

Agenda item:

Source: Philips
Title: Corrections to power control
Document for: Decision

Introduction

The attached CR corrects some minor errors and inconsistencies which have come to light in the power control sections of TS25.214:

1. The current definition of the recovery period length can be ambiguous owing to the fact that the power changes due to inner loop power control occur at the slot boundaries.

A clarification is proposed to make it clear that the recovery period power control mode affects the power changes at the start of each of RPL slots after the first slot after a transmission gap.

2. Some clarification was requested on the email reflector regarding the setting of uplink TPC commands during periods of downlink out-of-sync.

Section 5.2.1.2.1 states that the UE shall set the UL TPC commands to “1” during periods of downlink out-of-sync, whereas section 5.1.2.2.1.1 states that the UE shall shut its transmitter off during periods of out-of-sync. The potential ambiguity may arise from a need for some clarification of the meaning of “out-of-synchronisation” in section 5.2.1.2.1.

In fact, there may be occasions when the UE is unable to generate UL TPC commands owing to short-term inability to decode the DL; however, if these periods are short, they may not result in the official state of “downlink out-of-synchronisation”.

The attached CR therefore proposes to clarify the setting of UL TPC commands in section 5.2.1.2.1 to avoid explicit mention of a state of “downlink out-of-synchronisation”.

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	$\Delta_{\text{RESUME}} = d_{\text{last}}$

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:

$$d_i = 0.9375d_{i-1} - 0.96875\text{TPC_cmd}_i\Delta_{\text{TPC}}$$

$$d_{i-1} = d_i$$

TPC_cmd_i is the power control command derived by the UE in that slot.

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 $\Delta_{\text{RP-TPC}}$ 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 $\Delta_{\text{RP-TPC}}$ instead of Δ_{TPC} , regardless of the value of PCA. The change in uplink DPCCH transmit power at the start of each of the first RPL slots (except for after the first slot after the transmission gap) is given by:

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

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

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

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

5.2 Downlink power control

The transmit power of the downlink channels is determined by the network. In general the ratio of the transmit power between different downlink channels is not specified and may change with time. However, regulations exist as described in the following subclauses.

Higher layer power settings shall be interpreted as setting of the total power, i.e. the sum of the power from the two antennas in case of transmit diversity.

5.2.1 DPCCH/DPDCH

5.2.1.1 General

The downlink 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, i.e. the relative power difference between the DPCCH and DPDCHs is not changed.

The relative transmit power offset between DPCCH fields and DPDCHs is determined by the network. The TFCI, TPC and pilot fields of the DPCCH are offset relative to the DPDCHs power by PO1, PO2 and PO3 dB respectively. The power offsets may vary in time.

The power of CCC field in DL DPCCH for CPCH is the same as the power of the pilot field.

5.2.1.2 Ordinary transmit power control

5.2.1.2.1 UE behaviour

The UE shall generate TPC commands to control the network transmit power and send them in the TPC field of the uplink DPCCH. An example on how to derive the TPC commands is given in Annex B.2.

The UE shall check the downlink power control mode (DPC_MODE) before generating the TPC command:

- if DPC_MODE = 0 : the UE sends a unique TPC command in each slot and the TPC command generated is transmitted in the first available TPC field in the uplink DPCCH;
- if DPC_MODE = 1 : the UE repeats the same TPC command over 3 slots and the new TPC command is transmitted such that there is a new command at the beginning of the frame.

The DPC_MODE parameter is a UE specific parameter controlled by the UTRAN.

The UE shall not make any assumptions on how the downlink power is set by UTRAN, in order to not prohibit usage of other UTRAN power control algorithms than what is defined in subclause 5.2.1.2.2.

~~In any slot ~~When a~~ TPC commands cannot be generated in the UE ~~due to downlink out of synchronisation~~, the TPC command transmitted shall be set as "1" ~~during the period of out of synchronisation~~.~~

5.2.1.2.2 UTRAN behaviour

Upon receiving the TPC commands UTRAN shall adjust its downlink DPCCH/DPDCH power accordingly. For DPC_MODE = 0, UTRAN shall estimate the transmitted TPC command TPC_{est} to be 0 or 1, and shall update the power every slot. If DPC_MODE = 1, UTRAN shall estimate the transmitted TPC command TPC_{est} over three slots to be 0 or 1, and shall update the power every three slots.

After estimating the k :th TPC command, UTRAN shall adjust the current downlink power $P(k-1)$ [dB] to a new power $P(k)$ [dB] according to the following formula:

$$P(k) = P(k - 1) + P_{TPC}(k) + P_{bal}(k),$$

where $P_{TPC}(k)$ is the k :th power adjustment due to the inner loop power control, and $P_{bal}(k)$ [dB] is a correction according to the downlink power control procedure for balancing radio link powers towards a common reference power.