
Agenda item:

Source: Philips

Title: Clarification of power control at maximum and minimum power (revised)

Document for: Decision

Introduction

The attached CR is a revision of CR25214-118r2 which was accepted in R1-00-0973 at RAN1 #15 in Oulu. The revised CR incorporates the correction proposed by Siemens in CR25214-125 in R1-00-1055.

Original introduction to R1-00-973:

Some clarification appears to be necessary for the power control behaviour of the UE at maximum and minimum power.

The current specification in TS25.214 requires UEs to avoid exceeding the maximum allowed power by means of scaling the total transmit power after applying all adjustments to the DPCCH power and gain factors. This is specified in sub-clause 5.1.2.5.

However, the behaviour when the calculated value of the total transmit power would be below the minimum required value is not specified in sub-clause 5.1.2.5, but it is stated in sub-clause 5.1.2.1 that the UE may reduce the value of Δ_{DPCCH} in such circumstances. This does not cover the case when a change of TFC causes the required power to fall below the minimum required transmit power.

In the attached CR we propose a clarification of the behaviour at minimum power, to permit the UE to scale the total transmit power if applying the DPCCH power adjustments and gain factors would decrease the total power and result in a value below the minimum required power, subject to the following constraints:

- The total transmit power after applying additional scaling shall not exceed the required minimum power, nor the previous total transmit power;
- The magnitude of the change in total transmit power after applying additional scaling shall not exceed the magnitude of the calculated power change before the additional scaling.

For clarity and ease of reference, we have gathered the various references to power scaling at maximum and minimum power together into sub-clause 5.1.2.6.

Some corresponding minor changes have also been made to the compressed mode power control section where clarification is needed of the behaviour at maximum and minimum power.

The PCPCH power control section has also been updated with a cross-reference to sub-clause 5.1.2.6, to ensure that the behaviour is consistent with DCHs.

Sub-clause 5.1.2.6 is also cross-referenced from the general DCH UL power control section (5.1.2.1).

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| CHANGE REQUEST | | Please see embedded help file at the bottom of this page for instructions on how to fill in this form correctly. |
| 25.214 | CR | 118r3 |
| GSM (AA.BB) or 3G (AA.BBB) specification number ↑ | | ↑ CR number as allocated by MCC support team |
| For submission to: RAN #9 list expected approval meeting # here ↑ | for approval for information | Current Version: 3.3.0 |
| | <input checked="" type="checkbox"/> | strategic <input type="checkbox"/> non-strategic <input type="checkbox"/> (for SMG use only) |

Form: CR cover sheet, version 2 for 3GPP and SMG The latest version of this form is available from: ftp://ftp.3gpp.org/Information/CR-Form-v2.doc

Proposed change affects: (U)SIM ME UTRAN / Radio Core Network
 (at least one should be marked with an X)

Source: Philips **Date:** 2000-08-18

Subject: Clarification of power control at maximum and minimum power (revised)

Work item:

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| Category: | F Correction <input checked="" type="checkbox"/> A Corresponds to a correction in an earlier release <input type="checkbox"/> B Addition of feature <input type="checkbox"/> C Functional modification of feature <input type="checkbox"/> D Editorial modification <input type="checkbox"/> | Release: | Phase 2 <input type="checkbox"/> Release 96 <input type="checkbox"/> Release 97 <input type="checkbox"/> Release 98 <input type="checkbox"/> Release 99 <input checked="" type="checkbox"/> Release 00 <input type="checkbox"/> |
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(only one category shall be marked with an X)

Reason for change: Current text is incomplete and inconsistent.

Clauses affected: 5.1.2.1, 5.1.2.3, 5.1.2.5, 5.1.2.6

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| Other specs affected: | Other 3G core specifications <input type="checkbox"/> Other GSM core specifications <input type="checkbox"/> MS test specifications <input type="checkbox"/> BSS test specifications <input type="checkbox"/> O&M specifications <input type="checkbox"/> | → List of CRs: → List of CRs: → List of CRs: → List of CRs: → List of CRs: | |
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Other comments:



<----- double-click here for help and instructions on how to create a CR.

5.1.2 DPCCH/DPDCH

5.1.2.1 General

The initial uplink DPCCH transmit power is set by higher layers. Subsequently the uplink transmit power control procedure simultaneously controls the power of a DPCCH and its corresponding DPDCHs (if present). The relative transmit power offset between DPCCH and DPDCHs is determined by the network and is computed according to subclause 5.1.2.5 using the gain factors signalled to the UE using higher layer signalling.

The operation of the inner power control loop, described in sub clause 5.1.2.2, adjusts the power of the DPCCH and DPDCHs by the same amount, provided there are no changes in gain factors. Additional adjustments to the power of the DPCCH associated with the use of compressed mode are described in sub clause 5.1.2.3.

Any change in the uplink DPCCH transmit power shall take place immediately before the start of the pilot field on the DPCCH. The change in DPCCH power with respect to its previous value is derived by the UE and is denoted by Δ_{DPCCH} (in dB). The previous value of DPCCH power shall be that used in the previous slot, except in the event of an interruption in transmission due to the use of compressed mode, when the previous value shall be that used in the last slot before the transmission gap.

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power. ~~If the UE transmit power is below the required minimum output power [as defined in TS 25.101] and the derived value of Δ_{DPCCH} is less than zero, the UE may reduce the magnitude of Δ_{DPCCH} .~~

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

5.1.2.2 Ordinary transmit power control

5.1.2.2.1 General

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, $\text{SIR}_{\text{target}}$.

The serving cells (cells in the active set) should estimate signal-to-interference ratio SIR_{est} of the received uplink DPCH. The serving cells should then generate TPC commands and transmit the commands once per slot according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "0", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "1".

Upon reception of one or more TPC commands in a slot, the UE shall derive a single TPC command, TPC_{cmd} , for each slot, combining multiple TPC commands if more than one is received in a slot. Two algorithms shall be supported by the UE for deriving a TPC_{cmd} . Which of these two algorithms is used is determined by a UE-specific higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the UE-specific higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB.

After deriving of the combined TPC command TPC_{cmd} using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink DPCCH with a step of Δ_{DPCCH} (in dB) which is given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{TPC}} \times \text{TPC}_{\text{cmd}}.$$

5.1.2.2.1.1 Out of synchronisation handling

The UE shall shut its transmitter off when the UE estimates the DPCCH quality over the last 200 ms period to be worse than a threshold Q_{out} . This criterion is never fulfilled during the first 200 ms of the dedicated channel's existence. Q_{out} is defined implicitly by the relevant tests in TS 25.101.

The UE can turn its transmitter on when the UE estimates the DPCCH quality over the last 200 ms period to be better than a threshold Q_{in} . This criterion is always fulfilled during the first 200 ms of the dedicated channel's existence. Q_{in} is defined implicitly by the relevant tests in TS 25.101. When transmission is resumed, the power of the DPCCH shall be the same as when the UE transmitter was shut off.

5.1.2.2.2 Algorithm 1 for processing TPC commands

5.1.2.2.2.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the value of TPC_cmd shall be derived as follows:

- If the received TPC command is equal to 0 then TPC_cmd for that slot is -1.
- If the received TPC command is equal to 1, then TPC_cmd for that slot is 1.

5.1.2.2.2.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from the same radio link set shall be combined into one TPC command, to be further combined with other TPC commands as described in subclause 5.1.2.2.2.3.

5.1.2.2.2.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

First, the UE shall conduct a soft symbol decision W_i on each of the power control commands TPC_i , where $i = 1, 2, \dots, N$, where N is greater than 1 and is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.2.2.

Finally, the UE derives a combined TPC command, TPC_cmd, as a function γ of all the N soft symbol decisions W_i :

- $TPC_cmd = \gamma(W_1, W_2, \dots, W_N)$, where TPC_cmd can take the values 1 or -1.

The function γ shall fulfil the following criteria:

If the N TPC_i commands are random and uncorrelated, with equal probability of being transmitted as "0" or "1", the probability that the output of γ is equal to 1 shall be greater than or equal to $1/(2^N)$, and the probability that the output of γ is equal to -1 shall be greater than or equal to 0.5.

5.1.2.2.3 Algorithm 2 for processing TPC commands

NOTE: Algorithm 2 makes it possible to emulate smaller step sizes than the minimum power control step specified in subclause 5.1.2.2.1, or to turn off uplink power control by transmitting an alternating series of TPC commands.

5.1.2.2.3.1 Derivation of TPC_cmd when only one TPC command is received in each slot

When a UE is not in soft handover, only one TPC command will be received in each slot. In this case, the UE shall process received TPC commands on a 5-slot cycle, where the sets of 5 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 5 slots.

The value of TPC_cmd shall be derived as follows:

- For the first 4 slots of a set, TPC_cmd = 0.
- For the fifth slot of a set, the UE uses hard decisions on each of the 5 received TPC commands as follows:
 - If all 5 hard decisions within a set are 1 then TPC_cmd = 1 in the 5th slot.
 - If all 5 hard decisions within a set are 0 then TPC_cmd = -1 in the 5th slot.
 - Otherwise, TPC_cmd = 0 in the 5th slot.

5.1.2.2.3.2 Combining of TPC commands from radio links of the same radio link set

When a UE is in soft handover, multiple TPC commands may be received in each slot from different cells in the active set. In some cases, the UE has the knowledge that some of the transmitted TPC commands in a slot are the same. This is the case when the radio links are in the same radio link set. For these cases, the TPC commands from radio links of the same radio link set shall be combined into one TPC command, to be processed and further combined with any other TPC commands as described in subclause 5.1.2.2.3.3.

5.1.2.2.3.3 Combining of TPC commands from radio links of different radio link sets

This subclause describes the general scheme for combination of the TPC commands from radio links of different radio link sets.

The UE shall make a hard decision on the value of each TPC_i, where i = 1, 2, ..., N and N is the number of TPC commands from radio links of different radio link sets, that may be the result of a first phase of combination according to subclause 5.1.2.2.3.2.

The UE shall follow this procedure for 3 consecutive slots, resulting in N hard decisions for each of the 3 slots.

The sets of 3 slots shall be aligned to the frame boundaries and there shall be no overlap between each set of 3 slots.

The value of TPC_cmd is zero for the first 2 slots. After 3 slots have elapsed, the UE shall determine the value of TPC_cmd for the third slot in the following way:

The UE first determines one temporary TPC command, TPC_temp_i, for each of the N sets of 3 TPC commands as follows:

- If all 3 hard decisions within a set are "1", TPC_temp_i = 1.
- If all 3 hard decisions within a set are "0", TPC_temp_i = -1.
- Otherwise, TPC_temp_i = 0.

Finally, the UE derives a combined TPC command for the third slot, TPC_cmd, as a function γ of all the N temporary power control commands TPC_temp_i:

TPC_cmd(3rd slot) = γ (TPC_temp₁, TPC_temp₂, ..., TPC_temp_N), where TPC_cmd(3rd slot) can take the values 1, 0 or -1, and γ is given by the following definition:

- TPC_cmd is set to 1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i > 0.5$.
- TPC_cmd is set to -1 if $\frac{1}{N} \sum_{i=1}^N TPC_temp_i < -0.5$.

Otherwise, TPC_cmd is set to 0.

5.1.2.3 Transmit power control in compressed mode

In compressed mode, some frames are compressed and contain transmission gaps. The uplink power control procedure is as specified in clause 5.1.2.2, using the same UTRAN supplied parameters for Power Control Algorithm and step size (Δ_{TPC}), but with additional features which aim to recover as rapidly as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

In compressed mode, compressed frames may occur in either the uplink or the downlink or both. In uplink compressed frames, the transmission of uplink DPDCH(s) and DPCCH shall both be stopped during transmission gaps.

Due to the transmission gaps in compressed frames, there may be missing TPC commands in the downlink. If no downlink TPC command is transmitted, the corresponding TPC_cmd derived by the UE shall be set to zero.

Compressed and non-compressed frames in the uplink DPCCH may have a different number of pilot bits per slot. A change in the transmit power of the uplink DPCCH would be needed in order to compensate for the change in the total pilot energy. Therefore at the start of each slot the UE shall derive the value of a power offset Δ_{PILOT} . If the number of pilot bits per slot in the uplink DPCCH is different from its value in the most recently transmitted slot, Δ_{PILOT} (in dB) shall be given by:

$$\Delta_{\text{PILOT}} = 10\text{Log}_{10} (N_{\text{pilot,prev}}/N_{\text{pilot,curr}});$$

where $N_{\text{pilot,prev}}$ is the number of pilot bits in the most recently transmitted slot, and $N_{\text{pilot,curr}}$ is the number of pilot bits in the current slot. Otherwise, including during transmission gaps in the downlink, Δ_{PILOT} shall be zero.

Unless otherwise specified, in every slot during compressed mode the UE shall adjust the transmit power of the uplink DPCCH with a step of Δ_{DPCCH} (in dB) which is given by:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{TPC}} \times \text{TPC_cmd} + \Delta_{\text{PILOT}}.$$

At the start of the first slot after an uplink or downlink transmission gap the UE shall apply a change in the transmit power of the uplink DPCCH by an amount Δ_{DPCCH} (in dB), with respect to the uplink DPCCH power in the most recently transmitted uplink slot, where:

$$\Delta_{\text{DPCCH}} = \Delta_{\text{RESUME}} + \Delta_{\text{PILOT}}.$$

The value of Δ_{RESUME} (in dB) shall be determined by the UE according to the Initial Transmit Power mode (ITP). The ITP is a UE specific parameter, which is signalled by the network with the other compressed mode parameters (see TS 25.215). The different modes are summarised in table 1.

Table 1: Initial Transmit Power modes during compressed mode

| Initial Transmit Power mode | Description |
|-----------------------------|--|
| 0 | $\Delta_{\text{RESUME}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}_{\text{gap}}$ |
| 1 | $\Delta_{\text{RESUME}} = \delta_{\text{last}}$ |

In the case of a transmission gap in the uplink, $\text{TPC_cmd}_{\text{gap}}$ shall be the value of TPC_cmd derived in the first slot of the uplink transmission gap, if a downlink TPC_command is transmitted in that slot. Otherwise $\text{TPC_cmd}_{\text{gap}}$ shall be zero.

δ_{last} shall be equal to the most recently computed value of δ_i . δ_i shall be updated according to the following recursive relations, which shall be executed in all slots in which both the uplink DPCCH and a downlink TPC command are transmitted, and in the first slot of an uplink transmission gap if a downlink TPC command is transmitted in that slot:

$$\begin{aligned} \underline{\delta_i} &= 0.9375\underline{\delta_{i-1}} - 0.96875\underline{\text{TPC_cmd}_i} \Delta_{\text{TPC}} & \underline{\delta_i} &= 0.9375\underline{\delta_{i-1}} - 0.96875\underline{\text{TPC_cmd}_i} \Delta_{\text{TPC}} k_{sc} \\ \underline{\delta_{i-1}} &= \underline{\delta_i} & \underline{\delta_{i-1}} &= \underline{\delta_i} \end{aligned}$$

where: $\underline{\text{TPC_cmd}_i}$ is the power control command derived by the UE in that slot;

$k_{sc} = 0$ if additional scaling is applied in the current slot and the previous slot as described in sub-clause 5.1.2.6, and $k_{sc} = 1$ otherwise.

δ_{i-1} is the value of δ_i computed for the previous slot. The value of δ_{i-1} shall be initialised to zero when the uplink DPCCH is activated, and also at the end of the first slot after each uplink transmission gap, and also at the end of the first slot after each downlink transmission gap. The value of δ_i shall be set to zero at the end of the first slot after each uplink transmission gap.

After a transmission gap in either the uplink or the downlink, the period following resumption of simultaneous uplink and downlink DPCCH transmission is called a recovery period. RPL is the recovery period length and is expressed as a number of slots. RPL is equal to the minimum value out of the transmission gap length and 7 slots. If a transmission gap is scheduled to start before RPL slots have elapsed, then the recovery period shall end at the start of the gap, and the value of RPL shall be reduced accordingly.

During the recovery period, 2 modes are possible for the power control algorithm. The Recovery Period Power control mode (RPP) is signalled with the other compressed mode parameters (see TS 25.215). The different modes are summarised in the table 2:

Table 2: Recovery Period Power control modes during compressed mode

| Recovery Period power control mode | Description |
|------------------------------------|--|
| 0 | Transmit power control is applied using the algorithm determined by the value of PCA, as in subclause 5.1.2.2 with step size Δ_{TPC} . |
| 1 | Transmit power control is applied using algorithm 1 (see subclause 5.1.2.2.2) with step size Δ_{RP-TPC} during RPL slots after each transmission gap. |

For RPP mode 0, the step size is not changed during the recovery period and ordinary transmit power control is applied (see subclause 5.1.2.2), using the algorithm for processing TPC commands determined by the value of PCA (see subclauses 5.1.2.2.2 and 5.1.2.2.3).

For RPP mode 1, during RPL slots after each transmission gap, power control algorithm 1 is applied with a step size Δ_{RP-TPC} instead of Δ_{TPC} , regardless of the value of PCA. The change in uplink DPCCH transmit power (except for the first slot after the transmission gap) is given by:

$$\Delta_{DPCCH} = \Delta_{RP-TPC} \times TPC_cmd + \Delta_{PILOT}$$

Δ_{RP-TPC} is called the recovery power control step size and is expressed in dB. If PCA has the value 1, Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$. If PCA has the value 2, Δ_{RP-TPC} is equal to 1 dB.

After the recovery period, ordinary transmit power control resumes using the algorithm specified by the value of PCA and with step size Δ_{TPC} .

If PCA has the value 2, the sets of slots over which the TPC commands are processed shall remain aligned to the frame boundaries in the compressed frame. For both RPP mode 0 and RPP mode 1, if the transmission gap or the recovery period results in any incomplete sets of TPC commands, TPC_cmd shall be zero for those sets of slots which are incomplete.

5.1.2.4 Transmit power control in DPCCH power control preamble

A power control preamble may be used for initialisation of a DCH. Both the UL and DL DPCCHs shall be transmitted during the uplink power control preamble. The UL DPDCH shall not commence before the end of the power control preamble.

The length of the power control preamble is a UE-specific parameter signalled by the network, and can take the values 0 slots or 15 slots.

If the length of the power control preamble is greater than zero, the details of power control used during the power control preamble differ from the ordinary power control which is used afterwards. After the first slot of the power control preamble the change in uplink DPCCH transmit power shall initially be given by:

$$\Delta_{DPCCH} = \Delta_{TPC-init} \times TPC_cmd.$$

For PCA equal to 1 and 2, the value of $\Delta_{TPC-init}$ is set to Δ_{TPC} .

TPC_cmd is derived according to algorithm 1 as described in sub clause 5.1.2.2.1, regardless of the value of PCA.

Ordinary power control (see subclause 5.1.2.2), with the power control algorithm determined by the value of PCA and step size Δ_{TPC} , shall be used as soon as the sign of TPC_cmd reverses for the first time, or at the end of the power control preamble if the power control preamble ends first.

5.1.2.5 Setting of the uplink DPCCH/DPDCH power difference

5.1.2.5.1 General

The uplink DPCCH and DPDCH(s) are transmitted on different codes as defined in subclause 4.2.1 of TS 25.213. The gain factors β_c and β_d may vary for each TFC. There are two ways of controlling the gain factors of the DPCCH code and the DPDCH codes for different TFCs in normal (non-compressed) frames:

- \mathbf{b}_c and \mathbf{b}_d are signalled for the TFC, or
- \mathbf{b}_c and \mathbf{b}_d is computed for the TFC, based on the signalled settings for a reference TFC.

Combinations of the two above methods may be used to associate \mathbf{b}_c and \mathbf{b}_d values to all TFCs in the TFCS. The two methods are described in subclauses 5.1.2.5.2 and 5.1.2.5.3 respectively. Several reference TFCs may be signalled from higher layers.

The gain factors may vary on radio frame basis depending on the current TFC used. Further, the setting of gain factors is independent of the inner loop power control.

After applying the gain factors, the UE shall scale the total transmit power of the DPCCH and DPDCH(s), such that the DPCCH output power follows the changes required by the power control procedure with power adjustments of Δ_{DPCCH} dB, subject to the provisions of sub-clause 5.1.2.6, unless this would result in a UE transmit power above the maximum allowed power. In this case the UE shall scale the total transmit power so that it is equal to the maximum allowed power.

The gain factors during compressed frames are based on the nominal power relation defined in normal frames, as specified in subclause 5.1.2.5.4.

5.1.2.5.2 Signalled gain factors

When the gain factors \mathbf{b}_c and \mathbf{b}_d are signalled by higher layers for a certain TFC, the signalled values are used directly for weighting of DPCCH and DPDCH(s). The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\mathbf{b}_d}{\mathbf{b}_c}.$$

5.1.2.5.3 Computed gain factors

The gain factors \mathbf{b}_c and \mathbf{b}_d may also be computed for certain TFCs, based on the signalled settings for a reference TFC.

Let $\mathbf{b}_{c,ref}$ and $\mathbf{b}_{d,ref}$ denote the signalled gain factors for the reference TFC. Further, let $\mathbf{b}_{c,j}$ and $\mathbf{b}_{d,j}$ denote the gain factors used for the j :th TFC. Also let L_{ref} denote the number of DPDCHs used for the reference TFC and L_j denote the number of DPDCHs used for the j :th TFC.

Define the variable

$$K_{ref} = \sum_i RM_i \cdot N_i ;$$

where RM_i is the semi-static rate matching attribute for transport channel i (defined in TS 25.212 subclause 4.2.7), N_i is the number of bits output from the radio frame segmentation block for transport channel i (defined in TS 25.212 subclause 4.2.6.1), and the sum is taken over all the transport channels i in the reference TFC.

Similarly, define the variable

$$K_j = \sum_i RM_i \cdot N_i ;$$

where the sum is taken over all the transport channels i in the j :th TFC.

The variable A_j , called the nominal power relation is then computed as:

$$A_j = \frac{\mathbf{b}_{d,ref}}{\mathbf{b}_{c,ref}} \cdot \sqrt{\frac{L_{ref}}{L_j}} \sqrt{\frac{K_j}{K_{ref}}}$$

The gain factors for the j :th TFC are then computed as follows:

- If $A_j > 1$, then $\mathbf{b}_{d,j} = 1.0$ and $\mathbf{b}_{c,j}$ is the largest quantized \mathbf{b} -value, for which the condition $\mathbf{b}_{c,j} \leq 1 / A_j$ holds. Since $\mathbf{b}_{c,j}$ may not be set to zero, if the above rounding results in a zero value, $\mathbf{b}_{c,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in TS 25.213.
- If $A_j \leq 1$, then $\mathbf{b}_{d,j}$ is the smallest quantized \mathbf{b} -value, for which the condition $\mathbf{b}_{d,j} \geq A_j$ holds and $\mathbf{b}_{c,j} = 1.0$.

The quantized β -values are defined in TS 25.213 subclause 4.2.1, table 1.

5.1.2.5.4 Setting of the uplink DPCCH/DPDCH power difference in compressed mode

The gain factors used during a compressed frame for a certain TFC are calculated from the nominal power relation used in normal (non-compressed) frames for that TFC. Let A_j denote the nominal power relation for the j :th TFC in a normal frame. Further, let $\mathbf{b}_{c,C,j}$ and $\mathbf{b}_{d,C,j}$ denote the gain factors used for the j :th TFC when the frame is compressed. The variable $A_{C,j}$ is computed as:

$$A_{C,j} = A_j \cdot \sqrt{\frac{15 \cdot N_{pilot,C}}{N_{slots,C} \cdot N_{pilot,N}}}$$

where $N_{pilot,C}$ is the number of pilot bits per slot when in compressed mode, and $N_{pilot,N}$ is the number of pilot bits per slot in normal mode. $N_{slots,C}$ is the number of slots in the compressed frame used for transmitting the data.

The gain factors for the j :th TFC in a compressed frame are computed as follows:

- If $A_{C,j} > 1$, then $\mathbf{b}_{d,C,j} = 1.0$ and $\mathbf{b}_{c,C,j}$ is the largest quantized \mathbf{b} -value, for which the condition $\mathbf{b}_{c,C,j} \leq 1 / A_{C,j}$ holds. Since $\mathbf{b}_{c,C,j}$ may not be set to zero, if the above rounding results in a zero value, $\mathbf{b}_{c,C,j}$ shall be set to the lowest quantized amplitude ratio of 1/15 as specified in TS 25.213.
- If $A_{C,j} \leq 1$, then $\mathbf{b}_{d,C,j}$ is the smallest quantized \mathbf{b} -value, for which the condition $\mathbf{b}_{d,C,j} \geq A_{C,j}$ holds and $\mathbf{b}_{c,C,j} = 1.0$.

The quantized β -values are defined in TS 25.213 subclause 4.2.1, table 1.

5.1.2.6 Maximum and minimum power limits

In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would exceed the maximum allowed value, the UE shall apply additional scaling to the total transmit power so that it is equal to the maximum allowed power. This additional scaling shall be such that the power ratio between DPCCH and DPDCH remains as required by sub-clause 5.1.2.5.

When transmitting on a DPCH the UE is not required to be capable of reducing its total transmit power below the minimum level required in [7]. However, it may do so, provided that the power ratio between DPCCH and DPDCH remains as specified in sub clause 5.1.2.5. Some further regulations also apply as follows: In the case that the total UE transmit power (after applying DPCCH power adjustments and gain factors) would be at or below the total transmit power in the previously transmitted slot and also at or below the required minimum power specified in [7], the UE may apply additional scaling to the total transmit power, subject to the following restrictions:

- The total transmit power after applying any additional scaling shall not exceed the required minimum power, nor the total transmit power in the previously transmitted slot;
- The magnitude of any reduction in total transmit power between slots after applying any additional scaling shall not exceed the magnitude of the calculated power reduction before the additional scaling.

In the case that the total UE transmit power in the previously transmitted slot is at or below the required minimum power specified in [7] and the DPCCH power adjustment and gain factors for the current slot would result in an increase in total power, then no additional scaling shall be used (i.e. power control shall operate as normal).

If the UE applies any additional scaling to the total transmit power as described above, this scaling shall be included in the computation of any DPCCH power adjustments to be applied in the next transmitted slot.

5.1.3 PCPCH

5.1.3.1 General

The power control during the CPCH access procedure is described in clause 6.2. The inner loop power control for the PCPCH is described in the following sub-clauses.

5.1.3.2 Power control in the message part

The uplink transmit power control procedure simultaneously controls the power of a PCPCH control part and its corresponding PCPCH data part. The relative transmit power offset between the PCPCH control part and the PCPCH data part is determined by the network and is computed according to sub-clause 5.1.2.5 using the gain factors signalled to the UE using higher-layer signalling, with the difference that:

- b_c is the gain factor for the PCPCH control part (similar to DPCCH);
- b_d is the gain factor for the PCPCH data part (similar to DPDCH).

The gain factors are applied as shown in sub clause 4.2.3.2 of 25.213.

The operation of the inner power control loop adjusts the power of the PCPCH control part and PCPCH data part by the same amount, provided there are no changes in gain factors.

Any change in the uplink PCPCH control part transmit power shall take place immediately before the start of the pilot field on the control part of the message part. The change in PCPCH control part power with respect to its value in the previous slot is derived by the UE and is denoted by $\Delta_{\text{PCPCH-CP}}$ (in dB).

During the operation of the uplink power control procedure the UE transmit power shall not exceed a maximum allowed value which is the lower out of the maximum output power of the terminal power class and a value which may be set by higher layer signalling.

~~Uplink power control shall be performed while the UE transmit power is below the maximum allowed output power. If the UE transmit power is below the required minimum output power [as defined in TS 25.101] and the derived value of $\Delta_{\text{PCPCH-CP}}$ is less than zero, the UE may reduce the magnitude of $\Delta_{\text{PCPCH-CP}}$.~~

The provisions for power control at the maximum allowed value and below the required minimum output power (as defined in [7]) are described in sub-clause 5.1.2.6.

The uplink inner-loop power control adjusts the UE transmit power in order to keep the received uplink signal-to-interference ratio (SIR) at a given SIR target, $\text{SIR}_{\text{target}}$, which is set by the higher layer outer loop.

The network should estimate the signal-to-interference ratio SIR_{est} of the received PCPCH. The network should then generate TPC commands and transmit the commands once per slot according to the following rule: if $\text{SIR}_{\text{est}} > \text{SIR}_{\text{target}}$ then the TPC command to transmit is "0", while if $\text{SIR}_{\text{est}} < \text{SIR}_{\text{target}}$ then the TPC command to transmit is "1".

The UE derives a TPC command, TPC_{cmd} , for each slot. Two algorithms shall be supported by the UE for deriving a TPC_{cmd} . Which of these two algorithms is used is determined by a higher-layer parameter, "PowerControlAlgorithm", and is under the control of the UTRAN. If "PowerControlAlgorithm" indicates "algorithm1", then the layer 1 parameter PCA shall take the value 1 and if "PowerControlAlgorithm" indicates "algorithm2" then PCA shall take the value 2.

If PCA has the value 1, Algorithm 1, described in subclause 5.1.2.2.2, shall be used for processing TPC commands.

If PCA has the value 2, Algorithm 2, described in subclause 5.1.2.2.3, shall be used for processing TPC commands.

The step size Δ_{TPC} is a layer 1 parameter which is derived from the higher-layer parameter "TPC-StepSize" which is under the control of the UTRAN. If "TPC-StepSize" has the value "dB1", then the layer 1 parameter Δ_{TPC} shall take the value 1 dB and if "TPC-StepSize" has the value "dB2", then Δ_{TPC} shall take the value 2 dB.

After deriving the TPC command TPC_cmd using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink PCPCH control part with a step of $\Delta_{\text{PCPCH-CP}}$ (in dB) which is given by:

$$\Delta_{\text{PCPCH-CP}} = \Delta_{\text{TPC}} \times \text{TPC_cmd}$$