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Agenda item:

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Title: Uplink compressed mode performance results

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1 Introduction

The use of compressed mode for measurements on other frequencies, modes and systems is necessary to avoid expensive and current consuming receiver structures. The major drawback when using compressed mode in the uplink is the performance loss due to the limited output power of the UE. Many of the schemes, such as modifying the spreading factor or the channel coding compresses the information in time but needs to be transmitted with a higher power in order to maintain the targeted bit-error-rate (BER) or frame-error-rate (FER).

This document presents simulation results on the degradation of the uplink due to uplink compressed mode.

2 Models

2.1 Simulation set-up

An overview of the UTRA/FDD uplink simulator is shown in Figure 1. As seen in the figure, the simulator uses antenna diversity in the receiver. For the closed loop power control commands, the downlink is modelled as a binary symmetrical channel with an error rate of 4%. No error recovery scheme as recently discussed in WG1 has been employed.

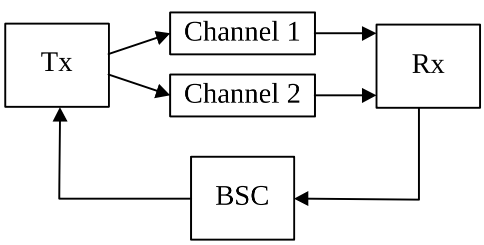

Figure 1. Overview of the WCDMA simulator

2.2 The speech service

When evaluating compressed mode, the services of interest are real-time services, like speech. For other services, the measurement period can be accomplished by delaying the data one extra frame and then use the idle frame for measurements.

The service evaluated in this paper is the 8 kbps speech service. The set-up of the service is presented in Table 1.

Table 1. Service set-up

Physical channel rate	32 kbps
Info/CRC/tail bit per 20 ms	160/16/8
Convolutional coding rate	1/3
Repetition per 20 ms	88 bits
Interleaver	20 ms
Pilot/TPC/TFI bits per slot	7/3/0

2.3 Compressed mode

In the compressed mode simulations, two successive frames are operating in compressed mode, creating a transmission gap length of 10 ms (see Figure 2). This is repeated every 12 frames, creating a pattern of measurement slots where 2/12 of the frames are compressed. The speech service, described earlier, uses 20 ms interleaving.

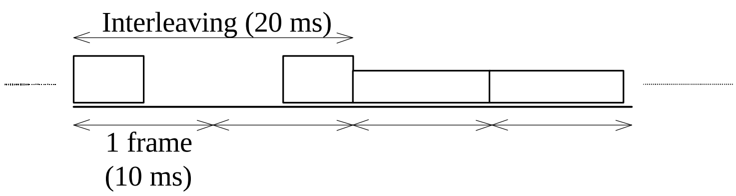

Figure 2. Compressed mode transmission.

To compress the transmission, the spreading factor is reduced by a factor two. The transmit power during compressed mode is increased by 3 dB to compensate for the lower spreading factor.

3 Simulation Results

The evaluation was done both for users inside the cell and for users at the cell border. The difference between these two cases is that inside the cell, the UE can increase the transmit power during compressed mode operation but at the cell border, the UE is constantly operating at its maximum power and can therefore not increase the power during compressed mode.

3.1 Performance at the cell border

At the cell border, the UE will be operating constantly on the maximum power of the power amplifier. Hence, the power control will not work.

First, the performance without closed loop power control was evaluated. The performance was evaluated by finding the required E_b/N_0 for a target bit error rate (BER) of 0.1 %. As seen in Figure 3, the performance for compressed mode is very close to the performance for the normal mode. The performance is slightly better for the compressed mode. This since the power of the pilot symbols is higher, thereby improving the quality of the channel estimates.

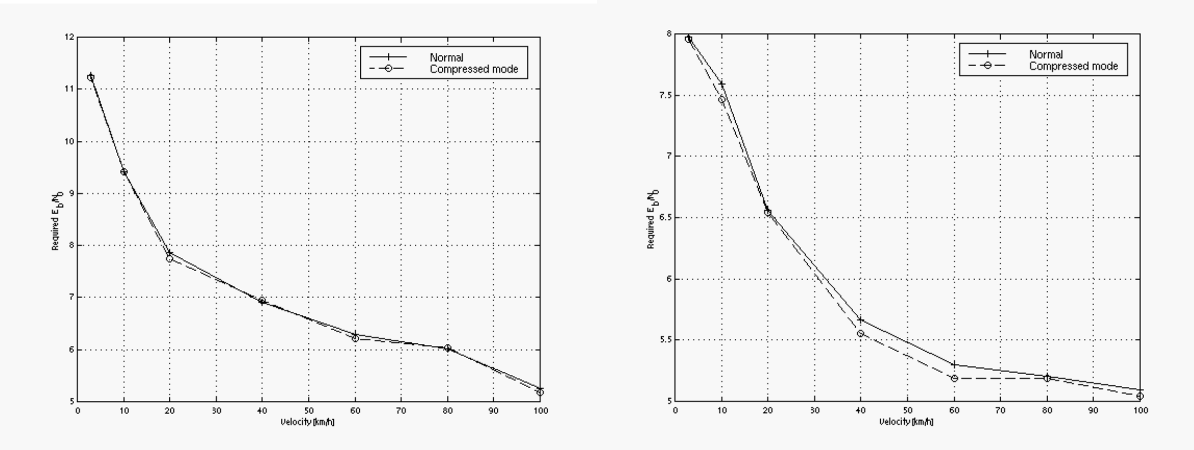

Figure 3. Required E_b/N_0 for a BER of 0.1%. Simulations without closed loop power control in the *Outdoor to indoor A* (left) and *Vehicular A* (right) environment.

In the above evaluation it was assumed that the power during compressed mode was increased by 3 dB to compensate for the lower spreading factor. Since the UE in this case is operating at the cell border, it can not increase the peak power in compressed mode. This will therefore degrade the performance.

To evaluate this, the indoor environment at low speed (3 km/h) was chosen. The performance for the frames in compressed mode and for the frames in normal mode is shown in Figure 4. As seen in the figure, the frame error rate (FER) for the compressed frames is slightly lower than for the normal frames.

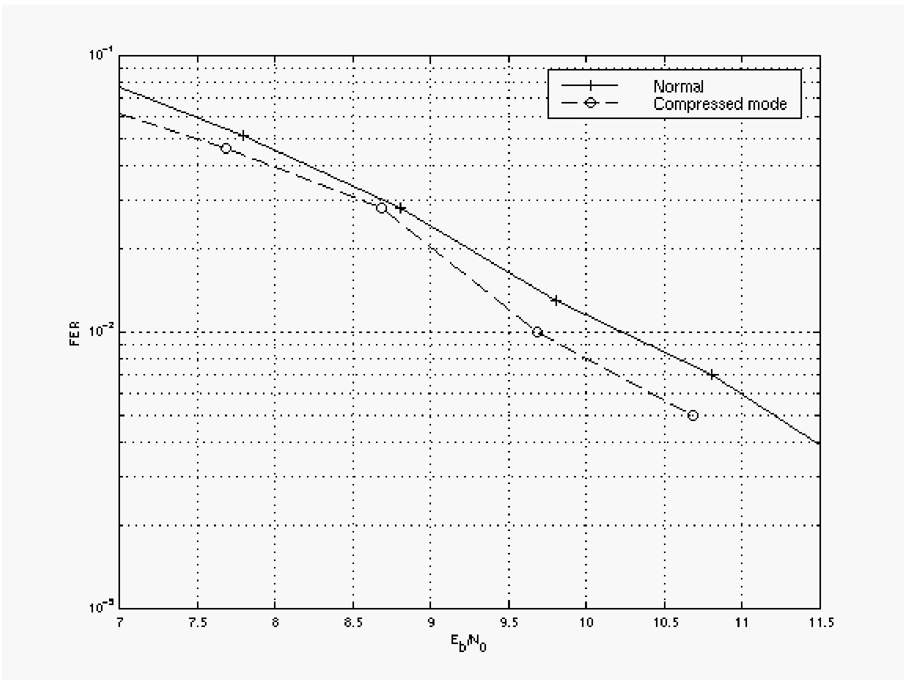

Figure 4. FER versus E_b/N_0 for the normal and the compressed frames in the *Outdoor to indoor A* environment at a UE velocity of 3 km/h.

A target FER of 1% can be achieved at an E_b/N_0 of 10.25 dB for the normal frames. If the UE output power is limited, and thereby the E_b/N_0 decreased by 3 dB, resulting in E_b/N_0 of 7.25 dB, the FER for the compressed frames are 5.5%.

Assuming that 1/6 of the frames are operating in compressed mode, the average FER will be *5/6*1% +1/6*5.5% = 1.75%*. It can also be found that in order to maintain an average FER of 1%, the E_b/N_0 have to be increased by 1 dB (11.25 dB and 8.25 dB respectively).

3.2 Performance inside the cell

Figure 5 and Figure 6 show the performance when the closed loop power control is used. In Figure 5, the BER is plotted against the received E_b/N_0 and in Figure 6 the BER is plotted against the transmitted E_b/N_0. As seen in the figures, the performance is degraded by at the most 0.3 dB for both the indoor and vehicular case. This degradation is due to the worse performance of the closed loop power control.

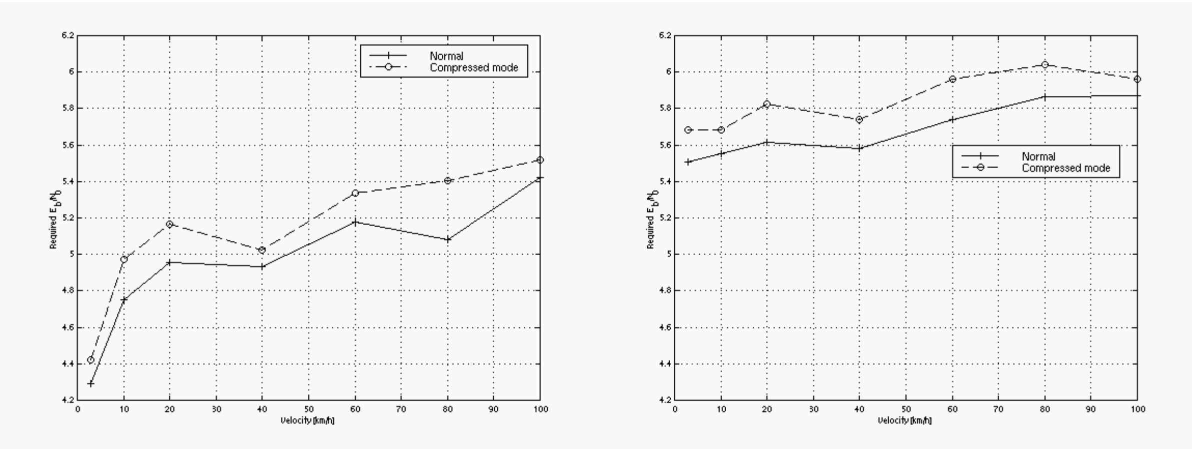

Figure 5. Required received E_b/N_0 for a BER of 0.1%. Simulations with closed loop power control in the *Outdoor to indoor A* (left) and *Vehicular A* (right) environment.

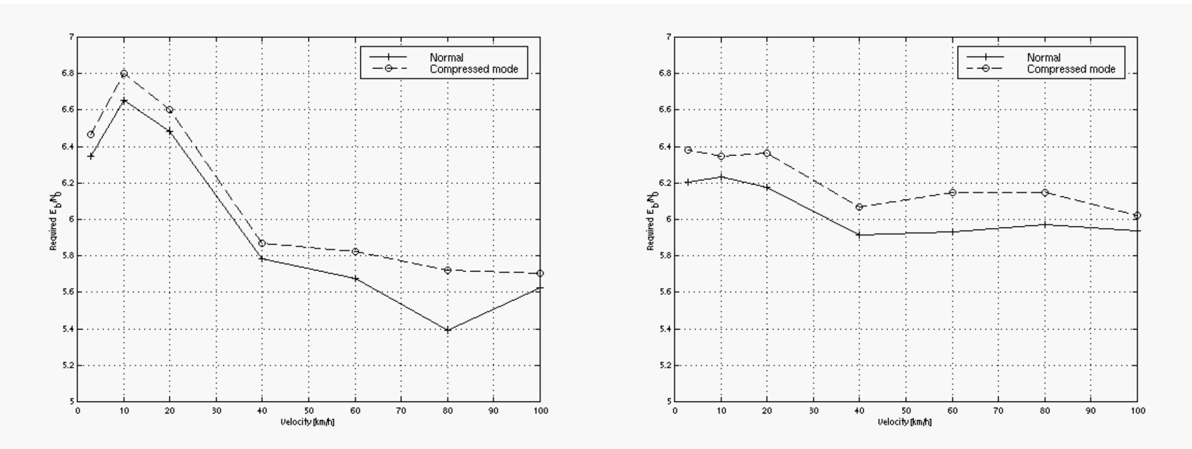

Figure 6. Required transmitted E_b/N_0 for a BER of 0.1%. Simulations with closed loop power control in *Outdoor to indoor A* (left) and *Vehicular A* (right) environment.

4 Conclusions

Simulations of uplink compressed mode have been performed where a 10 ms transmission gap is created every 12 frames, or equivalently, one frame out of six is compressed. The difference in performance for frames operating in normal and compressed mode is less than 0.3 dB inside the cell, where the output power is not limited by the power amplifier. When the limited output power of the amplifier for an UE operating at the cell border is considered it is found that the average FER is increased from 1% to 1.75% and that the E_b/N_0 needs to be increased by 1 dB to combat this.

It should be noted that if the system is planned to allow for some degree of power control even at the cell border, the loss indicated at the cell border will be smaller. Also, if the transmission gaps needed are smaller or less frequent, the loss will be smaller as well.