3GPP TSG RAN WG1 ***TSGR1#8(99)g23***
October 12-15, 1999, New York, USA

Agenda item:	**Ad hoc 9**
Source:	**Philips**
Title:	**Further simulation results on power control on initialisation (DCH and CPCH)**
Document for:	**Discussion**

---

1 Introduction

It may be possible to reduce the required Eb/No of a data transmission by using a power control preamble prior to the commencement of data transmission. For example, in CPCH it may be useful to include a power control preamble between the power ramping phase and the start of the message part. Also, in rapid initialisation of a DCH, it is intended that the data transmission starts some time after the control part(s), to allow the inner power control loops to converge.

In CPCH the usefulness of such a preamble will depend on the power offset at the end of the power ramping phase compared to the power required to meet the outer loop SIR target. The size of this offset will depend on a number of factors, including the power level at which the BS acknowledges the final step of power ramping and the change in channel attenuation (due to fast and/or slow fading) between the end of power ramping and the start of the message part. Similarly, in DCH initialisation there is significant delay between the end of transmission on PRACH (or end of previous DCH transmission) and the start of transmission on the DCH. Thus there will be a power offset with respect to the optimum power value for the DCH. If the delay is very long, the initial power for the DCH might need to be set using an open loop procedure, with the consequent errors in power level.

In [1] we presented simulation results to show the size of the reduction in required Eb/No which can potentially be obtained by using a power control preamble.

In this paper we present fuller simulation results for a wider range of UE speeds. A text proposal will be presented separately.

2 Description of Simulations

To simplify the simulation model it is assumed that a DCH starts in both uplink and downlink at the same time with a power level which is nominally correct, but subject to a random offset. The offset is drawn from a log-normal distribution (Gaussian in dB's). The simulations consider only the uplink transmission (with a simplified model for the TPC error rate in the downlink).

Simulations were run to compare the required Eb/No in frames which are not affected by initialisation effects, with the required Eb/No in the first 8 slots of the data transmission.

The simulation conditions were as follows:

2GHz carrier frequency
Pedestrian A channel
1 slot power control loop delay in message part
AWGN TPC error: 7% in 1st 8 slots of message part; 4% thereafter
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
Physical channel rate 32kbps
AWGN interference
Approx. 4dB coding gain from $^{1}/_{3}$-rate K=9 convolutional coder
Target BER after decoding = 10^{-3}

The power control mechanisms were those shown (e.g. in [2]) to be optimal for the given UE speeds, as shown below:

UE Speed / km/h	Normal power control mechanism
10	Algorithm 1, 1dB step size
20	Algorithm 1, 1dB step size
40	Algorithm 1, 2dB step size
60	Algorithm 1, 2dB step size
100	Algorithm 2, 1dB step size
300	Algorithm 2, 1dB step size

Where a different power control step size or algorithm was used at the start of the transmission, the power control algorithm and step size revert to normal when the received TPC commands change sign for the first time.

3 Simulation Results

Figure 1 to Figure 6 below show the increase in required Eb/No for the first eight slots of transmission, compared with the Eb/No for normal transmission (without any interruptions).

The detailed simulation results are shown in Annex B.

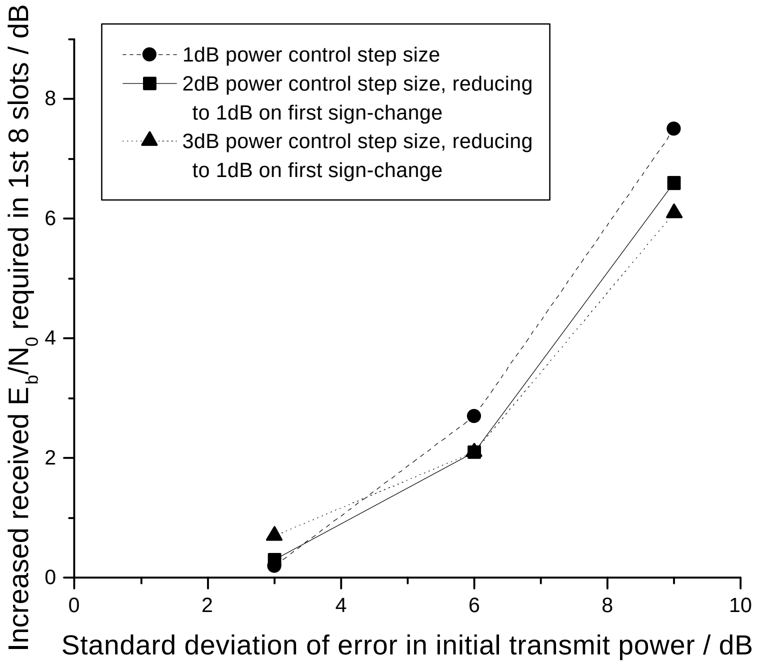

Figure 1: Increase in Eb/No required in 1st 8 slots at 10kmh

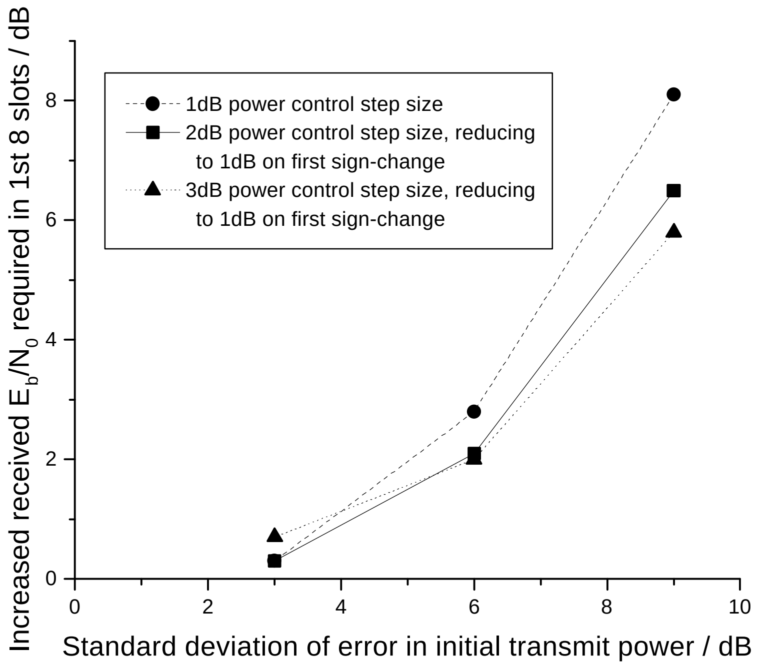

Figure 2: Increase in Eb/No required in 1st 8 slots at 20kmh

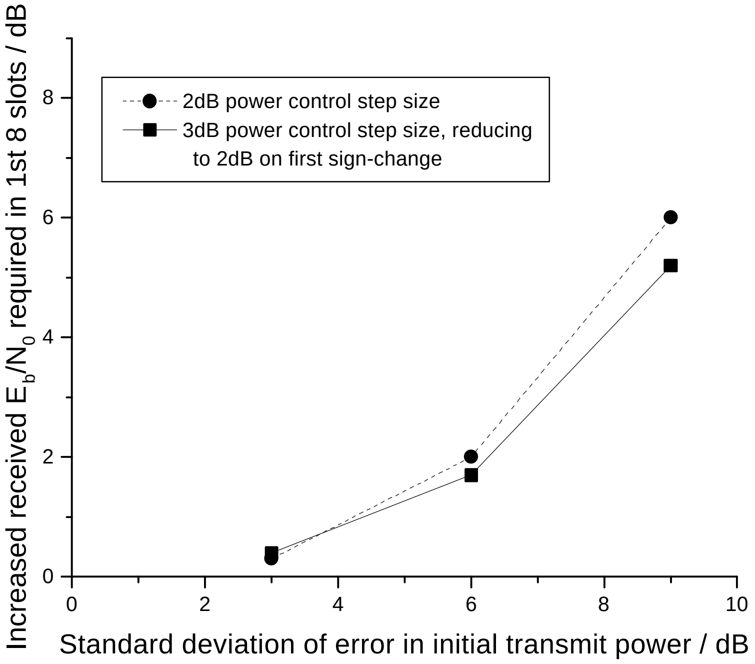

Figure 3: Increase in Eb/No required in 1st 8 slots at 40kmh

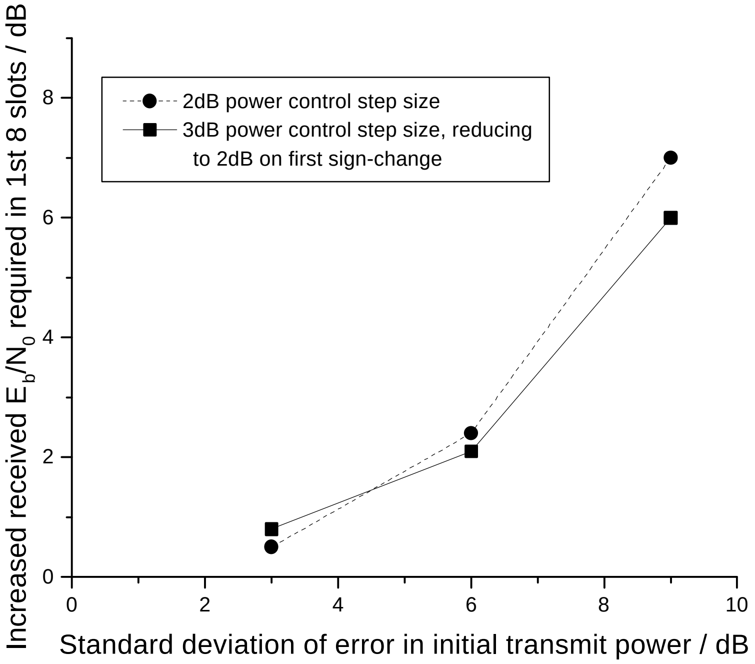

Figure 4: Increase in Eb/No required in 1st 8 slots at 60kmh

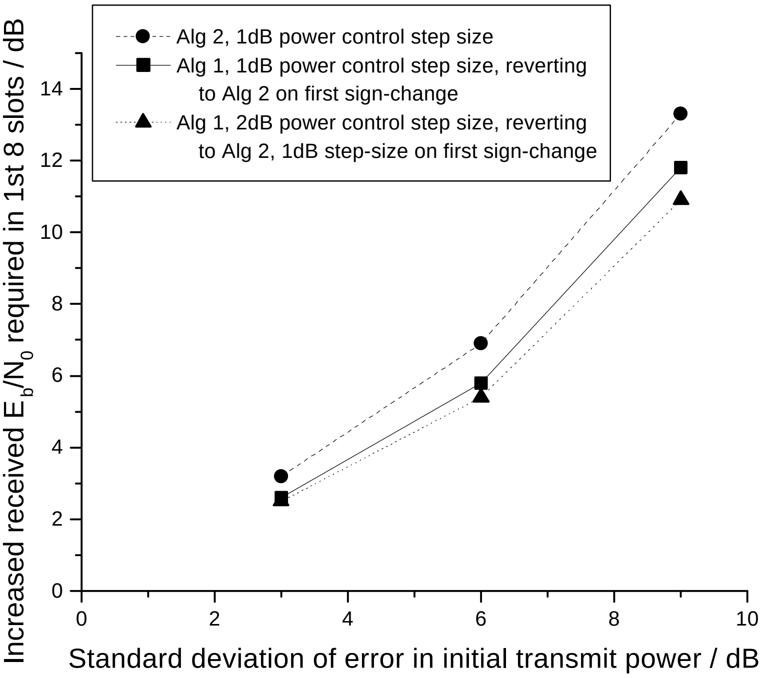

Figure 5: Increase in Eb/No required in 1st 8 slots at 100kmh

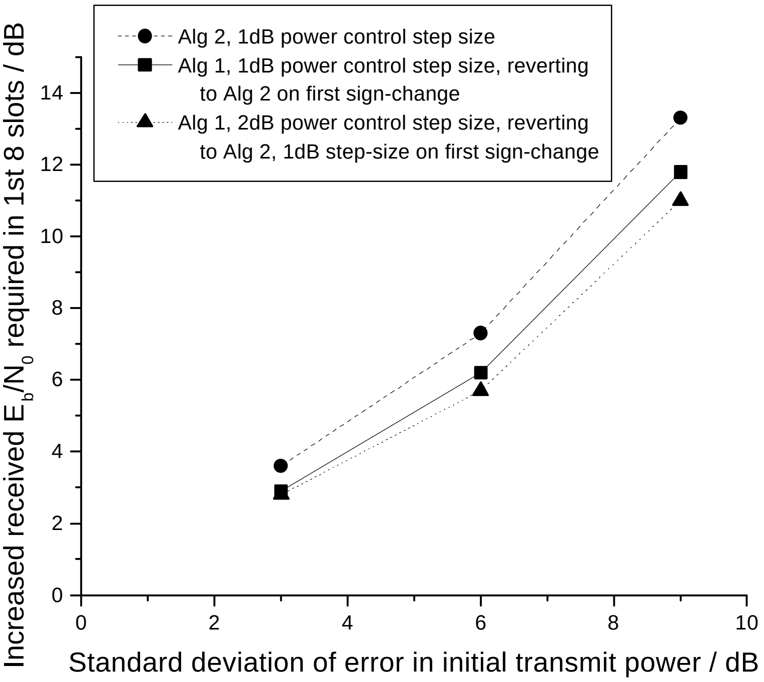

Figure 6: Increase in Eb/No required in 1st 8 slots at 300kmh

4 Discussion

The results in section 3 show that the effect on Eb/No of increasing the standard deviation of the initial error is very similar for all speeds: the required Eb/No in the first eight slots increases rapidly as the standard deviation of the error increases beyond about 3dB.

Some beneficial effect can be obtained by initially using a 2dB step size when the normal mode step size is 1dB, and a 3dB step size when the normal mode step size is 2dB. When Algorithm 2 power control is being used, it is beneficial initially to use Algorithm 1 with a step size of 2dB.

It is interesting to compare the magnitude of the errors used in these simulations with the power difference due to fast fading between two slots separated in time. This is shown for the Pedestrian A channel in Table 1 below.

Table 1: Change in properties of a Pedestrian A channel with time

UE Speed (km/h)	Std. Dev of power difference, separation 1 slot (dB)	Std. Dev. of power difference, separation 9 slots (dB)	Std. Dev.of power difference, large separation (dB)
3	0.14	1	5.7
10	0.33	2.6	5.7
20	0.71	4.6	5.7
40	1.4	5.7	5.7

We can see that for large enough separations (e.g. 1 frame at 20km/hr) the standard deviation of power difference approaches 6dB. This power difference is one of the factors contributing to the error in starting power for CPCH (or a DCH). Of course there may also be others (such as slow fading, or implementation errors).

The values for degradation in Eb/No and SIR variance shown in Table 2 for a standard deviation of 6dB could therefore be considered as an approximate “baseline” for the degradation which is likely to occur due to fast fading. In addition there could be other factors increasing the standard deviation beyond this value. Therefore results with Std Dev = 6dB probably represent the minimum gain to be expected from the use of a power control preamble.

In the case of DCH initialisation after a long gap, the initial power error could be closer to the error of open loop power estimation, which may be of the order of 9dB.

The additional Eb/No cost of using a power control preamble is shown in Annex A to be typically less than this potential gain.

Although the results presented here were obtained for a 16 slot frame, they seem also to be applicable for a 15 slot frame.

5 Conclusions and recommendations

A power control preamble will improve Eb/No in the uplink under typical conditions, and gives small (probably insignificant) degradation in others. The additional energy needed in the uplink is insignificant (see Annex A).

If a power control preamble is used then it is beneficial to use initially a different power control step size from normal, as shown below:

Normal power control method	**Initial power control method**
Algorithm 1, step size $_{TPC}$	Algorithm 1, step size = min(3dB, 2 $_{TPC}$)
Algorithm 2	Algorithm 1, step size = 2dB

The preamble should not need to be longer than about 7 slots, since a 2dB step size can then correct power errors of up to 14dB. Larger errors will occur only rarely.

For CPCH, where the spreading factor is 64 or lower, a fixed preamble of length 7 slots seems reasonable.

For DCH initialisation in cases with higher spreading factors than 64 and resumption after a short gap, then operation without a preamble may be give slightly better performance. Therefore we recommend that the network should be able to select between two values of preamble length (0 and 7 slots).

6 References

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

[2] TSGR1#7bis(99)e76 *"Power control on intialisation (DCH and CPCH)"*, Philips, October 1999

Annex A - Eb/No benefits of a power control preamble.

We consider an uplink data transmission with no data on the downlink. With a DCH with SF=64 on the uplink DPDCH and SF=256 on both uplink and downlink DPCCH’s, then it is possible to estimate the energy required to transmit the first frame of data, both with and without a power control preamble. We also assume that the preamble length is half the frame duration, and that the inner power control loop converges within half a frame.

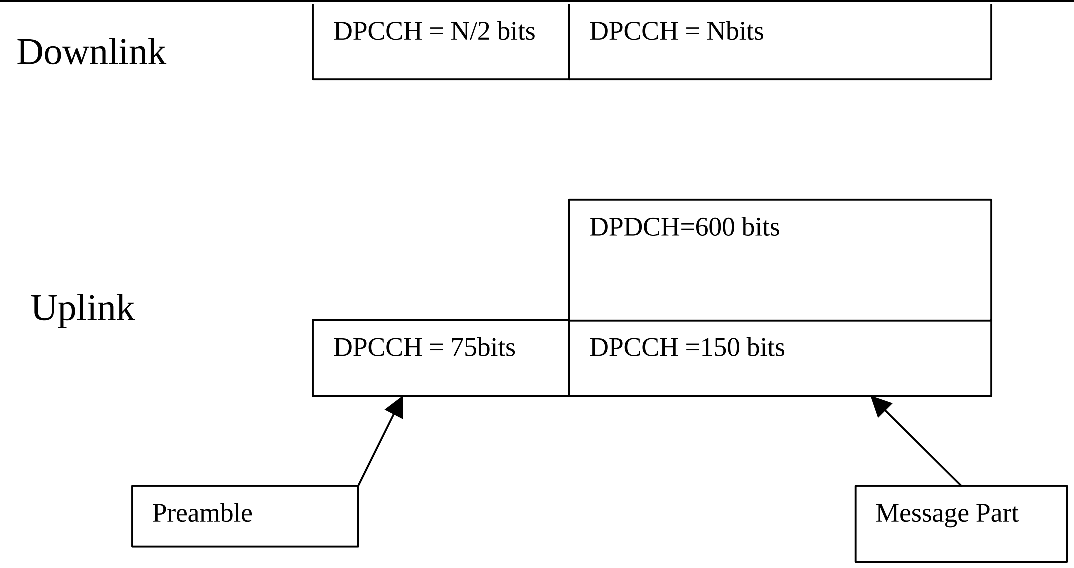

Figure 7: Transmission with preamble

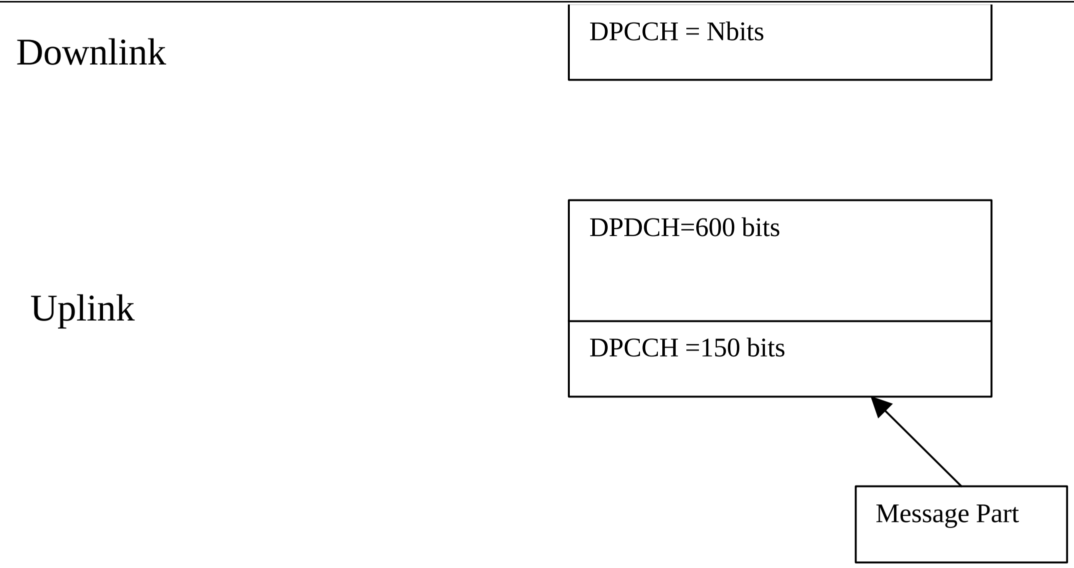

Figure 8: Transmission without preamble

Uplink

Here we consider just the first frame of data. The energy sent in the case with the preamble is

$$75*E_{init} + 750*E_{norm}$$

where E_{init} is the energy required per bit during initialisation and E_{norm} is the energy per bit in normal operation

The energy sent in the case without preamble is

$$750*(E_{norm}+E_{init})/2$$

Here we assume that the first half of the frame requires E_{init}.

For a benefit from the preamble we require that

$$75*E_{init} + 750*E_{norm} < 750*(E_{norm}+E_{init})/2$$

or

$$E_{init} > (375/300)E_{norm}$$

This means that E_{init} would need to exceed E_{norm} by about 1dB in order for a preamble to be worthwhile. This margin would be smaller for higher bit rates and larger for lower bit rates.

Downlink

In the case of a downlink with data, the same relation applies as for the uplink. For a downlink without data a different approach is needed.

Here we consider the whole packet length. With the preamble, the total energy sent on the downlink control channels is

$$E_{init}*N/2 + E_{norm}*N*L$$

Where L is the length of the packet in frames.

Without the preamble the total energy sent in the downlink is

$$E_{init}*N/2 + E_{norm}*N*(L-1/2)$$

The ratio of energy in the two cases is $(E_{init}/E_{norm}+2*L)/(E_{init}/E_{norm}+2*L-1)$.

It is not obvious what the exact value for E_{init} should be, but it may depend on whether any open loop power estimate is available for the downlink. In general it will be rather larger than E_{norm}. For E_{init}/E_{norm} =2 (i.e. 3dB), L=3, the increase in energy is 0.6dB. For E_{init}/E_{norm} =4 (i.e. 6dB), L=3, the increase in energy is 0.5dB. If a high spreading factor is used, this can be considered a small increase.

Annex B – Detailed simulation results

Table 2: Effect of error in starting power on Eb/No and SIR variance

UE speed / km/h	Std. dev.of starting power error / dB	Initial power control step size / dB and algorithm	Normal power control step size / dB and algorithm	Increase in Received Eb/No / dB	Increase in Transmitted Eb/No / dB	Increase in SIR variance / %
10	3	1dB, Alg 1	1dB, Alg 1	0.2	0.9	16
	3	2dB, Alg 1	1dB, Alg 1	0.3	1.0	30
	3	3dB, Alg 1	1dB, Alg 1	0.7	1.4	75
	6	1dB, Alg 1	1dB, Alg 1	2.7	3.3	267
	6	2dB, Alg 1	1dB, Alg 1	2.1	2.7	197
	6	3dB, Alg 1	1dB, Alg 1	2.1	2.7	200
	9	1dB, Alg 1	1dB, Alg 1	7.5	7.8	780
	9	2dB, Alg 1	1dB, Alg 1	6.6	6.9	563
	9	3dB, Alg 1	1dB, Alg 1	6.1	6.3	485
20	3	1dB, Alg 1	1dB, Alg 1	0.3	1.0	6
	3	2dB, Alg 1	1dB, Alg 1	0.3	1.2	13
	3	3dB, Alg 1	1dB, Alg 1	0.7	1.6	42
	6	1dB, Alg 1	1dB, Alg 1	2.8	3.5	173
	6	2dB, Alg 1	1dB, Alg 1	2.1	2.9	125
	6	3dB, Alg 1	1dB, Alg 1	2.0	3.0	125
	9	1dB, Alg 1	1dB, Alg 1	8.1	8.6	501
	9	2dB, Alg 1	1dB, Alg 1	6.5	7.2	367
	9	3dB, Alg 1	1dB, Alg 1	5.8	6.7	313
40	3	2dB, Alg 1	2dB, Alg 1	0.3	0.7	2
	3	3dB, Alg 1	2dB, Alg 1	0.4	0.9	13
	6	2dB, Alg 1	2dB, Alg 1	2.0	2.4	70
	6	3dB, Alg 1	2dB, Alg 1	1.7	2.3	68
	9	2dB, Alg 1	2dB, Alg 1	6.0	6.4	233
	9	3dB, Alg 1	2dB, Alg 1	5.2	5.7	189
60	3	2dB, Alg 1	2dB, Alg 1	0.5	0.8	13
	3	3dB, Alg 1	2dB, Alg 1	0.8	1.1	22
	6	2dB, Alg 1	2dB, Alg 1	2.4	2.8	79
	6	3dB, Alg 1	2dB, Alg 1	2.1	2.7	71
	9	2dB, Alg 1	2dB, Alg 1	7.0	8.1	219
	9	3dB, Alg 1	2dB, Alg 1	6.0	7.3	180
100	3	1dB, Alg 2	1dB, Alg 2	3.2	3.6	110
	3	1dB, Alg 1	1dB, Alg 2	2.6	3.1	83
	3	2dB, Alg 1	1dB, Alg 2	2.5	3.0	75
	6	1dB, Alg 2	1dB, Alg 2	6.9	7.4	269
	6	1dB, Alg 1	1dB, Alg 2	5.8	6.4	217
	6	2dB, Alg 1	1dB, Alg 2	5.4	6.0	188
	9	1dB, Alg 2	1dB, Alg 2	13.3	13.9	535
	9	1dB, Alg 1	1dB, Alg 2	11.8	12.5	449
	9	2dB, Alg 1	1dB, Alg 2	10.9	11.6	393
300	3	1dB, Alg 2	1dB, Alg 2	3.6	3.6	136
	3	1dB, Alg 1	1dB, Alg 2	2.9	3.0	111
	3	2dB, Alg 1	1dB, Alg 2	2.8	2.8	105
	6	1dB, Alg 2	1dB, Alg 2	7.3	7.3	296
	6	1dB, Alg 1	1dB, Alg 2	6.2	6.2	246
	6	2dB, Alg 1	1dB, Alg 2	5.7	5.8	222
	9	1dB, Alg 2	1dB, Alg 2	13.3	13.4	564
	9	1dB, Alg 1	1dB, Alg 2	11.8	11.8	480
	9	2dB, Alg 1	1dB, Alg 2	11.0	11.0	426