3GPP TSG RAN WG1 ***TSGR1#7(99)e74***
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Title: **Proposal for initial transmit power level after transmission gap in compressed mode**

Document for: **Discussion**

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1 Introduction

In downlink compressed mode, no TPC commands are transmitted during the transmission gap in the compressed frame. This means that the transmit powers of the uplink DPDCH(s) and DPCCH are not changed during the transmission gaps.

After a transmission gap, it is desirable that the closed loop power control converges on the SIR target as quickly as possible.

The current working assumption (as in [1]) allows for two alternative modes of responding to TPC commands to be employed. The mode to be used is signalled by the network along with the other downlink compressed mode parameters. The choice of a suitable mode enables the best power control step size to be used for a few slots after each transmission gap to bring about rapid convergence.

However, the intial uplink transmit power after a transmission gap has not yet been specified.

In [2] it was proposed that the network should be able to signal as a separate parameter to the UE the **initial transmit power level**, P_{resume}, which should be used in the first slot after the transmission gaps. It was proposed that P_{resume} should take one of two values:

1. P_{resume} = Transmit power at start of transmission gap

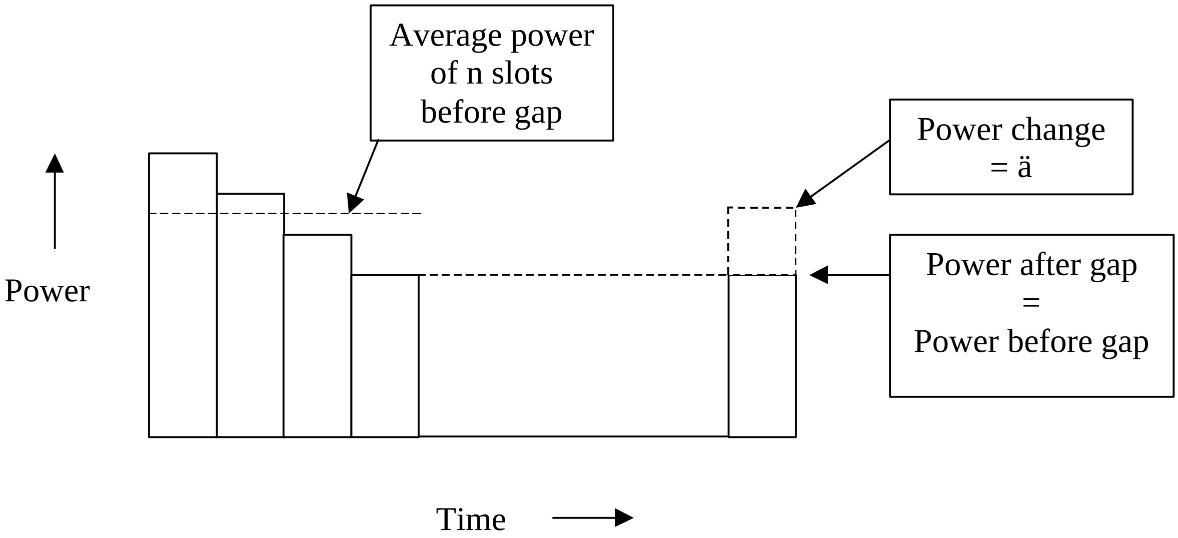
2. P_{resume} = Average transmit power over the 32 slots preceding the transmission gap. (In these simulations we use 16 slots per frame.) In calculating the average, the power of the slots in the compressed frame is weighted in inverse proportion to the power offset in the compressed frame.

In this way the value of P_{resume} could be signalled with just one bit along with the other compressed mode parameters. Simulation results were presented which demonstrated that recommencing transmission using the average power level can result in significant improvements in both Eb/No and SIR variance.

In this paper we present a method for calculating an approximation to the average power based on the received TPC commands. We also present simulation results which show that this method can give similar improvements to the use of the actual average power.

2 Calculation of Average Power

If the UL transmit power after a transmission gap is to be (approximately) equal to the average transmit power over a number of slots prior to the transmission gap, a change in power of will be required with respect to the transmit power in the last slot before the transmission gap. This is shown in Figure 1.



The estimate of the value of the power change which would be required after a transmission gap, can be computed on a slot-by-slot basis until the beginning of a transmission gap.

The following formula enables to be updated recursively from the DL TPC commands alone forming an approximately exponentially weighted average, without requiring any power measurements:

$$d_t = k_1 d_{t-1} - k_2 (TPC\_cmd)_t \Delta_{TPC}$$ **Equation (1)**

where $_t$ is the value of calculated at time t; i.e. the power change which would be required at the end of a transmission gap which begins at the end of the current slot.
$_{t-1}$ is the previous value of which was calculated in the previous slot. (This could be initialised to zero.)
TPC_cmd is the TPC command received in the current slot.
$_{TPC}$ is the power control step size (in dB).
k_1 and k_2 are constants which represent the length of the effective averaging period. These constants can be defined as follows:

$$k_1 = 0, \quad n = 1$$
$$k_1 = \frac{n-2}{n}, \quad n > 1$$

and $k_2 = \frac{n-1}{n}, \quad n \geq 1$ where *n* is the number of slots over which the averaging is approximated. These values of k_1 and k_2 cause the approximated average to converge to the actual average when a series of identical TPC commands are transmitted. For consistency, we restrict n to be a positive integer.

We propose that the 2 possibilities for the value of P_{resume} are signalled by allowing *n* to take one of two values, n = 1 or n = 32.

The value n=1 will result in the transmit power after the transmission gap being equal to the transmission power in the last slot before the transmission gap.

The value n=32 will result in the transmit power after the transmission gap being approximately equal to the average transmit power of the 32 slots prior to the transmission gap.

If the value n=32 is used, it is expected that the result of equation (1) would be quantised to the nearest 1dB for ease of implementation, and for consistency with the smallest mandatory step size.

This iterative method for calculating   avoids the need to store large numbers of past TPC commands in the UE.

3 Simulation Conditions

The basic simulation conditions were as follows:

2GHz carrier frequency
Pedestrian A channel
1 slot power control loop delay
AWGN TPC error: 4% in normal mode; 7% in recovery period
SIR estimation error based on uplink SIR, using 6 pilot bits
No control channel overhead in Eb/No
Perfect Rake receiver
Ideal channel estimation
16 slots per frame
Transmission gap length 8 slots
Recovery period length 8 slots
Transmission gap positioned at end of compressed frame
Physical channel rate 32kbps
AWGN interference
Approx. 4dB coding gain from $^1/_3$-rate K=9 convolutional coder
Target BER after decoding = 10^{-3} (BER before decoding = 0.13)

The power control step sizes and compressed mode power control modes used for different UE speeds are shown in the table of results.

According to the current working assumption, compressed mode power control mode 0 entails using the same power control mechanism as in normal mode during the recovery period after a transmission gap.

Compressed mode power control mode 1 entails using a larger step size than in normal mode for a certain number of slots after a transmission gap.

Compressed mode power control mode 1 was used for speeds up to 50km/h as this is the range of speeds over which this mode has been shown to be beneficial (e.g. in [3] and [4]). For this mode, a fixed recovery period length of 8 slots was used. Compressed mode power control mode 0 was used for higher speeds.

4 Simulation Results

The following table of simulation results relates to the period of 8 slots immediately following each transmission gap.

The required values of received E_b/N_0, transmitted E_b/N_0 and SIR variance are shown for a target BER of 10^{-3} after channel coding.

UE speed / km/h	P(resume)	Normal mode step size / dB	Recovery period power control mode	Rx'ed Eb/No / dB	Tx'ed Eb/No / dB	SIR variance / dB^2
3	Norm	1	1	3.7	7.4	7.0
	Delta	1	1	3.8	7.1	7.7
10	Norm	1	1	4.2	6.9	10.9
	Delta	1	1	4.2	6.5	11.5
20	Norm	1	1	4.6	6.7	14.1
	Delta	1	1	4.4	6.4	12.7
40	Norm	2	1	5.5	7.5	20.2
	Delta	2	1	5.2	7.2	18.1
60	Norm	2	0	5.4	6.7	19.5
	Delta	2	0	5.0	6.3	17.1
100	Norm	1	0	5.1	5.7	18.0
	Delta	1	0	4.8	5.4	16.4
300	Norm	1	0	5.1	5.5	19.5
	Delta	1	0	5.0	5.4	18.4

Figure 1: Comparison of performance in recovery period using normal and average transmit power levels after transmission gaps

Note: P_{resume} = “Norm” implies that the initial transmit power in the first slot after a transmission gap is equal to the transmit power in the last slot before the transmission gap.

P_{resume} = “Delta” implies that the initial transmit power in the first slot after a transmission gap is equal to the approximate weighted average transmit power over the 32 slots immediately preceding the transmission gap, calculated according to equation (1) and quantised to the nearest 1dB.

It can be seen that the required E_b/N_0 and the SIR variance can be significantly improved over a range of UE speeds by recommencing transmission using the approximated average power level instead of the power level used before the transmission gap.

The benefits are summarised in the following graphs:

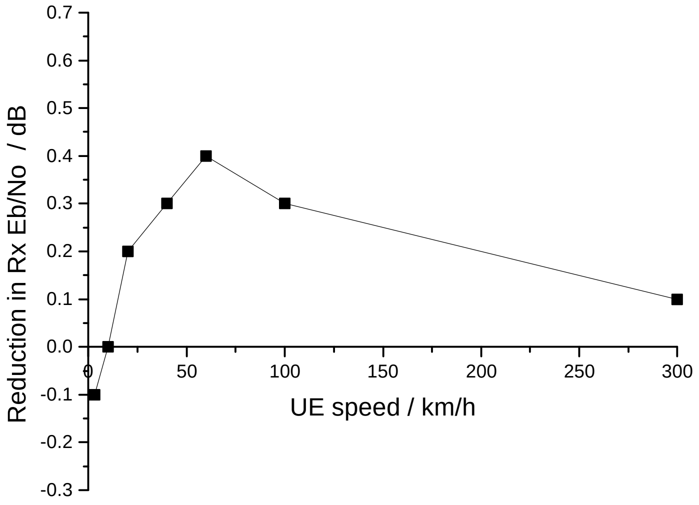


Figure 2:Improvement in recovery period Eb/No given by using average power after transmission gaps, calculated using equation (1).

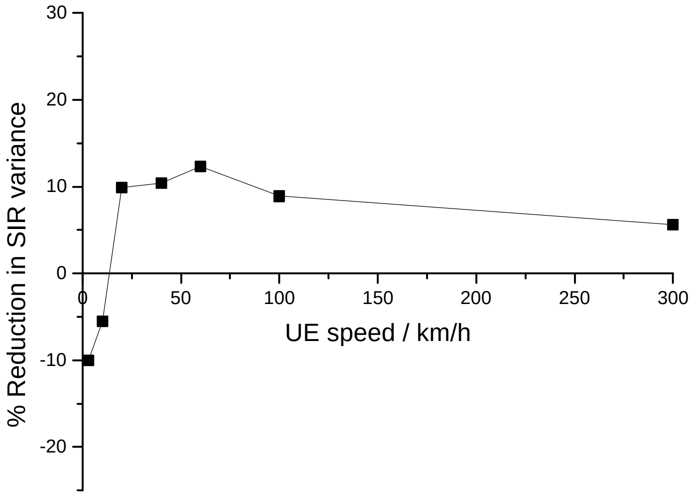


Figure 3: Improvement in recovery period SIR variance given by using average power after transmission gaps, calculated using equation (1).

5 Further Discussion

As suggested in [2], it would also be possible to allow P_{resume} to have a fixed offset added to increase the power at the start of the recovery period. This would result in modifying equation (1) as follows:

$$d_t = Offset + k_1(d_{t-1} - Offset) - k_2(TPC\_cmd)_t \Delta_{TPC}$$

Simulations were run to test this using an offset of 0.5dB, but the results did not show any significant improvement over not using such an offset.

Some simulations were also run to test the effect of a longer transmission gap, of 2 frames instead of 8 slots. The results are shown below:

UE speed / km/h	$P_{(resume)}$	Normal mode step size / dB	Recovery period power control mode	Rx'ed Eb/No / dB	Tx'ed Eb/No / dB	SIR variance / dB^2
20	Norm	1	1	4.9	6.6	15.7
	Delta	1	1	4.5	6.4	13.7

This shows that the improvement gained by using the approximated average transmit power after the transmission gap becomes more significant for longer transmission gap lengths.

6 Conclusions

The current text on power control in compressed mode provides no indication of the initial transmit power level which should be used by a UE on resuming transmission after a transmission gap in compressed mode.

The simulation results presented in this paper show that, for a wide range of UE speeds, it is possible to achieve a significant improvement in E_b/N_0 and SIR variance during the recovery frame if transmission resumes at approximately the average power level of the 2 frames preceding the transmission gap, rather than at the same level as the last slot before the transmission gap.

Equation (1) shows how the average power over the 2 frames preceding the transmission gap can be approximated using only the received TPC commands, without the need for any power measurement.

We propose that the relative power level for resuming transmission after transmission gaps in compressed mode should be signalled to the UE along with the other compressed mode parameters. This parameter should enable *n* in equation (1) to take one of 2 values, as follows:

1. n = 1 so that P_{resume} = Transmit power at start of transmission gap

2. n = 32 so that P_{resume} = Approximated average transmit power over the 32 slots preceding the transmission gap.

We propose that the initial power after the transmission gap in compressed mode should be specified in the way outlined above.

, Philips, August 1999

[3] TSGR1#6(99)822 *“Optimum Recovery Period Power Control Algorithms for*
, Philips, July 1999

[4] TSGR1#5(99)542 “*Additional results for fixed-step closed loop power control algorithm in compressed mode”*, Alcatel, June 1999

Text Proposal for 25.214

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. >.*~~

The initial transmit power of each uplink DPDCH and DPCCH after the transmission gap is equal to the power before the gap, but with an offset $_{RESUME}$. The value of $_{RESUME}$ (in dB) is determined according to the Power Resume Mode (PRM). The PRM is a UE specific parameter which is signalled by the network with the other parameters of the downlink compressed mode (see TS 25.231). The different modes are summarised in Table X.

Table X. Power control resume modes during compressed mode

Power Resume Mode	**Description**
0	$_{RESUME} = 0$
1	$_{RESUME} = \text{Int}[\ _{last} / \ _{TPCmin}]\ $ $_{TPCmin}$

Here Int[] means round to the nearest integer and $_{TPCmin}$ is the minimum power control step size supported by the UE. δ_{last} is the power offset computed at the last slot before the transmission gap according to the following recursive relations which are executed every slot during uplink transmission:

$$d_{last} = 0.9375 d_{previous} - 0.96875 TPC\_cmd_{last} \Delta_{TPC}$$

$$d_{previous} = d_{last}$$

TPC_cmd is the power control command executed by the UE in the last slot before the transmission gap. $\delta_{previous}$ is the power offset computed for the previous slot. The value of $\delta_{previous}$ shall be initialised to zero when a DCH is activated, or during the first slot after a transmission gap.

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~~:

Table 1. Power control modes during compressed mode.

Mode	**Description**
0	Ordinary power control is applied with step size Δ_{TPC}
1	Ordinary power control is applied with step size Δ_{RP-TPC} during one or more slots after each transmission gap.