3GPP TSG RAN WG1

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Agenda item: **Ad hoc 9**

Source: **Philips**

Title: **Text proposal on power control**

Document for: **Decision**

Introduction

This text proposal for TS25.214 is based on [1]. The description of power control "Algorithm 2" as agreed at WG1 #6 has been elaborated following the further simulation results presented in [2].

The "General" section on ordinary transmit power control (5.1.2.2.1) now describes the changes in transmit power which are executed in response to the different possible values of "
commands by means of Algorithm 1 or Algorithm 2. TPC_cmd may now have the values 1, 0 or –1, although Algorithm 1 only uses the values 1 or –1.

For clarity, two subsections have been created for the descriptions of Algorithm 1 and Algorithm 2. The description of each algorithm is divided into 3, showing how the values of TPC_cmd are derived:

- when the UE is not in soft handover, and only one TPC command is received in each slot;
- when the UE is in soft handover and some received TPC commands are known to be the same (based on the previous section 5.1.2.2.2 in [1]);
- when the UE is in soft handover and some of the received TPC commands are not known to be the same (based on the previous section 5.1.2.2.3 in [1]).

This enables a clear definition of both algorithms when in soft handover and when not in soft handover.

The section on compressed mode power control has also been updated to define behaviour for each mode in the two cases of algorithm 1 or algorithm 2 being used.

References

[1] TSGR1#6(99)A69, TS25.214 v1.1.1

[2] TSGR1#7(99)abc *"Algorithm 2 Power Control in Normal Mode"*, Philips, August 1999

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5 Power control

5.1 Uplink power control

5.1.1 PRACH

< Editor's note: This clause describes open loop power control scheme for PRACH. To be confirmed appropriate S documents for open loop power control, and moved this description to the appropriate S document.>

- The transmitter power of UE shall be calculated by following equation:
  $P_{RACH} = L_{Perch} + I_{BTS} +$ Constant value

where,
P_{RACH}: transmitter power level in dBm,
L_{Pearch}: measured path loss in dB,
I_{BTS}: interference signal power level at BTS in dBm, which is broadcasted on BCH,
Constant value: This value shall be designated via Layer 3 message (operator matter).

5.1.2 DPCCH/DPDCH

5.1.2.1 General

The uplink transmit power control procedure controls simultaneously the power of a DPCCH and its corresponding DPDCHs. The power control loop adjusts the power of the DPCCH and DPDCHs with the same amount. The relative transmit power offset between DPCCH and DPDCHs is determined by the network and signalled to the UE using higher layer signalling.

5.1.2.2 Ordinary transmit power control

5.1.2.2.1 General

The initial uplink transmit power to use is decided using an open-loop power estimate, similar to the random access procedure. < *Editor's note: This needs to be elaborated, how is the estimate derived?* >

The maximum transmission power at the maximum rate of DPDCH is designated for uplink and control must be performed within this range. < *Editor's note: The necessity of this range needs to be confirmed.* > The maximum transmit power value of the closed-loop TPC is set by the network using higher layer signalling.

The uplink closed-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, SIR_{target}. An higher layer outer loop adjusts SIR_{target} independently for each cell in the active set.

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

~~If multiple TPC commands are received, then U~~Uupon reception of one or more~~these~~ TPC commands in a slot, the UE ~~combines the received commands into~~ derives 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 ~~The combination process~~deriving a TPC_cmd, as described in subclauses 5.1.2.2.2 and 5.1.2.2.3. Which of these two algorithms is used is a UE-specific parameter. ~~depends on whether the transmitted TPC commands are known to be the same or not. The combination process for each of these two cases is described in subclauses 5.1.2.2.2 and 5.1.2.2.3 respectively.~~

The step size Δ_{TPC} is a UE specific parameter that can have the values 1 dB or 2 dB.

Note : the maximum power control step to be support by the UE shall be 3 dB, 3 dB being allowed for the compressed mode. It is FFS whether the 3 dB should also be allowed in normal mode.

~~Two algorithms shall be supported by the UE and are described in the following sections :~~

~~5.1.2.2.1.1 Algorithm 1~~

After ~~calculation of~~deriving the combined TPC command TPC_cmd using one of the two supported algorithms, the UE shall adjust the transmit power of the uplink dedicated physical channels with a step of Δ_{TPC} dB according to the TPC command. If TPC_cmd equals 1 then the transmit power of the uplink DPCCH and uplink DPDCHs shall be increased by Δ_{TPC} dB. If TPC_cmd equals ~~0~~ -1 then the transmit power of the uplink DPCCH and uplink DPDCHs shall be decreased by Δ_{TPC} dB. If TPC_cmd equals 0 then the transmit power of the uplink DPCCH and uplink DPDCHs shall be unchanged.

~~The~~ Any power increase or decrease shall take place immediately before the start of the pilot field on the DPCCH.

~~5.1.2.2.1.2 Algorithm 2~~

~~After calculation on a slot basis of the combined TPC command (TPC_cmd) for N consecutive slots, the UE will determine a global command. The set of N concatenated commands do not overlap (no running concatenation), and the sets are aligned to the frame boundary. This global command will result in an increase or decrease of the transmit power of the uplink dedicated physical channels with a step of Δ_{TPC} dB or no change of the transmit power.~~

~~The exact computation of the global command to calculate every N slots was agreed as a working assumption. Characteristics of this algorithms are as follows :~~

~~- N=3 or N=5~~

~~- Hard decision on the N commands is performed~~

~~- A power increase or decrease is applied if the N commands are identical~~

~~*Editor's note : The deadline for the number of concatenated commands and other details is WG1#7, in absence of input at WG1#7 the above described algorithm with N=3 will become the agreement. A more detailed text proposal needs to be done, and the behaviour in compressed mode as well as soft handover with TPC combining needs to be elaborated.*~~ ~~>~~

~~NOTE : The algorithm 2 allows to emulate smaller step sizes than the minimum power control step as specified above.~~

~~The power increase or decrease shall take place immediately before the start of the pilot field on the DPCCH.~~

5.1.2.2.1.1~~3~~ Out of synchronisation handling

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 is 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 known to be the same

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 e.g. with receiver diversity or so called softer handover when the UTRAN transmits the same command in all the serving cells the UE is in softer handover with. For these cases, the TPC commands known to be the same are combined into one TPC command, to be further combined with other TPC commands as described in subclause 5.1.2.2.2.3~~3~~.

5.1.2.2.2.3 Combining of TPC commands not known to be the same

In general in case of soft handover, the TPC commands transmitted in the same slot in the different cells may be different.

This subclause describes the general scheme for combination of the TPC commands not known to be ~~different~~ the same and then provides an example of such scheme. It is to be further decided what should be subject to detailed standardisation, depending on final requirements. The example might be considered as the scheme from which minimum requirement will be derived or may become the mandatory algorithm.

5.1.2.2.2.3.1 General scheme

First, the UE shall estimate the signal-to-interference ratio PC_SIR_i on each of the power control commands TPC_i, where i = 1, 2, …, N and N is the number of TPC commands not known to be differentthe same, that may be the results of a first phase of combination according to subclause 5.1.2.2.32.2.

Then the UE assigns to each of the TPC_i command a reliability figure W_i, where W_i is a function β of PC_SIR_i, $W_i = \beta(PC\_SIR_i)$. Finally, the UE derives a combined TPC command, TPC_cmd, as a function γ of all the N power control commands TPC_i and reliability estimates W_i:

$TPC\_cmd = \gamma (W_1, W_2, \ldots W_N, TPC_1, TPC_2, \ldots, TPC_N)$, where TPC_cmd can take the values 0 1 or -1.

5.1.2.2.2.3.2 Example of the scheme

A particular example of the scheme is obtained when using the following definition of the functions β and γ:

For β: the reliability figure W_i is set to 0 if $PC\_SIR_i < PC\_thr$, otherwise W_i is set to 1. This means that the power control command is assumed unreliable if the signal-to-interference ratio of the TPC commands is lower than a minimum value PC_thr.

For γ: if there is at least one TPC_i command, for which $W_i = 1$ and $TPC_i = 0$, or if $W_i = 0$ and $TPC_i = 0$ for all N TPC_i commands, then TPC_cmd is set to 0-1, otherwise TPC_cmd is set to 1. Such a function γ means that the power is decreased if at least one cell for which the reliability criterion is satisfied asks for a power decrease.

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 section 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 is 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 5^{th} slot.
  - If all 5 hard decisions within a set are 0 then TPC_cmd = -1 in the 5^{th} slot.
  - Otherwise, TPC_cmd = 0 in the 5^{th} slot.

5.1.2.2.3.2 Combining of TPC commands known to be the same

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 e.g. with receiver diversity or so called softer handover when the UTRAN transmits the same command in all the serving cells the UE is in softer handover with. For these cases, the TPC commands known to be the same are 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 not known to be the same

In general in case of soft handover, the TPC commands transmitted in the same slot in the different cells may be different.

This subclause describes the general scheme for combination of the TPC commands not known to be the same and then provides an example of such scheme. It is to be further decided what should be subject to detailed standardisation, depending on final requirements. The example might be considered as the scheme from which minimum requirement will be derived or may become the mandatory algorithm.

5.1.2.2.3.3.1 General scheme

First, the UE shall estimate the signal-to-interference ratio PC_SIR_i on each of the power control commands TPC_i, where i = 1, 2, …, N and N is the number of TPC commands not known to be the same, that may be the result of a first phase of combination according to subclause 5.1.2.2.3.2. The UE shall also make a hard decision on the value of each TPC_i.

The UE shall follow this procedure for 5 consecutive slots, resulting in N signal-to-interference ratio estimations for each of the five slots and N hard decisions for each of the 5 slots.

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 is zero for the first 4 slots.

After 5 slots have elapsed, the UE shall calculate the mean SIR, $PC\_SIR\_av_i$, for each of the N sets of 5 TPC commands, so that $PC\_SIR\_av_i = [(PC\_SIR_i)_{slot1} + (PC\_SIR_i)_{slot2} + (PC\_SIR_i)_{slot3} + (PC\_SIR_i)_{slot4} + (PC\_SIR_i)_{slot5}]/5$. The UE shall then determine the value of TPC_cmd for the fifth slot in the following way:

The UE first determines one temporary TPC command, TPC_temp_i, for each of the N sets of 5 TPC commands as follows:

- If all 5 hard decisions within a set are "1", $TPC\_temp_i = 1$
- If all 5 hard decisions within a set are "0", $TPC\_temp_i = -1$
- Otherwise, $TPC\_temp_i = 0$

Then the UE assigns to each of the TPC_temp_i commands a reliability figure W_i, where W_i is a function β of $PC\_SIR\_av_i$, $W_i = \beta(PC\_SIR\_av_i)$. Finally, the UE derives a combined TPC command for the fifth slot, TPC_cmd, as a function γ of all the N temp power control commands TPC_temp_i and reliability estimates W_i:

$TPC\_cmd(5^{th}\ slot) = \gamma(W_1, W_2, \ldots W_N, TPC\_temp_1, TPC\_temp_2, \ldots, TPC\_temp_N)$, where $TPC\_cmd(5^{th}$ slot) can take the values 1, 0 or –1.

5.1.2.2.3.3.2 Example of the scheme

A particular example of the scheme is obtained when using the following definition of the functions β and γ:

For β: The reliability figure W_i is set to 0 if $PC\_SIR\_av_i < PC\_thr$, otherwise W_i is set to 1. This means that the power control command is assumed unreliable if the average signal-to-interference ratio of the 5 TPC commands is lower than a minimum value PC_thr.

For γ: If there is at least one TPC_temp_i command for which $W_i = 1$ and $TPC\_temp_i = -1$, or if $W_i = 0$ and $TPC\_temp_i = -1$ for all N TPC_temp_i commands, then TPC_cmd is set to –1. Otherwise, if there is at least one TPC_temp_i command for which $W_i = 1$ and $TPC\_temp_i = 0$, or if $W_i = 0$ and $TPC\_temp_i = 0$ for all N TPC_temp_i commands, then TPC_cmd is set to 0. Otherwise TPC_cmd is set to 1.

5.1.2.3 Transmit power control in compressed mode

< Note: The following is a working assumption of WG1. >

The aim of uplink power control in downlink or/and uplink compressed mode is to recover as fast as possible a signal-to-interference ratio (SIR) close to the target SIR after each transmission gap.

In downlink compressed mode, no power control is applied during transmission gaps, since no downlink TPC command is sent. Thus, the transmit powers of the uplink DPDCH(s) and DPCCH are not changed during the transmission gaps.

In simultaneous downlink and uplink compressed mode, the transmission of uplink DPDCH(s) and DPCCH is stopped during transmission gaps. *<Note: the initial transmit power of each uplink DPDCH or DPCCH after the transmission gap is FFS. >*.

After each transmission gap, 2 modes are possible for the power control algorithm. The power control mode (PCM) is fixed and signalled with the other parameters of the downlink compressed mode (see TS 25.231). The different modes are summarised in the table 1:

Table 1. Power control modes during compressed mode.

Mode	**Description**
0	Ordinary transmit power control is applied with step size Δ_{TPC}
1	If algorithm 1 is being used, Oordinary transmit power control is applied with step size Δ_{RP-TPC} during one or more slots after each transmission gap. If algorithm 2 is being used, algorithm 1 is applied with step size 1dB during one or more slots after each transmission gap.

~~<Note: The exact power control algorithm in compressed mode when concatenation of TPC commands are used in normal mode is still FFS. The current description only applies when no concatenation is done in normal mode. >~~

For mode 0, the step size is not changed and the ordinary transmit power control is still applied during compressed mode (see subclause 5.1.2.2), using the same algorithm for processing TPC commands as in normal mode (see sections 5.1.2.2.2 and 5.1.2.2.3).

If algorithm 2 (section 5.1.2.2.3) is being used, the sets of 5 slots shall remain aligned to the frame boundaries in the compressed frame. If the transmission gap results in a set of five slots not containing 5 TPC_i commands, no TPC_temp_i command will be determined for that set of slots, and there will be no change in transmit power level for that set of slots.

For mode 1, if algorithm 1 (section 5.1.2.2.2) is being used, then during one or more slots after each transmission gap, called the recovery period, the ~~ordinary~~ same power control algorithm is applied but with a step size Δ_{RP-TPC} instead of Δ_{TPC}, where Δ_{RP-TPC} is called recovery power control step size and is expressed in dB. The step size Δ_{RP-TPC} is equal to the minimum value of 3 dB and $2\Delta_{TPC}$. If algorithm 2 (see section 5.1.2.2.3) is being used , then during one or more slots after each transmission gap, called the recovery period, algorithm 1 (section 5.1.2.2.2) is applied with a step size of 1dB.

After the recovery period the ordinary transmit power control ~~algorithm~~ with step Δ_{TPC} is performed.

The recovery period length (RL) determination is still FSS and is to be chosen between the two following possibilities:

- The recovery period length is fixed and derived as a function of the Transmission mode parameters mostly the transmission gap period and possibly the spreading factor.
- The recovery period length is adapted and ends when the current and previous received power control commands are opposite or after TGL slots after the transmission gap.