TSG-RAN Working Group 1 meeting #15
Berlin, Germany

TSGR1-00-1056

August 22nd – 25th, 2000

Agenda Item: Ad Hoc 99

Source: **Siemens AG**

Title: **Clarification of power control at maximum and minimum power**

Document for: **Discussion and Approval**

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1. Introduction

At the last meeting in Oulu Philips presented a CR [1] clarifying the power control issue at maximum and minimum power limits. Thus chapter 5.1.2.6 was introduced. Nevertheless a UE operating at the power boundaries still encounters some problems particular in the case of changing data rates. Especially the power adjustment due to rearranged gain factors raise temporary inconvenient power attitudes, which disturb either the UE's uplink or the uplink channels of all other users camping in this cell.

Chapter 2 depicts the current problem at the power limits assisted by a case study. Chapter 3 introduces an enhanced method avoiding the current troubles. Therefore P^{trace} is introduced.

2. Current power control at power limits

Chapter 5.1.2.6 of [1] prescribes that the total transmit power (after applying DPCCH power adjustment and gain factors) shall not exceed the maximum allowed value fixed in [2]. Thus the UE is supposed to apply an additional scaling.
In the following case we consider a UE at the cell borders far away from the Node B transmitting with 1 dB below the maximum power limit. At the beginning the considered DPCH consists of a 30 kbits/sec link.

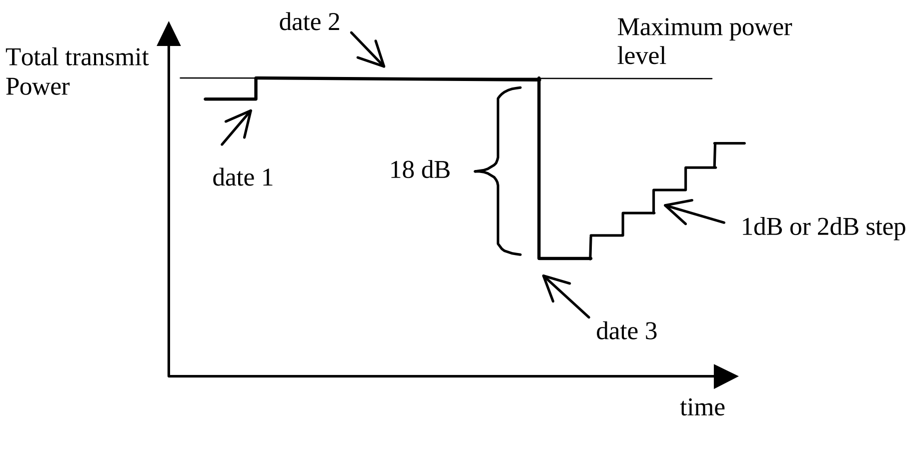

Figure 1: *Power behaviour scenario at the maximum*

If a higher data rate, for example 495 kbits/sec is requested, the total transmit power will increase (date 1), but also be scaled to the maximum allowed transmit power. If additionally a further data rate increase to 975 kbit/sec is required, the total transmit power will remain unchanged because of the performed scaling (date 2). If the high data rate is released again (date 3), i. e. for example a total data rate of 30 kbits/sec, and the UE has not moved remarkably, the channel and power condition should prevail unchanged. But as depicted in figure 1 the power adjustment due to gain factor readjustment is switched according to the current proposal [1] to a power level, which is 17 dB below the expected right attitude.

At the minimum power level the same problem occurs, even in the same way, when the UE does not admit the reduction of its transmit power below the minimum power level (see figure 2). Looking at a UE residing immediately next to or in the closer area of the base station, having additional a line of sight connection, the total transmit power could be very low, for example only a few dBm above the minimum power level, even there is a high data rate DPCH connection, e. g. about 975 kbits/sec. In the case of changing data rates it could be the case, that the existing DPCH will be decreased to about 495 kbits/sec (date 1) followed by a second decrease to 30 kbit/sec (date2). In that case the mobile is not forced to be able to reduce the transmit power below the minimum power level. That means the UE conveys the remaining DPCH with too much power. If the UE shall increase the total date rate to 975 kbits/sec again (date 3), the power adjustment due to gain factor readjustment would increase the power in the conventional way i. e. adding the power amount to the previously transmitted power. Like demonstrated in figure 2 the result of the power readjustment would be 17 dB over the expected power level (assuming that the UE has not moved to far in the meantime).

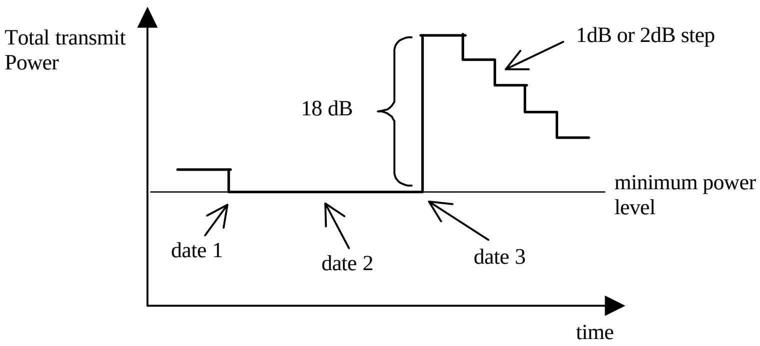

Figure 2: *Power behaviour scenario at the minimum power level*

This disturbed power control is exactly the same result as described for a UE operating at the maximum power level. But the impacts are really different. In figure 1 the UE would send with too low power and so the UE's uplink could be disturbed for a while. But the impacts caused by the example of figure 2 are devastating, since during the UE transmitting with too much power all uplink channels of the entire cell would be disturbed.

3. Improved Power Control at power limits

Neglecting the power commands and gain factor readjustments, which leads to an overstep of the power limits, provokes the described problems. Thus we propose to consider and evaluate these neglected power adjustments for further transmit power attitudes.

We propose to introduce P^{trace} (refer to CR), which traces each first requested exceeding of the maximum power limit and also traces power adjustments due to gain factor readjustments while the UE is transmitting at the maximum power level and TPC_cmd is equal to 1. In the minimum power level case P^{trace} traces each first requested falling below the minimum power limit and also traces power adjustments due to gain factor readjustments while the UE is transmitting at minimum power level and TPC_cmd is equal to –1.
Figure 3 and figure 4 present the improvement in comparison to figure 1 and 2.

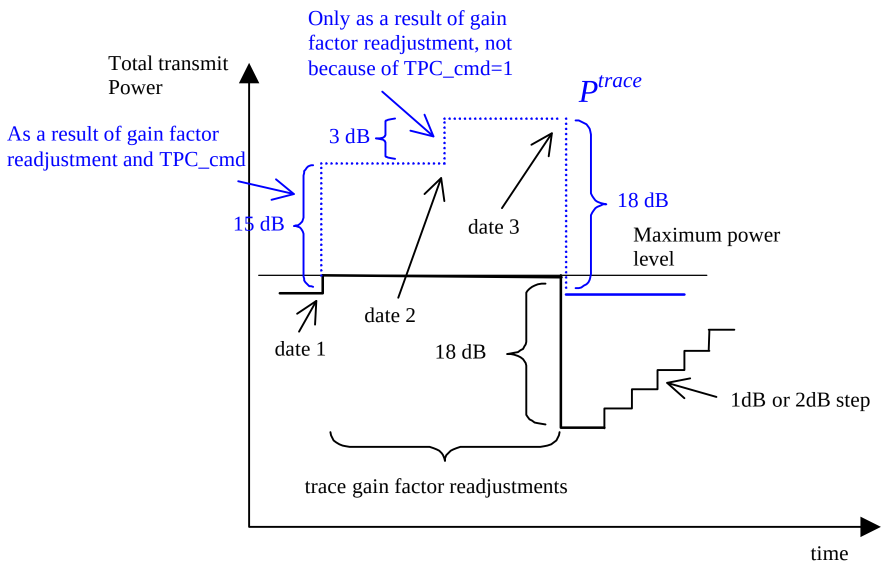

Figure 3: *Improved power behaviour scenario at the maximum power level*

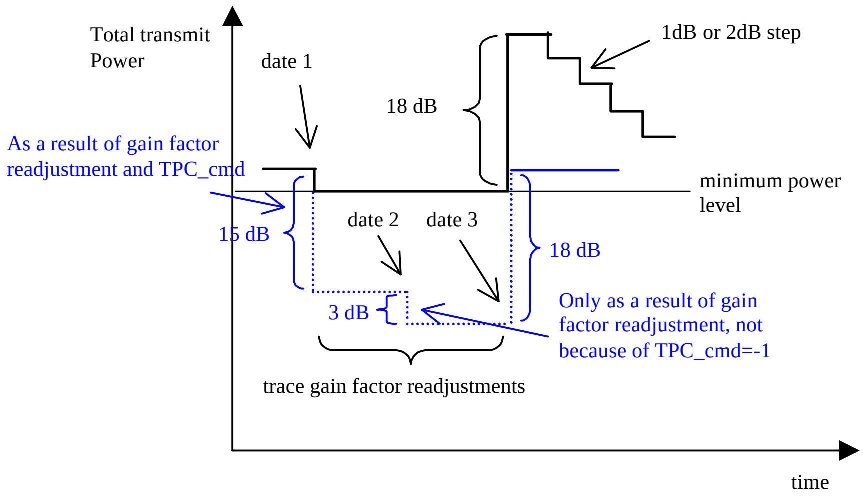

Figure 4: *Improved power behaviour scenario at the minimum power level*

The blue coloured endorsements depict the proposed enhanced method at the power limits. P^{trace} recognizes and saves the first passing over of the power limit (date 1) and also traces power adjustments due to gain factor readjustments (date 2). After leaving the power limits the power attitude is more reliable because of tracing the power adjustments during the UE transmitting with maximum power and minimum power, respectively.

4. Conclusions

The introduction of P^{trace} improves the power control behaviour at the power limits and avoids a possible disturbance of the UE's uplink and of all other UEs residing in this cell.

5. References

[1] TSGR1#14(00)0973; Oulu, Finland;7-2000; Philips; CR 25.214-118r2: Clarification of power control at maximum and minimum power

[2] TS 25.101 V3.3.1: "UE Radio transmission and Reception (FDD)"

3GPP TSG RAN WG1 Meeting #15
Berlin, Germany, 22-25 August 2000

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e.g. for 3GPP use the format TP-99xxx
or for SMG, use the format P-99-xxx

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**	**126**	Current Version:	3.3.0

GSM (AA.BB) or 3G (AA.BBB) specification number ↑ *↑ CR number as allocated by MCC support team*

For submission to:	RAN #9	for approval	X	strategic		(for SMG use only)
list expected approval meeting # here ↑		for information		non-strategic		

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

Source: Siemens AG **Date:** 2000-08-16

Subject: Clarification of power control at maximum and minimum power

Work item:

Category:				**Release:**	
	F	Correction	X	Phase 2	
	A	Corresponds to a correction in an earlier release		Release 96	
(only one category	B	Addition of feature		Release 97	
shall be marked	C	Functional modification of feature		Release 98	
with an X)	D	Editorial modification		Release 99	X
				Release 00	

Reason for change: At the last meeting Philips inserted chapter 5.1.2.6, which intends to clarify the power control at maximum and minimum power. Some extension are introduced in order to improve the power control behaviour at the power limits.

Clauses affected:

Other specs affected:			
	Other 3G core specifications		→ List of CRs:
	Other GSM core specifications		→ List of CRs:
	MS test specifications		→ List of CRs:
	BSS test specifications		→ List of CRs:
	O&M specifications		→ List of CRs:

Other comments: This CR supersedes the changes in section 5.1.2.6 performed by CR 118r2 (Tdoc 000973).

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

- If $A_j \le 1$, then $b_{d,j}$ is the smallest quantized b -value, for which the condition $b_{d,j} \ge A_j$ holds and $b_{c,j} = 1.0$.

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

If $A_{C,j} \le 1$, then $b_{d,C,j}$ is the smallest quantized b -value, for which the condition $b_{d,C,j} \ge A_{C,j}$ holds and $b_{c,C,j} = 1.0$.

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 the executed total transmit power 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.

P^{trace} traces each first exceeding of the maximum power limit and also traces power adjustments due to gain factor readjustments while the UE is transmitting at the maximum power level and TPC_cmd is equal to 1. If the total transmit power operates below the maximum allowed value, then P^{trace} is equal to the total UE transmit power.

If the total UE transmit power in the previously transmitted slot is at the maximum power and the current TPC_cmd is equal to 1 and the total power shall be reduced due to gain factor readjustments, then the total UE transmit power value should be computed on relation to P^{trace} of the previously transmitted slot and not on relation to the total UE transmit power in the previously transmitted slot, whereas also scaling will be applied if necessary.

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).

In case that the UE allows the total UE transmit power being below the minimum level, then P^{trace} is always equal to the total UE transmit power. If the UE is not capable of reducing its total transmit power below the minimum level required in [7], P^{trace} traces each first falling below the minimum power limit and also traces power adjustments due to gain factor readjustments while the UE is transmitting at the minimum power level and TPC_cmd is equal to -1.

If the total UE transmit power in the previously transmitted slot is at the minimum power level and the current TPC_cmd is equal to -1 and the total power shall be increased due to gain factor readjustments, then the total UE transmit power value should be computed on relation to P^{trace} of the previously transmitted slot and not on relation to the total UE transmit power in the previously transmitted slot, whereas also scaling will be applied if necessary.

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 $\Delta_{PCPCH-CP}$ (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 $\Delta_{PCPCH-CP}$ is less than zero, the UE may reduce the magnitude of $\Delta_{PCPCH-CP}$.

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, SIR_{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 $SIR_{est} > SIR_{target}$ then the TPC command to transmit is "0", while if $SIR_{est} < SIR_{target}$ then the TPC command to transmit is "1".

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 $\Delta_{PCPCH-CP}$ (in dB) which is given by:

$$\Delta_{PCPCH-CP} = \Delta_{TPC} \times TPC\_cmd$$

5.1.3.3 Power control in the power control preamble

A power control preamble may be used for initialisation of a PCPCH. Both the UL PCPCH control part and associated DL DPCCH shall be transmitted during the uplink power control preamble. The uplink PCPCH data part shall not commence before the end of the power control preamble.

The length of the power control preamble is a higher layer parameter, $L_{pc-preamble}$ (see section 6.2), and can take the value 0 slots or 8 slots.

If $L_{pc-preamble} > 0$, 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 PCPCH control part transmit power shall initially be given by:

$$\Delta_{PCPCH-CP} = \Delta_{TPC-init} \times TPC\_cmd$$

If the value of PCA is 1 then $\Delta_{TPC-init}$ is equal to the minimum value out of 3 dB and $2\Delta_{TPC}$.

If the value of PCA is 2 then $\Delta_{TPC-init}$ is equal to 2dB.

TPC_cmd is derived according to algorithm 1 as described in sub clause 5.1.2.2.2, regardless of the value of PCA.

Power control as defined for the message part (see sub-clause 5.1.3.2), with the power control algorithm determined by the value of PCA and step size $\Delta_{TPC,}$ 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.