Foreword

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where:

x the first digit:

1 presented to TSG for information;

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

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

1 Scope

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

2 References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Symbols and abbreviations

3.1 Symbols

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

n_f System frame number as defined in [3]

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

3.2 Abbreviations

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

ACK	Acknowledgement
BCH	Broadcast Channel
CCE	Control Channel Element
CDD	Cyclic Delay Diversity
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
DCI	Downlink Control Information
DL	Downlink
DL-SCH	Downlink Shared Channel
DTX	Discontinuous Transmission
EPDCCH	Enhanced Physical Downlink Control Channel
EPRE	Energy Per Resource Element
MCG	Master Cell Group
MCS	Modulation and Coding Scheme
NACK	Negative Acknowledgement
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
PUSCH	Physical Uplink Shared Channel
PTI	Precoding Type Indicator
RBG	Resource Block Group
RE	Resource Element
RI	Rank Indication
RS	Reference 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.

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 (Q_{out} and Q_{in}) defined by relevant tests in [10].

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

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

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

4.2.2 Inter-cell synchronization

No functionality is specified in this subclause in this release.

4.2.3 Transmission timing adjustments

Upon reception of a timing advance command 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 $N_{TA} \geq 624$.

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 $N_{TAoffset}$ = 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. $N_{TAoffset}$ is described in [3].

The timing adjustment indication specified in [11] indicates the initial N_{TA} 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 $16\,T_s$. The start timing of the random access preamble is specified in [3].

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

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

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

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 N_{TA} accordingly.

4.3 Timing for Secondary Cell Activation / Deactivation

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

- the actions related to CSI reporting 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 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

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

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

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

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.

5.1.1.1 UE behaviour

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

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

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

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

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

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

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

where,

- $P_{\mathrm{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] in subframe *i* for serving cell c and $\hat{P}_{\mathrm{CMAX,c}}(i)$ is the linear value of $P_{\mathrm{CMAX,c}}(i)$. If the UE transmits PUCCH without PUSCH in subframe i for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall assume $P_{\mathrm{CMAX,c}}(i)$ as given by Subclause 5.1.2.1. If the UE does not transmit PUCCH and PUSCH in subframe i for the serving cell c, for the accumulation of TPC command received with DCI format 3/3A for PUSCH, the UE shall compute $P_{\mathrm{CMAX,c}}(i)$ assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB, where MPR, A-MPR, P-MPR and ΔT_C are defined in [6].

- $\hat{P}_{\mathrm{PUCCH}}(i)$ is the linear value of $P_{\mathrm{PUCCH}}(i)$ defined in Subclause 5.1.2.1

- $M_{\mathrm{PUSCH,c}}(i)$ is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe *i* and serving cell c.

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

  - when j=0, $P_{\mathrm{O\_PUSCH,c}}(0)=P_{\mathrm{O\_UE\_PUSCH,c,2}}(0)+P_{\mathrm{O\_NOMINAL\_PUSCH,c,2}}(0)$, where j=0 is used for PUSCH (re)transmissions corresponding to a semi-persistent grant. $P_{\mathrm{O\_UE\_PUSCH,c,2}}(0)$ and $P_{\mathrm{O\_NOMINAL\_PUSCH,c,2}}(0)$ are the parameters *p0-UE-PUSCH-Persistent-SubframeSet2-r12 and p0-NominalPUSCH-Persistent -SubframeSet2-r12* respectively provided by higher layers, for each serving cell c.

  - when j=1, $P_{\mathrm{O\_PUSCH,c}}(1)=P_{\mathrm{O\_UE\_PUSCH,c,2}}(1)+P_{\mathrm{O\_NOMINAL\_PUSCH,c,2}}(1)$, where j=1 is used for PUSCH (re)transmissions corresponding to a dynamic scheduled grant. $P_{\mathrm{O\_UE\_PUSCH,c,2}}(1)$ and $P_{\mathrm{O\_NOMINAL\_PUSCH,c,2}}(1)$ are the parameters *p0-UE-PUSCH-SubframeSet2-r12 and p0-NominalPUSCH-SubframeSet2-r12* respectively, provided by higher layers for serving cell c.

  - when j=2, $P_{\mathrm{O\_PUSCH,c}}(2)=P_{\mathrm{O\_UE\_PUSCH,c}}(2)+P_{\mathrm{O\_NOMINAL\_PUSCH,c}}(2)$ where $P_{\mathrm{O\_UE\_PUSCH,c}}(2)=0$ and $P_{\mathrm{O\_NOMINAL\_PUSCH,c}}(2)=P_{\mathrm{O\_PRE}}+\Delta_{PREAMBLE\_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* [8] ($P_{\mathrm{O\_PRE}}$) and $\Delta_{PREAMBLE\_Msg3}$ are signalled from higher layers for serving cell c, where j=2 is used for PUSCH (re)transmissions corresponding to the random access response grant.

  Otherwise

  - $P_{\mathrm{O\_PUSCH,c}}(j)$ is a parameter composed of the sum of a component $P_{\mathrm{O\_NOMINAL\_PUSCH,c}}(j)$ provided from higher layers for *j=0* and *1* and a component $P_{\mathrm{O\_UE\_PUSCH,c}}(j)$ provided by higher layers for *j=0* and *1* for serving cell c. For PUSCH (re)transmissions corresponding to a semi-persistent grant then *j=0* , for

PUSCH (re)transmissions corresponding to a dynamic scheduled grant then *j=1* and for PUSCH (re)transmissions corresponding to the random access response grant then *j=2*. $P_{\text{O\_UE\_PUSCH,c}}(2) = 0$ and $P_{\text{O\_NOMINAL\_PUSCH,c}}(2) = P_{\text{O\_PRE}} + \Delta_{PREAMBLE\_Msg3}$, where the parameter *preambleInitialReceivedTargetPower* [8] ($P_{\text{O\_PRE}}$) and $\Delta_{PREAMBLE\_Msg3}$ are signalled from higher layers for serving cell c .

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12*,
  - For *j*=0 or 1, $\alpha_c(j) = \alpha_{c,2} \in \{0, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1\}$. $\alpha_{c,2}$ is the parameter *alpha-SubframeSet2-r12* provided by higher layers for each serving cell c .
  - For *j*=2, $\alpha_c(j) = 1$.

  Otherwise

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

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

- $\Delta_{TF,c}(i) = 10\log_{10}\left(\left(2^{BPRE\cdot K_s} - 1\right)\cdot \beta_{offset}^{PUSCH}\right)$ for $K_S = 1.25$ and 0 for $K_S = 0$ where K_S is given by the parameter *deltaMCS-Enabled* provided by higher layers for each serving cell c . $BPRE$ and β_{offset}^{PUSCH}, for each serving cell c , are computed as below. $K_S = 0$ for transmission mode 2.
  - $BPRE = O_{\text{CQI}} / N_{\text{RE}}$ for control data sent via PUSCH without UL-SCH data and $\sum_{r=0}^{C-1} K_r / N_{\text{RE}}$ for other cases.
    - where C is the number of code blocks, K_r is the size for code block r , O_{CQI} is the number of CQI/PMI bits including CRC bits and N_{RE} is the number of resource elements determined as $N_{\text{RE}} = M_{sc}^{PUSCH-initial} \cdot N_{\text{symb}}^{\text{PUSCH-initial}}$, where C , K_r , $M_{sc}^{PUSCH-initial}$ and $N_{\text{symb}}^{\text{PUSCH-initial}}$ are defined in [4].
  - $\beta_{offset}^{PUSCH} = \beta_{offset}^{CQI}$ for control data sent via PUSCH without UL-SCH data and 1 for other cases.

- $\delta_{\mathrm{PUSCH,c}}$ is a correction value, also referred to as a TPC command and is included in PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B or in MPDCCH with DCI format 6-0A for serving cell c 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 c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the current PUSCH power control adjustment state for serving cell c is given by $f_{c,2}(i)$, and the UE shall use $f_{c,2}(i)$ instead of $f_c(i)$ to determine $P_{\mathrm{PUSCH},c}(i)$. Otherwise, the current PUSCH power control adjustment state for serving cell c is given by $f_c(i)$. $f_{c,2}(i)$ and $f_c(i)$ are defined by:
  - $f_c(i) = f_c(i-1) + \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ and $f_{c,2}(i) = f_{c,2}(i-1) + \delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ if accumulation is enabled based on the parameter *Accumulation-enabled* provided by higher layers or if the TPC command $\delta_{\mathrm{PUSCH,c}}$ is included in a PDCCH/EPDCCH with DCI format 0 or in a MPDCCH with DCI format 6-0A for serving cell c where the CRC is scrambled by the Temporary C-RNTI
    - where $\delta_{\mathrm{PUSCH,c}}(i - K_{\mathrm{PUSCH}})$ was signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B or MPDCCH with DCI format 6-0A or PDCCH/MPDCCH with DCI format 3/3A on subframe $i - K_{PUSCH}$, and where $f_c(0)$ is the first value after reset of accumulation. For a BL/CE UE configured with CEModeA, subframe $i - K_{PUSCH}$ 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 K_{PUSCH} is
      - For FDD or FDD-TDD and serving cell frame structure type 1, K_{PUSCH} = 4
      - For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or for FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) for serving cell c.
      - For TDD UL/DL configurations 1-6 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c, K_{PUSCH} is given in Table 5.1.1.1-1.
      - For TDD UL/DL configuration 0 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c.
        - If the PUSCH transmission in subframe *2* or *7* is scheduled with 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, K_{PUSCH} = 7
        - For all other PUSCH transmissions, K_{PUSCH} is given in 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 c, K_{PUSCH} is given in Table 5.1.1.1-4.
      - For TDD UL/DL configuration 6 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c
        - If the PUSCH transmission in subframe *2* or *7* is scheduled with a PDCCH/EPDCCH of DCI format 0/4 in which the LSB of the UL index is set to 1, K_{PUSCH} = 6
        - For all other PUSCH transmissions, K_{PUSCH} is given in Table 5.1.1.1-4.
      - For a serving cell with frame structure type 3,

- For an uplink DCI format 0A/0B/4A/4B with PUSCH trigger A set to 0, K_{PUSCH} is equal to *k*+*l*, where *k* and *l* are defined in in Subclause 8.0.

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

- If a UE detected multiple TPC commands in subframe $i - K_{PUSCH}$, the UE shall use the TPC command in the PDCCH/EPDCCH with DCI format 0A/0B/4A/4B which schedules PUSCH transmission in subframe *i*.

- For serving cell c and a non-BL/CE UE, the UE attempts to decode a PDCCH/EPDCCH of DCI format 0/0A/0B/4/4A/4B with the UE's C-RNTI or DCI format 0 for SPS C-RNTI or 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 c is deactivated.

- For serving cell c 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 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, if DCI format 0/0A/0B/4/4A/4B for serving cell c and DCI format 3/3A are both detected in the same subframe, then the UE shall use the $\delta_{\mathrm{PUSCH,c}}$ provided in DCI format 0/0A/0B/4/4A/4B.

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

- $\delta_{\mathrm{PUSCH,c}} = 0$ dB for a subframe where no TPC command is decoded for serving cell c or where DRX occurs or *i* is not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.

- $\delta_{\mathrm{PUSCH,c}} = 0$ dB if the subframe *i* is not the first subframe scheduled by a PDCCH/EPDCCH of DCI format 0B/4B.

- The $\delta_{\mathrm{PUSCH,c}}$ dB accumulated values signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B 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 MPDCCH with DCI format 6-0A is validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH, then $\delta_{\mathrm{PUSCH,c}}$ is 0dB.

- The δ_{PUSCH} 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 $P_{\mathrm{CMAX,c}}(i)$ for serving cell c, positive TPC commands for serving cell c shall not be accumulated

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

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

  - For serving cell c, when $P_{\mathrm{O\_UE\_PUSCH,c}}$ value is changed by higher layers

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

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

  - the UE shall reset accumulation corresponding to $f_c(*)$ for serving cell c

- when $P_{\text{O\_UE\_PUSCH},c}$ value is changed by higher layers
- when the UE receives random access response message for serving cell c

- the UE shall reset accumulation corresponding to $f_{c,2}(*)$ for serving cell c
  - when $P_{\text{O\_UE\_PUSCH},c,2}$ value is changed by higher layers

- If the UE is configured with higher layer parameter *UplinkPowerControlDedicated-v12x0* for serving cell c and
  - if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_c(i) = f_c(i-1)$
  - if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_{c,2}(i) = f_{c,2}(i-1)$

- $f_c(i) = \delta_{\text{PUSCH,c}}(i - K_{\text{PUSCH}})$ and $f_{c,2}(i) = \delta_{\text{PUSCH,c}}(i - K_{\text{PUSCH}})$ if accumulation is not enabled for serving cell c based on the parameter *Accumulation-enabled* provided by higher layers
  - where $\delta_{\text{PUSCH,c}}(i - K_{\text{PUSCH}})$ was signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B or MPDCCH with DCI format 6-0A for serving cell c on subframe $i - K_{PUSCH}$. For a BL/CE UE configured with CEModeA, subframe $i - K_{PUSCH}$ 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 K_{PUSCH} is
    - For FDD or FDD-TDD and serving cell frame structure type 1, K_{PUSCH} = 4
    - For TDD, if the UE is configured with more than one serving cell and the TDD UL/DL configuration of at least two configured serving cells is not the same, or if the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for at least one serving cell, or FDD-TDD and serving cell frame structure type 2, the "TDD UL/DL configuration" refers to the UL-reference UL/DL configuration (defined in Subclause 8.0) for serving cell c .
    - For TDD UL/DL configurations 1-6 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c , K_{PUSCH} is given in Table 5.1.1.1-1.
    - For TDD UL/DL configuration 0 and UE not configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c .
      - If the PUSCH transmission in subframe *2* or *7* is scheduled with 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, K_{PUSCH} = 7
      - For all other PUSCH transmissions, K_{PUSCH} is given in 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 c , K_{PUSCH} is given in Table 5.1.1.1-4.
    - For TDD UL/DL configuration 6 and UE configured with higher layer parameter *symPUSCH-UpPts-r14* for the serving cell c
      - If the PUSCH transmission in subframe *2* or *7* is scheduled with a PDCCH/EPDCCH of DCI format 0/4 in which the LSB of the UL index is set to 1, K_{PUSCH} = 6
      - For all other PUSCH transmissions, K_{PUSCH} is given in Table 5.1.1.1-4.

- For a serving cell with frame structure type 3,
  - For an uplink DCI format 0A/4A with PUSCH trigger A set to 0, K_{PUSCH} is equal to *k*+*l*, where *k* and *l* are defined in in Subclause 8.0.
  - For an uplink DCI format 0B/4B with PUSCH trigger A set to 0, K_{PUSCH} is equal to *k*+*l*+*i'* with $i' = \mathrm{mod}\left(n^{\mathrm{i}}_{\mathrm{HARQ\_ID}} - n_{\mathrm{HARQ\_ID}}, N_{HARQ}\right)$, where $n^{i}_{\mathrm{HARQ\_ID}}$ is HARQ process number in subframe *i*, and *k*, *l*, $n_{\mathrm{HARQ\_ID}}$ and N_{HARQ} are defined in Subclause 8.0.
  - For an uplink DCI format 0A/4A with PUSCH trigger A set to 1 and upon the detection of PDCCH with DCI CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' described in Subclause 8.0, K_{PUSCH} is equal to *p*+*k*+*l*, where *p*, *k* and *l* are defined in Subclause 8.0.
  - For an uplink DCI format 0B/4B with PUSCH trigger A set to 1 and upon the detection of PDCCH with DCI CRC scrambled by CC-RNTI and with 'PUSCH trigger B' field set to '1' described in Subclause 8.0, K_{PUSCH} is equal to *p*+*k*+*l*+*i'* with $i' = \mathrm{mod}\left(n^{\mathrm{i}}_{\mathrm{HARQ\_ID}} - n_{\mathrm{HARQ\_ID}}, N_{HARQ}\right)$, where $n^{i}_{\mathrm{HARQ\_ID}}$ is HARQ process number in subframe *i*, and *p*, *k*, *l*, $n_{\mathrm{HARQ\_ID}}$ and N_{HARQ} are defined in Subclause 8.0.
  - If a UE detected multiple TPC commands in subframe $i - K_{PUSCH}$, the UE shall use the TPC command in the PDCCH/EPDCCH with DCI format 0A/0B/4A/4B which schedules PUSCH transmission in subframe *i*.
- The $\delta_{\mathrm{PUSCH,c}}$ dB absolute values signalled on PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B 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 a MPDCCH with DCI format 6-0A is validated as a SPS activation or release PDCCH/EPDCCH/MPDCCH, then $\delta_{\mathrm{PUSCH,c}}$ is 0dB.
- for a non-BL/CE UE, $f_c(i) = f_c(i-1)$ and $f_{c,2}(i) = f_{c,2}(i-1)$ for a subframe where no PDCCH/EPDCCH with DCI format 0/0A/0B/4/4A/4B is decoded for serving cell c or where DRX occurs or *i* is not an uplink subframe in TDD or FDD-TDD and serving cell c frame structure type 2.
- for a BL/CE UE configured with CEModeA, $f_c(i) = f_c(i-1)$ and $f_{c,2}(i) = f_{c,2}(i-1)$ for a subframe where no MPDCCH with DCI format 6-0A is decoded for serving cell c 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 c and
  - if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_c(i) = f_c(i-1)$
  - if subframe i does not belong to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12* $f_{c,2}(i) = f_{c,2}(i-1)$

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

- $f_c(0) = \Delta P_{rampup,c} + \delta_{msg2,c}$, where

  - $\delta_{msg2,c}$ is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell c , see Subclause 6.2, and

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

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

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

  - $f_{c,2}(0) = 0$

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

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

Table 5.1.1.1-2: Mapping of TPC Command Field in DCI format 0/0A/0B/3/4/4A/4B/6-0A/3B to absolute and accumulated $\delta_{\mathrm{PUSCH,c}}$ values

TPC Command Field in DCI format 0/0A/0B/3/4/4A/4B/6-0A/3B	Accumulated $\delta_{\mathrm{PUSCH,c}}$ [dB]	Absolute $\delta_{\mathrm{PUSCH,c}}$ [dB] only DCI format 0/0A/0B/4/4A/4B/6-0A
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 $\delta_{\mathrm{PUSCH,c}}$ values

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

Table 5.1.1.1-4: K_{PUSCH} 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	-

If the UE is not configured with an SCG or a PUCCH-SCell, and if the total transmit power of the UE would exceed $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\mathrm{PUSCH},c}(i)$ for the serving cell c in subframe *i* such that the condition

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

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

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 $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\mathrm{PUSCH},c}(i)$ for the serving cells without UCI in subframe *i* such that the condition

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

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

For a UE not configured with a SCG or a PUCCH-SCell, note that $w(i)$ values are the same across serving cells when $w(i) > 0$ but for certain serving cells $w(i)$ may be zero.

If the UE 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 $\hat{P}_{CMAX}(i)$, the UE obtains $\hat{P}_{\mathrm{PUSCH},c}(i)$ according to

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

and

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

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

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

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

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

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

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

If the UE is configured with a LAA SCell for uplink transmissions, the UE may compute the scaling factor $w(i)$ 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 Subclause 15.2.1.

For a BL/CE UE configured with CEModeA, if the PUSCH is transmitted in more than one subframe i_0, i_1, …, i_{N-1} where $i_0 < i_1 < \ldots < i_{N-1}$, the PUSCH transmit power in subframe i_k , k=0, 1, …, N-1, is determined by

$$P_{\mathrm{PUSCH},c}(i_k) = P_{\mathrm{PUSCH},c}(i_0)$$

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

$$P_{\mathrm{PUSCH},c}(i_k) = P_{\mathrm{CMAX},c}(i_0)$$

5.1.1.2 Power headroom

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

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.

If the UE is configured with a SCG,

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

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

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 Subclause 15.2.1.

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*+4, if in subrame *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*+4.
- 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*+4, if in subrame *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*+4.

Type 1:

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

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

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

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

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

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

If the UE does not transmit PUSCH in subframe i for serving cell c, 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

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

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

Type 2:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Type 3:

Computation of power headroom for Type 3 report is described in Subclause 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 c and if subframe i belongs to uplink power control subframe set 2 as indicated by the higher layer parameter *tpc-SubframeSet-r12,* the UE shall use $f_{c,2}(i)$ instead of $f_c(i)$ to compute $PH_{\text{type1,c}}(i)$ and $PH_{\text{type2,c}}(i)$ for subframe *i* and serving cell c , where $f_{c,2}(i)$ is defined in Subclause 5.1.1.1.

5.1.2 Physical uplink control channel

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

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

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

5.1.2.1 UE behaviour

If serving cell c is the primary cell, for PUCCH format 1/1a/1b/2/2a/2b/3, the setting of the UE Transmit power P_{PUCCH} for the physical uplink control channel (PUCCH) transmission in subframe i for serving cell c is defined by

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

If serving cell c is the primary cell, for PUCCH format 4/5, the setting of the UE Transmit power P_{PUCCH} for the physical uplink control channel (PUCCH) transmission in subframe i for serving cell c is defined by

$$P_{\mathrm{PUCCH}}(i) = \min \begin{Bmatrix} P_{\mathrm{CMAX,c}}(i), \\ P_{0\_\mathrm{PUCCH}} + PL_c + 10\log_{10}\left(M_{\mathrm{PUCCH,c}}(i)\right) + \Delta_{\mathrm{TF,c}}(i) + \Delta_{\mathrm{F\_PUCCH}}(F) + g(i) \end{Bmatrix} \quad [\mathrm{dBm}]$$

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

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

where

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

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

  - For PUCCH format 2 and extended cyclic prefix

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

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

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

  - Otherwise

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

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

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

  - Otherwise

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

- For PUCCH format 4, $M_{\mathrm{PUCCH},c}(i)$ is the bandwidth of the PUCCH format 4 expressed in number of resource blocks valid for subframe *i* and serving cell c. For PUCCH format 5, $M_{\mathrm{PUCCH},c}(i)=1$.
- $\Delta_{TF,c}(i)=10\log_{10}\left(2^{1.25\cdot BPRE(i)}-1\right)$ where $BPRE(i)=O_{\mathrm{UCI}}(i)/N_{\mathrm{RE}}(i)$,
  - $O_{\mathrm{UCI}}(i)$ is the number of HARQ-ACK/SR/RI/CQI/PMI bits including CRC bits transmitted on PUCCH format 4/5 in subframe *i*;
  - $N_{\mathrm{RE}}(i)=M_{\mathrm{PUCCH},c}(i)\cdot N_{sc}^{RB}\cdot N_{\mathrm{symb}}^{\mathrm{PUCCH}}$ for PUCCH format 4 and $N_{\mathrm{RE}}(i)=N_{sc}^{RB}\cdot N_{\mathrm{symb}}^{\mathrm{PUCCH}}/2$ for PUCCH format 5;
  - $N_{\mathrm{symb}}^{\mathrm{PUCCH}}=2\cdot\left(N_{\mathrm{symb}}^{\mathrm{UL}}-1\right)-1$ if shortened PUCCH format 4 or shortened PUCCH format 5 is used in subframe *i* and $N_{\mathrm{symb}}^{\mathrm{PUCCH}}=2\cdot\left(N_{\mathrm{symb}}^{\mathrm{UL}}-1\right)$ otherwise.

- $P_{\mathrm{O\_PUCCH}}$ is a parameter composed of the sum of a parameter $P_{\mathrm{O\_NOMINAL\_PUCCH}}$ provided by higher layers and a parameter $P_{\mathrm{O\_UE\_PUCCH}}$ provided by higher layers.
- δ_{PUCCH} is a UE specific correction value, also referred to as a TPC command, included in a PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D for the primary cell, or included in 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 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.
  - If a UE is configured for EPDCCH monitoring, the UE attempts to decode

  - a PDCCH of DCI format 3/3A with the UE's TPC-PUCCH-RNTI and one or several PDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI as described in Subclause 9.1.1, and
  - one or several EPDCCHs of DCI format 1A/1B/1D/1/2A/2/2B/2C/2D with the UE's C-RNTI or SPS C-RNTI, as described in Subclause 9.1.4.
- 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 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 or
  - an EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or
  - an MPDCCH with DCI format 6-1A

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

  Else

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

    else the UE shall set δ_{PUCCH} = 0 dB.
- $g(i) = g(i-1) + \sum_{m=0}^{M-1} \delta_{PUCCH}(i-k_m)$ where $g(i)$ is the current PUCCH power control adjustment state and where $g(0)$ is the first value after reset.
  - For FDD or FDD-TDD and primary cell frame structure type 1, $M = 1$ and $k_0 = 4$.
  - For TDD, values of M and k_m are given in Table 10.1.3.1-1, where the "UL/DL configuration" in Table 10.1.3.1-1 corresponds to the *eimta-HARQ-ReferenceConfig-r12* for the primary cell when the UE is configured with the parameter *EIMTA-MainConfigServCell-r12* for the primary cell.
  - The δ_{PUCCH} dB values signalled on PDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or EPDCCH with DCI format 1A/1B/1D/1/2A/2/2B/2C/2D or MPDCCH with DCI format 6-1A 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 is validated as an SPS activation PDCCH/EPDCCH/MPDCCH, or the PDCCH/EPDCCH with DCI format 1A or MPDCCH with DCI format 6-1A is validated as an SPS release PDCCH/EPDCCH/MPDCCH, then δ_{PUCCH} is 0dB.
  - The δ_{PUCCH} 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 $P_{\mathrm{O\_UE\_PUCCH}}$ value is changed by higher layers,
    - $g(0) = 0$
  - Else
    - $g(0) = \Delta P_{rampup} + \delta_{msg2}$, where

- δ_{msg2} is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the primary cell, see Subclause 6.2 and

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

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

Otherwise,

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

- If UE has reached $P_{\text{CMAX,c}}(i)$ for the primary cell, positive TPC commands for the primary cell shall not be accumulated.
- If UE has reached minimum power, negative TPC commands shall not be accumulated.
- UE shall reset accumulation
  - when $P_{\text{O\_UE\_PUCCH}}$ value is changed by higher layers
  - when the UE receives a random access response message for the primary cell
  - $g(i) = g(i-1)$ if i is not an uplink subframe in TDD or FDD-TDD and primary cell frame structure type 2.

For a BL/CE UE configured with CEModeA, if the PUCCH is transmitted in more than one subframe i_0, i_1, …, i_{N-1} where $i_0 < i_1 < \ldots < i_{N-1}$, the PUCCH transmit power in subframe i_k , k=0, 1, …, N-1is determined by

$$P_{\text{PUCCH},c}(i_k) = P_{\text{PUCCH},c}(i_0)$$

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

$$P_{\text{PUCCH},c}(i_k) = P_{\text{CMAX},c}(i_0)$$

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 to δ_{PUCCH} values

TPC Command Field in DCI format 1A/1B/1D/1/2A/2B/2C/2D/2/3/6-1A	δ_{PUCCH} [dB]
0	-1
1	0
2	1
3	3

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

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

5.1.3 Sounding Reference Symbol (SRS)

5.1.3.1 UE behaviour

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

for serving cell c with frame structure type 2, and not configured for PUSCH/PUCCH transmission

$$P_{\text{SRS,c}}(i) = \min\left\{ P_{\text{CMAX,c}}(i),\ 10\log_{10}(M_{\text{SRS,c}}) + P_{\text{O\_SRS,c}}(m) + \alpha_{SRS,c} \cdot PL_c + f_{SRS,c}(i) \right\} \text{ [dBm]}$$

otherwise

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

where

- $P_{\text{CMAX,c}}(i)$ is the configured UE transmit power defined in [6] in subframe *i* for serving cell c.
- $P_{\text{SRS\_OFFSET,c}}(m)$ is semi-statically configured by higher layers for *m=0* and *m=1* for serving cell c. For SRS transmission given trigger type 0 then *m=0* and for SRS transmission given trigger type 1 then *m=1*.
- $M_{\text{SRS,c}}$ is the bandwidth of the SRS transmission in subframe *i* for serving cell c expressed in number of resource blocks.
- $f_c(i)$ is the current PUSCH power control adjustment state for serving cell c, see Subclause 5.1.1.1.
- $P_{\text{O\_PUSCH,c}}(j)$ and $\alpha_c(j)$ are parameters as defined in Subclause 5.1.1.1 for subframe i, where $j = 1$.
- $\alpha_{SRS,c}$ is the higher layer parameter *alpha-SRS* configured by higher layers for serving cell c.
- $P_{\text{O\_SRS,c}}(m)$ is a parameter composed of the sum of a component $P_{\text{O\_NOMINAL\_SRS,c}}(m)$ which is *p0-Nominal-PeriodicSRS* or *p0-Nominal-AperiodicSRS* provided from higher layers for *m=0* or *1* and a component $P_{\text{O\_UE\_SRS,c}}(m)$ which is *p0-UE-PeriodicSRS* or *p0-UE-AperiodicSRS* which is *p0-UE-PeriodicSRS* or *p0-UE-AperiodicSRS* provided by higher layers for *m=0* or *1* for serving cell c. For SRS transmission given trigger type 0 then *m=0* and for SRS transmission given trigger type 1 then *m=1*.
- For serving cell c with frame structure type 2, and not configured for PUSCH/PUCCH transmission, the current SRS power control adjustment state is given by $f_{SRS,c}(i)$ and is defined by:
  - $f_{SRS,c}(i) = f_{SRS,c}(i-1) + \delta_{\text{SRS,c}}(i - K_{\text{SRS}})$ if accumulation is enabled, and $f_{SRS,c}(i) = \delta_{\text{SRS,c}}(i - K_{\text{SRS}})$ if accumulation is not enabled based on higher layer parameter *Accumulation-enabled*, where
  - $\delta_{\text{SRS,c}}(i - K_{\text{SRS}})$ is a correction value, also referred to as a SRS TPC command signalled on PDCCH with DCI format 3B in the most recent subframe $i - K_{SRS}$, where $K_{SRS} \geq 4$.
  - The UE is not expected to receive different SRS TPC command values for serving cell c in the same subframe.

- 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 c is deactivated.

- $\delta_{\mathrm{SRS,c}} = 0$ dB for a subframe where no TPC command in PDCCH with DCI format 3B is decoded for serving cell c 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* indicates 2-bit TPC command, the δ_{SRS} dB values signalled on PDCCH with DCI format 3B are given in Table 5.1.1.1-2 by replacing $\delta_{\mathrm{PUSCH,c}}$ with δ_{SRS}, or if higher layer parameter *fieldTypeFormat3B* indicates 1-bit TPC command, the δ_{SRS} dB values signalled on PDCCH with DCI format 3B are given in Table 5.1.1.1-3 by replacing $\delta_{\mathrm{PUSCH,c}}$ with δ_{SRS}.

- If accumulation is enabled, $f_{SRS,c}(0)$ is the first value after reset of accumulation. The UE shall reset accumulation
  - For serving cell c, when $P_{\mathrm{O\_UE\_SRS,c}}$ value is changed by higher layers
  - For serving cell c, when the UE receives random access response message for serving cell c.

- For both types of $f_{SRS,c}(*)$ (accumulation or current absolute) the first value is set as follows:
  - If $P_{\mathrm{O\_UE\_SRS,c}}$ value is received by higher layers
    - $f_{SRS,c}(0) = 0$
  - else
    - if the UE receives the random access response message for a serving cell c
      - $f_{SRS,c}(0) = \Delta P_{rampup,c} + \delta_{msg2,c}$, where

        $\delta_{msg2,c}$ is the TPC command indicated in the random access response corresponding to the random access preamble transmitted in the serving cell c, see Subclause 6.2, and

$$\Delta P_{rampup,c} = \min\left[\begin{matrix}\left\{\max\left(\begin{matrix}0, \\ P_{\mathrm{CMAX,c}} - \left(10\log_{10}(M_{\mathrm{SRS,c}}(0)) + P_{\mathrm{O\_SRS,c}}(m) + \alpha_{\mathrm{SRS},c} \cdot PL_c\right)\end{matrix}\right)\right\}, \\ \Delta P_{rampuprequested,c}\end{matrix}\right]$$

        and $\Delta P_{rampuprequested,c}$ is provided by higher layers and corresponds to the total power ramp-up requested by higher layers from the first to the last preamble in the serving cell c, $M_{\mathrm{SRS,c}}(0)$ 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 c.

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 $\hat{P}_{CMAX}(i)$, the UE scales $\hat{P}_{\mathrm{SRS},c}(i)$ for the serving cell c and the SC-FDMA symbol in subframe *i* such that the condition

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

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

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

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

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

If the UE is configured with a LAA SCell for uplink transmissions, the UE may compute the scaling factor $w(i)$ 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 Subclause 15.2.1.

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

5.1.3.2 Power headroom for Type3 report

For serving cell c with frame structure type 2, and not configured for PUSCH/PUCCH transmission,

if the UE transmits SRS in subframe i for serving cell c, power headroom for a Type 3 report is computed using

$$PH_{\mathrm{type3,c}}(i) = P_{\mathrm{CMAX},c}(i) - \left\{ 10\log_{10}(M_{\mathrm{SRS,c}}) + P_{\mathrm{O\_SRS,c}}(m) + \alpha_{SRS,c} \cdot PL_c + f_{SRS,c}(i) \right\} \text{ [dB]}$$

where PL_c is defined in Subclause 5.1.1.1. $P_{\mathrm{CMAX},c}(i)$, $M_{\mathrm{SRS,\,c}}$, $P_{\mathrm{O\_SRS,c}}(m)$, $\alpha_{SRS,c}$, $f_{SRS,c}(i)$ are defined in Subclause 5.1.3.1.

if the UE does not transmit SRS in subframe i for serving cell c, power headroom for a Type 3 report is computed using

$$PH_{\mathrm{type3,c}}(i) = \tilde{P}_{\mathrm{CMAX},c}(i) - \left\{ P_{\mathrm{O\_SRS,c}}(1) + \alpha_{SRS,c} \cdot PL_c + f_{SRS,c}(i) \right\} \text{ [dB]}$$

where PL_c is defined in Subclause 5.1.1.1., $P_{\mathrm{O\_SRS,c}}(1)$, $\alpha_{SRS,c}$, $f_{SRS,c}(i)$ are defined in Subclause 5.1.3.1. $\tilde{P}_{\mathrm{CMAX},c}(i)$ is computed based on the requirements in [6] assuming a SRS transmission in subframe i, and assuming MPR=0dB, A-MPR=0dB, P-MPR=0dB and ΔT_C =0dB. MPR, A-MPR, P-MPR and ΔT_C are defined in [6]. For this case, the physical layer delivers $\tilde{P}_{\mathrm{CMAX},c}(i)$ instead of $P_{\mathrm{CMAX},c}(i)$ to higher layers.

5.1.4 Power allocation for dual connectivity

If a UE is configured with multiple cell groups,

- 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 $i1$ of MCG overlaps in time domain with another PRACH transmission of the UE starting in subframe $i2$ of SCG, and if subframe $i1$ and subframe $i2$ overlap in time with more than one symbol, and if the total power of both the PRACH transmissions would exceed $\hat{P}_{\text{CMAX}}(i1,i2)$, the UE shall transmit the PRACH on the Pcell using the preamble transmission power P_{PRACH} described in Subclause 6.1. The UE may drop or adjust the power of the PRACH transmission in subframe $i2$ of SCG such that the total power does not exceed $\hat{P}_{\text{CMAX}}(i1,i2)$, where $\hat{P}_{\text{CMAX}}(i1,i2)$ is the linear value configured transmitted power for Dual Connectivity for the subframe pair $(i1,i2)$ 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 $i1$ of MCG overlaps in time another PRACH transmission in subframe $i2$ of SCG, and if the time difference between the start of the two PRACH transmissions is less than $30720 \cdot T_s$, and if the transmission timing of the PRACH on the Pcell (according to Subclause 6.1.1) is such that the UE is ready to transmit the PRACH on Pcell at least one subframe before subframe $i1$ of MCG, and if the total power of both the PRACH transmissions exceeds $\hat{P}_{\text{CMAX}}(i1,i2)$, the UE shall transmit the PRACH on the Pcell using the preamble transmission power P_{PRACH} described in Subclause 6.1. The UE may drop or adjust the power of the PRACH transmission in subframe $i2$ of SCG such that the total power does not exceed $\hat{P}_{\text{CMAX}}(i1,i2)$, where $\hat{P}_{\text{CMAX}}(i1,i2)$ is the linear value configured transmitted power for Dual Connectivity for the subframe pair $(i1,i2)$ 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 $i1$ of CG1 overlap in time with PUSCH/PUCCH transmission(s) in more than one symbol of subframe $i2$ of CG2 or if at least the last symbol the UE PUSCH/PUCCH transmission(s) in subframe $i1$ of CG1 overlap in time with SRS transmission(s) of subframe $i2$, and

- if the UE has a PUCCH/PUSCH transmission with UCI including HARQ-ACK/SR in subframe $i1$ of CG1: If the UE has a PUCCH transmission with UCI including HARQ-ACK/SR in subframe $i1$ of CG1 and if $\hat{P}_{PUCCH\_CG1}(i1)$ would exceed $S1(i1)$, the UE scales $\hat{P}_{PUCCH\_CG1}(i1)$ such that the condition $\alpha1(i1)\cdot\hat{P}_{PUCCH\_CG1}(i1)=\max\{0,S1(i1)\}$ is satisfied where $0\le\alpha1(i1)\le1$ and $\hat{P}'_{PUCCH\_CG1}(i1)=\alpha1(i1)\cdot\hat{P}_{PUCCH\_CG1}(i1)$. If $\hat{P}_{PUCCH\_CG1}(i1)$ would not exceed $S1(i1)$, $\hat{P}'_{PUCCH\_CG1}(i1)=\hat{P}_{PUCCH\_CG1}(i1)$. If the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe $i1$ of serving cell $c_1\in CG1$, and if $\hat{P}_{PUSCH,c_1}(i1)$ would exceed $S1(i1)$, the UE scales $\hat{P}_{PUSCH,c_1}(i1)$ such that the condition $\alpha1(i1)\cdot\hat{P}_{PUSCH,c_1}(i1)=\max\{0,S1(i1)\}$ is satisfied where $0\le\alpha1(i1)\le1$ and $\hat{P}'_{PUSCH,c_1}(i1)=\alpha1(i1)\cdot\hat{P}_{PUSCH,c_1}(i1)$. If $\hat{P}_{PUSCH,c_1}(i1)$ would not exceed $S1(i1)$,

$\hat{P}'_{PUSCH,c_1}(i1) = \hat{P}_{PUSCH,c_1}(i1)$.

$S1(i1)$ is determined as follows

$$S1(i1) = \hat{P}_{\mathrm{CMAX}}(i1,i2) - \hat{P}_{u1}(i1) - \hat{P}_{q1}(i2) - \min\left\{ \begin{array}{l} \max\left\{ \begin{array}{l} 0, \\ \hat{P}_{\mathrm{CMAX}}(i1,i2)\cdot\frac{\gamma_{CG2}}{100} - \hat{P}_{q1}(i2) \end{array} \right\}, \\ \hat{P}'_{q1}(i2) \end{array} \right\};$$

where

- $\hat{P}_{u1}(i1) = \hat{P}_{PRACH\_CG1}(i1)$;
- if CG1 is MCG and CG2 is SCG,
  - $\hat{P}_{q1}(i2) = \hat{P}_{PRACH\_CG2}(i2)$;
  - $\hat{P}'_{q1}(i2) = \hat{P}_{PUCCH\_CG2}(i2) + \sum_{c_2 \in CG2}\left(\hat{P}_{PUSCH,c_2}(i2) + \hat{\tilde{P}}_{SRS,c_2}(i2)\right)$;
- if CG1 is SCG and CG2 is MCG
  - if the UE has a PUCCH transmission with UCI including HARQ-ACK/SR subframe $i2$ of CG2,
    - $\hat{P}_{q1}(i2) = \hat{P}_{PRACH\_CG2}(i2) + \hat{P}'_{PUCCH\_CG2}(i2)$;
    - $\hat{P}'_{q1}(i2) = \sum_{c_2 \in CG2}\left(\hat{P}_{PUSCH,c_2}(i2) + \hat{\tilde{P}}_{SRS,c_2}(i2)\right)$
  - else if the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe $i2$ of serving cell $j_2 \in CG2$,
    - $\hat{P}_{q1}(i2) = \hat{P}_{PRACH\_CG2}(i2) + \hat{P}'_{PUSCH,j_2}(i2)$;
    - $\hat{P}'_{q1}(i2) = \sum_{c_2 \in CG2, c_2 \neq j_2}\hat{P}_{PUSCH,c_2}(i2) + \sum_{c_2 \in CG2}\hat{\tilde{P}}_{SRS,c_2}(i2)$;
  - otherwise,
    - $\hat{P}_{q1}(i2) = \hat{P}_{PRACH\_CG2}(i2)$;
    - $\hat{P}'_{q1}(i2) = \hat{P}_{PUCCH\_CG2}(i2) + \sum_{c_2 \in CG2}\left(\hat{P}_{PUSCH,c_2}(i2) + \hat{\tilde{P}}_{SRS,c_2}(i2)\right)$

- if the UE has a PUCCH/PUSCH transmission with UCI not including HARQ-ACK/SR in subframe $i1$ of CG1: If the UE has a PUCCH transmission with UCI not including HARQ-ACK/SR in subframe $i1$ of CG1 and if $\hat{P}_{PUCCH\_CG1}(i1)$ would exceed $S2(i1)$, the UE scales $\hat{P}_{PUCCH\_CG1}(i1)$ such that the condition $\alpha2(i1)\cdot\hat{P}_{PUCCH\_CG1}(i1) = \max\{0, S2(i1)\}$ is satisfied where $0 \le \alpha2(i1) \le 1$ and $\hat{P}'_{PUCCH\_CG1}(i1) = \alpha2(i1)\cdot\hat{P}_{PUCCH\_CG1}(i1)$. If $\hat{P}_{PUCCH\_CG1}(i1)$ would not exceed $S2(i1)$, $\hat{P}'_{PUCCH\_CG1}(i1) = \hat{P}_{PUCCH\_CG1}(i1)$. If the UE has a PUSCH transmission with UCI not including HARQ-ACK in subframe $i1$ of serving cell $c_1 \in CG1$, and if $\hat{P}_{PUSCH,c_1}(i1)$ would exceed $S2(i1)$, the UE scales

$\hat{P}_{PUSCH,c_1}(i1)$ such that the condition $\alpha 2(i1)\cdot\hat{P}_{PUSCH,c_1}(i1)=\max\{0,S2(i1)\}$ is satisfied where $0\le\alpha 2(i1)\le 1$ and $\hat{P}'_{PUSCH,c_1}(i1)=\alpha 2(i1)\cdot\hat{P}_{PUSCH,c_1}(i1)$. If $\hat{P}_{PUSCH,c_1}(i1)$ would not exceed $S2(i1)$, $\hat{P}'_{PUSCH,c_1}(i1)=\hat{P}_{PUSCH,c_1}(i1)$.

$S2(i1)$ is determined as follows

$$S2(i1)=\hat{P}_{\text{CMAX}}(i1,i2)-\hat{P}_{u2}(i1)-\hat{P}_{q2}(i2)-\min\left\{\begin{array}{l}\max\left\{\begin{array}{l}0,\\ \hat{P}_{\text{CMAX}}(i1,i2)\cdot\frac{\gamma_{CG2}}{100}-\hat{P}_{q2}(i2)\end{array}\right\}\\ \hat{P}'_{q2}(i2)\end{array}\right\}$$

where

- $\hat{P}_{u2}(i1)=\hat{P}_{PRACH\_CG1}(i1)+\hat{P}'_{PUCCH\_CG1}(i1)$ if the UE has a PUCCH transmission with HARQ-ACK/SR and a PUSCH transmission with UCI not including HARQ-ACK in subframe $i1$ of CG1, otherwise, $\hat{P}_{u2}(i1)=\hat{P}_{PRACH\_CG1}(i1)$.
- if CG1 is MCG and CG2 is SCG
  - if the UE has a PUCCH transmission with UCI including HARQ-ACK/SR in subframe $i2$ of CG2,
    - $\hat{P}_{q2}(i2)=\hat{P}_{PRACH\_CG2}(i2)+\hat{P}'_{PUCCH\_CG2}(i2)$
    - $\hat{P}'_{q2}(i2)=\sum_{c_2\in CG2}\left(\hat{P}_{PUSCH,c_2}(i2)+\hat{\tilde{P}}_{SRS,c_2}(i2)\right)$;
  - else if the UE has a PUSCH transmission with UCI including HARQ-ACK in subframe $i2$ of serving cell $j_2\in CG2$,
    - $\hat{P}_{q2}(i2)=\hat{P}_{PRACH\_CG2}(i2)+\hat{P}'_{PUSCH,j_2}(i2)$
    - $\hat{P}'_{q2}(i2)=\sum_{c_2\in CG2,c_2\ne j_2}\hat{P}_{PUSCH,c_2}(i2)+\sum_{c_2\in CG2}\hat{\tilde{P}}_{SRS,c_2}(i2)$;
  - otherwise,
    - $\hat{P}_{q2}(i2)=\hat{P}_{PRACH\_CG2}(i2)$
    - $\hat{P}'_{q2}(i2)=\hat{P}_{PUCCH\_CG2}(i2)+\sum_{c_2\in CG2}\left(\hat{P}_{PUSCH,c_2}(i2)+\hat{\tilde{P}}_{SRS,c_2}(i2)\right)$
- if CG1 is SCG and CG2 is MCG
  - if the UE has a PUCCH transmission in subframe $i2$ of CG2 and/or a PUSCH transmission with UCI in in subframe $i2$ of serving cell $j_2\in CG2$
    - $\hat{P}_{q2}(i2)=\hat{P}_{PRACH\_CG2}(i2)+\hat{P}'_{PUCCH\_CG2}(i2)+\hat{P}'_{PUSCH,j_2}(i2)$

- $\hat{P}'_{q2}(i2) = \sum_{c_2 \in CG2, c_2 \neq j_2} \hat{P}_{PUSCH,c_2}(i2) + \sum_{c_2 \in CG2} \hat{\tilde{P}}_{SRS,c_2}(i2)$

  where, $\hat{P}_{PUCCH\_CG2}(i2) = 0$ if the UE does not have a PUCCH transmission in subframe $i2$ of CG2; $\hat{P}_{PUSCH,j_2}(i2) = 0$ if the UE does not have a PUSCH transmission with UCI in subframe $i2$ of CG2;

- otherwise

  - $\hat{P}_{q2}(i2) = \hat{P}_{PRACH\_CG2}(i2)$

  - $\hat{P}'_{q2}(i2) = \sum_{c_2 \in CG2} \left(\hat{P}_{PUSCH,c_2}(i2) + \hat{\tilde{P}}_{SRS,c_2}(i2) \right)$

- If the UE has PUSCH transmission(s) without UCI in subframe $i1$ of CG1, the UE shall determine

$$S3(i1) = \hat{P}_{\mathrm{CMAX}}(i1,i2) - \hat{P}_{u3}(i1) - \hat{P}_{q3}(i2) - \min\left\{ \begin{matrix} \max\left\{ \begin{matrix} 0, \\ \left(\hat{P}_{\mathrm{CMAX}}(i1,i2) \cdot \frac{\gamma_{CG2}}{100} - \hat{P}_{q3}(i2) \right) \end{matrix} \right\} \\ \hat{P}'_{q3}(i2) \end{matrix} \right\}$$

where

- if the UE has a PUCCH transmission in subframe $i1$ of CG1 and/or a PUSCH transmission with UCI in in subframe $i1$ of serving cell $j_1 \in CG1$ $\hat{P}_{u3}(i1) = \hat{P}_{PRACH\_CG1}(i1) + \hat{P}'_{PUCCH\_CG1}(i1) + \hat{P}'_{PUSCH,j_1}(i1)$, where $\hat{P}_{PUCCH\_CG1}(i1) = 0$ if the UE does not have a PUCCH transmission in subframe $i1$ of CG1, $\hat{P}_{PUSCH,j_1}(i1) = 0$ if the UE does not have a PUSCH transmission with UCI in subframe $i1$ of CG1; otherwise $\hat{P}_{u3}(i1) = \hat{P}_{PRACH\_CG1}(i1)$;

- if CG1 is MCG and CG2 is SCG

  - if the UE has a PUCCH transmission in subframe $i2$ of CG2 and/or a PUSCH transmission with UCI in in subframe $i2$ of serving cell $j_2 \in CG2$

    - $\hat{P}_{q3}(i2) = \hat{P}_{PRACH\_CG2}(i2) + \hat{P}'_{PUCCH\_CG2}(i2) + \hat{P}'_{PUSCH,j_2}(i2)$

    - $\hat{P}'_{q3}(i2) = \sum_{c_2 \in CG2, c_2 \neq j_2} \hat{P}_{PUSCH,c_2}(i2) + \sum_{c_2 \in CG2} \hat{\tilde{P}}_{SRS,c_2}(i2)$

    where, $\hat{P}_{PUCCH\_CG2}(i2) = 0$ if the UE does not have a PUCCH transmission in subframe $i2$ of CG2; $\hat{P}_{PUSCH,j_2}(i2) = 0$ if the UE does not have a PUSCH transmission with UCI in subframe $i2$ of CG2;

  - otherwise

    - $\hat{P}_{q3}(i2) = \hat{P}_{PRACH\_CG2}(i2)$

    - $\hat{P}'_{q3}(i2) = \sum_{c_2 \in CG2} \left(\hat{P}_{PUSCH,c_2}(i2) + \hat{\tilde{P}}_{SRS,c_2}(i2) \right)$;

- if CG1 is SCG and CG2 is MCG

- $\hat{P}_{q3}(i2) = \hat{P}_{PRACH\_CG2}(i2) + \hat{P}'_{PUCCH\_CG2}(i2) + \sum_{c_2 \in CG2} \hat{P}'_{PUSCH,c_2}(i2)$

- $\hat{P}'_{q3}(i2) = \sum_{c_2 \in CG2} \hat{\tilde{P}}_{SRS,c_2}(i2)$;

- If the total transmit power of all the PUSCH transmission(s) without UCI in subframe $i1$ of CG1 would exceed $S3(i1)$, the UE scales $\hat{P}_{\mathrm{PUSCH},c1}(i1)$ for each serving cell $c_1 \in CG1$ with a PUSCH transmission without UCI in subframe $i1$ such that the condition $\sum_{c_1 \in CG1} w(i1) \cdot \hat{P}_{\mathrm{PUSCH},c_1}(i1) \le \max\{0, S3(i1)\}$ is satisfied, where $\hat{P}'_{\mathrm{PUSCH},c_1}(i1) = w(i1) \cdot \hat{P}_{\mathrm{PUSCH},c_1}(i1)$, and where $w(i1)$ is a scaling factor of $\hat{P}_{\mathrm{PUSCH},c_1}(i1)$ for serving cell c_1 where $0 \le w(i1) \le 1$. Note that $w(i1)$ values are the same across serving cells within a cell group when $w(i1) > 0$ but for certain serving cells within the cell group $w(i1)$ may be zero. If the total transmit power of all the PUSCH transmission(s) without UCI in subframe $i1$ of CG1 would not exceed $S3(i1)$, $\hat{P}'_{\mathrm{PUSCH},c_1}(i1) = \hat{P}_{\mathrm{PUSCH},c_1}(i1)$.

where

- $\hat{P}_{\mathrm{CMAX}}(i1, i2)$ is the linear value of configured transmitted power for Dual Connectivity for the subframe pair $(i1, i2)$ as described in [6];
- if CG1 is MCG and CG2 is SCG
  - $\hat{P}_{\mathrm{PUCCH\_CG1}}(i1)$ is the linear value of $P_{\mathrm{PUCCH}}(i1)$ corresponding to PUCCH transmission on the primary cell ; $\hat{P}_{\mathrm{PUCCH\_CG2}}(i2)$ is the linear value of $P_{\mathrm{PUCCH}}(i2)$ corresponding to PUCCH transmission on the PSCell.
  - $\gamma_{CG1} = \gamma_{MCG}$;
- if CG1 is SCG and CG2 is MCG;
  - $\hat{P}_{\mathrm{PUCCH\_CG1}}(i1)$ is the linear value of $P_{\mathrm{PUCCH}}(i1)$ corresponding to PUCCH transmission on the PSCell; $\hat{P}_{\mathrm{PUCCH\_CG2}}(i2)$ is the linear value of $P_{\mathrm{PUCCH}}(i2)$ corresponding to PUCCH transmission on the primary cell.
  - $\gamma_{CG1} = \gamma_{SCG}$;
- $\hat{P}_{\mathrm{PUSCH},c_1}(i1)$ is the linear value of $P_{\mathrm{PUSCH},c_1}(i1)$ for subframe $i1$ of serving cell of serving cell $c_1 \in CG1$, and $\hat{P}_{\mathrm{PUSCH},c_2}(i2)$ is the linear value of $P_{\mathrm{PUSCH},c_2}(i2)$ for subframe $i2$ of serving cell of serving cell $c_2 \in CG2$.
- γ_{MCG} and γ_{SCG} 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 $i1$ of CG1, $\hat{P}_{PRACH\_CG1}(i1)$ is the linear value of the transmission power of that PRACH transmission; otherwise, $\hat{P}_{PRACH\_CG1}(i1) = 0$;

- If the UE has a PRACH transmission for CG2 overlapping with subframe $i2$ of CG2, $\hat{P}_{PRACH\_CG2}(i2)$ is the linear value of the transmission power of that PRACH transmission; otherwise, $\hat{P}_{PRACH\_CG2}(i2) = 0$.

- $\hat{\tilde{P}}_{SRS,c_2}(i2)$ is determined as follows

  - if the PUSCH/PUCCH is not transmitted in the last symbol of subframe $i1$ of CG1, or if the UE does not have an SRS transmission in subframe $i2$ of serving cell $c_2 \in CG2$ or if the UE drops SRS transmission in subframe $i2$ of serving cell $c_2 \in CG2$ due to collision with PUCCH in subframe $i2$ of serving cell $c_2 \in CG2$

    - $\hat{\tilde{P}}_{SRS,c_2}(i2) = 0$;

  - if the UE has an SRS transmission and does not have a PUCCH/PUSCH transmission in subframe $i2$ of serving cell $c_2 \in CG2$

    - $\hat{\tilde{P}}_{SRS,c_2}(i2) = \hat{P}_{SRS,c_2}(i2)$;

  - if the UE has an SRS transmission and a has PUCCH transmission, and does not have a PUSCH transmission in subframe $i2$ of serving cell $c_2 \in CG2$

    - $$\hat{\tilde{P}}_{SRS,c_2}(i2) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c_2}(i2) - \hat{P}_{PUCCH\_CG2}(i2) \end{matrix}\right\}$$

  - if the UE has an SRS transmission and a has PUSCH transmission, and does not have a PUCCH transmission in subframe $i2$ of serving cell $c_2 \in CG2$

    - $$\hat{\tilde{P}}_{SRS,c_2}(i2) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c_2}(i2) - \hat{P}_{PUSCH,c_2}(i2) \end{matrix}\right\}$$

  - if the UE has an SRS transmission and has a PUSCH transmission and a PUCCH transmission in in subframe $i2$ of serving cell $c_2 \in CG2$

    - $$\hat{\tilde{P}}_{SRS,c_2}(i2) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c_2}(i2) - \hat{P}_{PUSCH,c_2}(i2) - \hat{P}_{PUCCH\_CG2}(i2) \end{matrix}\right\}$$

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 $S4(i1)$, the UE scales $\hat{P}_{\mathrm{SRS},c_1}(i1)$ for the serving cell $c_1 \in CG1$ and the SC-FDMA symbol in subframe $i1$ such that the condition $\sum_{c_1 \in CG1} v(i1) \cdot \hat{P}_{\mathrm{SRS},c_1}(i1) \le S4(i1)$

is satisfied, where $\hat{P}'_{\mathrm{SRS},c_1}(i1) = v(i1) \cdot \hat{P}_{\mathrm{SRS},c_1}(i1)$ is the transmission power of SRS after scaling and where $\hat{P}_{\mathrm{SRS},c_1}(i1)$ is the linear value of $P_{\mathrm{SRS},c_1}(i1)$ described in Subclause 5.1.3.1, and $v(i)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c_1}(i1)$ for serving cell $c_1 \in CG1$ where $0 < v(i) \le 1$. Note that $v(i)$ values 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 $i1$ in a TAG belonging to CG1 overlaps with the SRS transmission in another SC-FDMA symbol in subframe $i1$ 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 $S4(i1)$, the UE scales $\hat{P}_{\mathrm{SRS},c_1}(i1)$ for the serving cell $c_1 \in CG1$ and each of the overlapped SRS SC-FDMA symbols in subframe $i1$ such that the condition $\sum_{c_1 \in CG1} v(i1) \cdot \hat{P}_{\mathrm{SRS},c_1}(i1) \le S4(i1)$ is satisfied, where $\hat{P}'_{\mathrm{SRS},c_1}(i1) = v(i1) \cdot \hat{P}_{\mathrm{SRS},c_1}(i1)$ is the transmission power of SRS after scaling, and where $v(i1)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c_1}(i1)$ for serving cell c_1 where $0 \le v(i1) \le 1$. Note that $v(i1)$ values are the same across serving cells within a cell group.

$S4(i1)$ is determined as follows

$$S4(i1) = \hat{P}_{\mathrm{CMAX}}(i1,i2) - \hat{P}_{q4}(i2) - \min\left\{ \begin{array}{l} \max\left\{ \begin{array}{l} 0, \\ \hat{P}_{\mathrm{CMAX}}(i1,i2) \cdot \dfrac{\gamma_{CG2}}{100} - \hat{P}_{q4}(i2) \end{array} \right\} \\ \hat{P}'_{q4}(i2) \end{array} \right\}$$

where

- if CG1 is MCG and CG2 is SCG
  - $\hat{P}_{q4}(i2) = \hat{\tilde{P}}_{PRACH\_CG2}(i2) + \hat{\tilde{P}}'_{PUCCH\_CG2}(i2) + \sum_{c_2 \in CG2} \hat{\tilde{P}}'_{PUSCH,c_2}(i2)$
  - $\hat{P}'_{q4}(i2) = \sum_{c_2 \in CG2} \hat{P}_{SRS,c_2}(i2)$
- if CG1 is SCG and CG2 is MCG
  - $\hat{P}_{q4}(i2) = \hat{\tilde{P}}_{PRACH\_CG2}(i2) + \hat{\tilde{P}}'_{PUCCH\_CG2}(i2) + \sum_{c_2 \in CG2} \hat{\tilde{P}}'_{PUSCH,c_2}(i2) + \sum_{c_2 \in CG2} \hat{P}'_{SRS,c_2}(i2)$
  - $\hat{P}'_{q4}(i2) = 0$
- if the UE has no PUCCH transmission or has a shortened PUCCH transmission in subframe $i2$ of CG2, $\hat{\tilde{P}}'_{PUCCH\_CG2}(i2) = 0$; otherwise $\hat{\tilde{P}}'_{PUCCH\_CG2}(i2) = \hat{P}'_{PUCCH\_CG2}(i2)$
- if the UE has no PUSCH transmission in the last symbol of subframe $i2$ of serving cell $c_2 \in CG2$, $\hat{\tilde{P}}'_{PUSCH,c_2}(i2) = 0$; otherwise $\hat{\tilde{P}}'_{PUSCH,c_2}(i2) = \hat{P}'_{PUSCH,c_2}(i2)$
- if the UE has PRACH transmission in CG2 that overlaps with the last symbol of subframe $i2$ of CG2, $\hat{\tilde{P}}_{PRACH\_CG2}(i2) = \hat{P}_{PRACH\_CG2}(i2)$; otherwise $\hat{\tilde{P}}_{PRACH\_CG2}(i2) = 0$

For both cell groups

- if the PUCCH/PUSCH transmission of the UE on subframe $i1$ for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUSCH transmission on subframe $i1+1$ for a different serving cell in another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe $i2+1$ 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 P_{CMAX} on any overlapped portion.

- if the PUSCH transmission of the UE on subframe $i1$ for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUCCH transmission on subframe $i1+1$ for a different serving cell in another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe $i2+1$ 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 P_{CMAX} on any overlapped portion.

- if the SRS transmission of the UE in a symbol on subframe $i1$ for a given serving cell in a TAG of CG1 overlaps with the PUCCH/PUSCH transmission on subframe $i1$ or subframe $i1+1$ for a different serving cell in the same or another TAG of CG1 and/or overlaps with the PUCCH/PUSCH transmission on subframe $i2+1$ for a serving cell of CG2, the UE shall drop the SRS in CG1 if its total transmission power across all CGs exceeds P_{CMAX} on any overlapped portion of the symbol.

- if the SRS transmission of the UE in a symbol on subframe $i1$ for a given serving cell in CG1 overlaps with the SRS transmission on subframe $i1$ for a different serving cell(s) in CG1 or overlaps with SRS transmission on subframe $i2$ for a serving cell(s) in CG2, and if the SRS transmissions overlap with PUSCH/PUCCH transmission on subframe $i1$ or subframe $i1+1$ for another serving cell(s) in CG1, and/or if the SRS transmissions overlap with PUSCH/PUCCH transmission on subframe $i2+1$ for a serving cell of CG2, the UE shall drop the SRS transmissions in CG1 if its total transmission power across all CGs exceeds P_{CMAX} on any overlapped portion of the symbol.

- UE shall, when requested by higher layers, to transmit PRACH on subframe $i1$ or subframe $i1+1$ in a secondary serving cell in CG1 and/or to transmit PRACH on subframe $i2+1$ in a serving cell in CG2 in parallel with SRS transmission in a symbol on subframe $i1$ 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 P_{CMAX} on any overlapped portion of the symbol.

- UE shall, when requested by higher layers, to transmit PRACH on subframe $i1+1$ in a secondary serving cell in CG1 and/or to transmit PRACH on subframe $i2+1$ in a serving cell in CG2 in parallel with PUSCH/PUCCH on subframe $i1$ 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 P_{CMAX} on the overlapped portion.

5.1.4.2 Dual connectivity power control Mode 2

If subframe $i1$ of CG1 overlaps in time with subframe $i2-1$ and subframe $i2$ of CG2, and if the UE has transmission(s) in subframe $i1$ of CG1,

- if the UE determines based on higher layer signalling that transmission(s) in subframe $i1$ of CG1 cannot overlap in time with transmission(s) in subframe $i2$ of CG2, the UE shall determine

$$\hat{P}^{1}_{CG1}(i1) = \min\left\{ \begin{array}{l} \hat{P}_{\mathrm{q1}}(i1)\,, \\ \hat{P}_{\mathrm{CMAX}}(i1, i2-1) - \hat{P}_{\mathrm{PRACH\_CG1}}(i1) - \hat{P}^{1}_{CG2}(i2-1) - \hat{P}_{\mathrm{PRACH\_CG2}}(i2-1) \end{array} \right\}$$

- Otherwise, the UE shall determine

$$\hat{P}_{CG1}^{1}(i1)=\min\left\{\begin{array}{l}\hat{P}_{\mathrm{q1}}(i1)\,,\\ \hat{P}_{\mathrm{CMAX}}(i1,i2-1)-\hat{P}_{\mathrm{PRACH\_CG1}}(i1)-\max\left\{\begin{array}{l}\hat{P}_{\mathrm{CMAX}}(i1,i2-1)\cdot\dfrac{\gamma_{CG2}}{100},\\ \hat{P}_{CG2}^{1}(i2-1)+\hat{P}_{\mathrm{PRACH\_CG2}}(i2-1),\\ \hat{P}_{\mathrm{PRACH\_CG2}}(i2)\end{array}\right\}\end{array}\right\}.$$

where,

- $\hat{P}_{q1}(i1)=\hat{P}_{PUCCH\_CG1}(i1)+\sum_{c\in CG1}\left(\hat{P}_{PUSCH,c}(i1)+\hat{\tilde{P}}_{SRS,c}(i1)\right)$
- $\hat{P}_{\mathrm{CMAX}}(i1,i2-1)$ is the linear value of configured transmitted power for Dual Connectivity for the subframe pair $(i1,i2-1)$, as described in [6];
- $\hat{P}_{PUSCH,c}(i1)=0$, if the UE does not have a PUSCH transmission in serving cell $c\in CG1$;
- $\hat{P}_{PUCCH\_CG1}(i1)=0$ if the UE does not have a PUCCH transmission in CG1;
- $\hat{P}_{CG2}^{1}(i2-1)=0$ if the UE has no transmission of PUCCH, PUSCH, or SRS in subframe $i2-1$ of CG2;
- $\gamma_{CG1}=\gamma_{MCG}$, and $\gamma_{CG2}=\gamma_{SCG}$ if CG1 is MCG and CG2 is SCG;
- $\gamma_{CG1}=\gamma_{SCG}$, and $\gamma_{CG2}=\gamma_{MCG}$, if CG1 is SCG and CG2 is MCG;
- γ_{MCG} and γ_{SCG} 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 $i1$ of CG1, $\hat{P}_{PRACH\_CG1}(i1)$ is the linear value of the transmission power of that PRACH transmission; otherwise, $\hat{P}_{PRACH\_CG1}(i1)=0$.
- If the UE has a PRACH transmission for CG2 overlapping with subframe $i2$ of CG2, and if the transmission timing of the PRACH transmission (according to Subclause 6.1.1) is such that the UE is ready to transmit the PRACH at least one subframe before subframe $i2$ of CG2, $\hat{P}_{PRACH\_CG2}(i2)$ is the linear value of the transmission power of that PRACH transmission; otherwise, $\hat{P}_{PRACH\_CG2}(i2)=0$.
- If the UE has a PRACH transmission for CG2 overlapping with subframe $i2-1$ of CG2, $\hat{P}_{\mathrm{PRACH\_CG2}}(i2-1)$ is the linear value of the transmission power of that PRACH transmission; otherwise, $\hat{P}_{\mathrm{PRACH\_CG2}}(i2-1)=0$.
- $\hat{\tilde{P}}_{SRS,c}(i1)$ is determined as follows
  - if the UE does not have an SRS transmission in subframe $i1$ of serving cell $c\in CG1$ or if the UE drops the SRS transmission in subframe $i1$ of serving cell $c\in CG1$ due to collision with a PUCCH transmission in subframe $i1$ of serving cell $c\in CG1$

- $\hat{\hat{P}}_{SRS,c}(i1) = 0$;

- if the UE has an SRS transmission and does not have a PUCCH/PUSCH transmission in subframe $i1$ of serving cell $c \in CG1$

- $\hat{\hat{P}}_{SRS,c}(i1) = \hat{P}_{SRS,c}(i1)$;

- if the UE has an SRS transmission and a has PUCCH transmission, and does not have a PUSCH transmission in subframe $i1$ of serving cell $c \in CG1$

- $\hat{\hat{P}}_{SRS,c}(i1) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c}(i1) - \hat{P}_{PUCCH\_CG1}(i1) \end{matrix}\right\}$

- if the UE has an SRS transmission and a has PUSCH transmission, and does not have a PUCCH transmission in subframe $i1$ of serving cell $c \in CG1$

- $\hat{\hat{P}}_{SRS,c}(i1) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c}(i1) - \hat{P}_{PUSCH,c}(i1) \end{matrix}\right\}$

- if the UE has an SRS transmission and has a PUSCH transmission and a PUCCH transmission in subframe $i1$ of serving cell $c \in CG1$

- $\hat{\hat{P}}_{SRS,c}(i1) = \max\left\{\begin{matrix} 0, \\ \hat{P}_{SRS,c}(i1) - \hat{P}_{PUSCH,c}(i1) - \hat{P}_{PUCCH\_CG1}(i1) \end{matrix}\right\}$

where $\hat{P}_{SRS,c}(i1)$ is the linear value of $P_{SRS,c}(i1)$ described in Subclause 5.1.3.1.

If $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$ would exceed $\hat{P}^{1}_{CG1}(i)$, the UE scales $\hat{P}_{PUCCH\_CG1}(i)$ such that the condition $\alpha 1(i) \cdot \hat{P}_{PUCCH\_CG1}(i) \le \hat{P}^{1}_{CG1}(i)$ is satisfied where

- if CG1 is MCG, $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$ is the linear value of $P_{\mathrm{PUCCH}}(i)$ corresponding to PUCCH transmission on the primary cell, in case there is no PUCCH transmission in subframe *i* on the primary cell $\hat{P}_{\mathrm{PUCCH\_CG1}}(i) = 0$.

- if CG1 is SCG , $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$ is the linear value of $P_{\mathrm{PUCCH}}(i)$ corresponding to PUCCH transmission on PSCell, in case there is no PUCCH transmission in subframe *i* on the PSCell $\hat{P}_{\mathrm{PUCCH\_CG1}}(i) = 0$. $\hat{P}_{\mathrm{PUSCH},c}(i)$ is the linear value of $P_{\mathrm{PUSCH},c}(i)$

- $0 \le \alpha 1(i) \le 1$ is a scaling factor of $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$.

If the UE has PUSCH transmission with UCI on serving cell $j \in CG1$, and $\hat{P}_{\mathrm{PUSCH},j}(i)$ would exceed $\hat{P}^{1}_{CG1}(i)$ the UE scales $\hat{P}_{\mathrm{PUSCH},j}(i)$ such that the condition $\alpha 2(i) \cdot \hat{P}_{\mathrm{PUSCH},j}(i) \le \hat{P}^{1}_{CG1}(i)$ is satisfied where $\hat{P}_{\mathrm{PUSCH},j}(i)$ is the linear value of the PUSCH transmit power for the cell with UCI, and $0 \le \alpha 2(i) \le 1$ is a scaling factor of $\hat{P}_{\mathrm{PUSCH},j}(i)$ for serving cell $j \in CG1$.

If the total transmit power across all the serving cells of a cell group CG1 would exceed $\hat{P}^{1}_{CG1}(i)$, the UE scales $\hat{P}_{\mathrm{PUSCH},c}(i)$ for the serving cell $c \in CG1$ in subframe *i* such that the condition $\sum_{c \in CG1} w(i) \cdot \hat{P}_{\mathrm{PUSCH},c}(i) \le \left(\hat{P}^{1}_{CG1}(i) - \hat{P}_{\mathrm{PUCCH\_CG1}}(i)\right)$ is satisfied; and $w(i)$ is a scaling factor of $\hat{P}_{\mathrm{PUSCH},c}(i)$ for serving cell c where $0 \le w(i) \le 1$.

If the UE has PUSCH transmission with UCI on serving cell $j \in CG1$ 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 $\hat{P}^{1}_{CG1}(i)$, the UE scales $\hat{P}_{\mathrm{PUSCH},c}(i)$ for the serving cells belonging to CG1 without UCI in subframe *i* such that the condition $\sum_{c \in CG1, c \ne j} w(i) \cdot \hat{P}_{\mathrm{PUSCH},c}(i) \le \left(\hat{P}^{1}_{CG1}(i) - \hat{P}_{\mathrm{PUSCH},j}(i)\right)$ is satisfied;

where $\hat{P}_{\mathrm{PUSCH},j}(i)$ is the PUSCH transmit power for the cell with UCI and $w(i)$ is a scaling factor of $\hat{P}_{\mathrm{PUSCH},c}(i)$ for serving cell c without UCI. In this case, no power scaling is applied to $\hat{P}_{\mathrm{PUSCH},j}(i)$ unless $\sum_{c \in CG1, c \ne j} w(i) \cdot \hat{P}_{\mathrm{PUSCH},c}(i) = 0$ and the total transmit power across all of the serving cells of the CG1 still would exceed $\hat{P}^{1}_{CG1}(i)$.

If the UE has simultaneous PUCCH and PUSCH transmission with UCI on serving cell $j \in CG1$ 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 $\hat{P}^{1}_{CG1}(i)$, the UE obtains $\hat{P}_{\mathrm{PUSCH},c}(i)$ according to

$$\hat{P}_{\mathrm{PUSCH},j}(i) = \min\left(\hat{P}_{\mathrm{PUSCH},j}(i), \left(\hat{P}^{1}_{CG1}(i) - \hat{P}_{\mathrm{PUCCH\_CG1}}(i)\right)\right)$$ and

$$\sum_{c \in CG1, c \ne j} w(i) \cdot \hat{P}_{\mathrm{PUSCH},c}(i) \le \left(\hat{P}^{1}_{CG1}(i) - \hat{P}_{\mathrm{PUCCH\_CG1}}(i) - \hat{P}_{\mathrm{PUSCH},j}(i)\right)$$

where

- if CG1 is MCG, $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$ is the linear value of $P_{\mathrm{PUCCH}}(i)$ corresponding to PUCCH transmission on the primary cell.

- if CG1 is SCG , $\hat{P}_{\mathrm{PUCCH\_CG1}}(i)$ is the linear value of $P_{\mathrm{PUCCH}}(i)$ corresponding to PUCCH transmission on PSCell.

Note that $w(i)$ values are the same across serving cells within a cell group when $w(i) > 0$ but for certain serving cells within the cell group $w(i)$ 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 $\hat{P}^{1}_{CG1}(i)$, the UE scales $\hat{P}_{\mathrm{SRS},c}(i)$ for the serving cell $c \in CG1$ and the SC-FDMA symbol in subframe *i* such that the condition

$$\sum_{c \in CG1} v(i) \cdot \hat{P}_{\mathrm{SRS},c}(i) \le \hat{P}^{1}_{CG1}(i)$$

is satisfied where $\hat{P}_{\mathrm{SRS},c}(i)$ is the linear value of $P_{\mathrm{SRS},c}(i)$ described in Subclause 5.1.3.1, and $v(i)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c}(i)$ for serving cell $c \in CG1$ where $0 < v(i) \le 1$. Note that $v(i)$ values 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 i in a TAG belonging to CG1 overlaps with the SRS transmission in another SC-FDMA symbol in subframe i 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 $\hat{P}^{1}_{CG1}(i)$, the UE scales $\hat{P}_{\mathrm{SRS},c}(i)$ for the serving cell $c \in CG1$ and each of the overlapped SRS SC-FDMA symbols in subframe i such that the condition

$$\sum_{c \in CG1} v(i) \cdot \hat{P}_{\mathrm{SRS},c}(i) \le \hat{P}^{1}_{CG1}(i)$$

is satisfied where $\hat{P}_{\mathrm{SRS},c}(i)$ is the linear value of $P_{\mathrm{SRS},c}(i)$ described in Subclause 5.1.3.1, and $v(i)$ is a scaling factor of $\hat{P}_{\mathrm{SRS},c}(i)$ for serving cell $c \in CG1$ where $0 < v(i) \le 1$. Note that $v(i)$ values 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 i for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUSCH transmission on subframe $i+1$ for a different serving cell in another TAG of CG1, the UE shall adjust its total transmission power of CG1 to not exceed $\hat{P}^{1}_{CG1}$ on any overlapped portion.

- if the UE is configured with multiple TAGs within CG1, and if the PUSCH transmission of the UE on subframe i for a given serving cell in a TAG of CG1 overlaps some portion of the first symbol of the PUCCH transmission on subframe $i+1$ for a different serving cell in another TAG of CG1 the UE shall adjust its total transmission power of CG1 to not exceed $\hat{P}^{1}_{CG1}$ 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 i for a given serving cell in a TAG of CG1 overlaps with the PUCCH/PUSCH transmission on subframe i or subframe $i+1$ 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 $\hat{P}^{1}_{CG1}$ 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 i for a given serving cell in the CG1 overlaps with the SRS transmission on subframe i for a different serving cell(s) in CG1 and with PUSCH/PUCCH transmission on subframe i or subframe $i+1$ for another serving cell(s) in CG1, the UE shall drop the SRS transmissions in CG1 if the total transmission power of CG1 exceeds $\hat{P}^{1}_{CG1}$ 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 $\hat{P}^{1}_{CG1}$ 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 $\hat{P}^{1}_{CG1}$ on the overlapped portion.

Table 5.1.4.2-1: γ_{MCG} (or γ_{SCG}) values for determining power allocation for dual connectivity

p-MeNB (or p-SeNB)	γ_{MCG} (or γ_{SCG}) 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

5.1.5 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 Subclause 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';
- $i1 = i2 = i$ and $\hat{P}_{\text{CMAX}}(i1, i2) = \hat{P}_{\text{CMAX}}(i)$ is the linear value of the UE total configured maximum output power P_{CMAX} defined in [6] in subframe *i*; and
- $\gamma_{\text{MCG}} = \gamma_{\text{SCG}} = 0$.

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.

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

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

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

where $\delta_{\text{power-offset}}$ is 0 dB for all PDSCH transmission schemes except multi-user MIMO as described in Subclause 7.1.5 and where P_A 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 P_A.

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,

- ρ_A is equal to $P'_A + 10 \cdot \log_{10}(2)$ [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to Subclause 6.3.4.3 of [3];
- ρ_A is equal to P'_A [dB] otherwise

and where P'_A 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 P'_A.

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

- ρ_A is equal to $P''_A + 10 \cdot \log_{10}(2)$ [dB] when the UE receives a PDSCH data transmission using precoding for transmit diversity with 4 cell-specific antenna ports according to Subclause 6.3.4.3 of [3];
- ρ_A is equal to P''_A [dB] otherwise

where P''_A is configured per SC-MTCH and is given by higher layer parameter *p-a-r13*. If P''_A is not configured, the UE may assume that $P''_A = 0$ [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, or 256QAM, this ratio is 0 dB.

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

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

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

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 ρ_B / ρ_A is given by Table 5.2-1 according to cell-specific parameter P_B signalled by higher layers and the number of configured eNodeB cell specific antenna ports. P_B 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 P_B is not configured, the UE may assume that $\rho_B / \rho_A = 1$.

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

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

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

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

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

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

<table>
<tr><th rowspan="3">Number of antenna ports</th><th colspan="4">OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_A</th><th colspan="4">OFDM symbol indices within a slot where the ratio of the corresponding PDSCH EPRE to the cell-specific RS EPRE is denoted by ρ_B</th></tr>
<tr><th colspan="2">Normal cyclic prefix</th><th colspan="2">Extended cyclic prefix</th><th colspan="2">Normal cyclic prefix</th><th colspan="2">Extended cyclic prefix</th></tr>
<tr><th>n_s mod 2 = 0</th><th>n_s mod 2 = 1</th><th>n_s mod 2 = 0</th><th>n_s mod 2 = 1</th><th>n_s mod 2 = 0</th><th>n_s mod 2 = 1</th><th>n_s mod 2 = 0</th><th>n_s mod 2 = 1</th></tr>
<tr><td>One or two</td><td>1, 2, 3, 4, 5, 6</td><td>0, 1, 2, 3, 4, 5, 6</td><td>1, 2, 3, 4, 5</td><td>0, 1, 2, 3, 4, 5</td><td>0</td><td>-</td><td>0</td><td>-</td></tr>
<tr><td>Four</td><td>2, 3, 4, 5, 6</td><td>0, 1, 2, 3, 4, 5, 6</td><td>2, 4, 3, 5</td><td>0, 1, 2, 3, 4, 5</td><td>0, 1</td><td>-</td><td>0, 1</td><td>-</td></tr>
</table>

5.2.1 eNodeB Relative Narrowband TX Power (RNTP) restrictions

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

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

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

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

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