Agenda item:	**5.3**
Source:	**Motorola**
Title:	**Closed Loop Transmit Diversity on HS-SCCH and HS-PDSCH**
Document for:	**Discussion**

1. INTRODUCTION

Previous discussions [1], [2], have examined the performance of closed loop transmit diversity ('TxAA') on HS-SCCH in the presence of feedback error. We continue the discussion, addressing the impact of HS-SCCH degradations on HS-PDSCH throughput as well as HS-SCCH performance. We observe:

- As commented in [1], HS-SCCH performance degradation is dominated by feedback, rather than verification, errors.

- The loss in performance due to feedback and verification errors occurs at the lower HS-SCCH BLERs. The performance gains relative to STTD remain at the higher BLERs for TxAA mode 1 and for lower BLERs as well when TxAA mode 2 is used.

- Considering HS-PDSCH throughput, there is still gain from the use of either TxAA mode. When we examine an upper bound on the loss in HS-PDSCH throughput due to failing to decode HS-SCCH, we do not see a dramatic degradation from ideal TxAA behavior. If HS-SCCH power is set at a level such that the ideal HS-PDSCH throughput is within 5% of its maximum value, for TxAA mode 1 there is a 0.7 or 0.9 dB loss relative to perfect verification at 3 or 30 kmph when SBV is used without error mitigation at Node B ('Node B verification'). If Node B verification is used, the loss for mode 1 is 0.4 dB at both 3 and 30 kmph. We expect this loss is limited by correlation between HS-SCCH errors and HS-PDSCH errors. Since there is an approximate 1 dB gain from the use of mode 1 at both 3 and 30 kmph, we observe that even with this upper bound on loss, there is gain from the use of mode 1 over STTD.

- As has been observed previously [3], the behavior of the mode 1 codebook causes it to be somewhat less robust than mode 2 for HS-PDSCH. This behavior is also observed here for HS-SCCH, although we should caution that some improvements may be possible for mode 1, since these simulations are not optimized (we keep the simulations simple to allow replication of results). However, even with simple implementations, it seems that mode 2's robustness and additional gain of its codebook allow it to consistently provide a significant gain over STTD.

Given that these results are for ideal behavior of HS-PDSCH (no losses due to channel estimation, verification, CQI delay or error, etc.) and for simple implementations, we expect the net gain for TxAA on HS-SCCH given degradations to be greater than presented here. Because of this observed gain over STTD under these conditions, and because HS-SCCH often consumes a small amount of resource in the first place (especially when user diversity is present), and since there are existing robust techniques and codebooks for TxAA, we feel that further study is merited before completely removing TxAA from HS-SCCH.

2. SIMULATIONS

Simulations of the HS-SCCH on a single link were run with various transmit diversity configurations. We examine the frame errors of both part 1 and 2, but do not explicitly simulate the user specific CRC in part 1, or perform the CRC check in part 2. Frame error rates are reported as the logical 'or' of errors in parts one and two for HS-SCCH.

An idealized HS-PDSCH was simulated, since we are interested in the degradation in HS-PDSCH performance due to errors on the HS-SCCH. This method then produces an upper bound on the amount of degradation caused by failures to decode HS-SCCH: effects degrading HS-PDSCH would reduce the loss due to non-ideal HS-SCCH behavior. CQI was calculated using ideal knowledge of the channel, and applied immediately and without error at the transmitter. The received SNR was computed at the UE Rake receiver output, and used to calculate the BLER using static link curves. A block error was then determined with a random draw. We assume that an error in either of the two HS-SCCH parts will cause the decode to fail, and therefore calculate HS-PDSCH throughput using the logical 'or' of an error on HS-PDSCH or either of the two HS-SCCH parts.

TxAA Modes 1 and 2 were simulated. Ideal verification with error free feedback and UE verification with or without Node B verification [4] were simulated. A 2 equal path fading channel model with i.i.d. Rayleigh fading for all rays is used to help with comparisons against previous contributions. Also, to facilitate comparison of results, we use a simple version of power control, where Eb/Nt estimates are based on a single slot. Note that the outer loop is fixed, power control is on for all results, and that channel estimation and Eb/Nt estimation is used even for the 'ideal' results. We assume the gains on the dedicated pilot and HS-SCCH are equal, but use 4 pilot bits to compensate for the approximate difference in required HS-SCCH and DPCH power. We show the key parameters used in the simulation in Table 1.

Table 1. Simulation Parameters

Parameter	**Value**
Geometry (Ior/Ioc) for All Users:	0 dB
Channel	2-Path Rayleigh, Uncorrelated Antennas, Generated with filter based fader [5]
Mobile Speed	3 and 30 kmph
Number of Users	1
Power Control	On, No Feedback Error, Outer loop fixed
HS-SCCH Gain / Dedicated Pilot Gain	Fixed, at 0 dB
# dedicated pilot bits	4 (2 symbols)
Eb/Nt Estimation for Power Control	Single Slot, Using Pilot Bits
Allocation Step Size	1 dB
Number of HS-SCCH Frames Simulated	40,000
TxAA Feedback Delay	measure in slot *n*; apply in slot (*n*+2)
TxAA Feedback Error	0% or 4%
TxAA Modes	Modes 1 and 2, per TS25.214
TxAA UE Verification	On or Ideal
TxAA Node B Verification	On or Off
HS-SCCH Channel Estimation	On
Channel coding	Rate 1/3, K=9, Convolutional
Bits per HS-SCCH Part	Part1: 8 data, 8 tail Part 2: 13 data, 16 CRC, 8 tail
HS-PDSCH MCS States	QPSK: Rate 1/4,1/2,3/4 16QAM: Rate 1/2,5/8,3/4
CQI Feedback Delay & Error	0
HS-PDSCH Channel Estimation	Ideal
HS-PDSCH Receiver	Rake
HS-PDSCH Codes	12
HS-PDSCH Allocation	75%
HS-PDSCH H-ARQ	Repeat & Chase Combine

Figure 1 shows the transmit Eb/Nt vs. HS-SCCH BLER for STTD and TxAA modes 1 and 2 at 3kmph. Modes 1 and 2 are shown with error free feedback and verification or with verification at both UE and Node B. We observe that modes 1 and 2 gain about 1 dB and 2 dB, respectively, over STTD in the ideal case. With feedback and verification errors, mode 1 can have a loss over STTD at low BLER, whereas no loss relative to STTD was observed for mode 2 under these conditions. We should comment that the mode 1 performance is somewhat lower than one might predict; this is due to the simple nature of these simulations, where there is no compensation for the modes' differences in dedicated pilot behavior, etc. However, should performance improvements be possible for mode 1, then the use of TxAA on HS-SCCH is even more appealing.

Figures 2 and 3 show the ideal HS-PDSCH throughput for mode 1 when ideal verification, Node B and UE verification, or UE verification alone are used. Figures 2 and 3 are for 3 and 30 kmph, respectively. We note that HS-PDSCH throughput reaches a maximum at sufficiently high SNR for

all cases, where the HS-SCCH errors cease to have an effect on HS-PDSCH throughput. This maximum throughput is different for the Node B and UE verification cases, since Node B verification reduces the SNR loss on the HS-PDSCH, whereas UE verification can only improve channel estimation for HS-SCCH. This loss of maximum throughput due to feedback error on HS-PDSCH is 3-4% for UE verification only, and about 1% when both UE verification and Node B verification are used, considering both the 3 and 30kmph cases.

Figures 4 and 5 plot the loss in HS-PDSCH performance due to HS-SCCH error. They were generated by normalizing each curve in Figures 2 and 3 by their respective maxima, and then subtracting the normalized curves from unity. Since the maxima represent the HS-PDSCH throughput achievable in the absence of HS-SCCH error, and HS-PDSCH allocation is constant, these curves show the performance due to HS-SCCH errors.

Figures 4 and 5 show relatively small degradations for the 5% points of the curves, where 95% of HS-PDSCH throughput is reached. Note that at low SNR, 95% throughput corresponds to a loss of about 0.2 dB HS-PDSCH power. At this 5% point, for TxAA mode 1 there is a 0.7 or 0.9 dB loss relative to perfect verification and feedback at 3 or 30 kmph when SBV is used without Node B verification. If Node B verification is used, the loss is 0.4 dB at both 3 and 30 kmph. We expect this loss is limited due to correlation between HS-SCCH errors and HS-PDSCH errors. Since there is an approximate 1 dB gain from the use of mode 1 at both 3 and 30 kmph, we observe that even with this upper bound on loss, there is gain from the use of mode 1 over STTD. This gain will be greater for mode 2 (given the additional gain observed in Figure 1).

3. CONCLUSION

While feedback and verification errors affect HS-SCCH behavior, we have not yet found it inappropriate to use TxAA on HS-SCCH. Under the conditions studied, mode 1 still has gains over STTD. Also under the same conditions, mode 2 has gains relative to STTD of around 2 dB. We would prefer further analyses be presented that determine the impact on HS-PDSCH throughput as well as HS-SCCH. Analyses of soft handover conditions are also of interest.

4. REFERENCES

[1] Nokia, “Tx-diversity on HS-SCCH,” TSGR1#31(03)0291
[2] Lucent,” Robustness of Transmit Diversity on HS-SCCH,” TSGR1#26(02)0698
[3] Motorola, “HS-DSCH Closed Loop Tx Diversity Mode 1 and Mode 2 Link Throughput,” TSGR1#28(02)1124
[4] Motorola, “FBI Error Mitigation for Closed Loop Tx Diversity”, TSGR1#27(02)0979
[5] Comroe, R. A., “All-digital fading simulator”, Proc. Nat. Electron. Conf. 32 (1978), pp. 136-139

Figure 1

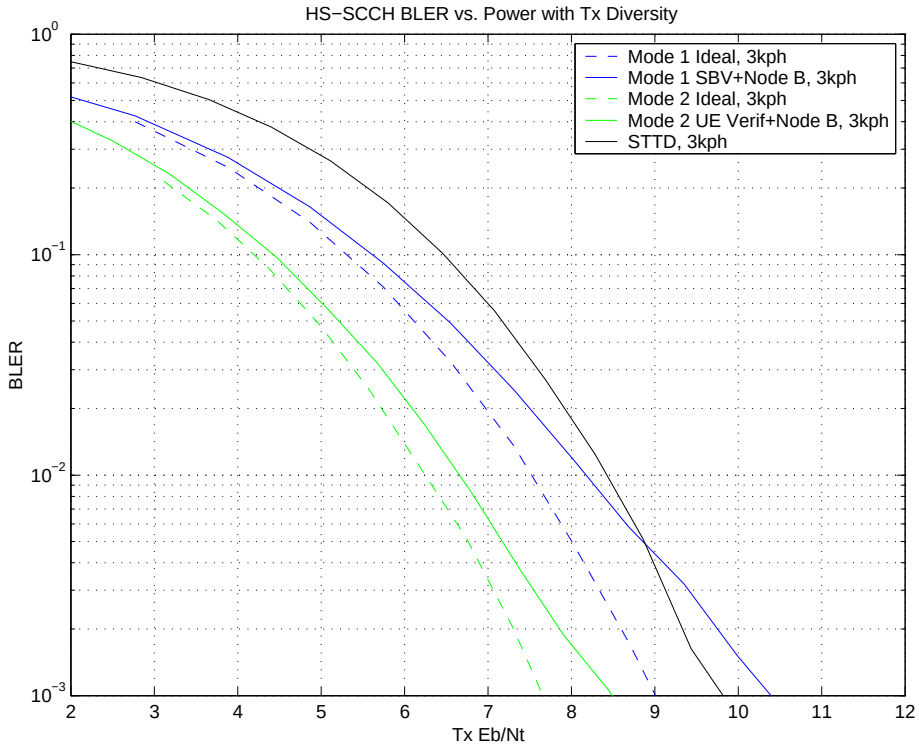


Figure 2

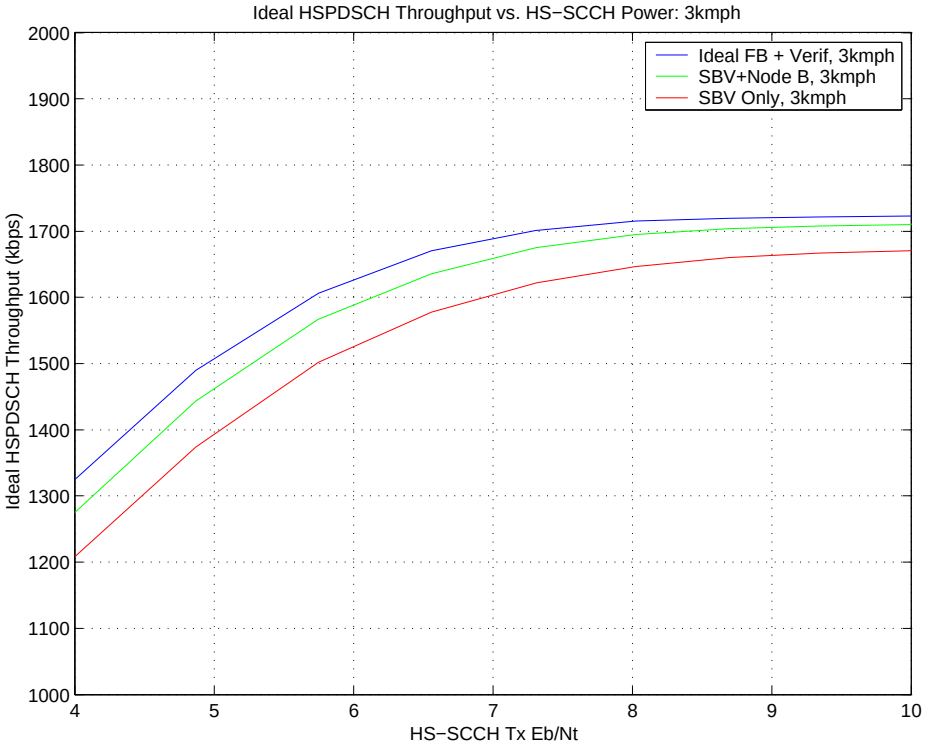


Figure 3

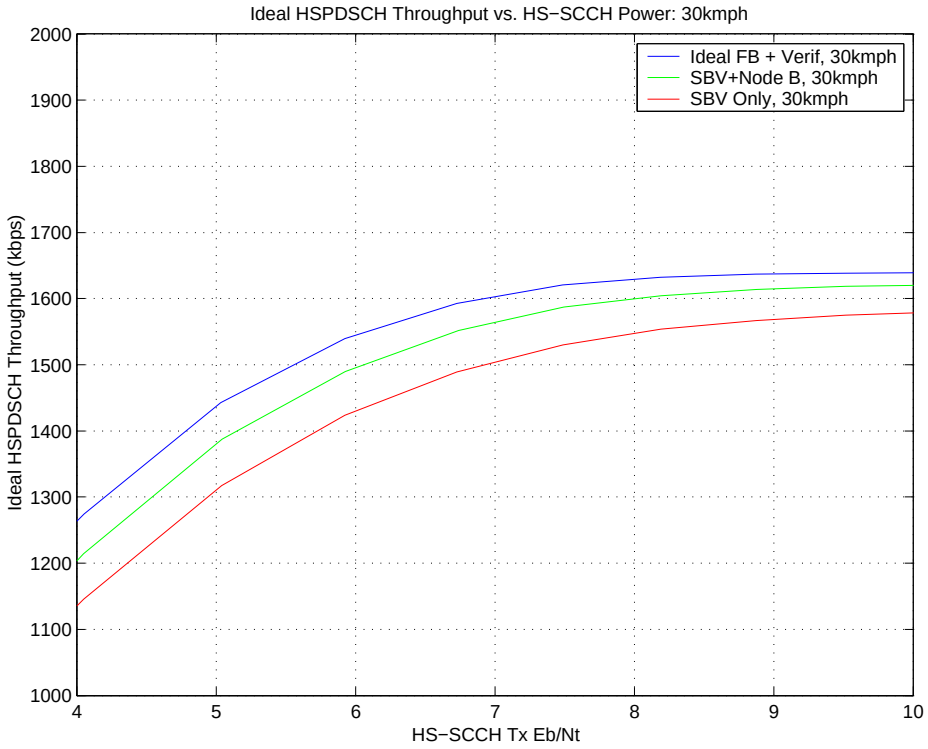


Figure 4

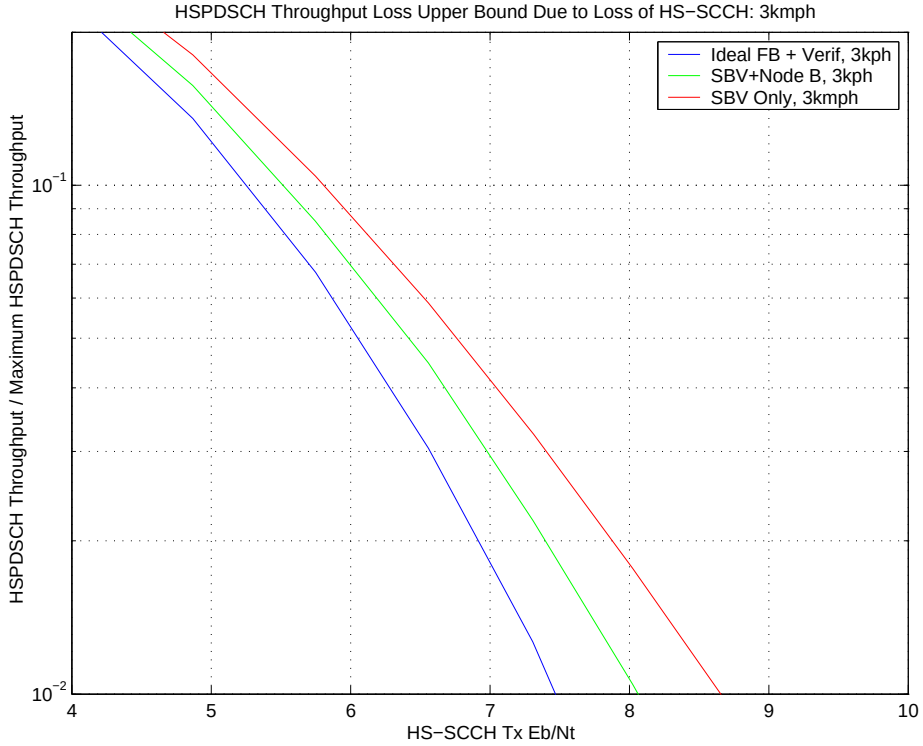
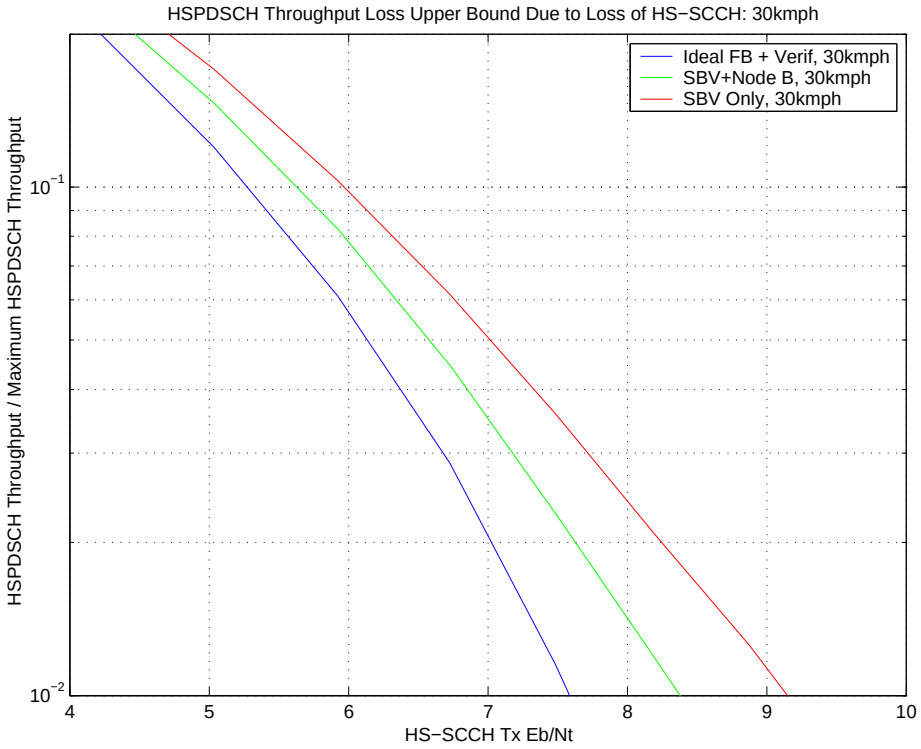


Figure 5


HSPDSCH Throughput Loss Upper Bound Due to Loss of HS−SCCH: 30kmph
Ideal FB + Verif, 30kmph
SBV+Node B, 30kmph
SBV Only, 30kmph
HSPDSCH Throughput / Maximum HSPDSCH Throughput
10^−1
10^−2
4
5
6
7
8
9
10
HS−SCCH Tx Eb/Nt