# Foreword

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The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of this present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

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

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

# 1 Scope

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

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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

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

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

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

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

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

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

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

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

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

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

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

[13] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access".

[14] 3GPP TS 36.304: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode".

[15] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[16] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

[17] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"

# 3 Symbols and abbreviations

## 3.1 Symbols

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

 System frame number as defined in [3]

 Slot number within a radio frame as defined in [3]

 Number of configured cells

 Downlink bandwidth configuration, expressed in units of as defined in [3]

 Uplink bandwidth configuration, expressed in units of as defined in [3]

 Number of SC-FDMA symbols in an uplink slot as defined in [3]

 Resource block size in the frequency domain, expressed as a number of subcarriers as defined in [3]

 Basic time unit as defined in [3]

## 3.2 Abbreviations

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

ACK Acknowledgement

AUL Autonomous Uplink

AUL-DFI AUL downlink feedback information

BCH Broadcast Channel

CCE Control Channel Element

CDD Cyclic Delay Diversity

CG Cell Group

CIF Carrier Indicator Field

CQI Channel Quality Indicator

CRC Cyclic Redundancy Check

CRI CSI-RS Resource Indicator

CSI Channel State Information

CSI-IM CSI-interference measurement

DAI Downlink Assignment Index

DC Dual Connectivity

DCI Downlink Control Information

DL Downlink

DL-SCH Downlink Shared Channel

DTX Discontinuous Transmission

EDT Early Data Transmission

EN-DC E-UTRA NR Dual Connectivity with MCG using E-UTRA and SCG using NR

EPDCCH Enhanced Physical Downlink Control Channel

EPRE Energy Per Resource Element

MCG Master Cell Group

MCS Modulation and Coding Scheme

NACK Negative Acknowledgement

NE-DC NR E-UTRA Dual Connectivity with MCG using NR and SCG using E-UTRA

NPBCH Narrowband Physical Broadcast CHannel

NPDCCH Narrowband Physical Downlink Control CHannel

NPDSCH Narrowband Physical Downlink Shared CHannel

NPRACH Narrowband Physical Random Access CHannel

NPUSCH Narrowband Physical Uplink Shared CHannel

NPSS Narrowband Primary Synchronization Signal

NSSS Narrowband Secondary Synchronization Signal

NRS Narrowband Reference Signal

PBCH Physical Broadcast Channel

PCFICH Physical Control Format Indicator Channel

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PHICH Physical Hybrid ARQ Indicator Channel

PMCH Physical Multicast Channel

PMI Precoding Matrix Indicator

PRACH Physical Random Access Channel

PRS Positioning Reference Signal

PRB Physical Resource Block

PSBCH Physical Sidelink Broadcast Channel

PSCCH Physical Sidelink Control Channel

PSCell Primary Secondary cell

PSDCH Physical Sidelink Discovery Channel

PSSCH Physical Sidelink Shared Channel

PSSS Primary Sidelink Synchronisation Signal

PUCCH Physical Uplink Control Channel

PUCCH-SCell PUCCH SCell

PUR Preconfigured Uplink Resource

PUSCH Physical Uplink Shared Channel

PTI Precoding Type Indicator

RBG Resource Block Group

RE Resource Element

RI Rank Indication

RS Reference Signal

RSS Resynchronization Signal

SCG Secondary Cell Group

SINR Signal to Interference plus Noise Ratio

SPS C-RNTI Semi-Persistent Scheduling C-RNTI

SR Scheduling Request

SRS Sounding Reference Symbol

SSSS Secondary Sidelink Synchronisation Signal

TAG Timing Advance Group

TBS Transport Block Size

UCI Uplink Control Information

UE User Equipment

UL Uplink

UL-SCH Uplink Shared Channel

VRB Virtual Resource Block

# 4 Synchronization procedures

## 4.1 Cell search

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

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

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

For a BL/CE UE, if the UE is configured with higher layer parameter *RSS-Config*, the UE can use the resynchronization signal (as defined in [3]) to re-acquire time and frequency synchronization with the cell.

## 4.2 Timing synchronization

### 4.2.1 Radio link monitoring

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

If the UE is configured with a SCG [11] and the parameter *rlf-TimersAndConstantsSCG* is provided by the higher layers and is not set to release, the downlink radio link quality of the PSCell [11] of the SCG 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 (Qout and Qin) 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 (Qout and Qin) defined by relevant tests in [10].

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

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

### 4.2.2 Inter-cell synchronization

No functionality is specified in this clause in this release.

### 4.2.3 Transmission timing adjustments

Upon reception of a timing advance command or a timing adjustment indication for a TAG containing the primary cell or PSCell, the UE shall adjust uplink transmission timing for PUCCH/PUSCH/SRS of the primary cell or PSCell based on the received timing advance command or a timing adjustment indication.

The UL transmission timing for PUSCH/SRS of a secondary cell is the same as the primary cell if the secondary cell and the primary cell belong to the same TAG. If the primary cell in a TAG has a frame structure type 1 and a secondary cell in the same TAG has a frame structure type 2 or frame structure 3, UE may assume that *NTA* ≥ 624.

If the UE is configured with a SCG, the UL transmission timing for PUSCH/SRS of a secondary cell other than the PSCell is the same as the PSCell if the secondary cell and the PSCell belong to the same TAG.

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

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

The timing adjustment indication specified in [11] indicates the initial *NTA* used for a TAG.The timing advance command for a TAG indicates the change of the uplink timing relative to the current uplink timing for the TAG as multiples of 16. The start timing of the random access preamble is specified in [3].

In case of random access response, an 11-bit timing advance command [8], *TA*, for a TAG indicates *NTA* values by index values of *TA* = 0, 1, 2, ..., 256 if the UE is configured with a SCG, and *TA* = 0, 1, 2, ..., 1282 otherwise, where an amount of the time alignment for the TAG is given by *NTA* = *TA* ×16. *NTA* is defined in [3].

In other cases, a 6-bit timing advance command [8] or the Timing advance adjustment field in DCI format 6-0A/B if present [4], *TA*, for a TAG indicates adjustment of the current *NTA* value, *NTA,old*, to the new *NTA* value, *NTA,new*, by index values of *TA* = 0, 1, 2,..., 63, where *NTA,new* = *NTA,old* + (*TA* −31)×16. Here, adjustment of *NTA* value by a positive or a negative amount indicates advancing or delaying the uplink transmission timing for the TAG by a given amount respectively.

For a non-BL/CE UE, for a timing advance command received on

- subframe *n*, the corresponding adjustment of the uplink transmission timing shall apply from the beginning of subframe *n+*5 if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, *n+6* otherwise.

- slot *n*, the corresponding adjustment of the uplink transmission timing shall apply from the first subframe boundary no earlier than slot *[n+8].*

- subslot *n*, the corresponding adjustment of the uplink transmission timing shall apply from the first subframe boundary no earlier than

- subslot *[n+16]* if higher layer parameter *proc-TimeAdv-r15*= '*nplus4set1*'*.*

- subslot *[n+18]* if higher layer parameter *proc-TimeAdv-r15*= '*nplus6set1*'or '*nplus6set2*'*.*

- subslot *[n+20]* if higher layer parameter *proc-TimeAdv-r15*= '*nplus8set2*'*.*

For serving cells in the same TAG, when the UE's uplink PUCCH/PUSCH/SRS transmissions in subframe *n* and subframe *n*+1 are overlapped due to the timing adjustment, the UE shall complete transmission of subframe *n* and not transmit the overlapped part of subframe *n*+1.

For a BL/CE UE, for a timing advance command received on subframe *n*, the corresponding adjustment of the uplink transmission timing shall apply for the uplink PUCCH/PUSCH/SRS transmissions in subframe *n+6*. When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe *n* and subframe *n*+1 are on the same narrowband and are overlapped due to the timing adjustment, the UE shall complete transmission of subframe *n* and is not required to transmit in subframe *n+1* until the first available symbol that has no overlapping portion with subframe *n*. When the BL/CE UE's uplink PUCCH/PUSCH/SRS transmissions in subframe *n* and subframe *n*+1 are on different narrowbands, and the timing adjustment occurs in the guard period for narrowband retuning, the UE is not required to transmit in subframe *n+1* until the first available symbol that has no overlapping portion with subframe *n* and which does not reduce the guard period.

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 *NTA* accordingly.

## 4.3 Timing for Secondary Cell Activation / Deactivation

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

- the actions related to CSI reporting on a serving cell which is active in subframe n+8

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

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

- the actions related to CSI reporting on a serving cell which is not active in subframe n+8

which shall be applied in the earliest subframe after n+8 in which the serving cell is active.

When a UE receives an RRC configuration which configures secondary cell as activated [11] in subframe *n*, the corresponding actions in [8] shall be applied no later than the minimum requirement defined in [10] and no earlier than subframe *n+20*, except for the following:

- the actions related to CSI reporting on a serving cell which is active in subframe *n+20*

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

which shall be applied in subframe *n+20*.

- the actions related to CSI reporting on a serving cell which is not active in subframe *n+20*

which shall be applied in the earliest subframe after *n+20* in which the serving cell is active.

If a UE has been configured with *cqi-ShortPeriodicSCell* for a secondary cell, parameters *cqi-pmi-ConfigIndex* and *ri-ConfigIndex* in clause 7.2 are given by *cqi-ShortPeriodicSCell* from subframe *n*+8 until subframe *n*+34.

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

# 5 Power control

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

## 5.1 Uplink power control

If the UE is configured with *shortTTI*, PUCCH in this clause refers to SPUCCH defined in [3] if the HARQ-ACK is sent in response to PDSCH scheduled by DCI format 7-1A/1B/1C/1D/1E/1F/1G or if the scheduling request is sent on resources configured by higher layer parameter *sr-SlotSPUCCH-IndexFH or sr-SlotSPUCCH-IndexNoFH or sr-subSlotSPUCCH-Resource* for slot/subslot-based transmissions, unless otherwise noted.

If the UE is not configured with *shortTTI* or the UE is configured with *shortTTI*, and UCI is to be transmitted in a subframe, the term 'subframe/slot/subslot' or 'subframe/slot' refers to a subframe in this clause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a slot, the term 'subframe/slot/subslot' or 'slot/subslot' or 'subframe/slot' refers to a slot in this clause.

If the UE is configured with *shortTTI*, and UCI is to be transmitted in a subslot, the term 'subframe/slot/subslot' or 'slot/subslot' refers to a subslot in this clause.

Throughout this clause,

- if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, **, otherwise **.

- if the UE is configured with higher layer parameter *shortTTI* and the corresponding PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is detected in a subslot, if the UE is configured for subslot uplink transmissions, **is given by higher layer parameter *proc-TimeAdv* from **, otherwise**.

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

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

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

For a UE configured with EN-DC with primary cell frame structure type 1, if the UE is configured with *tdm-PatternConfig2* for a serving cell, and if the UE indicates a capability *fdd-PCellUL-TX-AllUL-Subframe-r16* (as specified in [11]), the UE transmits any uplink physical channel or signal without associated DCI if configured, in the serving cell on any uplink subframes. Otherwise, if the UE is configured with *tdm-PatternConfig2* for the serving cell and if the UE does not indicate a capability *fdd-PCellUL-TX-AllUL-Subframe-r16*, the UE is not expected to transmit any uplink physical channel or signal without associated DCI except for PRACH in the serving cell on subframes other than offset-UL subframes, where the offset-UL subframes are determined by applying an offset value given by *harq-Offset-r16* to the subframes denoted as uplink in the UL/DL configuration *tdm-PatternConfig2*.

For a UE configured with EN-DC with primary cell frame structure type 2, if the UE is configured with *tdm-PatternConfig2* for a serving cell, and if the UE indicates a capability *tdd-PCellUL-TX-AllUL-Subframe-r16* (as specified in [11]), the UE transmits any uplink physical channel or signal without associated DCI if configured, in the serving cell on any uplink subframes. Otherwise, if the UE is configured with *tdm-PatternConfig2* for the serving cell and if the UE does not indicate a capability *tdd-PCellUL-TX-AllUL-Subframe-r16*, the UE is not expected to transmit any uplink physical channel or signal without associated DCI except for PRACH in the serving cell on subframes other than offset-UL subframes, where the offset-UL subframes are determined by applying an offset value given by *harq-Offset-r16* to the subframes denoted as uplink in the UL/DL configuration *tdm-PatternConfig2*.

For PUSCH, the transmit power  defined in Clause 5.1.1, is first scaled by the ratio of the number of antennas ports with a non-zero PUSCH transmission to the number of configured antenna ports for the transmission scheme. The resulting scaled power is then split equally across the antenna ports on which the non-zero PUSCH is transmitted.

For PUCCH or SRS, the transmit power , defined in Clause 5.1.1.1, or is split equally across the configured antenna ports for PUCCH or SRS.  is the linear value ofdefined in Clause 5.1.3.

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

For a serving cell with frame structure type 1, a UE is not expected to be configured with *UplinkPowerControlDedicated-v12x0*.

### 5.1.1 Physical uplink shared channel

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

- When the procedures are applied for MCG, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the MCG respectively.

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

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

- When the procedures are applied for primary PUCCH group, the terms 'secondary cell', 'secondary cells' , 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the primary PUCCH group respectively.

- When the procedures are applied for secondary PUCCH group, the terms 'secondary cell', 'secondary cells', 'serving cell', 'serving cells' in this clause refer to secondary cell, secondary cells, serving cell, serving cells belonging to the secondary PUCCH group respectively.

For PUSCH (re)transmissions corresponding to *ul-ConfigInfo-r14*, the UE shall apply the procedures corresponding to PUSCH (re)transmission corresponding to the random access response grant.

#### 5.1.1.1 UE behaviour

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

If the UE transmits PUSCH without a simultaneous PUCCH for the serving cell , then the UE transmit power  for PUSCH transmission in subframe/slot/subslot *i* for the serving cell is given by

 [dBm]

If the UE transmits PUSCH simultaneous with PUCCH for the serving cell , then the UE transmit power  for the PUSCH transmission in subframe/slot/subslot *i* for the serving cell  is given by

 [dBm]

If the UE is not transmitting PUSCH for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall assume that the UE transmit power  for the PUSCH transmission in subframe *i* for the serving cell  is computed by

 [dBm]

where,

- is the configured UE transmit power defined in [6] in subframe/slot/subslot *i* for serving cell  and  is the linear value of . If the UE transmits PUCCH without PUSCH in subframe for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall assume  as given by Clause 5.1.2.1. If the UE does not transmit PUCCH and PUSCH in subframe  for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall compute  assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and TC =0dB, where MPR, A-MPR, P-MPR and TC are defined in [6].

-  is the linear value of defined in Clause 5.1.2.1

- If the UE is a BL/CE UE configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment valid for subframe *i* and serving cell is using uplink resource allocation type 5, is the bandwidth of the PUSCH resource assignment expressed in fraction of a resource block and is given by  where  are defined in [3] and is defined in Clause 8.6.1 for subframe *i,* is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe/slot/subslot *i* and serving cell otherwise.

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*,

- when j=0, , where j=0 is used for PUSCH (re)transmissions corresponding to a semi-persistent grant. and  are the parameters *p0-UE-PUSCH-Persistent-SubframeSet2-r12 and* *p0-NominalPUSCH-Persistent -SubframeSet2-r12* respectively provided by higher layers, for each serving cell .

- when j=1,, where j=1 is used for PUSCH (re)transmissions corresponding to a dynamic scheduled grant. and are the parameters *p0-UE-PUSCH-SubframeSet2-r12 and p0-NominalPUSCH-SubframeSet2-r12* respectively, provided by higher layers for serving cell *.*

- when j=2, where  and , where the parameter *preambleInitialReceivedTargetPower* [8] () and  are signalled from higher layers for serving cell , where j=2 is used for PUSCH (re)transmissions corresponding to the random access response grant.

Otherwise

- is a parameter composed of the sum of a component  provided from higher layers for *j=0,* *1* and *3* and a component  provided by higher layers for *j=0,* *1* and *3* for serving cell . 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,* for PUSCH (re)transmissions corresponding to the random access response grant then *j=2* and for BL/CE UE PUSCH (re)transmission using preconfigured uplink resource then *j=3*.  and , where the parameter *preambleInitialReceivedTargetPower* [8] () and  are signalled from higher layers for serving cell .

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*,

- For *j*=0 or 1, . is the parameter *alpha-SubframeSet2-r12* provided by higher layers for each serving cell.

- For *j*=2, .

- Else if the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v15x0* for serving cell *c*,

- For *j*=0 or 1, . is the parameter *alpha-UE-r15* provided by higher layers for each serving cell.

- For *j*=2, .

Otherwise

- For *j* =0 or *1*,  is a 3-bit parameter provided by higher layers for serving cell. For *j*=2,  For *j*=*3*,  is the parameter *pur-PUSCH-power-control-alpha* provided by higher layers for serving cell.

-  is the downlink path loss estimate calculated in the UE for serving cell  in dB and  = *referenceSignalPower* – higher layer filtered RSRP, where *referenceSignalPower* is provided by higher layers and RSRP is defined in [5] for the reference serving cell and the higher layer filter configuration is defined in [11] for the reference serving cell.

- If serving cell  belongs to a TAG containing the primary cell then, for the uplink of the primary cell, the primary cell is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP. For the uplink of the secondary cell, the serving cell configured by the higher layer parameter *pathlossReferenceLinking* defined in [11] is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

- If serving cell  belongs to a TAG containing the PSCell then, for the uplink of the PSCell, the PSCell is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP; for the uplink of the secondary cell other than PSCell, the serving cell configured by the higher layer parameter *pathlossReferenceLinking* defined in [11] is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

- If serving cell  belongs to a TAG not containing the primary cell or PSCell then serving cell  is used as the reference serving cell for determining *referenceSignalPower* and higher layer filtered RSRP.

- for and 0 for where  is given by the parameter *deltaMCS-Enabled* provided by higher layers for each serving cell .  and , for each serving cell , are computed as below.  for transmission mode 2.

- for control data sent via subframe-PUSCH without UL-SCH data or slot/sublot-PUSCH without UL-SCH data if the UE is configured with a higher layer parameter *uplinkPower-CSIPayload,*  and withdefined as the number of CQI/PMI bits including CRC for a given RI value for slot/subslot-PUSCH without UL-SCH data if the UE is not configured with a higher layer parameter *uplinkPower-CSIPayload*, and *BPRE=*  for other cases.

- where  is the number of code blocks,  is the size for code block ,  is the number of CQI/PMI bits including CRC bits and  is the number of resource elements determined as , where , ,  and  are defined in [4].

-  for control data sent via PUSCH without UL-SCH data and  for other cases.

-  is a correction value, also referred to as a TPC command and is included in PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B or in PDCCH/SPDCCH with DCI format 7-0A/7-0B or in MPDCCH with DCI format 6-0A for serving cell or jointly coded with other TPC commands in PDCCH/MPDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUSCH-RNTI. If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the current PUSCH power control adjustment state for serving cell is given by, and the UE shall use  instead of to determine . Otherwise, the current PUSCH power control adjustment state for serving cell is given by. If the UE is configured with multiple UL SPS configurations,  is a correction value, also referred to as a TPC command and is jointly coded with other TPC commands in PDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUSCH-RNTI, where x is *SPS-ConfigIndex-r14*, and  and  are replaced by  and , respectively.

-  and  if accumulation is enabled based on the parameter *Accumulation-enabled* or *accumulationEnabledsTTI* provided by higher layers or if the TPC command  is included in a PDCCH/EPDCCH with DCI format 0 or in a MPDCCH with DCI format 6-0A for serving cell  where the CRC is scrambled by the Temporary C-RNTI or PUR-RNTI

-  and  if accumulation is enabled based on the parameter *Accumulation-enabled* or *accumulationEnabledsTTI* provided by higher layers and if the TPC command  is included in a PDCCH with DCI format 3/3A whose CRC parity bits are scrambled by TPC-PUSCH-RNTI and if the UE is configured with multiple UL SPS configurations.

- where was signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B or PDCCH/SPDCCH with DCI format 7-0A/7-0B or MPDCCH with DCI format 6-0A or PDCCH/MPDCCH with DCI format 3/3A on subframe/slot/subslot , and where  is the first value after reset of accumulation. For a BL/CE UE configured with CEModeA, subframe  is the last subframe in which the MPDCCH with DCI format 6-0A or MPDCCH with DCI format 3/3A is transmitted.

- The value of  is

- For FDD or FDD-TDD and serving cell frame structure type 1

- if the UE is configured with higher layer parameter *shortTTI* andthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0Band for PUSCH transmissions in a subslot, 

- the UE is configured with higher layer parameters *dl-STTI-Length='subslot'* and *ul-STTI-Length='slot'* andthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B and for PUSCH transmissions in a slot, corresponds to:

- a subslot among subslot *4* or *5* of subframe *N-3* or subslot *0* of subframe *N-2* in which the UE has received the TPC command if the slot PUSCH is to be transmitted in slot *0* of subframe *N*. A UE is not expected to receive TPC command in more than one subslot among subslot *4* or *5* of subframe *N-3* or subslot *0* of subframe *N-2* corresponding to slot-PUSCH transmission in slot *0* of subframe *N*.

- a subslot among subslot *1* or *2* or *3* of subframe *N-2* in which the UE has received the TPC command if the slot-PUSCH is to be transmitted in slot *1* of subframe *N*. A UE is not expected to receive TPC command in more than one subslot among subslot *1* or *2* or *3* of subframe *N-2* corresponding to slot-PUSCH transmission in slot *1*of subframe *N*.

- if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, 

- otherwise,  = 4 (in unit of slots for slot-PUSCH and the TPC command is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B, and in units of subframe for subframe-PUSCH and for slot/subslot-PUSCH with a TPC commandprovided in the PDCCH with DCI format 3/3A).

- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration (defined in Clause 8.0) for serving cell .

- For TDD UL/DL configurations 1-6 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell ,  is given

- in Table 5.1.1.1-1A if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PUSCH transmissions,

- in Table 5.1.1.1-1B for special subframe configuration 1, 2, 3, 4, 6, 7, 8 and Table 5.1.1.1-1C for special subframe configuration 0, 5, 9 if the UE is configured with higher layer parameter *shortTTI* andthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B, and for uplink transmissions in a slot,

- by  if the slot-PUSCH transmission in slot 15 or 16 is scheduled with a PDCCH/SPDCCH with DCI format 7-0A/7-0B in which the LSB of the UL index is set to 1 for TDD UL/DL configuration 6 and special subframe configuration 0, 5, 9,

- in Table 5.1.1.1-1 otherwise.

- For TDD UL/DL configuration 0 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell .

- If the subframe-PUSCH transmission in subframe *2* or *7* isscheduledwith a PDCCH/EPDCCH of DCI format 0/4 or a MPDCCH of DCI format 6-0A in which the LSB of the UL index is set to 1, = 7

- For slot-PUSCH transmissions, is given by Table 5.1.1.1-1B for special subframe configuration 1, 2, 3, 4, 6, 7, 8 and Table 5.1.1.1-1C for special subframe configuration 0, 5, 9 ifthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B. If the TPC command  is provided in the PDCCH with DCI format 3/3A,  is given in Table 5.1.1.1-1.

- For all other subframe-PUSCH transmissions,  is given in Table 5.1.1.1-1A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, otherwise Table 5.1.1.1-1.

- For TDD UL/DL configurations 0-5 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell ,  is given in

- Table 5.1.1.1-4A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,

- Table 5.1.1.1-4B for slot-PUSCH transmissions ifthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B,

- Table 5.1.1.1-4 otherwise.

- For TDD UL/DL configuration 6 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell 

* If the subframe-PUSCH transmission in subframe *2* or *7* isscheduledwith a PDCCH/EPDCCH of DCI format 0/4 if the UE is not configured with higher layer parameter *shortProcessingTime* or if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the common search space in which the LSB of the UL index is set to 1, = 6

- For all other PUSCH transmissions,  is given in

* Table 5.1.1.1-4A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,
* Table 5.1.1.1-4B for slot-PUSCH transmissions ifthe TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-0A/7-0B,

- Table 5.1.1.1-4 otherwise.

- For a serving cell with frame structure type 3,

- For an uplink DCI format 0A/4A carrying AUL-DFI according to clause 8.3A, =4.

- For an uplink DCI format 0A/0B/0C/4A/4B with CRC scrambled by C-RNTI with PUSCH trigger A set to 0, is equal to *k*+*l*, where *k* and *l* are defined in in Clause 8.0.

- For an uplink DCI format 0A/0B/0C/4A/4B with CRC scrambled by C-RNTI with PUSCH trigger A set to 1 and upon the detection of PDCCH with CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' described in Clause 8.0, is equal to *p*+*k*+*l*, where *p*, *k* and *l* are defined in Clause 8.0.

- If a UE detected multiple TPC commands in subframe , the UE shall use the TPC command in the PDCCH/EPDCCH with DCI format 0A/0B/0C/4A/4B with CRC scrambled by C-RNTI which schedules PUSCH transmission in subframe *i*.

- For serving cell  and a non-BL/CE UE, the UE attempts to decode a PDCCH/EPDCCH of DCI format 0/0A/0B/0C/4/4A/4B or a PDCCH/SPDCCH of DCI format 7-0A/7-0B with the UE's C-RNTI or a PDCCH/EPDCCH of DCI format 0 for SPS C-RNTI or a PDCCH/SPDCCH of DCI format 7-0A/7-0B for SPS C-RNTI or a PDCCH/EPDCCH of DCI format 0 for UL-SPS-V-RNTI and a PDCCH of DCI format 3/3A with this UE's TPC-PUSCH-RNTI in every subframe except when in DRX or where serving cell is deactivated.

- For serving cell  and a BL/CE UE configured with CEModeA, the UE attempts to decode a MPDCCH of DCI format 6-0A with the UE's C-RNTI or SPS C-RNTI or PUR-RNTI and a MPDCCH of DCI format 3/3A with this UE's TPC-PUSCH-RNTI in every BL/CE downlink subframe except when in DRX

- For a non-BL/CE UE and for subframe PUSCH transmissions, if DCI format 0/0A/0B/0C/4/4A/4B for serving cell and DCI format 3/3A are both detected in the same subframe, then the UE shall use the  provided in DCI format 0/0A/0B/0C/4/4A/4B.

- For slot/subslot-PUSCH transmissions corresponding to a PDCCH/SPDCCH with DCI format 7-0A/7-0B with the UE's C-RNTI for serving cell *c*, the UE shall use the provided in DCI format 7-0A/7-0B

- For serving cell *c* and slot/subslot-PUSCH transmissions without a corresponding PDCCH/SPDCCH in slot/subslot *i* of subframe *I*, the UE shall use the TPC command provided in the PDCCH with DCI format 3/3A received in a subframe not later than subframe  when configured by higher layer *parameter tpc-PDCCH-ConfigPUSCH-SPS* for the serving cell *c* and for the corresponding *SPS-ConfigIndex-r14* if the UE is configured with multiple UL SPS configurations.

- For a BL/CE UE configured with CEModeA, if DCI format 6-0A for serving cell and DCI format 3/3A are both detected in the same subframe, then the UE shall use the  provided in DCI format 6-0A.

- dB for a subframe/slot/subslot where no TPC command is decoded for serving cell or where DRX occurs or *i* is not an uplink subframe/slot/subslot in TDD or FDD-TDD and serving cell c frame structure type 2.

- dB for subframe-PUSCH transmissions if the subframe *i* is not the first subframe scheduled by a PDCCH/EPDCCH of DCI format 0B/4B.

- The  dB accumulated values signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B or PDCCH/SPDCCH with DCI format 7-0A/7-0B or MPDCCH with DCI format 6-0A are given in Table 5.1.1.1-2. If the PDCCH/EPDCCH with DCI format 0 or PDCCH/SPDCCH with DCI format 7-0A/7-0B or MPDCCH with DCI format 6-0A or PDCCH/SPDCCH with DCI format 7-0A/7-0B is validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH/SPDCCH, then  is 0dB.

- The  dB accumulated values signalled on PDCCH/MPDCCH 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  for serving cell , positive TPC commands for serving cell  shall not be accumulated

- If UE has reached minimum power, negative TPC commands shall not be accumulated

- For serving cell , when the UE is configured with higher layer parameter *shortTTI* or when there is a change in configuration corresponding to the higher layer parameter *shortTTI*,  for the first following PUSCH transmission in a slot or subslot in a given subframe is set to the value of  associated with PUSCH of the previous uplink subframe.

- If the UE is not configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell , the UE shall reset accumulation

- For serving cell , when  value is changed by higher layers

- For serving cell , when the UE receives random access response message for serving cell 

- For serving cell , and BL/CE UE configured with CEModeA, when the UE performs PUSCH transmission using preconfigured uplink resource

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell ,

- the UE shall reset accumulation corresponding to  for serving cell 

- when  value is changed by higher layers

- when the UE receives random access response message for serving cell 

- the UE shall reset accumulation corresponding to  for serving cell 

- when  value is changed by higher layers

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v15x0* for serving cell , the UE shall reset accumulation corresponding to  for serving cell 

- when  value is changed by higher layers

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and

- if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* 

- if subframe  does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* 

-  and  if accumulation is not enabled for serving cell  based on the parameter *Accumulation-enabled* or *accumulationEnabledsTTI* provided by higher layers

- where was signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B or PDCCH/SPDCCH with DCI format 7-0A/7-0B or MPDCCH with DCI format 6-0A for serving cell  on subframe  . For a BL/CE UE configured with CEModeA, subframe  is the last subframe in which the MPDCCH with DCI format 6-0A or MPDCCH with DCI format 3/3A is transmitted.

- The value of  is

- For FDD or FDD-TDD and serving cell frame structure type 1

- if the UE is configured with higher layer parameter *shortTTI* and for PUSCH transmissions in a subslot, 

- the UE is configured with higher layer parameters *dl-STTI-Length='subslot'* and *ul-STTI-Length='slot'* and for PUSCH transmissions in a slot, corresponds to:

- a subslot among subslot *4* or *5* of subframe *N-3* or subslot *0* of subframe *N-2* in which the UE has received the TPC command if the slot- PUSCH is to be transmitted in slot *0* of subframe *N*. A UE is not expected to receive TPC command in more than one subslot among subslot *4* or *5* of subframe *N-3* or subslot *0* of subframe *N-2* corresponding to slot-PUSCH transmission in slot *0* of subframe *N*.

- a subslot among subslot *1* or *2* or *3* of subframe *N-2* in which the UE has received the TPC command if the slot-PUSCH is to be transmitted in slot *1* of subframe *N*. A UE is not expected to receive TPC command in more than one subslot among subslot *1* or *2* or *3* of subframe *N-2* corresponding to slot-PUSCH transmission in slot *1*of subframe *N*.

- if configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, 

- otherwise, = 4

- For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration (defined in Clause 8.0) for serving cell .

- For TDD UL/DL configurations 1-6 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell ,  is given

- in Table 5.1.1.1-1A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space for subframe-PUSCH transmissions,

- in Table 5.1.1.1-1B for special subframe configuration 1, 2, 3, 4, 6, 7, 8 and Table 5.1.1.1-1C for special subframe configuration 0, 5, 9 if the UE is configured with higher layer parameter *sTTI*, and for uplink transmissions in a slot,

- by  if the slot-PUSCH transmission in slot 15 or 16 is scheduled with a PDCCH/SPDCCH with DCI format 7-0A/7-0B in which the LSB of the UL index is set to 1 for TDD UL/DL configuration 6 and special subframe configuration 0, 5, 9,

- in Table 5.1.1.1-1 otherwise.

- For TDD UL/DL configuration 0 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell .

- If the subframe-PUSCH transmission in subframe *2* or *7* isscheduledwith a PDCCH/EPDCCH of DCI format 0/4 or a MPDCCH with DCI format 6-0A in which the LSB of the UL index is set to 1, = 7

- For slot-PUSCH transmissions, is given by Table 5.1.1.1-1B for special subframe configuration 1, 2, 3, 4, 6, 7, 8 and Table 5.1.1.1-1C for special subframe configuration 0, 5, 9.

- For all other PUSCH transmissions,  is given in Table 5.1.1.1-1A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space, Table 5.1.1.1-1 otherwise.

- For TDD UL/DL configurations 0-5 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell ,  is given in

- Table 5.1.1.1-4A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,

- Table 5.1.1.1-4B for slot-PUSCH transmissions,

- Table 5.1.1.1-4 otherwise.

- For TDD UL/DL configuration 6 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell 

- If the subframe-PUSCH transmission in subframe *2* or *7* isscheduledwith a PDCCH/EPDCCH of DCI format 0/4 if the UE is not configured with higher layer parameter *shortProcessingTime* or if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the common search space in which the LSB of the UL index is set to 1, = 6.

* If the subframe-PUSCH transmission in subframe *s* isscheduledwith a PDCCH of DCI format 0/4, if the UE is configured with higher layer parameter *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space in which the LSB of the UL index is set to 1,
*  for *s= 1 or 2*
*  for *s= 3*

- If the slot-PUSCH transmission in slot 4, 15 or 16 is scheduled with a PDCCH/SPDCCH with DCI format 7-0A/7-0B in which the LSB of the UL index is set to 1, = 5.

- For all other PUSCH transmissions,  is given in

- Table 5.1.1.1-4A if the UE is configured with *shortProcessingTime* and the corresponding PDCCH with CRC scrambled by C-RNTI is in the UE-specific search space,

- Table 5.1.1.1-4B for slot- PUSCH transmissions,

- Table 5.1.1.1-4 otherwise.

- For a serving cell with frame structure type 3,

- For an uplink DCI format 0A/4A carrying AUL-DFI according to clause 8.3A, =4.

- For an uplink DCI format 0A/4A with CRC scrambled by C-RNTI with PUSCH trigger A set to 0, is equal to *k*+*l*, where *k* and *l* are defined in in Clause 8.0.

- For an uplink DCI format 0B/4B with CRC scrambled by C-RNTI with PUSCH trigger A set to 0, is equal to *k*+*l*+*i'* with , where *ni*HARQ\_IDis HARQ process number in subframe *i*, and *k*, *l*, *n*HARQ\_ID and *N*HARQ are defined in Clause 8.0.

- For an uplink DCI format 0A/4A with CRC scrambled by C-RNTI with PUSCH trigger A set to 1 and upon the detection of PDCCH with CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' described in Clause 8.0, is equal to *p*+*k*+*l*, where *p*, *k* and *l* are defined in Clause 8.0.

- For an uplink DCI format 0B/4B with CRC scrambled by C-RNTI with PUSCH trigger A set to 1 and upon the detection of PDCCH with CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' described in Clause 8.0, is equal to *p*+*k*+*l*+*i'* with , where *ni*HARQ\_IDis HARQ process number in subframe *i*, and *p*, *k*, *l*, *n*HARQ\_ID and *N*HARQ are defined in Clause 8.0.

* If a UE detected multiple TPC commands in subframe , the UE shall use the TPC command in the PDCCH/EPDCCH with DCI format 0A/0B/0C/4A/4B with CRC scrambled by C-RNTI which schedules PUSCH transmission in subframe *i*.

- The  dB absolute values signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B or PDCCH/SPDCCH with DCI format 7-0A/7-0B or a MPDCCH with DCI format 6-0A are given in Table 5.1.1.1-2. If the PDCCH/EPDCCH with DCI format 0 or PDCCH/SPDCCH with DCI format 7-0A/7-0B or a MPDCCH with DCI format 6-0A is validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH/SPDCCH, then  is 0dB.

- for a non-BL/CE UE,  and  for a subframe where no PDCCH/EPDCCH with DCI format 0/0A/0B/0C/4/4A/4B is decoded for serving cell  or where DRX occurs or *i* is not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.

- for a BL/CE UE configured with CEModeA, and  for a subframe where no MPDCCH with DCI format 6-0A is decoded for serving cell  or where DRX occurs or *i* is not an uplink subframe in TDD.

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and

- if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* 

- if subframe  does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* 

- For both types of  (accumulation or current absolute) the first value is set as follows:

- If  value is changed by higher layers and serving cell  is the primary cell or, if  value is received by higher layers and serving cell  is a Secondary cell or, if a BL/CE UE transmits using preconfigured uplink resources,

- 

- Note for a BL/CE UE, = 0 for i = 0,1,… up to the last subframe of the PUSCH transmission using preconfigured uplink resource.

- For serving cell , when the UE is configured with higher layer parameter *shortTTI* or when there is a change in configuration corresponding to the higher layer parameter *shortTTI*,  for the first following PUSCH transmission in a slot or subslot in a given subframe is set to the value of  associated with PUSCH of the previous uplink subframe.

- Else

- If the UE receives the random access response message for a serving cell 

- , where

-  is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell , see Clause 6.2, and

 and  is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the serving cell , is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for the subframe of first PUSCH transmission in the serving cell, and Δ*TF,c*(0) is the power adjustment of first PUSCH transmission in the serving cell *c*. If a UE is performing non-contention based random access procedure and is configured with higher layer parameter *pusch-EnhancementsConfig*, For a PUSCH transmission corresponding to *ul-ConfigInfo-r14,* the UE shall assume

- If value is received by higher layers for a serving cell *c.*

- 

Table 5.1.1.1-1: 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 5.1.1.1-1A: for TDD configuration 0-6, special subframe configuration 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 and UE configured with *shortProcessingTime*

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

Table 5.1.1.1-1B:  for TDD configurations 0-6, special subframe configuration 1, 2, 3, 4, 6, 7, 8 and UE configured with *ul-STTI-Length*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TDD UL/DL Configuration | slot number *i* | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 0 |  |  |  |  | 4 | 4 | 4 | 5 | 5 | 6 |  |  |  |  | 4 | 4 | 4 | 5 | 5 | 6 |
| 1 |  |  |  |  | 4 | 4 | 4 | 4 |  |  |  |  |  |  | 4 | 4 | 4 | 4 |  |  |
| 2 |  |  |  |  | 4 | 4 |  |  |  |  |  |  |  |  | 4 | 4 |  |  |  |  |
| 3 |  |  |  |  | 6 | 6 | 6 | 6 | 6 | 6 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  | 4 | 4 | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  | 6 | 6 | 6 | 6 | 6 | 6 |  |  |  |  | 4 | 4 | 4 | 4 |  |  |

Table 5.1.1.1-1C:  for TDD configurations 0-6, special subframe configuration 0, 5, 9 and UE configured with *ul-STTI-Length*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TDD UL/DL Configuration | slot number *i* | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 0 |  |  |  |  | 4 | 5 | 5 | 6 | 6 | 7 |  |  |  |  | 4 | 5 | 5 | 6 | 6 | 7 |
| 1 |  |  |  |  | 5 | 5 | 5 | 5 |  |  |  |  |  |  | 5 | 5 | 5 | 5 |  |  |
| 2 |  |  |  |  | 4 | 4 |  |  |  |  |  |  |  |  | 4 | 4 |  |  |  |  |
| 3 |  |  |  |  | 7 | 7 | 7 | 7 | 7 | 7 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  | 5 | 5 | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  | 4 | 5 | 5 | 6 | 6 | 7 |  |  |  |  | 4 | 4 | 4 | 5 |  |  |

Table 5.1.1.1-2: Mapping of TPC Command Field in DCI format 0/0A/0B/0C/3/4/4A/4B/6-0A/3B/7-0A/7-0B to absolute and accumulated  values

|  |  |  |
| --- | --- | --- |
| TPC Command Field in  DCI format 0/0A/0B/0C/3/4/4A/4B/6-0A/3B/7-0A/7-0B | Accumulated  [dB] | Absolute  [dB] only DCI format 0/0A/0B/0C/4/4A/4B/6-0A/7-0A/7-0B |
| 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/3B to accumulated  values

|  |  |
| --- | --- |
| TPC Command Field in  DCI format 3A/3B | Accumulated [dB] |
| 0 | -1 |
| 1 | 1 |

Table 5.1.1.1-4: for TDD configuration 0-6 and UE configured with *symPUSCH-UpPts-r14*

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

Table 5.1.1.1-4A: for TDD configuration 0-6 and UE configured with *symPUSCH-UpPts-r14* and UE configured with *shortProcessingTime*

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

Table 5.1.1.1-4B:  for TDD configurations 0-6 and UE configured with *symPUSCH-UpPts-r14*, and UE configured with *ul-STTI-Length*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TDD UL/DL Configuration | slot number *i* | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 0 |  |  |  | 11 | 4 | 5 | 5 | 6 | 6 | 7 |  |  |  | 11 | 4 | 5 | 5 | 6 | 6 | 7 |
| 1 |  |  |  | 5 | 5 | 5 | 5 | 5 |  |  |  |  |  | 5 | 5 | 5 | 5 | 5 |  |  |
| 2 |  |  |  | 4 | 4 | 4 |  |  |  |  |  |  |  | 4 | 4 | 4 |  |  |  |  |
| 3 |  |  |  | 7 | 7 | 7 | 7 | 7 | 7 | 7 |  |  |  |  |  |  |  |  |  |  |
| 4 |  |  |  | 5 | 5 | 5 | 5 | 5 |  |  |  |  |  |  |  |  |  |  |  |  |
| 5 |  |  |  | 4 | 4 | 4 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 6 |  |  |  | 4 | 4 | 5 | 5 | 6 | 6 | 7 |  |  |  | 11 | 4 | 4 | 4 | 5 |  |  |

For a given serving cell, if the UE is configured with higher layer parameter *shortProcessingTime* , the UE shall use the TPC command received with DCI format 0/4 mapped onto the UE-specific search space for subframe *i*.

For a UE capable of simultaneous transmission of different uplink signal durations to different serving cells as indicated by UE capability *simultaneousTx-differentTx-duration*, if PUSCH/PUCCH transmissions of different duration occur in different serving cells and in the same subframe and if the total transmit power of the UE would exceed , the UE shall follow the dropping rules described in Clause 5.1.5 until the total transmit power of the UE would not exceed or until there are only PUSCH/PUCCH transmissions of the same duration remaining in which case the following rules apply.

If the UE is not configured with an SCG or a PUCCH-SCell, and if the total transmit power of the UE would exceed , the UE scales for the serving cell  in subframe/slot/subslot *i* such that the condition



is satisfied where  is the linear value of ,  is the linear value of ,  is the linear value of the UE total configured maximum output power  defined in [6] in subframe/slot/subslot *i* and is a scaling factor of for serving cell  where . In case there is no PUCCH transmission in subframe/slot/subslot *i* .

If the UE is not configured with an SCG or a PUCCH-SCell, and if the UE has PUSCH transmission with UCI on serving cell *j* and PUSCH without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed , the UE scales for the serving cells without UCI in subframe/slot/subslot *i* such that the condition



is satisfied where  is the PUSCH transmit power for the cell with UCI andis a scaling factor of for serving cell  without UCI. In this case, no power scaling is applied to  unless and the total transmit power of the UE still would exceed .

For a UE not configured with a SCG or a PUCCH-SCell, note thatvalues are the same across serving cells whenbut for certain serving cells may be zero.

If the UE is not configured with an SCG or a PUCCH-SCell, and if the UE has simultaneous PUCCH and PUSCH transmission with UCI on serving cell j and PUSCH transmission without UCI in any of the remaining serving cells, and the total transmit power of the UE would exceed , the UE obtains according to



and



If the UE is not configured with a SCG or a PUCCH-SCell, and

- If the UE is configured with multiple TAGs, and if the PUCCH/PUSCH transmission of the UE on subframe/slot/subslot  for a given serving cell in a TAG overlaps some portion of the first symbol of the PUSCH transmission on subframe/slot/subslot  for a different serving cell in another TAG the UE shall adjust its total transmission power to not exceed on any overlapped portion.

- If the UE is configured with multiple TAGs, and if the PUSCH transmission of the UE on subframe/slot/subslot  for a given serving cell in a TAG overlaps some portion of the first symbol of the PUCCH transmission on subframe/slot/subslot  for a different serving cell in another TAG the UE shall adjust its total transmission power to not exceed on any overlapped portion.

- If the UE is configured with multiple TAGs, and if the trigger type 0/1 SRS transmission of the UE in a symbol on subframe/slot/subslot  for a given serving cell in a TAG overlaps with the PUCCH/PUSCH transmission on subframe/slot/subslot or subframe/slot/subslot  for a different serving cell in the same or another TAG the UE shall drop trigger type 0/1 SRS if its total transmission power exceeds on any overlapped portion of the symbol.

- If the UE is configured with multiple TAGs, and if the trigger type 2 SRS transmission of the UE in a symbol on subframe/slot/subslot for a given serving cell in a TAG overlaps with the PUCCH/PUSCH transmission on subframe/slot/subslot , or for a different serving cell in the same or another TAG, the UE shall drop the trigger type 2 SRS in the overlapped symbol if its total transmission power exceeds on any overlapped portion of the symbol.

- If the UE is configured with multiple TAGs and more than 2 serving cells, and if the trigger type 0/1 SRS transmission of the UE in a symbol on subframe/slot/subslot  for a given serving cell overlaps with the SRS transmission on subframe/slot/subslot  for a different serving cell(s) and with PUSCH/PUCCH transmission on subframe/slot/subslot or subframe/slot/subslot  for another serving cell(s) the UE shall drop the trigger type 0/1 SRS transmissions if the total transmission power exceeds on any overlapped portion of the symbol.

- If the UE is configured with multiple TAGs and more than 2 serving cells, and if the trigger type 2 SRS transmission of the UE in a symbol on subframe/slot/subslot for a given serving cell overlaps with the SRS transmission on subframe/slot/subslot , or for a different serving cell(s) and with PUSCH/PUCCH transmission on subframe/slot/subslot , or for another serving cell(s), the UE shall drop the trigger type 2 SRS transmission in the overlapped symbol if the total transmission power exceeds on any overlapped portion of the symbol.

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

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

If the UE is configured with a LAA SCell for uplink transmissions, the UE may compute the scaling factor  assuming that the UE performs a PUSCH transmission on the LAA SCell in subframe *i* irrespective of whether the UE can access the LAA SCell for the PUSCH transmission in subframe *i* according to the channel access procedures described in Clause 4.2.1 of [13].

For a BL/CE UE configured with CEModeA, if the PUSCH transmission, scheduled by one DCI, is transmitted in more than one subframe *i0*, *i1*, …, *iN-1* where *i0*< *i1*< …< *iN-1*, the PUSCH transmit power in subframe *ik* , *k*=0, 1, …, *N*-1, is determined by



except in case the DCI contains an UL index set to ‘11’.

For a BL/CE UE configured with CEModeB, the PUSCH transmit power in subframe *ik* is determined by



#### 5.1.1.2 Power headroom

There are three types of UE power headroom reports defined. A UE power headroom is valid for subframe/slot/subslot *i* for serving cell .

If the UE is configured with a SCG, and if the higher layer parameter *phr-ModeOtherCG-r12* for a CG indicates 'virtual', for power headroom reports transmitted on that CG, the UE shall compute PH assuming that it does not transmit PUSCH/PUCCH on any serving cell of the other CG.

For a UE configured with EN-DC/NE-DC and capable of dynamic power sharing, if a NR Multiple Entry PHR [15, TS 38.321] is triggered and if the NR slot on active UL BWP that carries the Multiple Entry PHR is not aligned with E-UTRA subframe due to asynchronous EN-DC/NE-DC [16, TS 38.133] or different duration between the NR slot and E-UTRA subframe, UE provides PH of the first E-UTRA subframe that overlaps with the NR slot.

If the UE is configured with a SCG,

- For computing power headroom for cells belonging to MCG, the term 'serving cell' in this clause refers to serving cell belonging to the MCG.

- For computing power headroom for cells belonging to SCG, the term 'serving cell' in this clause refers to serving cell belonging to the SCG. The term 'primary cell' in this clause refers to the PSCell of the SCG.

If the UE is configured with a PUCCH-SCell,

- For computing power headroom for cells belonging to primary PUCCH group, the term 'serving cell' in this clause refers to serving cell belonging to the primary PUCCH group.

- For computing power headroom for cells belonging to secondary PUCCH group, the term 'serving cell' in this clause refers to serving cell belonging to the secondary PUCCH group. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

In this clause,

- the term 'scheduled to transmit PUSCH' refers to PUSCH scheduled via an uplink scheduling grant or semi-persistent scheduling assignment.

- the terms 'PUCCH is prepared to be transmitted' or 'prepared to transmit PUCCH' refer to PUCCH for which the UE has started generating the UCI.

If the UE is configured with a LAA SCell for uplink transmissions, and the UE receives PDCCH/EPDCCH with DCI format 0A/0B/4A/4B with PUSCH trigger A set to 0 corresponding to a PUSCH transmission on the LAA SCell in subframe *i*, power headroom for subframe *i* is computed assuming that the UE performs a PUSCH transmission on the LAA SCell in subframe *i* irrespective of whether the UE can access the LAA SCell for the PUSCH transmission in subframe *i* according to the channel access procedures described in Clause 4.2.1 of [13].

If the UE is configured with an LAA SCell for uplink transmissions, and if the UE reports power headroom in subframe *i* in serving cell *c* in a PUSCH transmission scheduled using DCI format 0A/0B/4A/4B with 'PUSCH trigger A' set to 0 or in a PUSCH transmission scheduled using DCI format 0/4,

- for LAA SCells other than serving cell *c* on which UE receives a DCI format 0A/0B/4A/4B or PUSCH trigger B in subframe *i*-4 or earlier indicating a PUSCH transmission in subframe *i*, power headroom for the serving cell is computed assuming that the UE performs a PUSCH transmission on that serving cell in subframe *i.*

- for LAA SCells other than serving cell *c* on which UE does not receive a DCI format 0A/0B/4A/4B or PUSCH trigger B in subframe *i-4* or earlier, indicating a PUSCH transmission in subframe *i*, power headroom for the serving cell is computed assuming that the UE does not perform a PUSCH transmission on that serving cell in subframe *i*.

If the UE is configured with a LAA SCell for uplink transmissions, and if the UE receives a DCI format 0A/0B/4A/4B with PUSCH trigger A set to 1 in subframe *n* on serving cell *c*, and if the UE reports power headroom on serving cell *c* using the received DCI,

- for serving cells other than the serving cell *c,* the UE computes power headroom assuming that it performs a PUSCH transmission in subframe *n*+, if in subframe *n* or earlier, the UE receives a DCI format 0/4 or DCI format 0A/0B/4A/4B with PUSCH trigger A set to 0 or PUSCH trigger B set to 1, indicating PUSCH transmission in subframe *n*+.

- for serving cells other than the serving cell *c,* the UE computes power headroom assuming that it does not perform a PUSCH transmission in subframe *n*+*,* if in subframe *n* or earlier, the UE does not receive a DCI Format 0/4 or DCI format 0A/0B/4A/4B with PUSCH trigger A set to 0 or PUSCH trigger B set to 1, indicating PUSCH transmission in subframe *n*+.

If serving cell *c* is configured with higher layer parameter *ul-STTI-Length='subslot',* and if the UE reports power headroom on subslot *i* of serving cell *c*, for serving cells other than serving cell *c,* the UE computes power headroom for

- subslot *i*, if the serving cells are configured with higher layer parameter *ul-STTI-Length*=*'subslot'*

- the slot containing subslot *i*, if the serving cells are configured with higher layer parameter *ul-STTI-Length*=*'slot'*

- the subframe containing subslot *i*,otherwise.

If serving cell *c* is configured with higher layer parameter *ul-STTI-Length='slot',* and if the UE reports power headroom on slot *i* of serving cell *c* using slot-PUSCH, for serving cells other than serving cell *c,* the UE computes power headroom for

- slot *i*, if the serving cells are configured with higher layer parameter *ul-STTI-Length*=*'slot'*

- the subframe containing slot *i*,otherwise.

If the UE reports power headroom on subframe *i* of serving cell *c* using subframe-PUSCH, for serving cells other than serving cell *c,* the UE computes power headroom for subframe *i*.

Type 1:

If the UE is scheduled to transmit PUSCH and is not prepared to transmit PUCCH in subframe/slot/subslot  for serving cell , then power headroom for a Type 1 report is computed using

 [dB]

where, , , , , ,  and  are defined in Clause 5.1.1.1.

If the UE is scheduled to transmit PUSCH and is prepared to transmit PUCCH in subframe/slot/subslot  for serving cell , then power headroom for a Type 1 report is computed using

 [dB]

where, , , , ,  and  are defined in Clause 5.1.1.1. is computed based on the requirements in [6] assuming a PUSCH only transmission in subframe/slot/subslot . For this case, the physical layer delivers instead of  to higher layers.

If the UE is not scheduled to transmit PUSCH in subframe/slot/subslot  for serving cell , or if the UE is configured with an LAA SCell for uplink transmissions and receives DCI Format 0A/0B/4A/4B with PUSCH trigger A set to 1 on a serving cell *c* and if the UE reports power headroom in the PUSCH transmission corresponding to the DCI in serving cell *c*, then the power headroom for a Type 1 report is computed using

 [dB]

where, is computed assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and TC =0dB, where MPR , A-MPR, P-MPR and TC are defined in [6]. , , , and are defined in Clause 5.1.1.1.

Type 2:

If the UE is scheduled to transmit PUSCH and is prepared to transmit PUCCH in subframe/slot/subslot  for the primary cell, then power headroom for a Type 2 report is computed using

 [dB]

where, , , , , and  are the primary cell parameters as defined in Clause 5.1.1.1 and , , , ,  and  are defined in Clause 5.1.2.1

If the UE is scheduled to transmit PUSCH and is not prepared to transmit PUCCH in subframe/slot/subslot for the primary cell, then power headroom for a Type 2 report is computed using

 [dB]

where, , , , , and  are the primary cell parameters as defined in Clause 5.1.1.1 and , and  are defined in Clause 5.1.2.1.

If the UE is prepared to transmit PUCCH without PUSCH in subframe/slot/subslot for the primary cell, power headroom for a Type 2 report is computed using

 [dB]

where, , and  are the primary cell parameters as defined in Clause 5.1.1.1, ,, , , ,  and  are also defined in Clause 5.1.2.1.

If the UE is not scheduled to transmit PUSCH and is not prepared to transmit PUCCH in subframe/slot/subslot  for the primary cell, then power headroom for a Type 2 report is computed using

 [dB]

where,  is computed assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and TC =0dB, where MPR ,   
A-MPR, P-MPR and TC are defined in [6], ,  and  are the primary cell parameters as defined in Clause 5.1.1.1 and , and  are defined in Clause 5.1.2.1.

If the UE is unable to determine whether there is a PUCCH transmission corresponding to PDSCH transmission(s) or not, or which PUCCH resource is used, in subframe *i* for the primary cell, before generating power headroom for a Type 2 report, upon (E)PDCCH detection, with the following conditions:

- if both PUCCH format 1b with channel selection and *simultaneousPUCCH-PUSCH* are configured for the UE, or

- if PUCCH format 1b with channel selection is used for HARQ-ACK feedback for the UE configured with PUCCH format 3 and *simultaneousPUCCH-PUSCH* are configured,

then, UE is allowed to compute power headroom for a Type 2 using

 [dB]

where, , , , , and  are the primary cell parameters as defined in Clause 5.1.1.1 and , and  are defined in Clause 5.1.2.1.

Type 3:

Computation of power headroom for Type 3 report is described in Clause 5.1.3.2.

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

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the UE shall use  instead of to compute and  for subframe *i* and serving cell , where  is defined in Clause 5.1.1.1.

### 5.1.2 Physical uplink control channel

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

- When the procedures are applied for MCG, the term 'serving cell' in this clause refers to serving cell belonging to the MCG.

When the procedures are applied for SCG, the term 'serving cell' in this clause refers to serving cell belonging to the SCG. The term 'primary cell' in this clause refers to the PSCell of the SCG.If the UE is configured with a PUCCH-SCell, the UE shall apply the procedures described in this clause for both primary PUCCH group and secondary PUCCH group.

- When the procedures are applied for the primary PUCCH group, the term 'serving cell' in this clause refers to serving cell belonging to the primary PUCCH group.

- When the procedures are applied for the secondary PUCCH group, the term 'serving cell' in this clause refers to serving cell belonging to the secondary PUCCH group. The term 'primary cell' in this clause refers to the PUCCH-SCell of the secondary PUCCH group.

#### 5.1.2.1 UE behaviour

If serving cell is the primary cell, for PUCCH format 1/1a/1b/2/2a/2b/3, the setting of the UE Transmit powerfor the physical uplink control channel (PUCCH) transmission in subframe/slot/subslot *i* for serving cell  is defined by

 [dBm]

If serving cell is the primary cell, for PUCCH format 4/5, the setting of the UE Transmit powerfor the physical uplink control channel (PUCCH) transmission in subframe/slot/subslot *i* for serving cell  is defined by

 [dBm]

If the UE is not transmitting PUCCH for the primary cell, for the accumulation of TPC command for PUCCH, the UE shall assume that the UE transmit power  for PUCCH in subframe/slot/subslot *i* is computed by

 [dBm]

where

- is the configured UE transmit power defined in [6] in subframe/slot/subslot i for serving cell . If the UE transmits PUSCH without PUCCH in subframe  for the serving cell c, for the accumulation of TPC command for PUCCH, the UE shall assume  as given by Clause 5.1.1.1. If the UE does not transmit PUCCH and PUSCH in subframe/slot/subslot  for the serving cell c, for the accumulation of TPC command for PUCCH, the UE shall compute  assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and TC =0dB, where MPR, A-MPR, P-MPR and TC are defined in [6].

- The parameter  is provided by higher layers. Each  value corresponds to aPUCCH format (*F*) relative to subframe-PUCCH format 1a, where each PUCCH format (*F* ) is defined in Table 5.4-1 of [3] for subframe-PUCCH, in Table 5.4A-1 of [3] for slot-PUCCH, and in Table 5.4A-2 of [3] for subslot-PUCCH.

- If the UE is configured by higher layers to transmit PUCCH on two antenna ports, the value of is provided by higher layers where each PUCCH format *F'* is defined in Table 5.4-1 of [3] for subframe-PUCCH, in Table 5.4A-1 of [3] for slot-PUCCH, and in Table 5.4A-2 of [3] for subslot-PUCCH; otherwise, .

-  is a PUCCH format dependent value, where  corresponds to the number of information bits for the channel quality information defined in Clause 5.2.3.3 in [4].  = 1 if subframe/slot/subslot *i* is configured for SR for the UE not having any associated transport block for UL-SCH, otherwise =0. If the UE is configured with more than one serving cell, or the UE is configured with one serving cell and transmitting using PUCCH format 3, the value of  is defined in Clause 10.1; otherwise,  is the number of HARQ-ACK bits sent in subframe/slot/subslot *i*.

- For subframe-PUCCH format 1,1a and 1b 

- For PUCCH format 1b with channel selection, if the UE is configured with more than one serving cell, , otherwise, 

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



- For PUCCH format 2 and extended cyclic prefix



- For PUCCH format 3 or for all slot/subslot PUCCH formats except slot/subslot PUCCH format 4 and when UE transmits HARQ-ACK/SR without periodic CSI,

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



- Otherwise



- For PUCCH format 3 and when UE transmits HARQ-ACK/SR and periodic CSI,

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



- Otherwise



- For PUCCH format 4,  is the bandwidth of the PUCCH format 4 expressed in number of resource blocks valid for subframe/slot/subslot *i* and serving cell. For PUCCH format 5, .

-  where , and

- for subframe-PUCCH

-  is the number of HARQ-ACK/SR/RI/CQI/PMI bits including CRC bits transmitted on PUCCH format 4/5 in subframe *i*;

-  for PUCCH format 4 and  for PUCCH format 5;

-  if shortened PUCCH format 4 or shortened PUCCH format 5 is used in subframe *i* and  otherwise.

- for slot/subslot-PUCCH

-  is the total number of HARQ-ACK/SR bits including CRC bits transmitted on PUCCH format 4 in slot/subslot *i*;

-  is the number of REs used for slot/subslot-PUCCH format 4 transmission in slot/subslot *i*

-  is a parameter composed of the sum of a parameter  provided by higher layers and a parameter  provided by higher layers.

-  is a UE specific correction value, also referred to as a TPC command, included in a PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D for the primary cell, or included in a MPDCCH with DCI format 6-1A, or included in an EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D for the primary cell, or included in a PDCCH/SPDCCH with DCI format 7-1A/1B/1C/1D/1E/1F/1G if the UE is configured with higher layer parameter *shortTTI* for the primary cell, or sent jointly coded with other UE specific PUCCH correction values on a PDCCH/MPDCCH with DCI format 3/3A whose CRC parity bits are scrambled with TPC-PUCCH-RNTI.

- For a non-BL/CE UE, if the UE is not configured for EPDCCH monitoring, the UE attempts to decode

- a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and one or several PDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI on every subframe except when in DRX.

- a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI in case of slot/subslot-PUCCH transmissions associated with PDSCH/PUSCH transmissions without a corresponding PDCCH/SPDCCH, when configured by higher layer *parameter tpc-PDCCH-ConfigPUCCH-SPS*

- a PDCCH/SPDCCH of DCI format 7-1A/1B/1C/1D/1E/1F/1G if the UE is configured with higher layer parameter *shortTTI* in case of slot/subslot-PUCCH transmissions associated with PDSCH/PUSCH transmissions with corresponding PDCCH/SPDCCH

- If a UE is configured for EPDCCH monitoring, the UE attempts to decode

- a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and one or several PDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI as described in Clause 9.1.1, and

- one or several EPDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI, as described in Clause 9.1.4, and

- a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI in case of slot/subslot-PUCCH transmissions associated with PDSCH/PUSCH transmissions without a corresponding PDCCH/SPDCCH, when configured by higher layer *parameter tpc-PDCCH-ConfigPUCCH-SPS*

- a PDCCH/SPDCCH of DCI format 7-1A/1B/1C/1D/1E/1F/1G with the UE's C-RNTI as described in Clause 9.6.1if the UE is configured with higher layer parameter *shortTTI* in case of slot/subslot-PUCCH transmissions associated with PDSCH/PUSCH transmissions with corresponding PDCCH/SPDCCH.

- For a BL/CE UE configured with CEModeA, the UE attempts to decode a MPDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and MPDCCH of DCI format 6-1A with the UE's C-RNTI or SPS C-RNTI or PUR-RNTI on every BL/CE downlink subframe except when in DRX.

- If the UE decodes

- a PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D/7-1A/1B/1C/1D/1E/1F/1G or

- an EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or

- an MPDCCH with DCI format 6-1A or

- a SPDCCH with DCI format 7-1A/1B/1C/1D/1E/1F/1G

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

Else

- if the UE decodes a PDCCH/MPDCCH with DCI format 3/3A, the UE shall use the  provided in that PDCCH/MPDCCH

else the UE shall set  = 0 dB.

-  where  is the current PUCCH power control adjustment state and where is the first value after reset.

- For FDD or FDD-TDD and primary cell frame structure type 1,

-  and  for subframe-PUCCH,

-  and for slot-PUCCH if the TPC command is received in a slot and the TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G,

-  and when the TPC command is received in a subslot and the TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G,

- for slot-PUCCH if the TPC command is received in a subslot and the TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G and  corresponds to the index of the three last subslots sent at the latest  subslots earlier than the start of the slot-PUCCH.

- For a slot/subslot-PUCCH transmission in slot/subslot *i* of subframe *I* corresponding to a slot/subslot-PDSCH transmission without a corresponding PDCCH/SPDCCH, the UE shall use the provided in the PDCCH with DCI format 3/3A received in a subframe not later than subframe *I* - 4 when configured by higher layer *parameter tpc-PDCCH-ConfigPUCCH-SPS.*

- For TDD, values of  and  are given in Table 10.1.3.1-1C if the UE is configured with higher layer parameter *shortTTI* and the TPC command  is included in a PDCCH/ SPDCCH with DCI format 7-1A/1B/1C/1D/1E/1F/1G, in Table 10.1.3.1-1B if the UE is configured with higher layer parameter *shortProcessingTime* and the TPC command  is included in a PDCCH sent in the UE-specific search space, and in Table 10.1.3.1-1 otherwise, where the "UL/DL configuration" in Table 10.1.3.1-1 corresponds to the *eimta-HARQ-ReferenceConfig-r12* for the primary cell when the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for the primary cell, or to *harq-ReferenceConfig-r14* for the primary cell when the UE is configured with the parameter *harq-ReferenceConfig-r14*. For a slot-PUCCH transmission in slot *i* of subframe *I* corresponding to a slot-PDSCH transmission without a corresponding PDCCH/SPDCCH, the UE shall use the  provided in the PDCCH with DCI format 3/3A received in subframes not later than subframe *I* - *km* when configured by higher layer parameter *tpc-PDCCH-ConfigPUCCH-SPS*, where and  are given in Table 10.1.3.1-1.

- The  dB values signalled on PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or MPDCCH with DCI format 6-1A or PDCCH/SPDCCH with DCI format 7-1A/1B/1C/1D/1E/1F/1G are given in Table 5.1.2.1-1. If the PDCCH with DCI format 1/1A/2/2A/2B/2C/2D or EPDCCH with DCI format 1/1A/2A/2/2B/2C/2D or MPDCCH with DCI format 6-1A or PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is validated as an SPS activation PDCCH/EPDCCH/MPDCCH, or the PDCCH/EPDCCH with DCI format 1A or MPDCCH with DCI format 6-1A or PDCCH/SPDCCH with DCI format 7-1A/7-1B/7-1C/7-1D/7-1E/7-1F/7-1G is validated as an SPS release PDCCH/EPDCCH/MPDCCH/SPDCCH, then  is 0dB.

- The  dB values signalled on PDCCH/MPDCCH with DCI format 3/3A are given in Table 5.1.2.1-1 or in Table 5.1.2.1-2 as semi-statically configured by higher layers.

- If  value is changed by higher layers, or if a BL/CE UE transmits using preconfigured uplink resources,

- 

- If the UE is configured with higher layer parameter *shortTTI* or if there is a change in configuration corresponding to the higher layer parameter *shortTTI*,  for the first following slot/subslot-PUCCH transmission in a given subframe is set to  associated with PUCCH of the previous uplink subframe.

- Else

- , where

-  is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the primary cell, see Clause 6.2 and

- if UE is transmitting PUCCH in subframe *i*,



.

Otherwise,

and  is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the primary cell. A UE configured with *ul-ConfigInfo-r14,* the UE shall assume

- If UE has reached  for the primary cell, positive TPC commands for the primary cell shall not be accumulated.

- If UE has reached minimum power, negative TPC commands shall not be accumulated.

- UE shall reset accumulation

- when  value is changed by higher layers

- when the UE receives a random access response message for the primary cell

- when the UE performs PUSCH transmission using preconfigured uplink resource

-  if  is not an uplink subframe/slot in TDD or FDD-TDD and primary cell frame structure type 2.

For a BL/CE UE configured with CEModeA, if the PUCCH, or multiple PUCCHs corresponding to PDSCHs scheduling by one DCI, are transmitted in more than one subframe *i0*, *i1*, …, *iN-1* where *i0*< *i1*< …< *iN-1*, the PUCCH(s) transmit power in subframe *ik* , *k*=0, 1, …, *N*-1is determined by



For a BL/CE UE configured with CEModeB, the PUCCH transmit power in subframe *ik* is determined by



Table 5.1.2.1-1: Mapping of TPC Command Field in DCI format 1A/1B/1D/1/2A/2B/2C/2D/2/3/6-1A/7-1A/1B/1C/1D/1E/1F/1G to  values

|  |  |
| --- | --- |
| TPC Command Field in  DCI format 1A/1B/1D/1/2A/2B/2C/2D/2/3/6-1A/7-1A/1B/1C/1D/1E/1F/1G | [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  values

|  |  |
| --- | --- |
| TPC Command Field in  DCI format 3A | [dB] |
| 0 | -1 |
| 1 | 1 |

### 5.1.3 Sounding Reference Symbol (SRS)

#### 5.1.3.1 UE behaviour

The setting of the UE Transmit power for the SRS transmitted on subframe *i* for serving cell  is defined by:

for SRS transmission given trigger type 2 or for serving cell  with frame structure type 2, and not configured for PUSCH/PUCCH transmission

 [dBm]

otherwise

 [dBm]

where

-  is the configured UE transmit power defined in [6] in subframe *i* for serving cell .

-  is semi-statically configured by higher layers for *m=0* and *m=1* for serving cell . For SRS transmission given trigger type 0 then *m=0* and for SRS transmission given trigger type 1 then *m=1*.

-  is the bandwidth of the SRS transmission in subframe *i* for serving cell  expressed in number of resource blocks.

-  is the current PUSCH power control adjustment state for serving cell , see Clause 5.1.1.1.

-  and  are parameters as defined in Clause 5.1.1.1 for subframe , where .

-  is the higher layer parameter *alpha-SRS* for SRS transmission given trigger type 0, 1, or is the higher layer parameter *alphaSRS-Add* for SRS transmission given trigger type 2, configured by higher layers for serving cell .

- is a parameter composed of the sum of a component  which is *p0-Nominal-PeriodicSRS,* *p0-Nominal-AperiodicSRS*, or *p0-NominalSRS-Add* provided from higher layers for *m=0,* *1* or *2* respectively, and a component  which is *p0-UE-PeriodicSRS,* *p0-UE-AperiodicSRS*, or *p0-UE-SRS-Add* provided by higher layers for *m=0,* *1* or *2* respectively, for serving cell . For SRS transmission given trigger type 0 then *m=0* and for SRS transmission given trigger type 1 then *m=1* and for SRS transmission given trigger type 2 then *m=2*.

- For SRS transmission given trigger type 2 or for serving cell  with frame structure type 2, and not configured for PUSCH/PUCCH transmission, the current SRS power control adjustment state is given by and is defined by:

-  if accumulation is enabled, and if accumulation is not enabled based on higher layer parameter *accumulation-Enabled*, for SRS transmission given trigger type 0 or 1, or for higher layer parameter *accumulationEnabled-additionalSRS* given trigger type 2, where

-  is a correction value, also referred to as a SRS TPC command signalled on PDCCH with DCI format 3 or 3A for SRS transmission given trigger type 2, or DCI format 3B for SRS transmission for trigger type 0, 1, 2 SRS in the most recent subframe , where .

- The UE is not expected to receive different SRS TPC command values for serving cell  in the same subframe for SRS transmission given trigger type 0, or 1.

- The UE is not expected to receive different SRS TPC command values for serving cell in the same subframe for SRS transmission given trigger type 2.

- The UE attempts to decode a PDCCH of DCI format 3B with CRC scrambled by higher layer parameter *srs-TPC-RNTI-r14*in every subframe except where serving cell is deactivated.

- The UE attempts to decode a PDCCH of DCI format 3 or 3A with CRC scrambled by higher layer parameter *TPC-PUSCH-RNTI* in every subframe except where service cell is deactivated.

- dB for a subframe where no TPC command in PDCCH with DCI format 3/3A/3B is decoded for serving cell  or *i* is not an uplink/special subframe in TDD or FDD-TDD and serving cell c frame structure type 2.

- If higher layer parameter *fieldTypeFormat3B* or *fieldTypeFormat3B-SRS-Add* indicates 2-bit TPC command, the  dB values signalled on PDCCH with DCI format 3B are given in Table 5.1.1.1-2 by replacing  with , or if higher layer parameter *fieldTypeFormat3B* or *fieldTypeFormat3B-SRS-Add* indicates 1-bit TPC command, the  dB values signalled on PDCCH with DCI format 3B are given in Table 5.1.1.1-3 by replacing  with .

- The  dB values signalled on PDCCH with DCI format 3 are given in Table 5.1.1.1-2 by replacing  with , and the  dB values signalled on PDCCH with DCI format 3A are given in Table 5.1.1.1-3 by replacing  with .

- If accumulation is enabled,  is the first value after reset of accumulation. The UE shall reset accumulation

- For serving cell , when  value is changed by higher layers

- For serving cell , when the UE receives random access response message for serving cell .

- For both types of  (accumulation or current absolute) the first value is set as follows:

- If  value is received by higher layers

- 

- else

- if the UE receives the random access response message for a serving cell 

- , where

 is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell , see Clause 6.2, and and  is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the serving cell , is the bandwidth of the SRS transmission expressed in number of resource blocks valid for the subframe of first SRS transmission in the serving cell.

If the UE is not configured with an SCG or a PUCCH-SCell, and if the total transmit power of the UE for the Sounding Reference Symbol in an SC-FDMA symbol would exceed , the UE scales for the serving cell  and the SC-FDMA symbol in subframe *i* such that the condition



is satisfied where  is the linear value of ,  is the linear value of  defined in [6] in subframe *i* and is a scaling factor of  for serving cell  where . Note thatvalues are the same across serving cells.

If the UE is not configured with an SCG or a PUCCH-SCell, and if the UE is configured with multiple TAGs and the SRS transmission of the UE in an SC-FDMA symbol for a serving cell in subframe in a TAG overlaps with the SRS transmission in another SC-FDMA symbol in subframe for a serving cell in another TAG, and if the total transmit power of the UE for the Sounding Reference Symbol in the overlapped portion would exceed , the UE scales for the serving cell  and each of the overlapped SRS SC-FDMA symbols in subframe  such that the condition



is satisfied for all the overlapped SRS SC-FDMA symbol(s) in subframe  where  is the linear value of ,  is the transmit power of SRS trigger type 2 or trigger type 0/1 in subframe for serving cell ,  is the linear value of  defined in [6] in subframe *i* and is a scaling factor of  for serving cell  where . Note thatvalues are the same across serving cells.

If the UE is configured with a LAA SCell for uplink transmissions, the UE may compute the scaling factor  assuming that the UE performs a SRS transmission on the LAA SCell in subframe *i* irrespective of whether the UE can access the LAA SCell for the SRS transmission in subframe *i* according to the channel access procedures described in Clause 4.2.1 of [13].

If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell  and if subframe  belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the UE shall use  instead of to determine  for subframe *i* and serving cell , where  is defined in Clause 5.1.1.1.

#### 5.1.3.2 Power headroom for Type3 report

The UE is not expected to compute a Type 3 report on a slot/subslot.

For SRS transmission given trigger type 2, or for serving cell  with frame structure type 2 and not configured for PUSCH/PUCCH transmission,

- if the UE transmits SRS in subframe  for serving cell , or if the UE does not transmit SRS in subframe due to a collision with a higher priority physical channel or signal (as defined in Clause 8.2) in subframe, and the UE would have transmitted the SRS in subframe had the higher priority physical channel or signal in subframe not occurred, power headroom for a Type 3 report is computed using

 [dB]

where is defined in Clause 5.1.1.1. , , ,, are defined in Clause 5.1.3.1.

- otherwise, power headroom for a Type 3 report is computed using

 [dB]

where is defined in Clause 5.1.1.1., ,, are defined in Clause 5.1.3.1. is computed based on the requirements in [6] assuming a SRS transmission in subframe , and assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and TC =0dB. MPR, A-MPR, P-MPR and TC are defined in [6]. For this case, the physical layer delivers instead of  to higher layers.

### 5.1.4 Power allocation for EUTRA dual connectivity

If a UE is configured with multiple cell groups, the UE is not expected to be configured with SRS trigger type 2, and

- if the UE supports synchronous dual connectivity but does not support asynchronous dual connectivity, or if the UE supports both synchronous dual connectivity and asynchronous dual connectivity and if the higher layer parameter *powerControlMode* indicates dual connectivity power control mode 1

- if the maximum uplink timing difference between transmitted signals to different serving cells including serving cells belonging to different CGs is equal to or less than the minimum requirement for maximum transmission timing difference for synchronous dual connectivity defined in [10].

- The UE shall use the procedures described in sub clause 5.1.4.1.

- If a PRACH transmission of the UE on the Pcell starting in subframe of MCG overlaps in time domain with another PRACH transmission of the UE starting in subframe  of SCG, and if subframe  and subframe  overlap in time with more than one symbol, and if the total power of both the PRACH transmissions would exceed , the UE shall transmit the PRACH on the Pcell using the preamble transmission power described in Clause 6.1. The UE may drop or adjust the power of the PRACH transmission in subframe  of SCG such that the total power does not exceed , where is the linear value configured transmitted power for Dual Connectivity for the subframe pair as described in [6]. If the UE drops the PRACH transmission, it sends power ramping suspension indicator to the higher layers. If the UE adjusts the power of PRACH transmission, it may send power ramping suspension indicator to the higher layers.

- if the UE supports both synchronous dual connectivity and asynchronous dual connectivity and if the higher layer parameter *powerControlMode* does not indicate dual connectivity power control mode 1

- The UE shall use the procedures described in sub clause 5.1.4.2 .

- If a PRACH transmission on the Pcell in subframe of MCG overlaps in time another PRACH transmission in subframe of SCG, and if the time difference between the start of the two PRACH transmissions is less than , and if the transmission timing of the PRACH on the Pcell (according to Clause 6.1.1) is such that the UE is ready to transmit the PRACH on Pcell at least one subframe before subframe of MCG, and if the total power of both the PRACH transmissions exceeds , the UE shall transmit the PRACH on the Pcell using the preamble transmission power PPRACH described in Clause 6.1. The UE may drop or adjust the power of the PRACH transmission in subframe  of SCG such that the total power does not exceed , where is the linear value configured transmitted power for Dual Connectivity for the subframe pair as described in [6]. If the UE drops the PRACH transmissions, it sends power ramping suspension indicator to the higher layers. If the UE adjusts the power of PRACH transmission, it may send power ramping suspension indicator to the higher layers.

#### 5.1.4.1 Dual connectivity power control Mode 1

If the UE PUSCH/PUCCH transmission(s) in subframe  of CG1 overlap in time with PUSCH/PUCCH transmission(s) in more than one symbol of subframe of CG2 or if at least the last symbol the UE PUSCH/PUCCH transmission(s) in subframe  of CG1 overlap in time with SRS transmission(s) of subframe , and

- if the UE has a PUCCH/PUSCH transmission with UCI including HARQ-ACK/SR in subframe  of CG1: If the UE has a PUCCH transmission with UCI including HARQ-ACK/SR in subframe  of CG1 and if  would exceed , the UE scales such that the condition  is satisfied where  and . If  would not exceed , . If the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe of serving cell , and if  would exceed, the UE scales such that the condition  is satisfied where  and . If would not exceed , .   
 is determined as follows ;   
where

- ;

- if CG1 is MCG and CG2 is SCG,

- ;

- ;

- if CG1 is SCG and CG2 is MCG

- if the UE has a PUCCH transmission with UCI including HARQ-ACK/SR subframe of CG2,

- ;

- 

- else if the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe of serving cell ,

- ;

- ;

- otherwise,

- ;

- 

- if the UE has a PUCCH/PUSCH transmission with UCI not including HARQ-ACK/SR in subframe  of CG1: If the UE has a PUCCH transmission with UCI not including HARQ-ACK/SR in subframe  of CG1 and if would exceed , the UE scales such that the condition is satisfied where  and . If would not exceed , . If the UE has a PUSCH transmission with UCI not including HARQ-ACK in subframe of serving cell , and if  would exceed, the UE scales such that the condition  is satisfied where  and . If would not exceed , .  
is determined as follows  


where

- if the UE has a PUCCH transmission with HARQ-ACK/SR and a PUSCH transmission with UCI not including HARQ-ACK in subframe  of CG1, otherwise, .

- if CG1 is MCG and CG2 is SCG

- if the UE has a PUCCH transmission with UCI including HARQ-ACK/SR in subframe of CG2,

- 

- ;

- else if the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe of serving cell ,

- 

- ;

- otherwise,

- 

- 

- if CG1 is SCG and CG2 is MCG

- if the UE has a PUCCH transmission in subframe of CG2 and/or a PUSCH transmission with UCI in in subframe of serving cell 

- 

-   
where, if the UE does not have a PUCCH transmission in subframe of CG2; if the UE does not have a PUSCH transmission with UCI in subframe of CG2;

- otherwise

- 

- 

- If the UE has PUSCH transmission(s) without UCI in subframe of CG1, the UE shall determine  
  
where

- if the UE has a PUCCH transmission in subframe of CG1 and/or a PUSCH transmission with UCI in in subframe of serving cell ,  
where  if the UE does not have a PUCCH transmission in subframe of CG1,if the UE does not have a PUSCH transmission with UCI in subframe of CG1; otherwise;

- if CG1 is MCG and CG2 is SCG

- if the UE has a PUCCH transmission in subframe of CG2 and/or a PUSCH transmission with UCI in in subframe of serving cell 

- 

-   
where, if the UE does not have a PUCCH transmission in subframe of CG2; if the UE does not have a PUSCH transmission with UCI in subframe of CG2;

- otherwise

- 

- ;

- if CG1 is SCG and CG2 is MCG

- 

- ;

- If the total transmit power of all the PUSCH transmission(s) without UCI in subframe of CG1 would exceed , the UE scales for each serving cell  with a PUSCH transmission without UCI in subframe  such that the condition is satisfied, where , and where  is a scaling factor of for serving cell  where . Note thatvalues are the same across serving cells within a cell group whenbut for certain serving cells within the cell group may be zero. If the total transmit power of all the PUSCH transmission(s) without UCI in subframe of CG1 would not exceed , .

where

- is the linear value of configured transmitted power for Dual Connectivity for the subframe pair as described in [6];

- if CG1 is MCG and CG2 is SCG

-  is the linear value of corresponding to PUCCH transmission on the primary cell ;  is the linear value of corresponding to PUCCH transmission on the PSCell.

- ;

- if CG1 is SCG and CG2 is MCG;

-  is the linear value of corresponding to PUCCH transmission on the PSCell;  is the linear value of corresponding to PUCCH transmission on the primary cell.

- ;

- is the linear value of for subframe of serving cell of serving cell , and is the linear value of  for subframe of serving cell of serving cell .

- and are given by Table 5.1.4.2-1 according to higher layer parameters p-MeNB and p-SeNB respectively;

- If the UE has a PRACH transmission for CG1 overlapping with subframe  of CG1, is the linear value of the transmission power of that PRACH transmission; otherwise, ;

- If the UE has a PRACH transmission for CG2 overlapping with subframe  of CG2, is the linear value of the transmission power of that PRACH transmission; otherwise, .

-  is determined as follows

- if the PUSCH/PUCCH is not transmitted in the last symbol of subframe  of CG1, or if the UE does not have an SRS transmission in subframe  of serving cell or if the UE drops SRS transmission in subframe  of serving cell  due to collision with PUCCH in subframe  of serving cell 

- ;

- if the UE has an SRS transmission and does not have a PUCCH/PUSCH transmission in subframe  of serving cell 

- ;

- if the UE has an SRS transmission and a has PUCCH transmission, and does not have a PUSCH transmission in subframe  of serving cell 

- 

- if the UE has an SRS transmission and a has PUSCH transmission, and does not have a PUCCH transmission in subframe  of serving cell 

- 

- if the UE has an SRS transmission and has a PUSCH transmission and a PUCCH transmission in in subframe  of serving cell 

- 

If the total transmit power for the Sounding Reference Symbol in an SC-FDMA symbol across all the serving cells within a TAG of a cell group CG1 would exceed, the UE scales for the serving cell and the SC-FDMA symbol in subframe  such that the condition 

is satisfied, where  is the transmission power of SRS after scaling and where  is the linear value of described in Clause 5.1.3.1, and is a scaling factor of  for serving cell  where . Note thatvalues are the same across serving cells within the same CG.

If the UE is configured with multiple TAGs within CG1 and the SRS transmission of the UE in an SC-FDMA symbol for a serving cell in subframe in a TAG belonging to CG1 overlaps with the SRS transmission in another SC-FDMA symbol in subframe for a serving cell in another TAG belonging to CG1, and if the total transmit power of the UE for the Sounding Reference Symbol in the overlapped portion would exceed , the UE scales for the serving cell  and each of the overlapped SRS SC-FDMA symbols in subframe  such that the condition  is satisfied, where  is the transmission power of SRS after scaling, and where  is a scaling factor of for serving cell  where . Note thatvalues are the same across serving cells within a cell group.

 is determined as follows



where

- if CG1 is MCG and CG2 is SCG

- 

- 

- if CG1 is SCG and CG2 is MCG

- 

- 

- if the UE has no PUCCH transmission or has a shortened PUCCH transmission in subframe of CG2, ; otherwise 

- if the UE has no PUSCH transmission in the last symbol of subframe  of serving cell , ; otherwise

- if the UE has PRACH transmission in CG2 that overlaps with the last symbol of subframe of CG2, ; otherwise 

For both cell groups

- if the PUCCH/PUSCH transmission of the UE on subframe  for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUSCH transmission on subframe  for a different serving cell in another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe  for a serving cell in another TAG of CG2, the UE shall adjust its total transmission power of all CGs such that the total transmission power of the UE across all CGs does not exceed on any overlapped portion.

- if the PUSCH transmission of the UE on subframe  for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUCCH transmission on subframe  for a different serving cell in another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe  for a serving cell in another TAG of CG2, the UE shall adjust its total transmission power of all CGs such that the total transmission power of the UE across all CGs does not exceed on any overlapped portion.

- if the SRS transmission of the UE in a symbol on subframe  for a given serving cell in a TAG of CG1 overlaps with the PUCCH/PUSCH transmission on subframe or subframe  for a different serving cell in the same or another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe  for a serving cell of CG2, the UE shall drop the SRS in CG1 if its total transmission power across all CGs exceeds  on any overlapped portion of the symbol.

- if the SRS transmission of the UE in a symbol on subframe  for a given serving cell in CG1 overlaps with the SRS transmission on subframe  for a different serving cell(s) in CG1 or overlaps with SRS transmission on subframe  for a serving cell(s) in CG2, and if the SRS transmissions overlap with PUSCH/PUCCH transmission on subframe or subframe  for another serving cell(s) in CG1, and/or if the SRS transmissions overlap with PUSCH/PUCCH transmission on subframe  for a serving cell of CG2, the UE shall drop the SRS transmissions in CG1 if its total transmission power across all CGs exceeds  on any overlapped portion of the symbol.

- UE shall, when requested by higher layers, to transmit PRACH on subframe or subframe  in a secondary serving cell in CG1 and/or to transmit PRACH on subframe in a serving cell in CG2 in parallel with SRS transmission in a symbol on subframe  of a different serving cell belonging to a different TAG of CG1, drop SRS in CG1 if its total transmission power across all CGs exceeds  on any overlapped portion of the symbol.

- UE shall, when requested by higher layers, to transmit PRACH on subframe  in a secondary serving cell in CG1 and/or to transmit PRACH on subframe  in a serving cell in CG2 in parallel with PUSCH/PUCCH on subframe  in a different serving cell belonging to a different TAG of CG1, adjust the transmission power of PUSCH/PUCCH in CG1 so that the total transmission power of the UE across all CGs does not exceed on the overlapped portion.

#### 5.1.4.2 Dual connectivity power control Mode 2

If subframe  of CG1 overlaps in time with subframe  and subframe of CG2, and if the UE has transmission(s) in subframe  of CG1,

- if the UE determines based on higher layer signalling that transmission(s) in subframe  of CG1 cannot overlap in time with transmission(s) in subframe  of CG2, the UE shall determine



- Otherwise, the UE shall determine

.

where,

- 

- is the linear value of configured transmitted power for Dual Connectivity for the subframe pair , as described in [6];

- , if the UE does not have a PUSCH transmission in serving cell ;

-  if the UE does not have a PUCCH transmission in CG1;

- if the UE has no transmission of PUCCH, PUSCH, or SRS in subframe  of CG2;

-  , and  if CG1 is MCG and CG2 is SCG;

- , and , if CG1 is SCG and CG2 is MCG;

- and are given by Table 5.1.4.2-1 according to higher layer parameters *p-MeNB* and *p-SeNB* respectively;

- If the UE has a PRACH transmission for CG1 overlapping with subframe  of CG1, is the linear value of the transmission power of that PRACH transmission; otherwise, .

- If the UE has a PRACH transmission for CG2 overlapping with subframe  of CG2, and if the transmission timing of the PRACH transmission (according to Clause 6.1.1) is such that the UE is ready to transmit the PRACH at least one subframe before subframe of CG2, is the linear value of the transmission power of that PRACH transmission; otherwise, .

- If the UE has a PRACH transmission for CG2 overlapping with subframe  of CG2, is the linear value of the transmission power of that PRACH transmission; otherwise, .

-  is determined as follows

- if the UE does not have an SRS transmission in subframe  of serving cell or if the UE drops the SRS transmission in subframe  of serving cell due to collision with a PUCCH transmission in subframe  of serving cell 

- ;

- if the UE has an SRS transmission and does not have a PUCCH/PUSCH transmission in subframe  of serving cell 

- ;

- if the UE has an SRS transmission and a has PUCCH transmission, and does not have a PUSCH transmission in subframe  of serving cell 

- 

- if the UE has an SRS transmission and a has PUSCH transmission, and does not have a PUCCH transmission in subframe  of serving cell 

- 

- if the UE has an SRS transmission and has a PUSCH transmission and a PUCCH transmission in subframe  of serving cell 

- 

where is the linear value of described in Clause 5.1.3.1.

If would exceed , the UE scales  such that the condition is satisfied where

- if CG1 is MCG,  is the linear value of corresponding to PUCCH transmission on the primary cell, in case there is no PUCCH transmission in subframe *i* on the primary cell .

- if CG1 is SCG ,  is the linear value of corresponding to PUCCH transmission on PSCell, in case there is no PUCCH transmission in subframe *i* on the PSCell .  is the linear value of 

- is a scaling factor of .

If the UE has PUSCH transmission with UCI on serving cell , and would exceed  the UE scales  such that the condition is satisfied where  is the linear value of the PUSCH transmit power for the cell with UCI, and is a scaling factor of for serving cell .

If the total transmit power across all the serving cells of a cell group CG1 would exceed , the UE scales for the serving cell  in subframe *i* such that the condition is satisfied; and is a scaling factor of for serving cell  where .

If the UE has PUSCH transmission with UCI on serving cell  and PUSCH without UCI in any of the remaining serving cells belonging to CG1, and the total transmit power across all the serving cells of CG1 would exceed , the UE scales for the serving cells belonging to CG1 without UCI in subframe *i* such that the condition  is satisfied;

where  is the PUSCH transmit power for the cell with UCI andis a scaling factor of for serving cell  without UCI. In this case, no power scaling is applied to  unless and the total transmit power across all of the serving cells of the CG1 still would exceed .

If the UE has simultaneous PUCCH and PUSCH transmission with UCI on serving cell and PUSCH transmission without UCI in any of the remaining serving cells belonging to CG1, and the total transmit power across all the serving cells of the CG1 would exceed , the UE obtains according to  and 

where

- if CG1 is MCG,  is the linear value of corresponding to PUCCH transmission on the primary cell.

- if CG1 is SCG ,  is the linear value of corresponding to PUCCH transmission on PSCell.

Note thatvalues are the same across serving cells within a cell group whenbut for certain serving cells within the cell group may be zero.

If the total transmit power for the Sounding Reference Symbol in an SC-FDMA symbol across all the serving cells within a TAG of a cell group CG1 would exceed , the UE scales for the serving cell and the SC-FDMA symbol in subframe *i* such that the condition



is satisfied where  is the linear value of described in Clause 5.1.3.1, and is a scaling factor of  for serving cell  where . Note thatvalues are the same across serving cells within the same CG.

If the UE is configured with multiple TAGs within CG1 and the SRS transmission of the UE in an SC-FDMA symbol for a serving cell in subframe in a TAG belonging to CG1 overlaps with the SRS transmission in another SC-FDMA symbol in subframe for a serving cell in another TAG belonging to CG1, and if the total transmit power of the UE for the Sounding Reference Symbol in the overlapped portion would exceed, the UE scales for the serving cell  and each of the overlapped SRS SC-FDMA symbols in subframe  such that the condition



is satisfied where  is the linear value of  described in Clause 5.1.3.1, and is a scaling factor of  for serving cell  where . Note thatvalues are the same across serving cells within the same CG.

For a cell group CG1

- if the UE is configured with multiple TAGs within CG1, and if the PUCCH/PUSCH transmission of the UE on subframe  for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUSCH transmission on subframe  for a different serving cell in another TAG of CG1, the UE shall adjust its total transmission power of CG1 to not exceed on any overlapped portion.

- if the UE is configured with multiple TAGs within CG1, and if the PUSCH transmission of the UE on subframe  for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUCCH transmission on subframe  for a different serving cell in another TAG of CG1 the UE shall adjust its total transmission power of CG1 to not exceed on any overlapped portion.

- if the UE is configured with multiple TAGs within CG1, and if the SRS transmission of the UE in a symbol on subframe  for a given serving cell in a TAG of CG1 overlaps with the PUCCH/PUSCH transmission on subframe or subframe  for a different serving cell in the same or another TAG of CG1 the UE shall drop SRS if its total transmission power of CG exceeds  on any overlapped portion of the symbol.

- if the UE is configured with multiple TAGs within CG1 and more than 2 serving cells within CG1, and if the SRS transmission of the UE in a symbol on subframe  for a given serving cell in the CG1 overlaps with the SRS transmission on subframe  for a different serving cell(s) in CG1 and with PUSCH/PUCCH transmission on subframe or subframe  for another serving cell(s) in CG1, the UE shall drop the SRS transmissions in CG1 if the total transmission power of CG1 exceeds on any overlapped portion of the symbol.

- if the UE is configured with multiple TAGs within CG1, the UE shall, when requested by higher layers, to transmit PRACH in a secondary serving cell in CG1 in parallel with SRS transmission in a symbol on a subframe of a different serving cell belonging to a different TAG of CG1, drop SRS in CG1 if the total transmission power of CG1 exceeds  on any overlapped portion in the symbol.

- if the UE is configured with multiple TAGs within CG1, the UE shall, when requested by higher layers, to transmit PRACH in a secondary serving cell in CG1 in parallel with PUSCH/PUCCH in a different serving cell belonging to a different TAG in CG1, adjust the transmission power of PUSCH/PUCCH in CG1 so that its total transmission power of CG1 does not exceed on the overlapped portion.

Table 5.1.4.2-1:  (or ) values for determining power allocation for dual connectivity

|  |  |
| --- | --- |
| p-MeNB  (or p-SeNB) | (or ) Value (in %) |
| 0 | 0 |
| 1 | 5 |
| 2 | 10 |
| 3 | 15 |
| 4 | 20 |
| 5 | 30 |
| 6 | 37 |
| 7 | 44 |
| 8 | 50 |
| 9 | 56 |
| 10 | 63 |
| 11 | 70 |
| 12 | 80 |
| 13 | 90 |
| 14 | 95 |
| 15 | 100 |

### 5.1.4a Power allocation for dual active protocol stack

If a UE indicates a capability for dual active protocol stack based handover (DAPS HO), the UE can be provided with a source MCG and a target MCG.

If a UE is configured with a target MCG and a source MCG in different bands, and the UE is configured with *DAPS-PowerCoordinationInfo*, the UE shall apply the procedures described in clause 5.1.4 with the following modifications

- Consider the target MCG as the MCG and the source MCG as the SCG.

- Replace *p-MeNB* and *p-SeNB* by *p-DAPS-Target* and *p-DAPS-Source*, respectively.

- Replace "(a)synchronous dual connectivity" by "(a)synchronous DAPS".

- "Dual connectivity power control mode" is replaced by "DAPS power control mode", and is given by higher layer parameter *uplinkPowerSharingDAPS-Mode*.

- The UE assumes only Pcell exists in each MCG.

If UE does not indicate a capability for power sharing between source and target MCGs in DAPS handover, or if a UE is configured with a target MCG and a source MCG in the same band, the UE does not expect the transmissions on the target and source cell to overlap in time domain.

### 5.1.5 Power allocation for PUCCH-SCell

If a UE is configured with a PUCCH-SCell, power allocation for serving cells in the primary PUCCH group and secondary PUCCH group is performed according to Clause 5.1.4.1, with the following exceptions:

- the term 'MCG' is replaced by 'primary PUCCH group';

- the term 'SCG' is replaced by 'secondary PUCCH group';

-  and is the linear value of the UE total configured maximum output power  defined in [6] in subframe/slot/subslot *i*; and

- .

For a UE capable of simultaneous transmission of different uplink signal durations to different serving cells as indicated by UE capability *simultaneousTx-differentTx-duration*, if the UE is configured with a PUCCH-SCell and configured with different values of higher layer parameter *ul-STTI-Length* for serving cells in the primary PUCCH group and secondary PUCCH group, and if the total transmit power of the UE would exceed , the UE drops the following channels from the highest serving cell index to the lowest serving cell index in order until the total transmit power of the UE would not exceed which in that case, the UE would not drop any more channels or until there are only PUSCH/PUCCH transmissions of the same duration remaining in which case the corresponding power scaling rules described in Clause 5.1.1 apply:

- subframe-PUSCH without HARQ-ACK of the secondary PUCCH group

- subframe-PUSCH without HARQ-ACK of the primary PUCCH group

- slot-PUSCH without HARQ-ACK of the secondary PUCCH group

- slot- PUSCH without HARQ-ACK of the primary PUCCH group

- subslot-PUSCH without HARQ-ACK and without DMRS of the secondary PUCCH group

- subslot-PUSCH without HARQ-ACK and without DMRS of the primary PUCCH group

- subslot-PUSCH without HARQ-ACK and with DMRS of the secondary PUCCH group

- subslot-PUSCH without HARQ-ACK and with DMRS of the primary PUCCH group

- subframe-PUSCH with HARQ-ACK or subframe-PUCCH of the secondary PUCCH group

- subframe-PUSCH with HARQ-ACK or subframe-PUCCH of the primary PUCCH group

- slot-PUSCH with HARQ-ACK or slot-PUCCH of the secondary PUCCH group

- slot-PUSCH with HARQ-ACK or slot-PUCCH of the primary PUCCH group

- subslot-PUSCH with HARQ-ACK or subslot-PUCCH of the secondary PUCCH group

- subslot-PUSCH with HARQ-ACK or subslot-PUCCH of the primary PUCCH group

The HARQ-ACK of a dropped channel is transmitted on the channel of the same PUCCH group to be transmitted with highest priority.

If the UE is not configured with a PUCCH-SCell but configured with higher layer parameter *ul-STTI-Length*, and if the total transmit power of the UE would exceed , the UE above dropping rules would apply by removing the channels corresponding to the secondary PUCCH group.

## 5.2 Downlink power allocation

The eNodeB determines the downlink transmit energy per resource element.

For the purpose of RSRP and RSRQ measurements, the UE may assume downlink cell-specific RS EPRE is constant across the downlink system bandwidth and constant across all subframes with discovery signal transmissions until different cell-specific RS power information is received.

For a cell that is not a LAA SCell, the UE may assume downlink cell-specific RS EPRE is constant across the downlink system bandwidth and constant across all subframes until different cell-specific RS power information is received.

The downlink cell-specific reference-signal EPRE can be derived from the downlink reference-signal transmit power given by the parameter *referenceSignalPower* provided by higher layers. The downlink reference-signal transmit power is defined as the linear average over the power contributions (in [W]) of all resource elements that carry cell-specific reference signals within the operating system bandwidth.

For a LAA SCell, the UE may assume that the EPRE of downlink cell-specific RS in subframe n is same as the EPRE of downlink cell-specific RS in subframe n-1, if all OFDM symbols of at least the second slot of subframe n-1, are occupied.

For a BL/CE UE, if the UE is configured with higher layer parameter *RSS-Config*, the ratio of resynchronization signal EPRE to cell-specific RS EPRE is given by higher layer parameter *powerBoost* in *RSS-Config* , where and are the default values for and in Table 5.2-1a assuming the same transmitted power for symbols with or without CRS, and is the number of CRS ports.

For a BL/CE UE, if the UE is configured with higher layer parameter *WUS-Config*, the ratio of MWUS EPRE to cell-specific RS EPRE is given by higher layer parameter *powerBoost* in *WUS-Config*, where and are the default values for and in Table 5.2-1a assuming the same transmitted power for symbols with or without CRS, and is the number of CRS ports.

For a BL/CE UE, if the UE is configured with higher layer parameter *crs-ChEstMPDCCH-ConfigCommon* or *crs-ChEstMPDCCH-ConfigDedicated*, the ratio of Demodulation RS EPRE to cell-specific RS EPRE is given by higher layer parameter *powerRatio* in *crs-ChEstMPDCCH-ConfigCommon* or *crs-ChEstMPDCCH-ConfigDedicated*.

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  or according to the OFDM symbol index as given by Table 5.2-2 and Table 5.2-3. In addition, and are UE-specific.

For a UE in transmission mode 8 - 10 when UE-specific RSs are not present in the PRBs upon which the corresponding PDSCH is mapped or in transmission modes 1 – 7, the UE may assume that for 16 QAM, 64 QAM, 256QAM, or 1024QAM spatial multiplexing with more than one layer or for PDSCH transmissions associated with the multi-user MIMO transmission scheme, or for a UE in transmission modes 2-4 and configured with higher layer parameter *must-Config-r14* the UE may assume that for QPSK,

-  is equal to [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to Clause 6.3.4.3 of [3];

-  is equal to [dB] otherwise

whereis 0 dB for all PDSCH transmission schemes except multi-user MIMO as described in Clause 7.1.5 and where is a UE specific parameter provided by higher layers. If the UE is configured with higher layer parameter *must-Config-r14*, and if the UE is configured with higher layer parameter *p-a-must-r14*, and if the PDCCH/EPDCCH DCI of the corresponding PDSCH transmission indicates MUST interference is present [4], the UE shall use the higher layer parameter *p-a-must-r14* for determining.

For a UE configured with higher layers parameter *servCellp-a-r12*, and the UE in transmission modes 8-10 when UE-specific RSs are not present in the PRBs upon which the corresponding PDSCH is mapped or in transmission modes 1-7, the UE may assume that for QPSK and transmission with single-antenna port or transmit diversity transmission schemes or spatial multiplexing using a single transmission layer, and the PDSCH transmission is not associated with the multi-user MIMO transmission scheme, and the PDSCH is scheduled by a PDCCH/EPDCCH with CRC scrambled by C-RNTI,

-  is equal to  [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to Clause 6.3.4.3 of [3];

-  is equal to [dB] otherwise

and where is given by the parameter *servCellp-a-r12*. If the UE is also configured with higher layer parameter *must-Config-r14*, and if the UE is configured with higher layer parameter *p-a-must-r14*, and if the PDCCH/EPDCCH DCI of the corresponding PDSCH transmission indicates MUST interference is present [4], the UE shall use the higher layer parameter *p-a-must-r14* for determining .

For a cell supporting SC-PTM, the UE may assume that for the PDSCH scrambled by G-RNTI,

-  is equal to  [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to Clause 6.3.4.3 of [3];

-  is equal to  [dB] otherwise

where  is configured per SC-MTCH and is given by higher layer parameter *p-a-r13*. If  is not configured, the UE may assume that  [dB].

For transmission mode 7, if UE-specific RSs are present in the PRBs upon which the corresponding PDSCH is mapped, the ratio of PDSCH EPRE to UE-specific RS EPRE within each OFDM symbol containing UE-specific RSs shall be a constant, and that constant shall be maintained over all the OFDM symbols containing the UE-specific RSs in the corresponding PRBs. In addition, the UE may assume that for 16QAM, 64QAM, 256QAM, or 1024QAM this ratio is 0 dB.

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

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

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

For the purpose of RSRP and RSRQ measurements on CSI-RS of a discovery signal the UE may assume that the EPRE of CSI-RS is constant across the downlink system bandwidth and constant across all subframes with discovery signal transmissions for each CSI-RS resource.

If a serving cell is not configured for a UE as a LAA SCell, and if CSI-RS is configured in the serving cell then the UE shall assume downlink CSI-RS EPRE is constant across the downlink system bandwidth and constant across all subframes for each CSI-RS resource.

If a serving cell is configured for a UE as a LAA SCell, the UE may assume that EPRE of CSI-RS in subframe n2 is same as EPRE of CSI-RS in earlier subframe n1, if all OFDM symbols of subframe n1 and all subframes between subframe n1 and subframe n2, are occupied.

The cell-specific ratio  is given by Table 5.2-1 according to cell-specific parameter  signalled by higher layers and the number of configured eNodeB cell specific antenna ports.  is given by higher layer parameter *p-b-r13* for PDSCH scrambled by G-RNTI and by higher layer parameter *p-b* otherwise. In case PDSCH is scrambled by G-RNTI, if  is not configured, the UE may assume that .

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

|  |  |  |
| --- | --- | --- |
|  |  | |
| 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 |

Table 5.2-1a: and for 1, 2, or 4 cell specific antenna ports   
assuming the same transmitted power for symbols with or without CRS

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | One Antenna Port | | Two and Four Antenna Ports | |
|  |  |  |  |
| 0 | 1 | 1 | 1 | 5/4 |
| 1 | 1/2 | 2/5 | 1/2 | 1/2 |
| 2 | 1/3 | 1/5 | 1/3 | 1/4 |
| 3 | 1/4 | 1/10 | 1/4 | 1/8 |

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

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

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

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

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

### 5.2.1 eNodeB Relative Narrowband TX Power (RNTP) restrictions

The determination of reported Relative Narrowband TX Power indication  is defined as follows:



where  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*;* is the physical resource block number ;  takes on one of the following values[dB] and



where  is the base station maximum output power described in [7], and , and are defined in [3].