Agenda item: Adhoc 26

Source: Motorola

Title: Closed loop transmit diversity mode 2 with reduced states for 4 elements (updated)

Document for: Information and discussion

INTRODUCTION

Currently, different schemes of closed loop transmit diversity are being studied for more than 2 elements [1], [2], [3]. In this paper we provide further simulation results relative to R1-00-1132 *: " Closed loop transmit diversity mode 2 with reduced states for 4 elements".* The main updates are relative to the channel estimation and correlated channel models. Moreover, although the reduced states (4 phase only constellation of the antenna weights) is considered here, the actual Rel'99 mode 2 with higher resolution in terms of phase and amplitude is also applicable for the 4 elements case, which would bring additional gains in the correlated channel model cases, i.e. micro and macro cellular, as described in R1-00-1180 : *"Channel model for Tx diversity simulations using correlated antennas".*

Regarding channel estimation, the current assumptions in most of the studied schemes assume an ideal verification, that is the use of the channel estimates from CPICH (also assumed as the phase reference) for symbol demodulation, assuming the actuall applied coefficients at the UTRAN-AP to be perfectly known. In this paper, results are shown when channel estimation for symbol demodulation is done based on DPCCH pilots ONLY.

The results shows that the existing Rel'99 closed loop transmit diversity can be extended to the case of more than 2 elements with reasonable trade-off between resolution and feedback delay vs mobile speed. This is of main interest when considering limited feedback bit per slot (1 bit feedback per slot for Release 99 specs).

Finally, some comments are also included relative to the current extensions being proposed and the existing Rel'99 closed loop transmit diversity schemes.

1. DESCRIPTION OF THE MODIFIED CLOSED LOOP MODE 2 FOR 4 ELEMENTS.

Recalling the description of the modified mode 2 CL transmit diversity in R1-00-1132, we consider 4 phase states per element which are defined in Table 1.

Table 1: FSM of modified closed loop mode 2 signalling message per element

FS	Phase difference between antennas (degrees)
00	π
01	$-\pi/2$
11	$\pi/2$
10	0

Therefore we need 6 bits feedback per slot for the update of the antenna coefficients. In this paper we have considered **1 bit feedback per slot ("Mode2_4p0g")** to demonstrate the effect of feedback delay vs resolution and also for comparison to the current mode 1, i.e. 2 transmit antennas as per Rel 99' specifications.

2. SIMULATION ASSUMPTIONS.

Bit Rate	12.2 kbps
Chip Rate	3.84 Mcps
Convolutional code rate	1/3
Carrier frequency	2 GHz
Power control rate	1500 Hz
PC error rate	4 %
PC Step Size	1 dB total
Channel model(s) and UE velocities	Modified ITU Ped. A : 3 to 40 km/h
Number of Rake Fingers	2 fingers for ITU Ped. A Channel
CL feedback bit error rate	4 %
CL feedback delay	1 slot
TTI	20 ms
Target FER/BlkER	1 %
Geometry (G)	0 dB
Common Pilot	-10 dB total
Correlation between antennas	Pico and Micro models
Channel Estimation	DPCCH pilots ONLY and Ideal Verification
CL feedback rate	1500 bps

3. SIMULATION RESULTS

The performance of the 4-elements extension of Rel-99 mode 2 is compared here to the Rel-99 CL Tx diversity mode 1, which is used as reference for performance comparison to other schemes proposed.

3.1 Modified ITU Ped. A (ETRP) : Dedicated pilot channel estimation

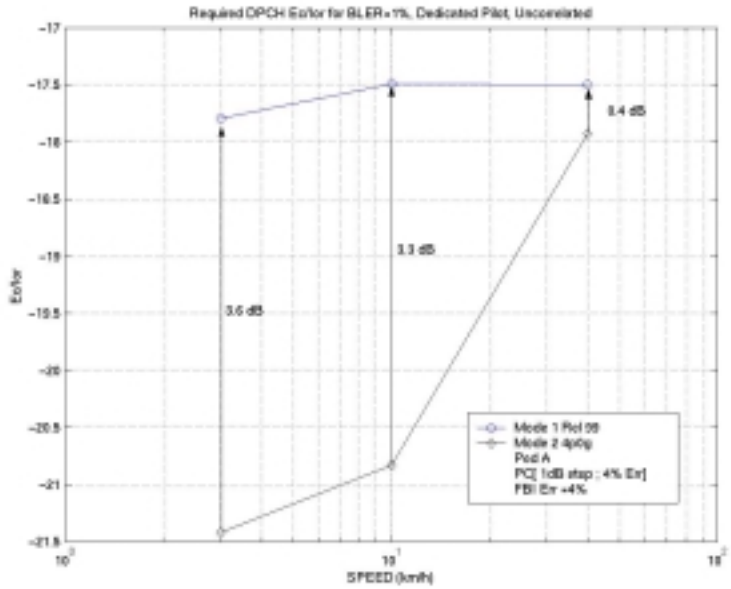

Figure 1 : 4-elements reduced state mode 2 for uncorrelated channel model

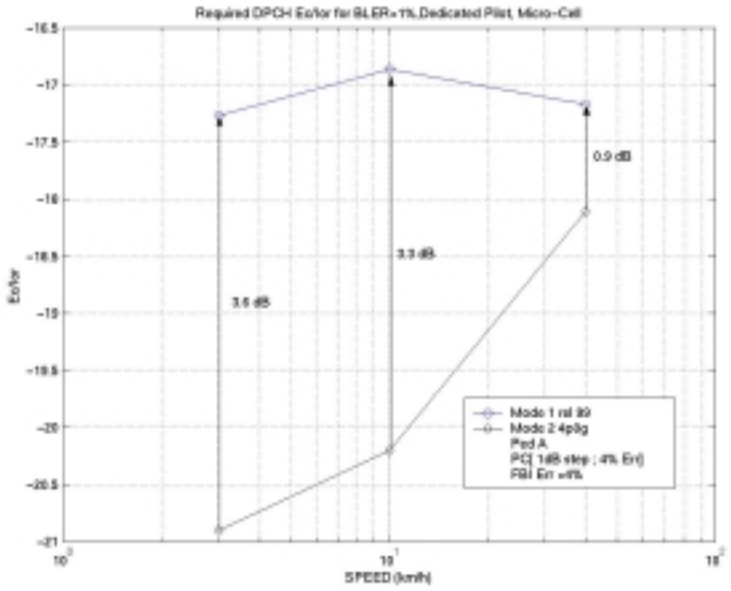

Figure 2 : 4-elements reduced state mode 2 for micro-cell channel

3.2 Modified ITU Ped. A (ETRP) : channel estimation assuming Ideal verification

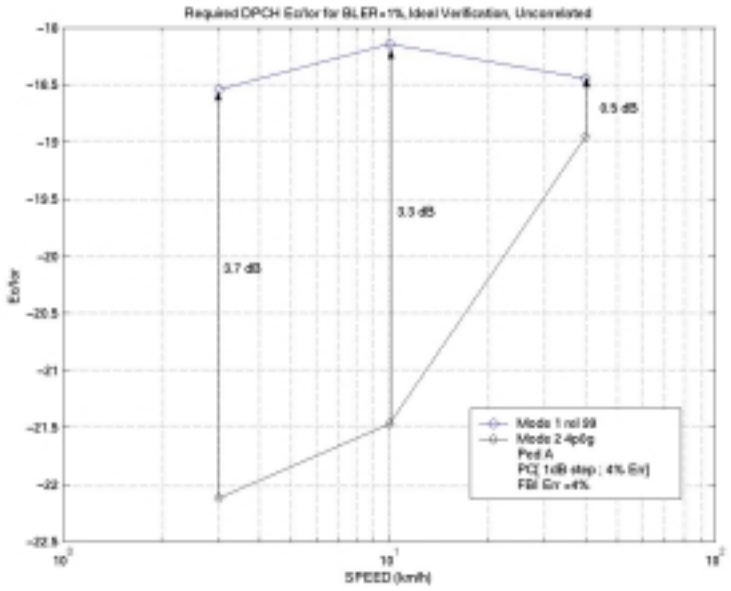

Figure 3 : 4-elements reduced state mode 2 for uncorrelated channel

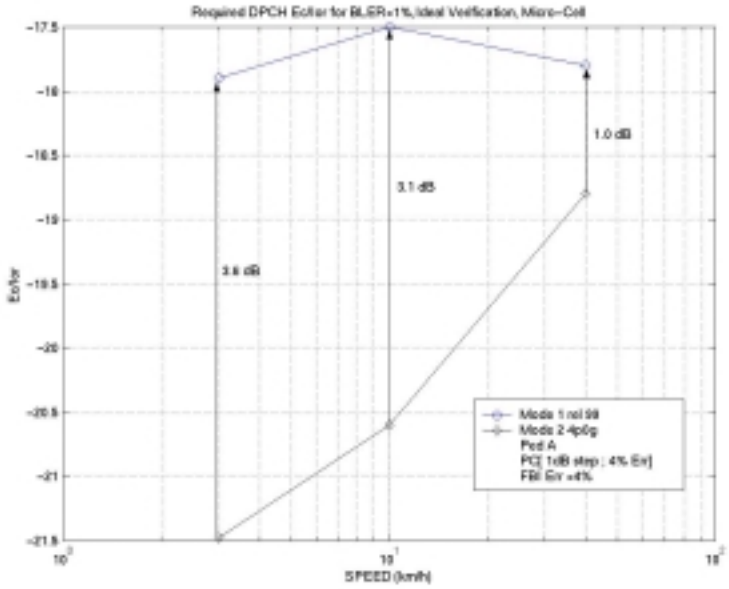

Figure 4 : 4-elements reduced state mode 2 for micro-cell channel

4. DISCUSSIONS

Dedicated pilot channel estimation :

Based on the results shown , it can be observed that for the case of **1500 bps**, i.e 1 bit feedback per slot, the gain obtained by the extended mode 2 with reduces phase states relative to Rel 99 Mode 1, ranges from **3.6 dB to 0.4 dB** within the range of **3 to 40 km/h,** for the uncorrelated channel model. Moreover, typically a gain of **1 dB @ 10kmh** is observed relative to the current other proposed schemes [R2F2 and Eigenbeamformer in R1-01-0203]. This shows that this mode, with limited quantization resolution, gives relatively high gains at very low speeds and maintain acceptable gains up to relatively high speeds given this low feedback rate.

Correlated channel case (micro cell case)

In the correlated channel conditions, the results shown here are for a 4-phase states constellation per antenna. It is clearly shown that, this limited phase resolution mode 2 provide gains relative to Rel 99 Mode 1, from **3.6 dB to 0.9 dB** within the range of **3 to 40 km/h,** for the micro-cell channel model. Moreover, typically a gain of **1 dB @ 10kmh** is observed relative to R2F2 and same performance as the Eigenbeamformer [R1-01-0203]

However, relative to the eigenbeamformer, for the mode 2-4p0g limited phase resolution is obtained, while performance highly depends on the quantization and transmission quality of the optimum antenna coefficients [see typically peformance of the eigenbeamformer in R1-01-0203]. Thus antenna coefficients with higher phase resolution, similar to the current Rel-99 mode 2 should improve the performance accordingly. It should also be noted that particularly for the eigenbeamformer, the feedback information on the beam selection is error free, thus further degradation in R1-01-0203 should be expected. Finally, for narrow angular spread, i.e. macro cell, sectorisation in conjunction with closed loop transmit diversity schemes (Rel 99 and their extensions) should also bring additional gains.

Another remark is that Open loop Adaptive Antenna with 0.5 wavelength spacing does not provide diversity gain, whereas with Closed loop transmit diversity modes, both beamforming and diversity gain are obtained and moreover there are calibration/installation issues with OL AA, which are not issues with closed loop transmit diversity.

Ideal verification :

The results shows that when ideal verification is assumed, there is no significant change in behaviour other than improved performance for both 2 elements and 4 elements schemes due to the use of channel estimates from the CPICH channel.

5. CONCLUSIONS

In this paper, results are presented for a simple extension of mode2, with reduced phase states per antenna coefficient. These results basically shows that :

- the existing Rel'99 closed loop transmit diversity can be extended to the case of more than 2 elements with reasonable trade-off between resolution and feedback delay vs mobile speed.

- The 4 elements extensions of mode 2 does bring "beamforming" gain too, without the need of calibration as for the case of "OL AA".

- For the correlated channel cases, higher phase resolution (similar to the 2 elements Rel 99 Mode 2) should enhance the beamforming gain and thus perform relatively well, given the already reasonable trade-off between resolution and feedback delay vs mobile speed.

6. REFERENCES

[1] Motorola, Closed loop transmit diversity mode 2 with reduced states for 4 elements, TSGR1#15(00)1132, 22-26th, August, 2000**,** Berlin, Germany

[2] Nokia, An extension of closed loop Tx Diversity mode 1 for multiple Tx antennas, TSGR1#13(00)0712, 22-25th May, Tokyo, Japan.

[3] Siemens, Advanced closed loop diversity concept (eigenbeamformer), TSGR1#14(00)0853, 4-7th 7th July, Oulu, Finland

[4] Siemens, Simulation parameters for Tx diversity simulations using correlated antennas, Tdoc R1-00-1180

[5] Samsung and Seoul National University, Preliminary version of algorithm and simulation results for Tx diversity with more than 2 Tx Antennas, TSGR1#14(00)0882, 4-7th July, Oulu, Finland.