3GPP TSG RAN WG1 **TSGR1#4(99)390**
Meeting #4
19-23, April, 1999
Yokohama, Japan

Source: **Philips**

Title: **Effect of Uplink Power Control Step Size in Different Channel Scenarios**

Agenda item: **5.6**

Document for: **Discussion**

Summary

The aim of this paper is to examine the performance of different uplink closed-loop power control step sizes in different channel environments. Simulations were carried out to find the optimum step size for relatively severe channel conditions, and to verify that this optimum is still satisfactory under favourable channel conditions. It is concluded that it may in some circumstances be significantly beneficial to use a step size larger than 1dB.

Simulation Results

Three channel scenarios were simulated to find the optimum power control step size in each case, under steady-state conditions.

The simulations were designed to be a generalisation of the worst and best cases for the radio environment. The simulated uplink data was BPSK modulated, assuming equivalence of the I and Q channels. The radio channel model used a number of parallel Rayleigh fading paths summed in magnitude and with no relative delay, assuming perfect channel estimation and a perfect rake receiver. The simulations do not include the effect of channel coding.

This enabled rapid generalised simulations to be run, giving a broad picture of the effect of varying the power control step size for a wide range of channel conditions. The results are in broad agreement with those presented by Nokia (in TSG-RAN WG1 (99)118, *The effect of power control step size in downlink*, Yokohama, 22-25 February 1999) .

The effects of errors in the power control information have been included, using an error rate of 1%. This simulates both channel-induced transmission errors in the TPC bits and, for example, any SIR estimation errors in the determination of the direction of the required power change. Higher error rates (e.g. up to 10%) give a general increase in the required Eb/No but do not otherwise alter the conclusions.

The FDD uplink direction was the primary consideration here, but the results should also be applicable to the downlink direction., and may also be relevant for TDD mode.

1. Approximation to the ITU Pedestrian A channel, at a speed of 20km/h

This channel approximation is based on the dominant path in the channel, using only a single Rayleigh path. The results for BER = 10^{-2} are probably representative of the typical operating point of the radio link, but the conclusions are not significantly different when a lower BER is considered. At a speed of 20km/h it is by no means worst case, as it may be necessary to cope with speeds of up to 300km/h. However, Figure 1 shows that even at 20km/h, a 1dB power control step size fails to give optimal performance, as it is unable to track the rapid changes in the channel.

This may be of particular concern if the tolerance on the step size is taken into account: For example, current discussions in TSG RAN WG4 have considered a step size of 1dB with a tolerance of +-0.5dB. At the lower limit, a worst case systematic error in the step size could lead to a value of 0.5dB in the implementation. This could result in a degradation of more than 4dB in Eb/No compared to a 1dB step size.

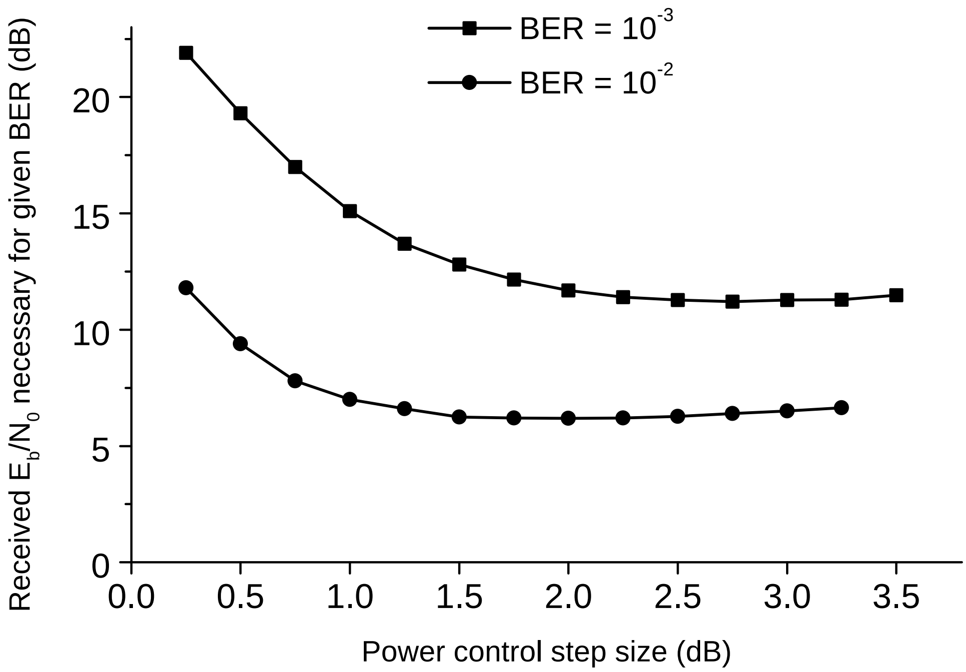

Figure 1: Required Eb/No against power control step size at 20km/h

For a BER of 10^{-3}, a 3.5dB gain in required E_b/N_0 can be obtained by using a 2dB step size instead of 1dB.

2. Approximation to the ITU Pedestrian A channel at a speed of 3km/h

This simulation again used only a single Rayleigh path. However, in this case it represents a more slowly-fading channel, where it is easier for a small power control step size to track the variations in the channel. Consequently it can be seen in Figure 2 that the required level of E_b/N_0 rises less steeply as the power control step size is reduced.

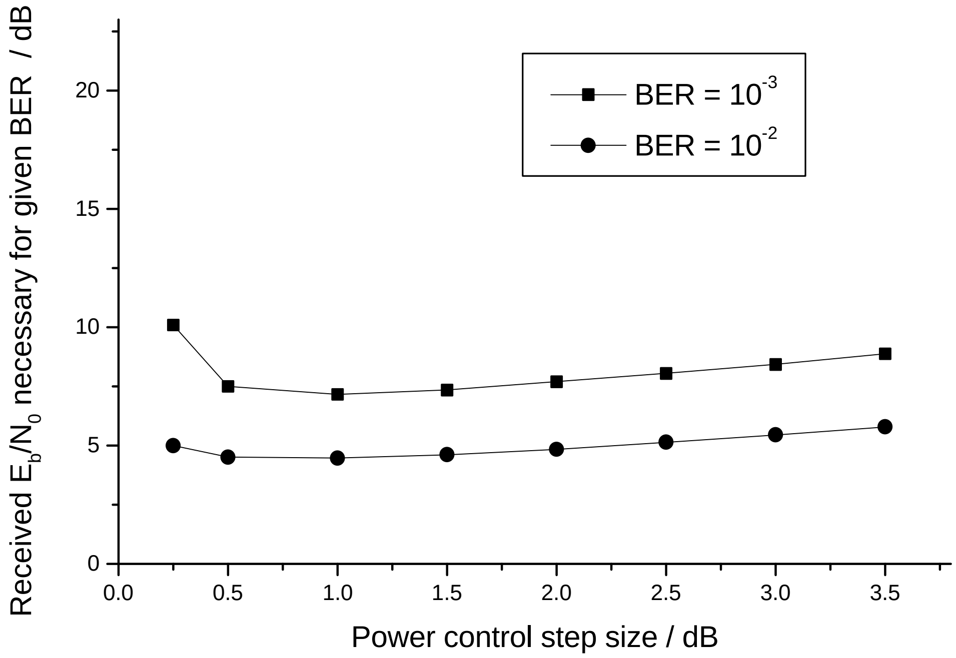

Figure 2: Required Eb/No against power control step size at 3km/h

In this more slowly-changing environment, there is also some degradation if the step size is made too large, as the power control steps themselves start to be the cause of SIR errors in the uplink. The effect of errors in the interpretation of the power control bits by the mobile terminal is also more severe if the step size is too large.

3. "Best-case" channel

The effect of a large power control step size is most likely to be adverse in a channel which is naturally fairly stationary. As a hypothetical best-case channel, 6 Rayleigh-fading paths with equal attenuations were simulated, at a speed of only 1km/h.

Figure 3 shows that in such a favourable channel, even very small power control step sizes are able to track the changes in the channel. The slight degradation due to larger step sizes can again be seen, but it is much less significant than the effect of small step sizes in adverse channel conditions. In this "best-case" channel, the degradation in required E_b/N_0 arising from using a 2dB step size instead of a 1dB step size is only 0.7dB.

It is only in such a "best-case" channel that there might be any advantage in using a power control step size smaller than 1dB. However, it can be seen from Figure 3 that reducing the power control step size from 1dB to 0.25dB only results in an improvement of ~0.2dB.

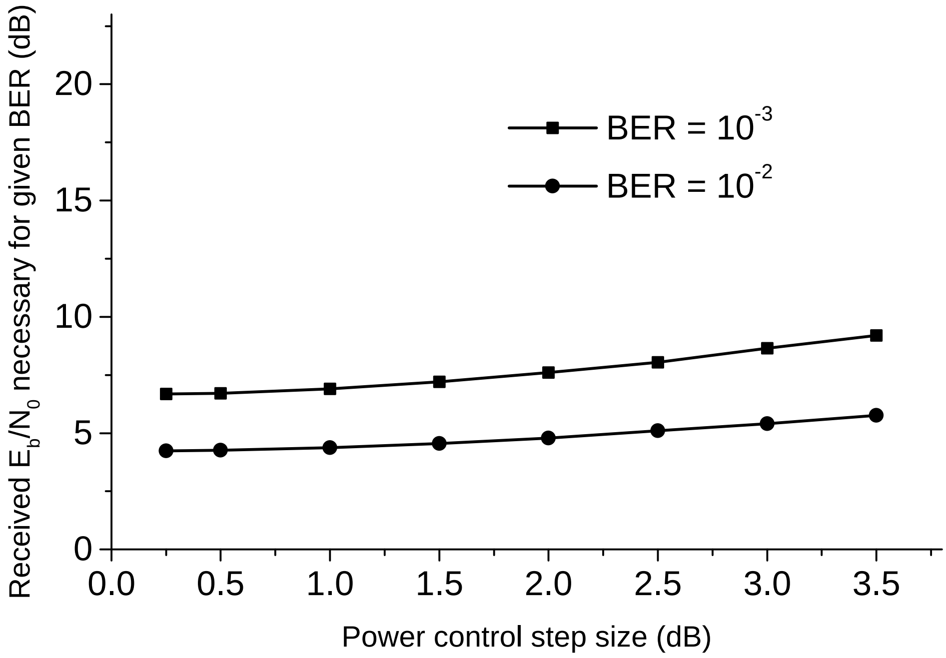

Figure 3: Required Eb/No against power control step size for "best-case" channel

Conclusions

The following conclusions can be drawn:

1. In channel environments which are changing relatively rapidly (Doppler frequency greater than about 10Hz), it is highly advantageous to be able to use a power control step size greater than 1dB (for example a 2dB step size can give 3.5dB improvement in Eb/No.)

2. Even in a "best-case" channel, the effect of a 2dB step size instead of 1dB is not serious (only 0.7dB degradation.)

3. There is little advantage in using a step size much smaller than 1dB, in any circumstance.

Based on the above results, we make the following recommendations for inclusion in S1.14:

1. A specification of a minimum step size of 1dB with a tolerance of +-0.5dB is reasonable for the UE, but smaller values may give more flexibility for optimization of Eb/No performance.

2. We propose that the infrastructure can request the UE to change its power control step size to some multiple of the minimum. There would need to be a corresponding change in the tolerance. Such updates are not expected to be frequent, perhaps typically once or twice per call.

3. A step size of up to at least 2dB should possible in the UE. This implies that step sizes of at least 4 times the minimum step size should be supported (based on a terminal with a "worst case" 0.5dB step size being required to operate with 2dB steps).

These proposals are also fully consistent with the idea of using larger step sizes under specific circumstances (e.g. after slotted mode).