
Agenda item: AH32: HSDPA
Source: Motorola
Title: HS-DSCH Closed Loop Tx Diversity Mode 1 and Mode 2 Robustness
Document for: Discussion

1. SUMMARY AND RECOMMENDATIONS

Questions remained during TSG RAN WG1 #28 on the robustness of closed loop modes when demodulation references are synthesized using antenna verification. Link throughput results [1] using verification, hybrid ARQ (HARQ) and adaptive modulation and coding (AMC) were presented at the meeting. These results indicated both closed loop modes provide significant gains over a single antenna. However, such link throughput comparisons do not provide insight on the behavior at the highest AMC states where robustness is of greatest concern. Furthermore, previous results did not indicate performance when less than 8 dedicated pilot bits are used. This contribution provides results on fairly challenging verification conditions. The FER for mode 1 and mode 2 for high AMC states in pedestrian A channels with 4 dedicated pilots bits is given. Corresponding link throughput numbers are also provided for pedestrian A and vehicular A channels. The results indicate:

- *Under light multipath conditions at pedestrian speeds, modes 1 and 2 have similar amounts of robustness at the highest AMC states, exhibiting similar trends in FER. While the trends in SNR are similar, mode 2 has consistently lower FER than mode 1.*
- *Mode 2 link throughput is consistently higher than mode 1, even at high SNR and with a reduced number of dedicated pilot bits. At 15 dB SNR, mode 2 has 5% higher capacity than mode 1 in vehicular A conditions.*
- *Results of a similar study [2] differ somewhat (particularly in regard to the performance of mode 2). Differences in the results may be in part due to the absence of forward DPCH power control in [2].*

When mode 1 was adopted for use on HS-DSCH in WG1 #28, the concerns expressed for the adoption of mode 2 were mostly related to its robustness when verification is used.

Since mode 2:

- **provides greater link throughput than mode 1 at pedestrian speeds, even under challenging verification conditions.**
- **is able to be used with any forward link slot format (mode 1 is restricted to two or more pilot symbols)**

And adopting both modes:

- **maintains compatibility with the mandated use of both closed loop modes in release '99 UEs.**
- **allows the best performance at low and high UE velocities (since mode 1 can perform better at high velocities)**

We recommend mode 2 also be permitted for use on the HS-DSCH.

2. LINK SIMULATIONS

Two sets of link (sub-chip resolution) simulations were run for closed loop transmit diversity modes 1 and 2: with and without adaptive modulation and coding (AMC) and Hybrid ARQ (HARQ). Table 1 contains simulation parameters common to both sets of simulations, while tables 2 and 3 have the settings for the fixed and AMC simulations, respectively.

In all simulations, the dedicated pilots of the associated DPCCH were simulated on the forward links. The reverse link is assumed to be static. The noise is adjusted on the reverse link so that the FBI feedback errors correspond to one-way soft-handoff (about 4%). Demodulation references were derived from the CPICH, and a Rake receiver was used. The simulations were run with UE verification of TxAA weights used at Node B only (using the verification method of [3] for mode 2 and of [4] for mode 1).

Table 1. Common Simulation Parameters

Parameters	Value
HS-PDSCH Ec/Ior	-1 dB
Mobile Speed	3 km/h
CPICH Channel Estimation	Ideal
Pilot Power Fraction	10% Total (5% Per Antenna)
Overhead Power Fraction	10% Total
UE TxAA Verification	Per 25.214
Node B Verification	Off
TxAA Update Technique	Modes 1 & 2 Per 25.214
Feedback Delay	TxAA: measure in slot n; apply in slot (n+2)
Channel coding	Turbo Codes
Inner-loop transmit power control (TPC)	On, Target=3 dB Es/Nt
Forward Link Pilot Bits	4 (as in slot format 9)
FBI Error Rate	4%
Forward Link DPCCH SF	128
Outer-loop power control	Off
TPC step size	0.5 dB
TPC command error rate	0%

Table 2. Fixed MCS Simulation Parameters

Parameters	Value
Channel	Pedestrian A
SNRs Tested	0-20 dB, in 5 dB steps
Mobile Speed	3 km/h
OVSF Codes Used for HS-PDSCH	5 codes out of 16
Frame Size	480 symbols
MCS States	16QAM: R={1/2 or 3/4} (fixed)

Table 3. AMC Simulation Parameters

Parameters	Value
SNRs Tested	5 and 15 dB
Channel	Pedestrian A and Vehicular A
OVSF Codes Used for HS-PDSCH	12 codes out of 16
Frame Size	1920 symbols
MCS States	QPSK: $R=\{1/4, 1/2, 3/4\}$; 16QAM: $R=\{1/2, 5/8, 3/4\}$
ARQ Delay	1 st transmit in TTI m 2 nd transmit in TTI $(m+4)$

3. LINK SIMULATION RESULTS

Figure 1 shows the throughput (in bits/symbol) for the 5 code, fixed MCS simulations. We observe that mode 2 has higher throughput over virtually all¹ SNRs for both the rate $1/2$ and $3/4$ codes. The higher throughput even at high SNR indicates the robustness of mode 2: the verification performance is not losing the capacity that can be achieved at high SNR.

Table 4 below contains results from the 12 code, AMC simulations. We observe that mode 2 has higher link throughput under all conditions tested.

Table 4. AMC Simulation Results

Velocity	SNR (dB)	Channel Model	Mode 1 Tput (bits/symbol)	Mode 2 Tput (bits/symbol)	Gain Mode 2 / Mode 1
3 km/h	5	Ped. A	1.07	1.14	6.5%
		Veh. A	0.63	0.65	3.2%
	15	Ped. A	1.83	1.85	1.1%
		Veh. A	0.81	0.85	5.0%

This relative robustness of mode 2 verification is contrary to the intuition that mode 2 verification must be significantly more error prone than mode 1. We observe that while there are more states to check for mode 2, this is not the only factor affecting verification performance. For example, mode 2 does not use orthogonal dedicated pilots, and so has more received power on the dedicated pilot. Furthermore, when there is a feedback error in mode 1, the phase will be off by at least 90 degrees, while a feedback error in mode 2 can be off by 45 degrees (and its error performance is improved by the Gray coding of the phase bits).

4. COMMENTS ON A RELATED CONTRIBUTION

Results examining mode 1 and mode 2 performance have been presented in [2]. While some similar conditions were examined, the relative throughput of the closed loop modes does not

¹ Throughputs are equal for the rate $3/4$, 15 dB SNR point.

compare well with results presented here. We observe that in [2], the DPCCH had fixed allocation, whereas these results use power control. Since DPCH power control sets the dedicated pilot power as a function of array gain, and the received dedicated pilot power is different for closed loop modes 1 and 2 (mode 1 does not get array gain on the dedicated pilots, since the pilot sequences transmitted on the two transmit antennas are orthogonal), we expect the verifier performance could significantly be affected by the presence of power control.

5. REFERENCES

- [1] Motorola, "HS-DSCH Closed Loop Tx Diversity Mode 1 and Mode 2 Link Throughput," TSGR1#28(02)1124, Seattle, USA, 19-22 August 2002
- [2] Nokia, "TxAA for HSDPA – some link simulation results" TSGR1#27(02)0972, Oulu, Finland, July 2-5, 2002
- [3] Motorola, "Closed loop transmit diversity mode 2 with antenna verification," TSGR1#28(02)1092, Seattle, USA, 19-22 August 2002
- [4] TR25.214, "Physical layer procedures (FDD)", Annex A

Figure 1. Fixed MCS Simulation Results

