^{(1)}$ | 0, 1         |

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

|                                   |                            |      |
|-----------------------------------|----------------------------|------|
| NACK/DTX, ACK, NACK/DTX, NACK/DTX | $n_{\text{PUCCH},1}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, ACK      | $n_{\text{PUCCH},3}^{(1)}$ | 0, 1 |
| NACK/DTX, NACK/DTX, ACK, NACK/DTX | $n_{\text{PUCCH},2}^{(1)}$ | 0, 0 |
| NACK/DTX, NACK/DTX, NACK/DTX, ACK | $n_{\text{PUCCH},3}^{(1)}$ | 0, 0 |
| DTX, DTX, DTX, DTX                | 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  $N_{\text{ANRep}}$ , where  $N_{\text{ANRep}}$  is provided by higher layers and includes 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  $N_{\text{ANRep}}$  times using PUCCH resource  $n_{\text{PUCCH}}^{(1)}$  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  $n_{\text{PUCCH}, \text{ANRep}}^{(1)}$ , where  $n_{\text{PUCCH}, \text{ANRep}}^{(1)}$  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  $n_{\text{PUCCH}}^{(1)} = n_{\text{PUCCH}, \text{SRI}}^{(1)}$  as defined in [3], where  $n_{\text{PUCCH}, \text{SRI}}^{(1)}$  is UE specific and configured by higher layers. The SR configuration for SR transmission periodicity and subframe offset is defined by SR configuration index  $I_{\text{SR}}$  in Table 10.1-5.

SR transmission instances are the subframes satisfying  $(10 \times n_f + \lfloor n_s / 2 \rfloor - N_{\text{OFFSET}, \text{SR}}) \bmod SR_{\text{Periodicity}} = 0$ , where  $n_f$  is the system frame number, and  $n_s = \{0, 1, \dots, 19\}$  is the slot index within the frame, and  $N_{\text{OFFSET}, \text{SR}}$  is the SR subframe offset defined in Table 10.1-5 and  $SR_{\text{Periodicity}}$  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 $I_{\text{SR}}$ | SR periodicity (ms) | SR subframe offset   |
|----------------------------------------|---------------------|----------------------|
| 0 – 4                                  | 5                   | $I_{\text{SR}}$      |
| 5 – 14                                 | 10                  | $I_{\text{SR}} - 5$  |
| 15 – 34                                | 20                  | $I_{\text{SR}} - 15$ |
| 35 – 74                                | 40                  | $I_{\text{SR}} - 35$ |
| 75 – 154                               | 80                  | $I_{\text{SR}} - 75$ |
| 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  $n - N_{\text{ANRep}} - 3, \dots, n - 5$ , the UE:

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

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 subframe  $n$  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  $N_{\text{ANRep}} - 1$  UL subframes denoted as  $n_1, \dots, n_{N_{\text{ANRep}}-1}$ ;
- shall not transmit any other signal in UL subframe  $n, n_1, \dots, n_{N_{\text{ANRep}}-1}$ ; 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  $1 \leq i \leq N_{\text{ANRep}} - 1$ .

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 Editor's version reflecting further comments                    | 1.3.4 | 1.3.5 |
| 2007-09        | RAN#37 | RP-070731 |      |     | Endorsed by RAN1                                                        | 1.3.5 | 2.0.0 |
| 2007-09        | RAN#37 | RP-070737 |      |     | For approval at RAN#37                                                  | 2.0.0 | 2.1.0 |
| 12/09/07       | 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 Miscellaneous | 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 format 1C                                                                         | 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 |

| Change history |        |           |     |     |                                                                                                                                                           |       |       |
|----------------|--------|-----------|-----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|
| 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 reference 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 |

| Change history |        |           |     |     |                                                                                                |       |       |
|----------------|--------|-----------|-----|-----|------------------------------------------------------------------------------------------------|-------|-------|
| 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 |
| 27/05/09       | RAN_44 | RP-090529 | 235 | 1   | Correction to the condition of resetting accumulated uplink power correction                   | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 236 | -   | Correction to the random access channel parameters received from higher layer                  | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 237 | -   | Correction on TDD ACKNACK                                                                      | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 238 | 1   | Correction on CQI reporting                                                                    | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 239 | -   | Correction on the HARQ process number                                                          | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 241 | 1   | CR correction of the description on TTI-bundling                                               | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 242 | 1   | Clarify latest and initial PDCCH for PDSCH and PUSCH transmissions, and NDI for SPS activation | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 243 | -   | Clarify DRS EPRE                                                                               | 8.6.0 | 8.7.0 |
| 27/05/09       | RAN_44 | RP-090529 | 244 | 1   | Clarification on TPC commands for SPS                                                          | 8.6.0 | 8.7.0 |
| 15/09/09       | RAN_45 | RP-090888 | 245 | 1   | Correction to PUSCH hopping and PHICH mapping procedures                                       | 8.7.0 | 8.8.0 |
| 15/09/09       | RAN_45 | RP-090888 | 246 | -   | Clarification on subband indexing in periodic CQI reporting                                    | 8.7.0 | 8.8.0 |
| 15/09/09       | RAN_45 | RP-090888 | 247 | 2   | Correction to DVRB operation in TDD transmission mode 7                                        | 8.7.0 | 8.8.0 |
| 15/09/09       | RAN_45 | RP-090888 | 249 | -   | Clarification of concurrent ACKNACK and periodic PMI/RI transmission on PUCCH for TDD          | 8.7.0 | 8.8.0 |
| 15/09/09       | RAN_45 | RP-090888 | 250 | -   | Clarify Inter-cell synchronization text                                                        | 8.7.0 | 8.8.0 |

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# 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 |
| V8.7.0           | June 2009     | Publication |
| V8.8.0           | October 2009  | Publication |