3GPP TSG RAN WG1 Meeting #5 ***TSGR1#5(99)553***
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Source: **Philips**

Title: **Implementation of small power control steps**

Agenda item:

Document for: **Discussion**

Summary

This document discusses possible improvements to power control which give improved performance in the two extreme cases of very slowly and very rapidly changing channels.

Discussion

It can be seen from simulation of closed loop power control that for any given channel conditions there is an optimum step size which minimises the required Eb/No. Where the channel changes very slowly, the optimum step size can be less than 0.5dB, since such values are sufficient to track changes in the channel, while giving minimal tracking error. On the other hand, as the Doppler frequency increases, larger steps give better performance, with optimum values perhaps being larger than 2db. However, as the Doppler frequency is further increased, at some point the power control rate becomes too low to properly track the channel, and the optimum step size is reduced (perhaps to less than 0.5dB). Since fast channel changes cannot be tracked, all that is needed is the ability to follow shadowing, which typically is a slow process.

One possibility under consideration is that the network instructs the UE which value of power control step size it should use in the uplink. Such a decision would be taken on the basis of available information in order to minimise the Eb/No. We assume for the moment that it is easy to implement power control step sizes that are multiples of some minimum value. Although improved performance could be obtained by implementing a small minimum step size in all UE (e.g. 0.5dB), this appears not to be cost effective. However, if the value of the minimum step size is optional, the UE may not be able to implement the step size requested by the network. A possible solution would be to use the nearest available step size. Another solution is developed here.

Emulation of small step size

We propose that when the UE is requested to implement a power control step size smaller than it is capable of, the power control action is modified as follows: The transmit power remains unchanged, unless N consecutive identical power control commands are received. In this case the power is adjusted in the corresponding direction by the smallest available increment (or decrement).

We propose that $N = D_{min}/D_{net}$, where D_{min} is the minimum step size implemented by the UE and D_{net} is the step size requested by the network. Thus if the UE has a minimum step size of 1dB, then setting N=2 will allow an approximation to the power control action achieved by using a step size of 0.5dB. Considering pairs of TPC bits, if both bits indicate ‘up’ then power is increased, if both indicate ‘down’ then power is decreased. Otherwise the power is not changed. It is not envisaged that operation with larger values of N than about 4 would be required (equivalent to a step size of 0.25dB, and assuming that all UE’s implement a step size of 1dB).

The proposed modification will reduce the effective power control update rate for the emulated small steps. However, when small step sizes are optimal, it appears that fast channel tracking is not required.

Simulation Results

Simulations of power control have been carried out with some ideal assumptions:

- 1 slot delay
- no channel coding
- perfect channel estimation
- perfect RAKE receiver
- no control channel overhead in Eb/No
- fixed TPC bit error rate
- simple N path Rayleigh channel model

Some illustrative results are presented.

Scenario 1: Terminal speed:300km/hr, Single path, TPC BER=0.01

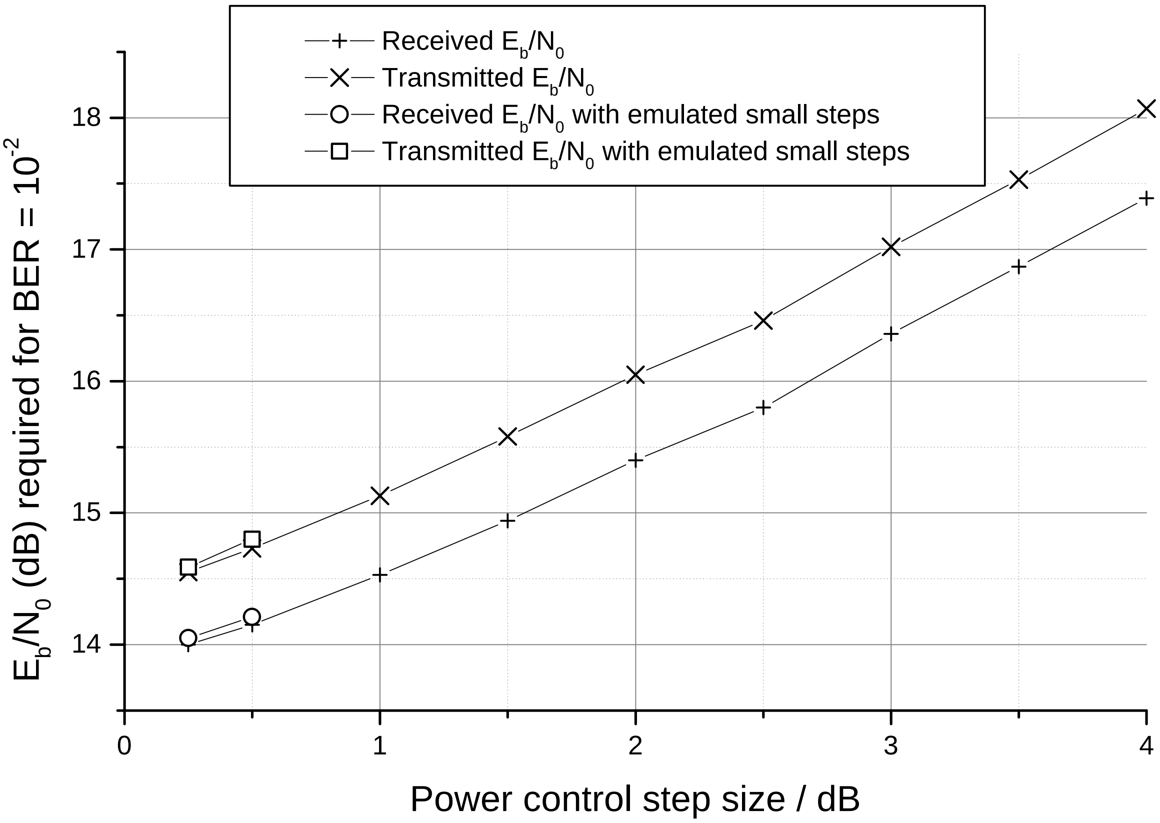

Figure 1: Eb/No for BER=0.01, terminal speed 300km/hr, single path

Figure 1 shows the Eb/No required to achieve a BER of 0.01 as a function of power control step size with a terminal speed of 300km/hr. It can be seen that the best performance is obtained for small step sizes (less than 1dB). For comparison we show results where small step sizes (0.25dB and 0.5dB) have been emulated using the scheme described above, assuming that the terminal can implement 1dB steps. It can be seen that the emulation introduces only a small implementation loss (about 0.05dB).

With a TPC BER=0.1 there is a general degradation of about 0.2dB in the Eb/No. However, the performance of the small step emulation remains very close to that of direct implementation for step sizes of both 0.25dB and 0.5dB.

Scenario 2: Terminal speed 1km/hr, 6 path channel, TPC BER=0.01

Figure 2 shows results for a slowly changing channel. Here there is a very small advantage in using small power control steps (i.e. less than 1dB). It can be seen that performance for emulation of 0.5dB and 0.25dB steps is very close to that achieved with direct implementation.

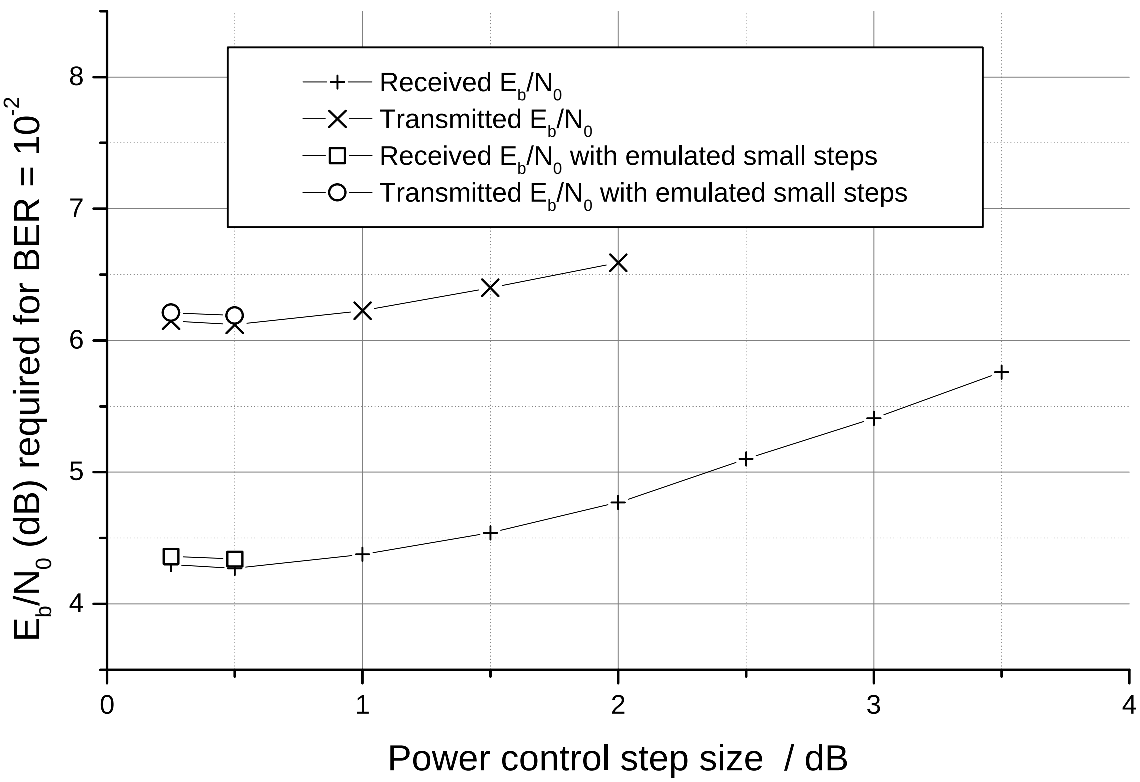

Figure 2 Eb/No for BER=0.01, terminal speed 1km/hr, 6 path channel

Conclusions

In some scenarios, notably with high terminal speeds, there is some performance advantage in the use of power control steps sizes smaller than 1dB. Our proposed modification to the power control algorithm in the UE achieves approximately the same performance improvement, but by emulation of small step sizes. It does not require direct implementation of a smaller step size than 1dB. It also has low implementation complexity and is robust to transmission errors.

We recommend that:

1. The network should be allowed to request that the UE uses a specific power control step size from the set [0.25, 0.5, 1.0, 2.0, 4.0]dB.
2. A mandatory minimum step size of 1dB is adopted in the UE. It would then be easy to support power control steps sizes equal to any multiple of 1dB, if required.
3. Implementation of 0.5dB and 0.25dB step sizes is mandatory, either directly or by emulation using the proposed algorithm.

It remains FFS whether 0.25dB is the smallest required step size. It might also be considered whether other step sizes are needed than the ones proposed.

The required accuracy of the power control steps is FFS (with WG4).