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1 Introduction

The aim of this paper is to provide a guide to the maximum possible benefits which might be achievable if tri-state TPC commands were used, instead of bi-state as currently assumed.

The currently-proposed bi-state TPC commands are interpreted by the UE as either “up” (e.g.+1dB) or “down” (e.g.-1dB). The tri-state algorithm evaluated here uses a third possibility, namely to transmit zero power in the TPC symbol; this is interpreted as “no change” by the UE.

Simulations were run to compare the performance of the tri-state algorithm with that of the currently-proposed bi-state TPC commands.

2 Description of Simulations

For the tri-state algorithm, the E_b/N_0 performance was evaluated on the uplink while the tri-state TPC commands were transmitted on the downlink. The Base Station used the difference between the received SIR and the target SIR to decide which TPC command to transmit. If this difference was less than a fixed decision threshold, the BS used the “no change” TPC command (i.e. no transmitted power in TPC symbol). Otherwise, the BS transmitted the usual +1 or –1 TPC commands.

The decision threshold in the BS was set at ±0.5dB for UE speeds 3km/h, 10km/h, 20km/h and 40km/h, and at ±1.0dB at 300km/h, as this combination was said in [1] to give the best performance.

At the UE, the ratio, X, between the received power of the TPC symbol and the average received power per pilot symbol was calculated: X = Pwr(TPC)/Pwr(per pilot symbol).

The value of X was then compared against a threshold. If X was smaller than the threshold, the uplink transmit power was not changed; otherwise, a + or – step was implemented depending on the sign of the TPC command. The size of these steps was 1dB for 3km/h, 10km/h, 20km/h and 300km/h, and 2dB at 40km/h, as these sizes were shown in [2] to be optimal for these speeds.

For each of the UE speeds, a range of simulations was carried out to determine the optimum position for the threshold in the UE.

The E_b/N_0 performance figures given below are for the optimum UE threshold position at each speed. The optimum position of the threshold was found to be dependent on Doppler frequency.

The bi-state TPC simulations which were used for comparison followed the normal “algorithm 1” as described in [3]. These simulations also used the optimal step-sizes described above.

Other simulation conditions were as follows:

2GHz carrier frequency
Pedestrian A channel
1 slot power control loop delay
AWGN on TPC bits; noise power set at level which gives 4% error rate for bi-state commands
SIR estimation error based on uplink SIR, using 6 pilot bits
No control channel overhead in Eb/No
Perfect Rake receiver
Ideal channel estimation
Physical channel rate 32kbps
AWGN interference
Approx. 4dB coding gain from $^{1}/_{3}$-rate K=9 convolutional coder
Target BER after decoding = 10^{-3}

3 Simulation Results

The following results were obtained:

UE speed / km/h	Gain (dB) in received Eb/No achievable using tri-state TPC commands with optimal threshold positioning at UE, compared to normal bi-state "Algorithm 1" power control
3	0.03dB
10	0.04dB
20	0.02dB
40	0.05dB
300	0.07dB

4 Conclusions

These gains are the maximum achievable assuming that the UE decision thresholds are positioned optimally, and are not thought to be significant. If the UE decision thresholds are not positioned optimally, the E_b/N_0 gains are even smaller.

5 References

[1] TSGR1#6(99)935 “*Simulation results for the 0dB power control command*”, Panasonic, July 1999

[2] TSGR1#6(99)821 “*Optimum Power Control Step Size in Normal Mode*”, Philips, July 1999

[3] TSGR1#6(99)a69 TS25.214 v1.1.1