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Title: Performance of uplink HS-DPCCH in SHO

Document for: Discussion and decision

1 Introduction

The performance of the uplink HS-DPCCH in SHO is discussed in this contribution. In WG1 meeting #25, some unrealistic simulation results for DPCCH channel estimation were presented [1]. We compare different channel estimation schemes and conclude that adding pilot bits to HS-DPCCH is not necessary. Furthermore, repetition is shown to be very efficient, in most cases two repetitions of the ACK/NAK is enough to keep the HS-DPCCH power offset at an acceptable level (0 .. 6 dB). In the worst case situations 4 repeats is shown to be enough.

2 HS-DPCCH performance in SHO

Link simulations were carried out using either 2 or 3 Node Bs in the SHO with the HSDPA terminal. The uplink closed loop power control algorithm was simulated ('up' only if all the Node Bs ask 'up', otherwise 'down') with 1 dB step size and with 4% TPC command error rate in the downlink (random errors). The channel model used in these simulations was the Case 1 (3GPP TS 24.141). It has two taps (0,-10) dB and is thus very close to ITU Ped A channel model. In the Node B receiver two diversity antennas were used.

The different channel estimation schemes simulated are:

- Ideal Chest: Ideal channel estimate

- Chest with 6 pilots: the channel estimate is calculated from DPCCH over the current slot (ACK/NAK slot)

- Chest with 3 slots: the channel estimate is calculated from DPCCH over the current slot (ACK/NAK slot) and two previous slots

- Chest with HS-DPCCH pilots: the channel estimate is calculated from 5 pilot bits inserted in the HS-DPCCH just before the ACK/NAK slot.

Notice that the HS-DPCCH pilots in this simulation were only sent with ACK/NAK, not in every TTI, and there was no separate power control for HS-DPCCH, i.e., the power offset between HS-DPCCH and DPCCH was constant during the simulation.

The simulation results show the needed HS-DPCCH power offset (x-axis) to UL-DPCCH channel to achieve the P(NACK|ACK)=1% requirement. The y-axis represents the power offset of HSDPA BTS to other BTSs in SHO with the UE (as well as the received UL-DPCCH Ec/No). In soft handover the received UL-DPCCH power depends on the channel and the power offset to the other BTSs in soft handover. A BTS doesn't know that the UE is in soft handover. Hence it performs normal closed loop power control, i.e., it measures the SIR and then compares it to the SIRtarget (-21 dB SIR target was used in the simulations). However, UE increases the TX-power only if all the BTSs requests that the power should be increased.

The decision border between ACK and DTX was set such that the probability of P(ACK|DTX) was smaller than 1%. Here it has been assumed that the requirement P(ACK|DTX)< 1% is dominating over the P(ACK|NACK) <0.01% requirement.

Some simulation results are presented in Annex A for 3 and 30 km/h for the case where there are 3 BTSs in SHO with the HSDPA UE. This case represents a worst case situation where both non-HSDPA BTSs have the same power offset to the HSDPA BTS, i.e., a –3 dB offset means that both non-HSDPA BTSs have 3 dB higher average received power

than the HSDPA BTS. Simulations were also carried out using only two BTSs, these simulation results are not shown in Annex but are included in the summary presented in the next section. The same is true for 120 km/h results.

3 Summary and discussion of simulation results

The simulation results in Annex show clearly that channel estimation from DPCCH performs well when the power offset of HS-DPCCH is at moderate level, say 0..6 dB above DPCCH. The pilot bits on HS-DPCCH would only help if the power offset were much higher. The simulation results show that these high power offsets are not needed and, therefore, the pilot bits on HS-DPCCH are not needed.

The following table summarises the required HS-DPCCH power offsets with realistic channel estimation schemes for different number of transmissions in different cases. The non-SHO case is read from the pictures assuming HSDPA BTS power offset of +6 dB to other BTSs, i.e., in practice the power control then follows the HSDPA BTS. SHO with 0 dB offset case assumes that HSDPA BTS is on average the best BTS and therefore the power offset of HSDPA BTS to other BTSs is 0 dB or higher. Finally, the last case (SHO with –3 dB offset), where HSDPA BTS is on average 3dB weaker than other BTSs (-3 dB power offset), represents a situation where the HS-DSCH should already have been swithed to another BTS.

Table 1 HS-DPCCH power offset (dB) relative to UL-DPCCH

Speed (km/h)	Non-SHO		SHO with 0 dB offset		SHO with –3 dB offset		
	1 transm	2 transm	1 transm	2 transm	1 transm	2 transm	4 transm
3	0	<0	7-10	4-6	11-13	7-9	4-6
30	4-6	<0	9-12	4-6	13-17	8-10	1-5
120	8-12	0-6	10-18	3-5	>>14	6-10	0-5

The simulation results clearly show that without SHO, one transmission of ACK/NAK is enough at low and medium speeds. At high speeds, two transmissions are needed to keep the power offset at an acceptable level. Also, with SHO two transmissions are typically enough, more repetitions are only needed if HS-DSCH is not switched to a stronger BTS in the active set.

Based on the simulation results we can conclude the following:

- HS-DPCCH pilots are not needed (they will not improve the performance at low and moderate HS-DPCCH power offsets)
- 0..6 dB range for HS-DPCCH power offset is enough since repetition is available (if for some reason higher power for HS-DPCCH is needed, DPCCH power (i.e., power control SIR target) can be increased, as proposed in [2])
- repetition is needed only in SHO and with high terminal speed, two transmissions is typically enough
- a maximum of 4 transmissions seems to be enough

Due to rapid changes in the operating environment, like changes in mobility or SHO conditions, which only the Node B can detect fast enough, there should be some faster signaling mechanism between the Node B and the UE besides the higher layer signaling. In the last WG1 meeting we proposed [3] to add two bits to HS-SCCH to tell additional repetition on a TTI basis. Based on the results presented, even one bit signaling seems to be enough. This bit would tell whether the repetition factor for ACK/NAK should be doubled or not. This fast signaling between Node B and UE allows to adapt faster to changes in channel conditions and therefore, it is not necessary to configure the power offset and number of repetitions according to the worst case. Especially for slowly moving terminals, a single transmission of ACK/NAK could be configured even in SHO and repetition would only be used when required.

It has been argued that undetected errors on HS-SCCH are a problem for this scheme. With 16 bit CRC and 1% FER target for the HS-SCCH, the probablity of undetected error is around 10^{-7}. With this low probability we don't believe that undetected errors are any bigger problem for this signaling bit than for other HS-SCCH bits. In worst case, an additional RLC level retransmission is needed, which is the case for most other HS-SCCH parameters.

4 Conclusions

Based on the simulation results and discussion above we conclude the following:

- HS-DPCCH pilots are not needed (they will not improve the performance at low and moderate HS-DPCCH power offsets)
- 0..6 dB range for HS-DPCCH power offset is enough since repetition is available
- repetition is needed only in SHO and with high terminal speed, two transmissions is typically enough
- maximum of four transmissions of ACK/NAK is enough
- one signaling bit on HS-SCCH should be added to enable the Node B to double the amount of repetition (1 to 2, 2 to 4) to react faster to changes in channel conditions

References

[1] R1-02-0554, HS-DPCCH Power requirements with HS-Pilot and Repetition, Lucent Technologies

[2] R1-02-0592, Channel Estimation for HS-DPCCH in Soft Handover, Ericsson

[3] R1-02-0538, Power and repetition control for uplink HS-DPCCH, Nokia

Annex A

A1 Simulation results with UE speed 3km/h

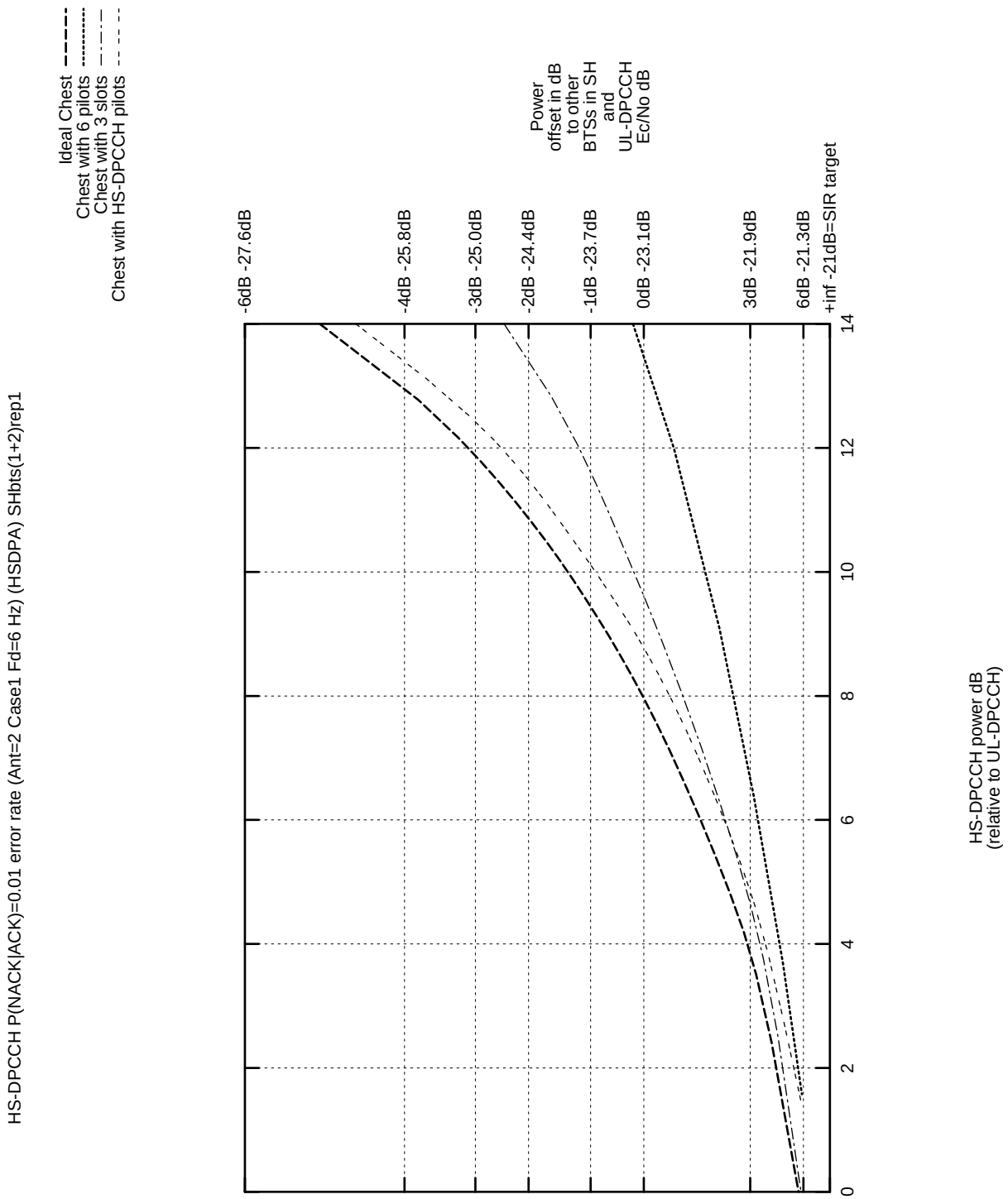

Figure 1 ACK->NACK error rate = 1%. Channel model: Case 1 (3km/h). Soft handover with 1+2 BTS. The ACK is transmitted one time.

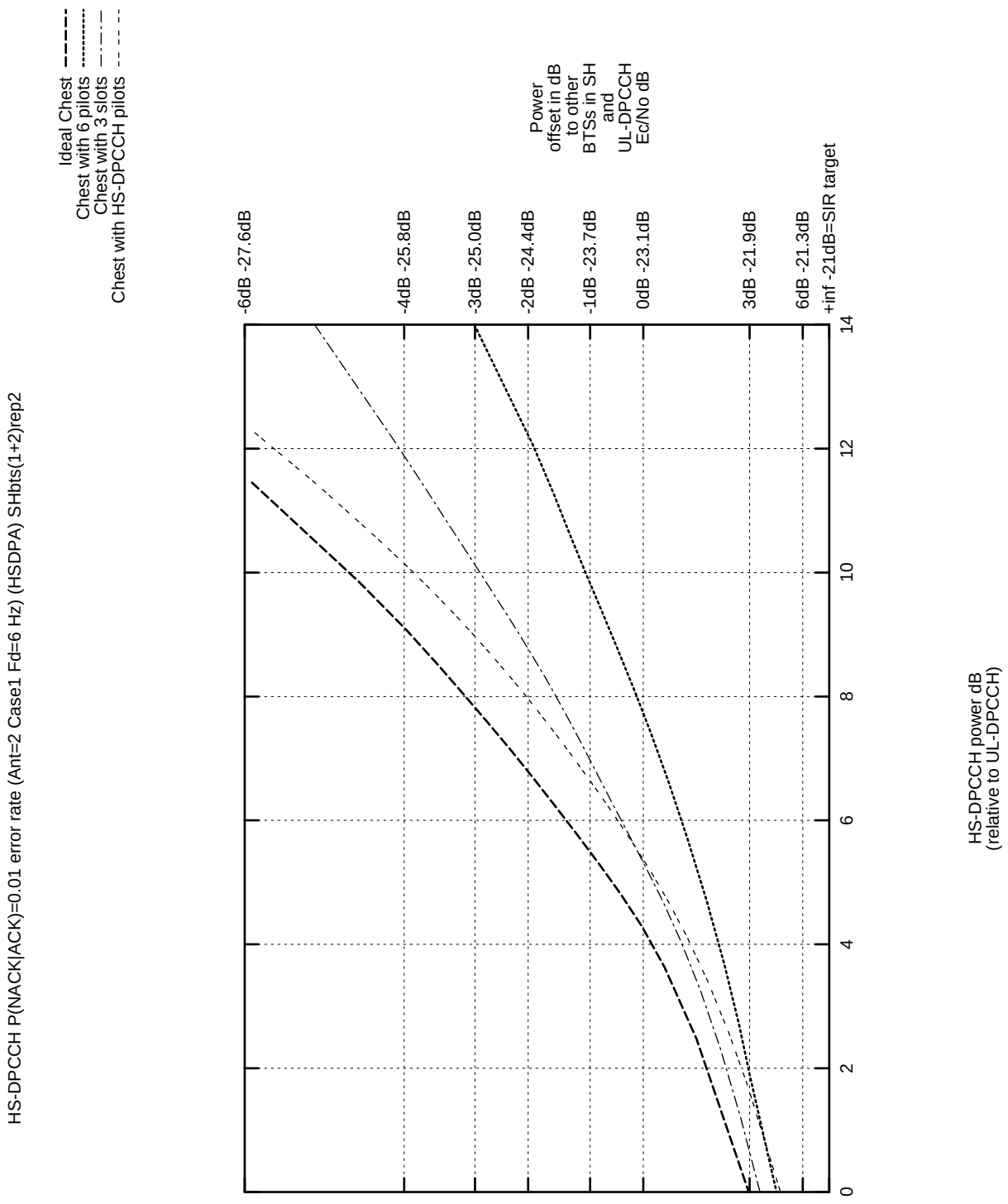

Figure 2 ACK->NACK error rate = 1%. Channel model: Case 1 (3km/h). Soft handover with 1+2 BTS. The ACK is transmitted two times.

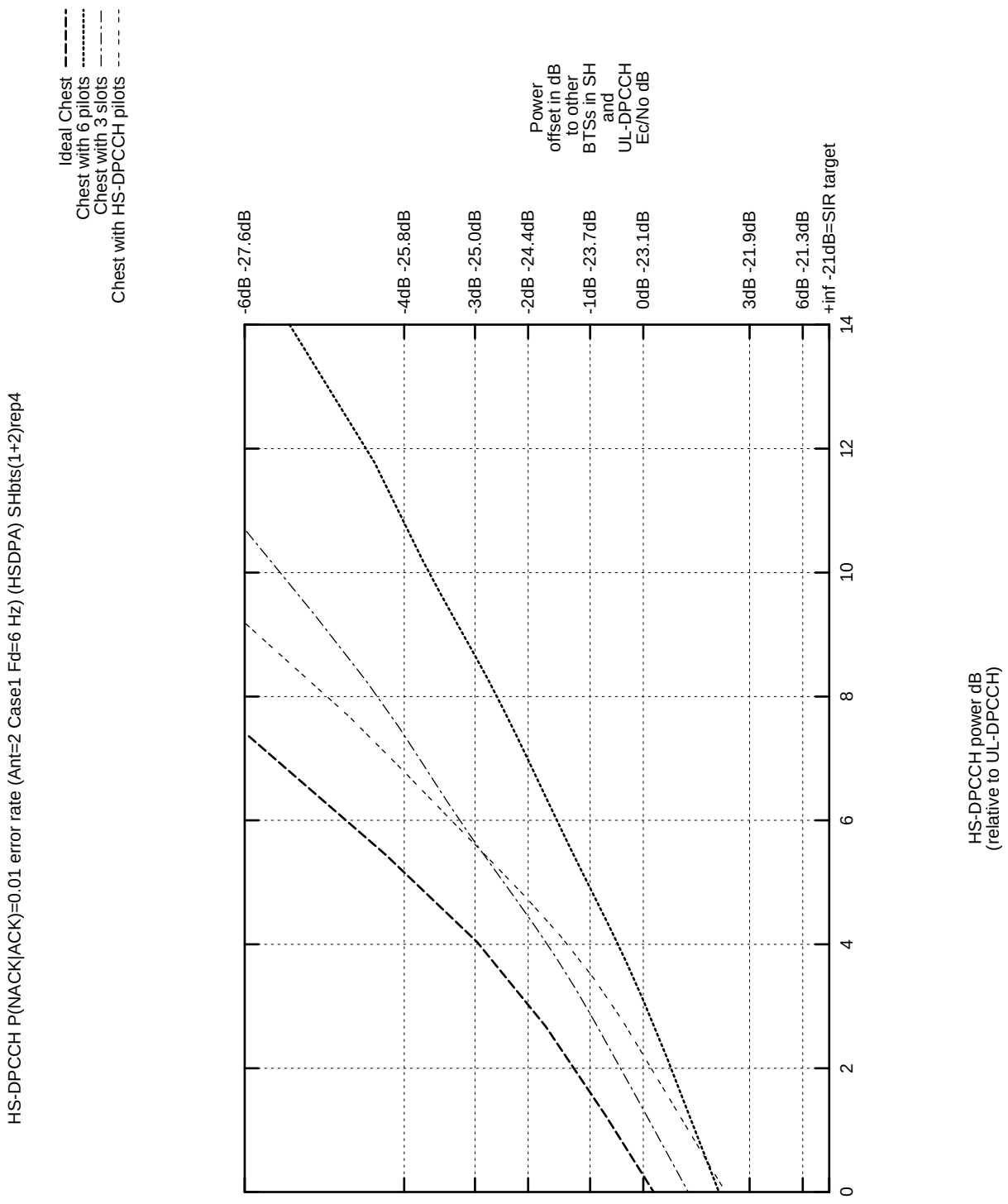

Figure 3 ACK->NACK error rate = 1%. Channel model: Case 1 (3km/h). Soft handover with 1+2 BTS. The ACK is transmitted four times.

A2 Simulation results with UE speed 30km/h

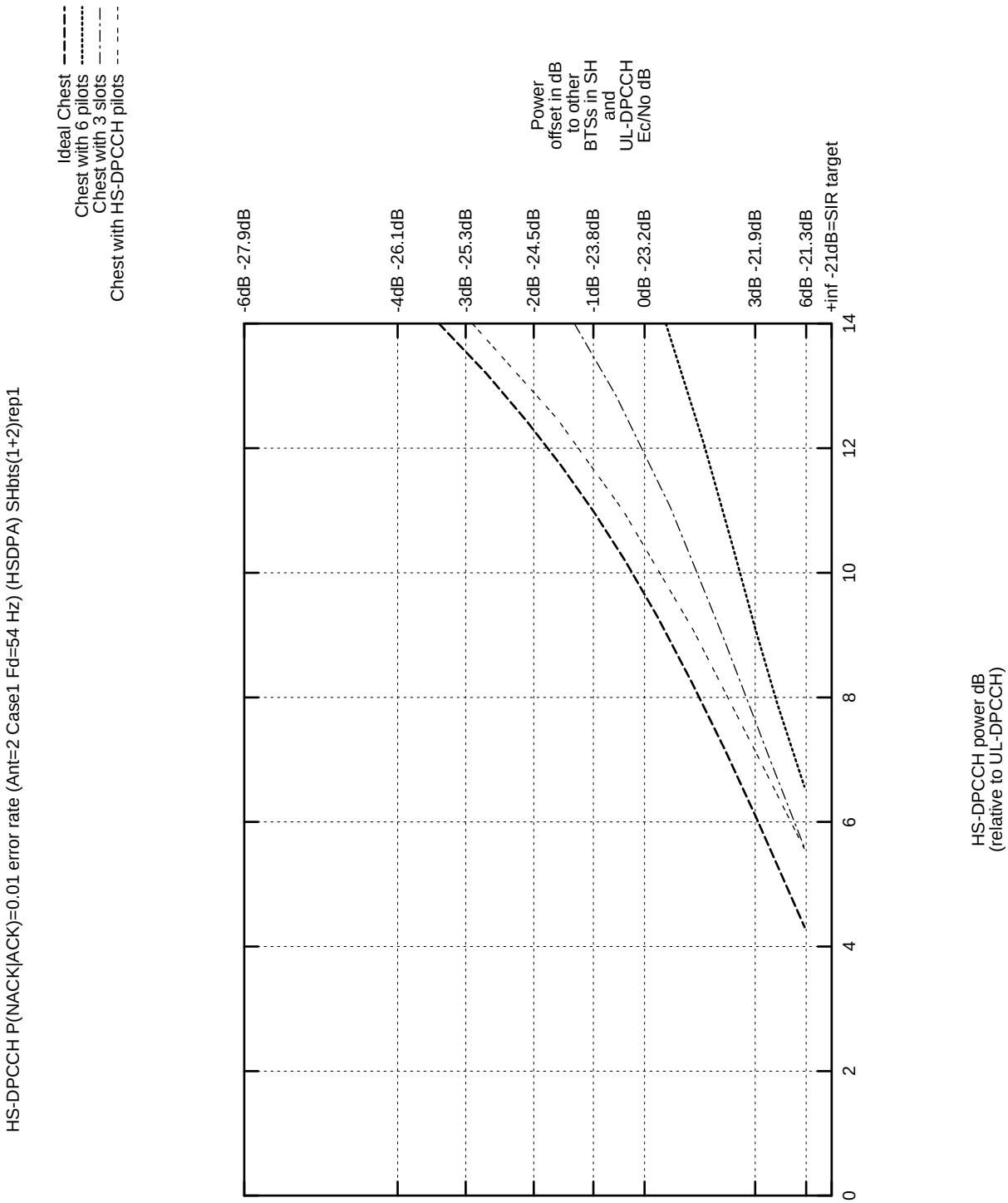

Figure 4 ACK->NACK error rate = 1%. Channel model: Case 1 (30km/h). Soft handover with 1+2 BTS. The ACK is transmitted one time.

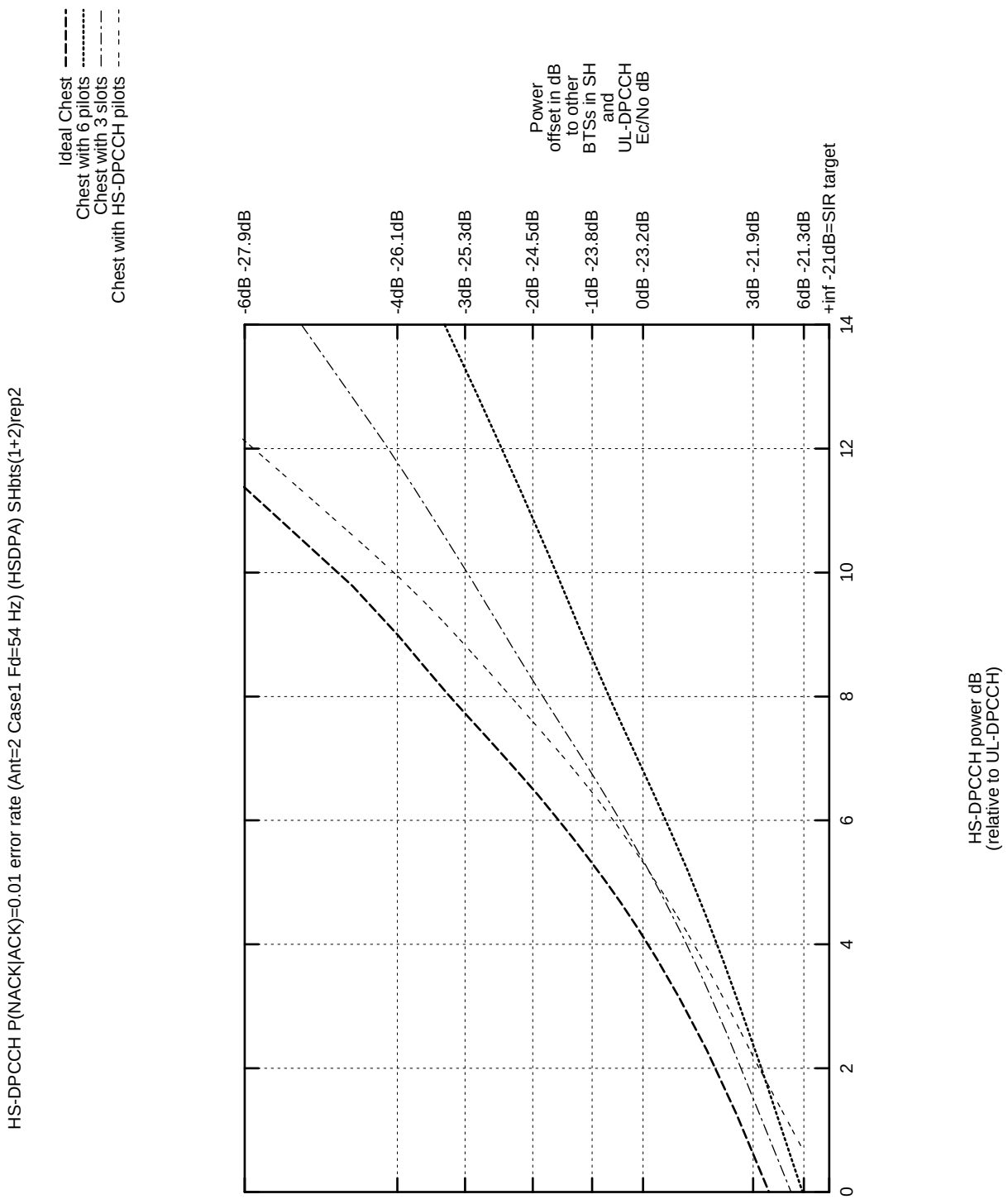

Figure 5 ACK->NACK error rate = 1%. Channel model: Case 1 (30km/h). Soft handover with 1+2 BTS. The ACK is transmitted two times.

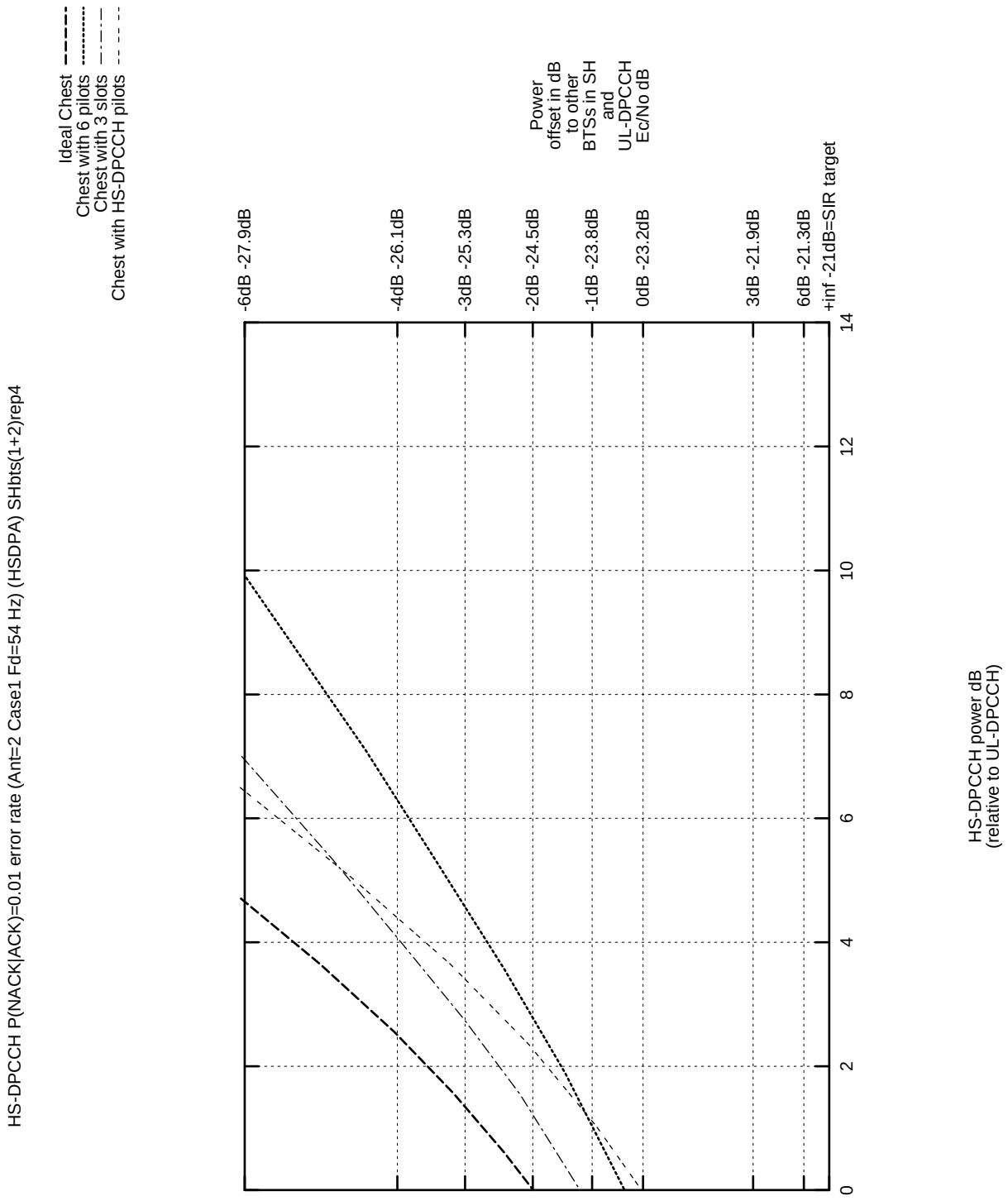

Figure 6 ACK->NACK error rate = 1%. Channel model: Case 1 (30km/h). Soft handover with 1+2 BTS. The ACK is transmitted four times.