TSG-RAN Working Group1 meeting #15
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Agenda Item:
Source: **SAMSUNG Electronics Co.**
Title: Revised Uplink Interference Reduction Gain of Gated DPCCH Transmission
Document for: **Discussion**

1. Introduction

At the last WG1#14 Oulu meeting Samsung presented the uplink interference reduction gain of gated DPCCH transmission [1]. There were several comments on the simulation parameters and, in this document, we update the results with considering those comments. The comments were:

- *DPDCH/DPCCH gain factor is not realistic (2.69dB)*
- *Practical channel estimation is not considered (ideal channel estimation)*

We change the simulation parameters as follows.

- *DPDCH/DPCCH = 5dB*
- *WMSA channel estimation*

From the updated results, we found that the new results are fairly equivalent from the previous results. One thing that should be noted is that the pilot field is always transmitted continuously when there is DPDCH frame during gating. The increased power of DPDCH reduces the required Eb/No while the decreased power of DPCCH affects the channel estimation performance. Thus the overall results reflect the increased DPDCH power and the deteriorated channel estimation. The rest part of this document is based on the previous one and we just update it.

In this document, we show the average uplink interference reduction gain in uplink/downlink gated DPCCH transmission mode. In gating mode, the following transmission cases are possible.

- DPCCH only transmission
- DPDCH and DPCCH transmission

That is, as shown in Figure 1, DPCCH is always transmitted but DPDCH can be transmitted when there's data to transmit during gating mode. (Here, for example, DPDCH transfers low rate data such as signaling message which is usually transmitted occasionally. Let "DPDCH frequency" be the probability of transmitting DPDCH during gating mode.)

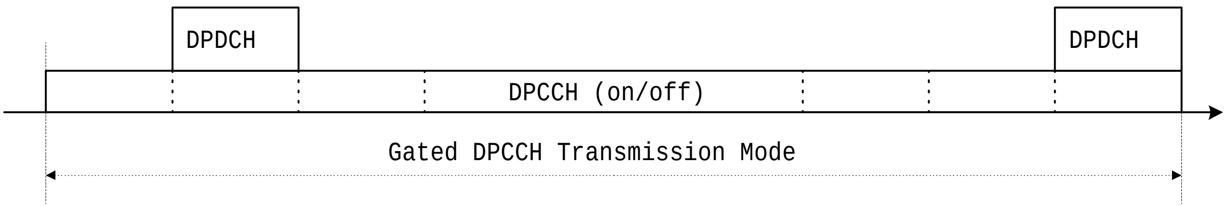

Figure 1. DPDCH Transmission during gated DPCCH transmission mode

The average interference reduction gain is defined as:

Average Uplink interference reduction gain
= (average transmit power when no gating)/(average transmit power when gating)

Note that the average uplink interference reduction gain is defined as the ratio of the average transmission power. Although the transmit power of DPDCH should be increased to compensate the reduced power control rate, the transmit power can be saved during DPCCH only transmission period. Thus the average interference reduction gain highly depends on the DPDCH frequency, and the results are shown with respect to the DPDCH frequency ranges from 1% to 30%.

Simulation and analysis results show that the average interference reduction gain is 4~6dB if the DPDCH frequency is 1%, 2.0~2.5dB if the DPDCH frequency is 10%. Since the average interference reduction gain the ratio of average transmit power, the gated DPCCH transmission provides gain in terms of UE Tx power saving.

2. Link level simulation

2.1 Simulation parameters

The link-level simulation was performed to evaluate the required Eb/No of uplink DPDCH during gated DPCCH transmission mode. Note that the performance of the uplink DPDCH depends on the uplink power control rate (downlink TPC rate). More precisely, the FER of uplink DPDCH is simulated when the downlink TPC is transmitted with rate 1, 1/3, and 1/5. The channel models are CASE1 for 3km/h and CASE3 for 120km/h[11]. The detail simulation parameters are shown in table 1.

Table 1. Simulation parameters (uplink)

Carrier frequency		2.0 GHz
Chip rate		3.84 Mcps
Channel bit rate	DPDCH	60 kbps
	DPCCH	15 kbps
Modulation	Data	BPSK
	Spreading	QPSK
Slot structure	DPCCH	Pilot: 6, TPC: 2, TFCI: 2
	DPDCH	Data: 40
Channel model	Multi-path fading	2-path Rayleigh
	Finger	2 fingers
	Receiver antenna diversity	On
	Doppler frequency [Hz]	5.6(3km/h) , 222(120km/h)
DPCCH/DPDCH [dB]		-5dB
Power control	Dynamic range	Unlimited (assume ideal power amplifier)
	Step size	1.0 dB
	Rate	1500Hz(1/1 gating = no gating), 500Hz(1/3 gating), 300Hz(1/5 gating)
	TPC error	4%
Channel estimation		WMSA

2.2 Simulation results

Figure 2 and 3 show the uplink DPDCH FER when the downlink TPC is transmitted with rate 1, 1/3, and 1/5, where R represents gating rate.

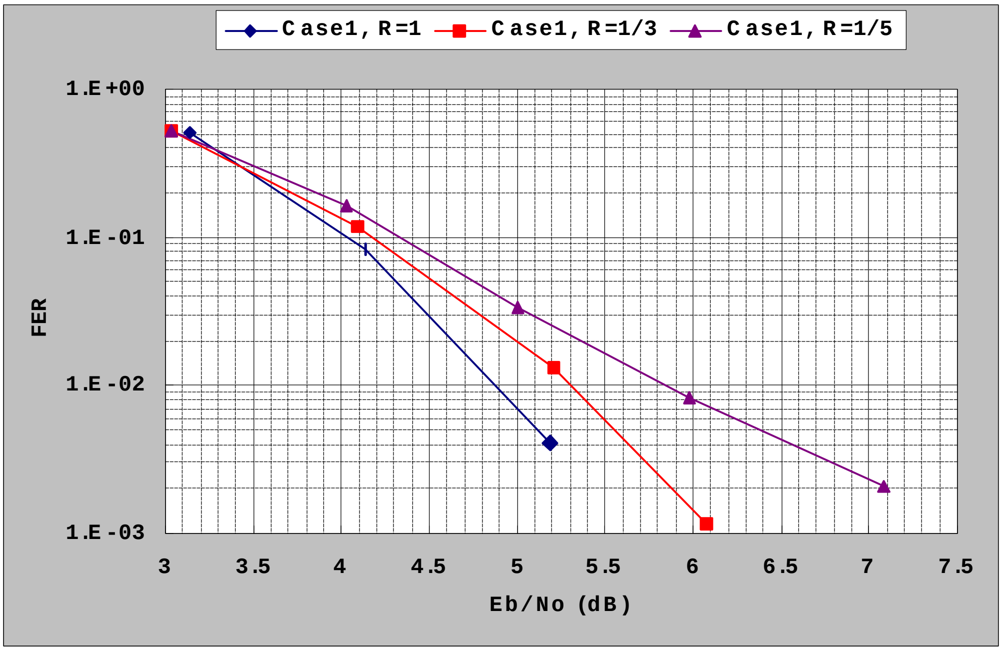

Figure 2. Uplink DPDCH Frame Error Rate with various gating rate and speed (Case 1)

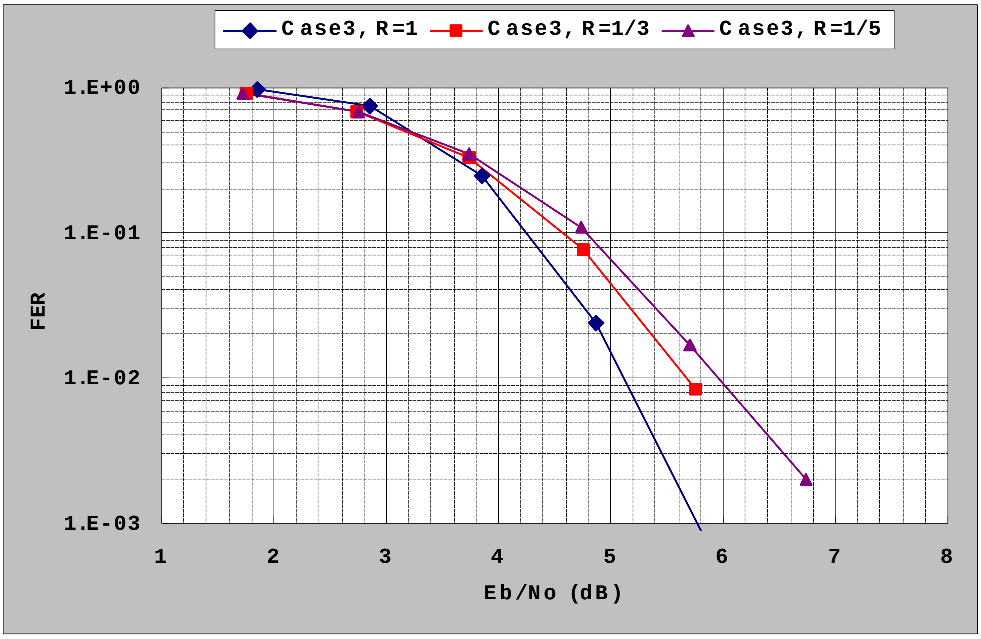

Figure 3. Uplink DPDCH Frame Error Rate with various gating rate and speed (Case 3)

The required received Eb/No for the uplink DPDCH to obtain 1% FER is summarised in table 2 when the gating pattern is random. In addition, the Eb/No difference compared with gate rate 1 is also given. From the results, we can see that the Eb/No loss by 1/3 rate gating at 3km/h is about 0.42dB, for example. The uplink DPCCH performance loss, which is measured by TPC BER, due to gated DPCCH transmission is max. 0.5dB for gating rate=1/5.

Table 2. Required Rx E_b/N_0[dB] to maintain 1% FER (Uplink DPDCH Performance with downlink random gating pattern[14])

UE speed	Gating Rate		
	1/1	1/3	1/5
Case1(3km/h)	**4.88**	5.3(+0.42)	5.88(1.0)
Case3(120km/) h	**5.1**	5.68(0.58)	6.0(0.9)

* ( ) indicates Eb/No difference compared with 1/1(no gating)
Rx. $E_b = E_{DPDCH} + E_{DPCCH}$ per one antenna

2.3 Uplink Interference Reduction Gain

In this subsection we analyse the average uplink interference reduction gain in gated DPCCH transmission mode based on the link simulation results in subsection 2.2. The disadvantage of the gated DPCCH transmission is the increase of the required Eb/No to obtain 1% DPDCH FER. In addition, the transmit power of DPCCH also should be increased due to reduced uplink power control rate. The average uplink interference reduction gain is defined in section 1 and restated for convenience.

Average uplink interference reduction gain
= (Average transmit power when no gating)/(Average transmit power when gating)

In order to see the gain, let's assume the following parameters.

F = DPDCH frequency (%), R = Gating rate (1, 1/3, or 1/5) P_{DPCCH} = Power of DPCCH, P_{DPDCH} = Power of DPDCH = $\alpha \times P_{DPCCH}$ (α=5dB) A_{DPCCH} = Additional Eb/No required for DPCCH only transmission (0.5dB) A_{DPCH} = Additional Eb/No required for DPDCH+DPCCH transmission (Given in table 2)

From the assumed parameters, only DPCCH is transmitted in F% of time, and both (DPDCH+DPCCH) are transmitted in (100-F)% of time. The average uplink interference reduction gain is defined as the ratio of average transmission power as follows.

Average Uplink Interference Reduction Gain

Average uplink interference reduction gain = 10 * log10 (P(no gating)/P(gating))

where P(no gating) and P(gating) represents the average transmit power when the gated DPCCH transmission is disabled and enabled, respectively.

P(no gating)

The average transmit power when the gated DPCCH transmission is disabled is given by

P(no gating) = (Average transmit power when no gating) = (100-F) * P_{DPCCH} + F * (P_{DPCCH} + P_{DPDCH}) = (100+$\alpha \times$F) P_{DPCCH}

P(gating)

The average transmit power when the gated DPCCH transmission is enabled is given by

P(gating) = (Average transmit power during only DPCCH transmission when gating) + (Average transmit power during (DPDCH+DPCCH) transmission when gating)

During DPCCH only transmission period, the average transmit power is given by

(Average transmit power during only DPCCH transmission when gating) = (100-F) * P_{DPCCH} * 10^(0.1*A_{DPCCH})* R

During both (DPDCH+DPCCH) transmission period, there is E_{DPCH} loss, so the required power is

(Average transmit power during (DPDCH+DPCCH) transmission when gating) = F * (P_{DPCCH} + P_{DPDCH}) * 10^(0.1*A_{DPCH}).

Based on the above method, we calculate the average uplink interference reduction gain for 1% DPDCH frequency as table 4 (F=1).

Table 4. Uplink interference reduction [dB] (1% DPDCH frequency)

UE speed	Overall interference reduction gain [dB]	
	1/3	1/5
3km/h	**3.94**	**5.75**
120km/h	**3.93**	**5.77**

Consequently, in case of 1% DPDCH frequency, the uplink interference reduction gain (~5.77dB) can be achieved by gated DPCCH transmission in spite of increasing transmission power of DPDCH during gating. The DPDCH frequency has an important role in the uplink interference reduction gain. Figure 4 shows the average uplink interference reduction gain against the DPDCH frequency for regular and random gating pattern, respectively. From these figures, we can see that more than 2.5dB gain can be achieved when the DPDCH duty cycle is 10%, and the gain increases as the DPDCH frequency decreases.

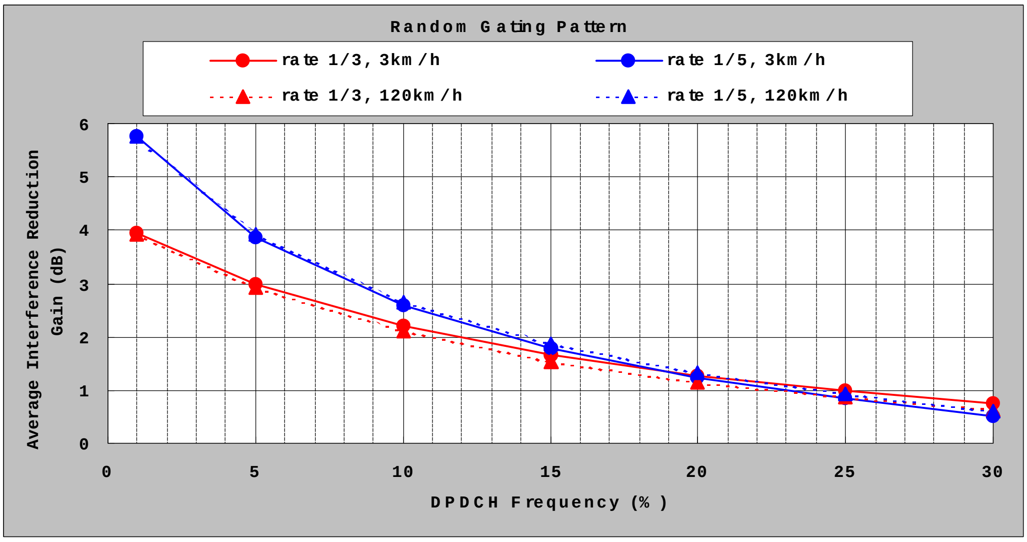

Figure 4. Average uplink interference reduction gain (Random Gating Pattern)

3. Conclusion

With the updated simulation parameters such as DPDCH/DPCCH gain factor and practical channel estimation we revised the previous simulation results to see the uplink interference reduction gain. From the updated results, we can see the gain even with the practical simulation parameters.

From the results, we can see that if the DPDCH duty cycle is 10%, the interference reduction gain is about 2.5dB, and the gain increases as the DPDCH frequency decreases. Consequently, we can conclude that the gated DPCCH transmission is beneficial to the interference reduction, that is, the transmit power reduction.

Reference

[1] TSGR1#14(00)907, “Uplink Interference Reduction Gain of Gated DPCCH Transmission”, SAMSUNG

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