TSG-RAN Working Group 1 meeting No. 9 ***TSGR1-01-0187***
Las Vegas, NE, USA Feb. 27-March 2, 2001

Agenda Item: **AH99**

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Title: **On the complexity of the Block STTD in TDD**

Document for: **Discussion**

1 Introduction

Block STTD (BSTTD) for P-CCPCH was adopted by WG1 TDD specifications based on performance/complexity results indicating that BSTTD gains can be achieved with only a slight increase in the complexity of the joint detection (JD) receiver [1,2]. The reduced complexity algorithm was derived using a first order approximation of the Cholesky decomposition. Recent results indicate however that in some propagation environments such as ITU pedestrian B and ITU Vehicular B, the block STTD-JD when operating on a time slot with 1 BCH + 7 DCHs causes a severe degradation in performance relative to the single antenna (no STTD case). The observed degradation for the BCH is in the order of 4 dB at raw BER of 1%.

To overcome this degradation a more refined approximation of the Cholesky decomposition was derived. However the complexity of the refined algorithm is significantly higher than originally reported in [1]. Based on these results we recommend to reconsider the option of BSTTD encoded P-CCPCH.

2 Performance and Complexity Results

The complexity results reported in [1] are based on the first order approximation of the Cholesky decomposition described in [2]. According to our results however, the first order approximation causes, in some cases, a significant degradation relative to the no STTD case. To overcome this problem, a more refined approximation is needed. The performance results for both algorithms (First order approximation and the refined algorithm) are given in the appendix. The most severe cases for the first order approximation are the ITU Pedestrian B (PB) channel with 1 BCH + 7 DCHs, and ITU Vehicular B (VB) channel with 1 BCH and 7 DCH. In these cases the first order approximation proposed in [1,2] causes a degradation of 3.75 dB compared to the no STTD case, at raw BER of 1%.

The complexity of the refined approximation is significantly higher than that of the first order approximation reported in [1]. Table 1 presents the relative increase in complexity of the refined algorithm compared to the standard (no STTD) JD receiver.

Table 1: Increase in complexity as a function of the number of DCHs

No. of DCHs	Relative increase in complexity
0	91.6 %
1	44.3 %
2	28.4 %
3	20.4 %
4	15.6 %
5	12.4 %
6	10.1 %
7	8.4 %

Since the increase in complexity is quite moderate for 7 DCHs and because the receiver has to be designed for the maximum numbers of DCHs, the increased complexity will only have a moderate impact on the hardware complexity (assuming that increase in the number of operations translated to the same increase in the number of gates). However, the increased complexity for the case of a few DCHs will have a significant impact on the UE power consumption.

In addition to the increase in complexity as expressed in the number of operations, the architecture of STTD-JD receiver with the refined approximation is considerably more complex than that of the standard JD. It appears likely therefore that the required increase in the hardware complexity will be higher than that predicted by the number of operations.

Note that for the case of 7 DCHs, the first order approximation algorithm results in 3% increase in complexity relative to the non-STTD joint detector [1].

3 Discussion and Summary

Based on the results presented in this paper we propose to remove the option of BSTTD encoded P-CCPCH from the TDD specifications.

We recognize the importance of applying transmit diversity to the P-CCPCH and therefore encourage introducing other approaches that has a lower impact on the UE receiver complexity and power consumption.

4 References

[1] Motorola, TI, 'Transmit Diversity scheme for Broadcast channels of the TDD mode (II)', R199g38, New York, WG1#8.

[1] Motorola, 'Transmit Diversity schemes for Broadcast channels of the TDD mode', R199c08, Hanover, WG1#7.

5 Appendix – Performance Results

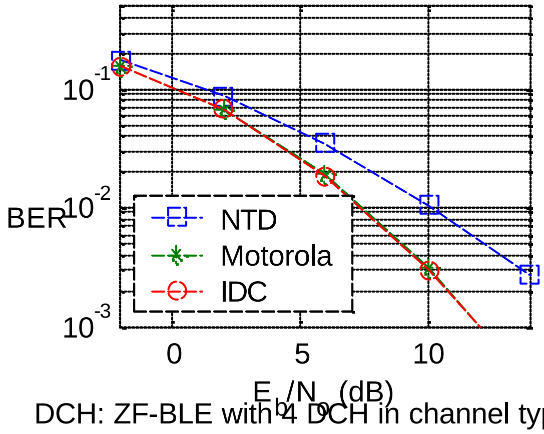
5.1 Simulation Assumptions

?? ZF BLE joint detection receiver
?? Scrambling code #0.
?? BCH uses the channelisation code #1.7 DCHs use the channelisation code #2, 3, 4, 5, 6, 7, 8.
?? 4 DCHs use the channelisation code #2, 3, 4, 5.
?? Perfect channel estimation. ([1,2] used real channel estimation with different midamble shift per code)
?? 400 number of Monte Carlo simulation.
?? ITU channel models

In the legend in the figures below NTD stands for No Transmit Diversity, Motorola stands for the STTD – JD first order approximation proposed in [1,2] and IDC stands for the STTD-JD with the refined approximation. The value in the parenthesis in the figures is provided in [1].

5.2 Simulation Results

BCH: ZF-BLE with 4 DCH in channel type IA

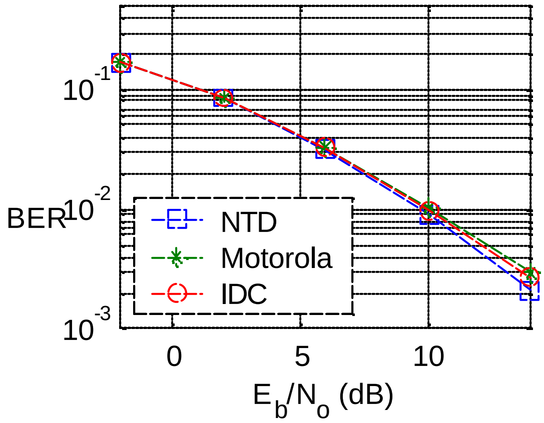


BCH gain at 10%
Motorola: 1.15 dB
IDCC: 1.15 dB

BCH gain at 1%
Motorola: 2.74 dB
IDCC: 2.79 dB

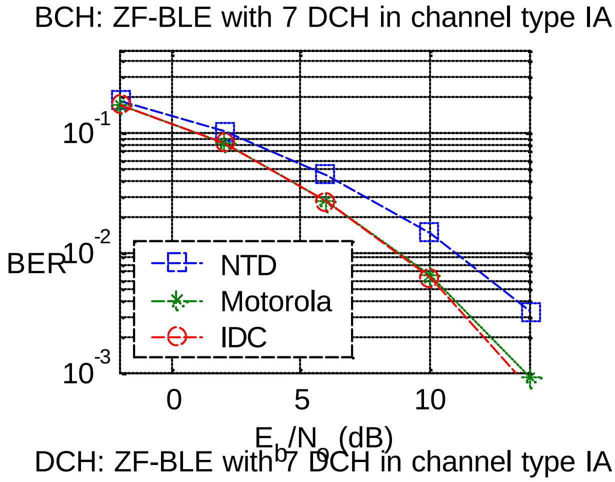
BCH gain at 2%
Motorola: 2.07 dB (4.0 dB)
IDCC: 2.03 dB

DCH: ZF-BLE with 4 DCH in channel type IA



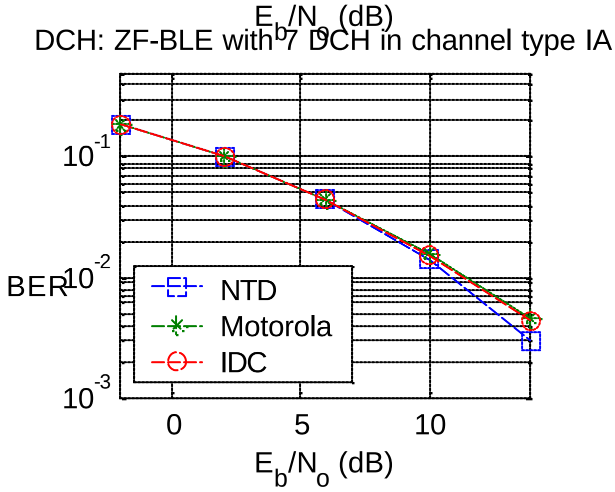
DCH gain at 10%
Motorola: -0.03 dB
IDCC: -0.01 dB

DCH gain at 1%
Motorola: -0.31 dB
IDCC: -0.17 dB



BCH gain at 10%
Motorola: 1.17 dB
IDCC: 1.19 dB

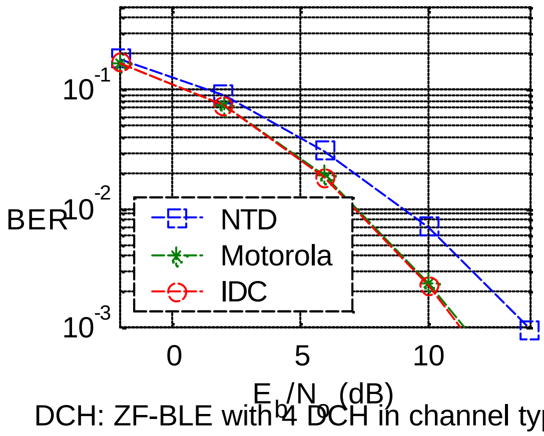
BCH gain at 1%
Motorola: 2.28 dB
IDCC: 2.4 dB



DCH gain at 10%
Motorola: -0.02 dB
IDCC: -0.02 dB

DCH gain at 1%
Motorola: -0.6 dB
IDCC: -0.47 dB

BCH: ZF-BLE with 4 DCH in channel type IB



BCH gain at 10%

Motorola: 0.92 dB

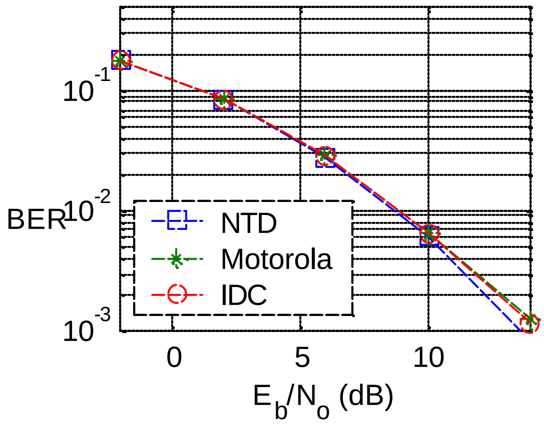
IDCC: 0.93 dB

BCH gain at 1%

Motorola: 1.78 dB

IDCC: 1.84 dB

DCH: ZF-BLE with 4 DCH in channel type IB



DCH gain at 10%

Motorola: -0.04 dB

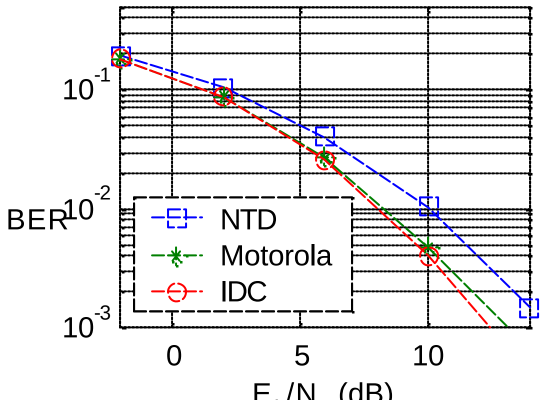
IDCC: -0.04 dB

DCH gain at 1%

Motorola: -0.17 dB

IDCC: -0.11 dB

BCH: ZF-BLE with 7 DCH in channel type IB



BCH gain at 10%

Motorola: 0.92 dB

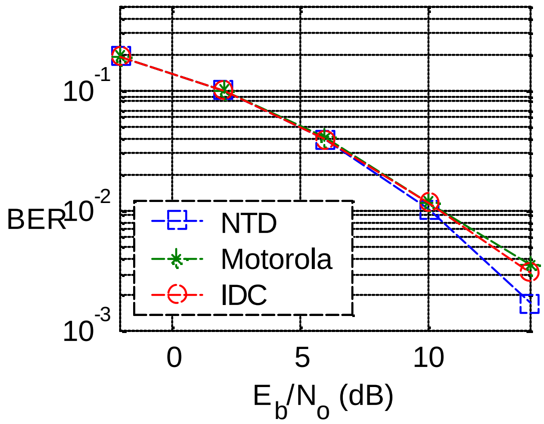
IDCC: 0.98 dB

BCH gain at 1%

Motorola: 1.73 dB

IDCC: 2.02 dB

DCH: ZF-BLE with 7 DCH in channel type IB



DCH gain at 10%

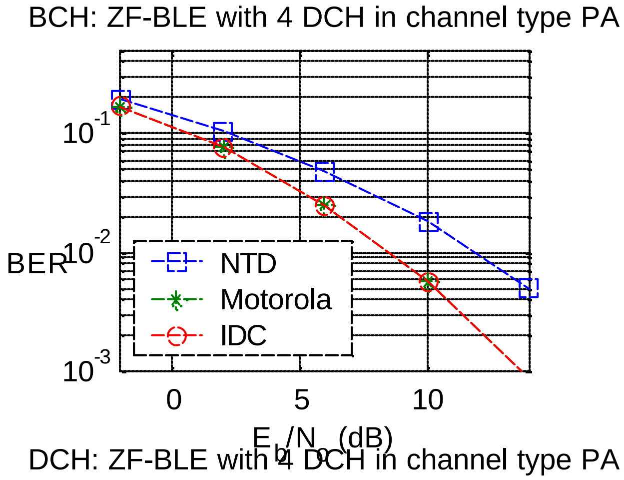
Motorola: -0.02 dB

IDCC: -0.01 dB

DCH gain at 1%

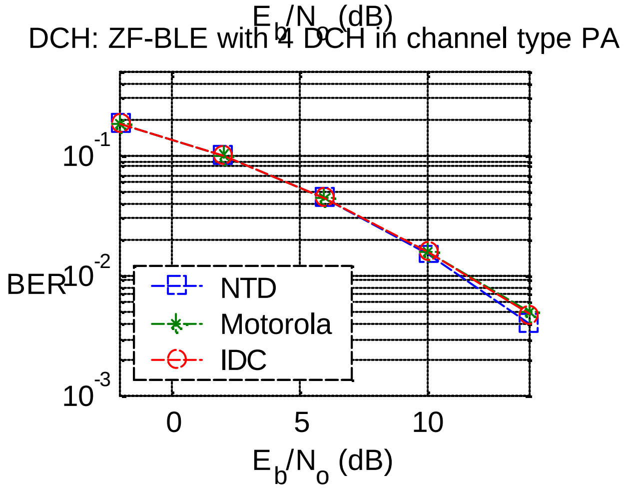
Motorola: -0.55 dB

IDCC: -0.39 dB



BCH gain at 10%
Motorola: 1.62 dB
IDCC: 1.6 dB

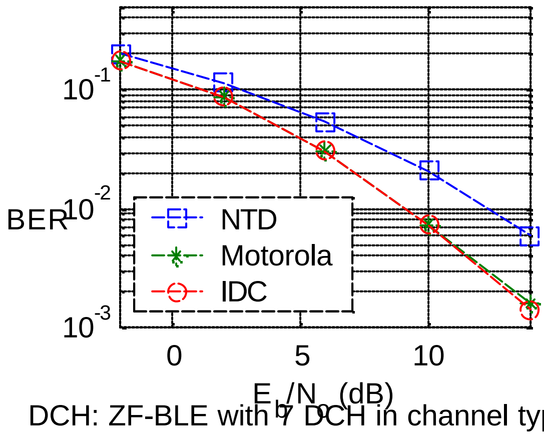
BCH gain at 1%
Motorola: 3.36 dB
IDCC: 3.35 dB



DCH gain at 10%
Motorola: 0 dB
IDCC: 0 dB

DCH gain at 1%
Motorola: -0.34 dB
IDCC: -0.24 dB

BCH: ZF-BLE with 7 DCH in channel type PA



BCH gain at 10%

Motorola: 1.43 dB

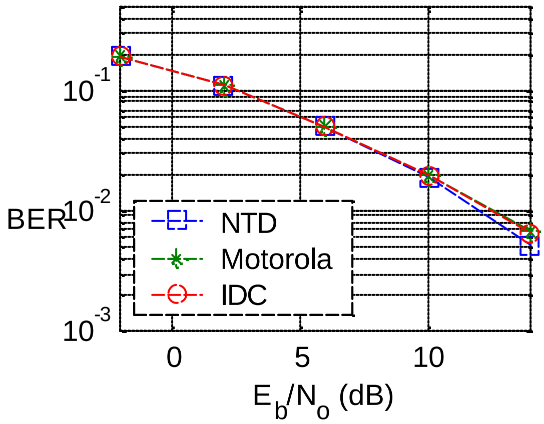
IDCC: 1.45 dB

BCH gain at 1%

Motorola: 3.12 dB

IDCC: 3.14 dB

DCH: ZF-BLE with 7 DCH in channel type PA



DCH gain at 10%

Motorola: 0 dB

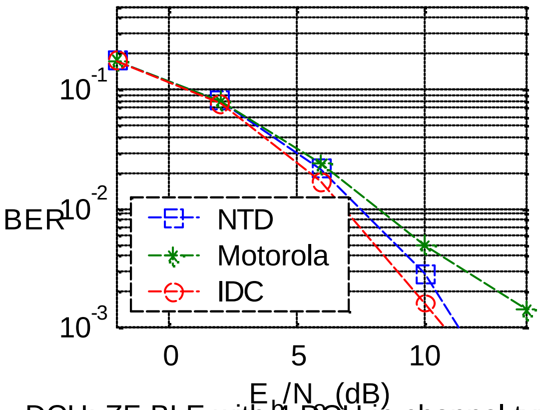
IDCC: 0 dB

DCH gain at 1%

Motorola: -0.6 dB

IDCC: -0.4 dB

BCH: ZF-BLE with 4 DCH in channel type PB



BCH gain at 10%

Motorola: 0.01 dB

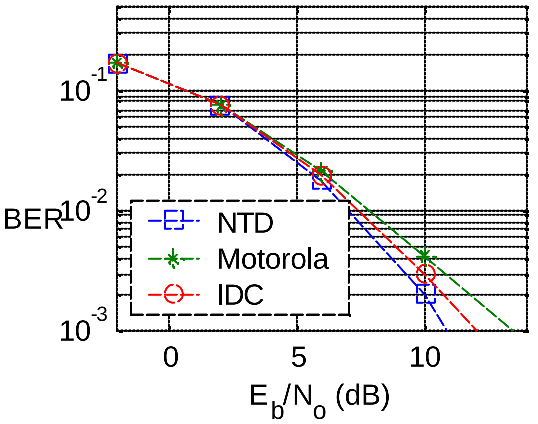
IDCC: 0.24 dB

BCH gain at 1%

Motorola: -0.68 dB (0.6 dB)

IDCC: 0.62 dB

DCH: ZF-BLE with 4 DCH in channel type PB



DCH gain at 10%

Motorola: -0.11 dB

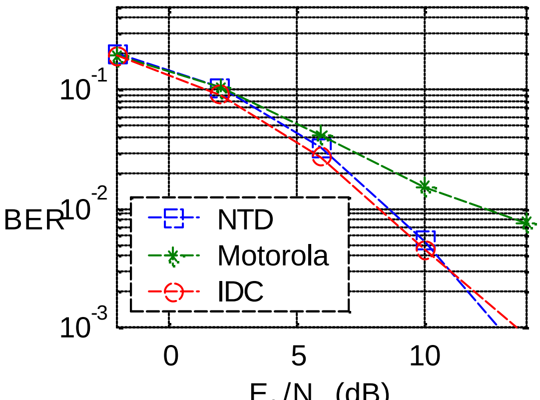
IDCC: -0.05 dB

DCH gain at 1%

Motorola: -0.76 dB (-0.5 dB)

IDCC: -0.31 dB

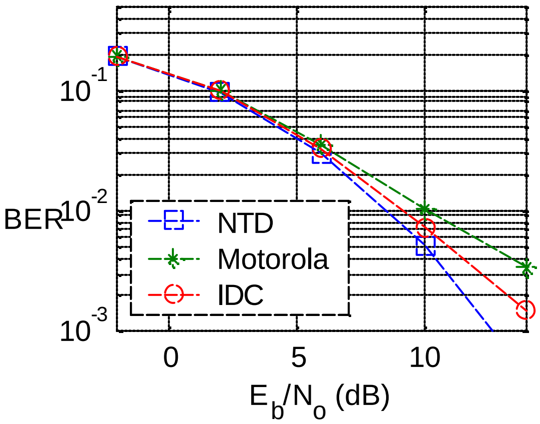
BCH: ZF-BLE with 7 DCH in channel type PB



BCH gain at 10%
Motorola: -0.01 dB
IDCC: 0.51 dB

BCH gain at 1%
Motorola: -3.82 dB
IDCC: 0.43 dB

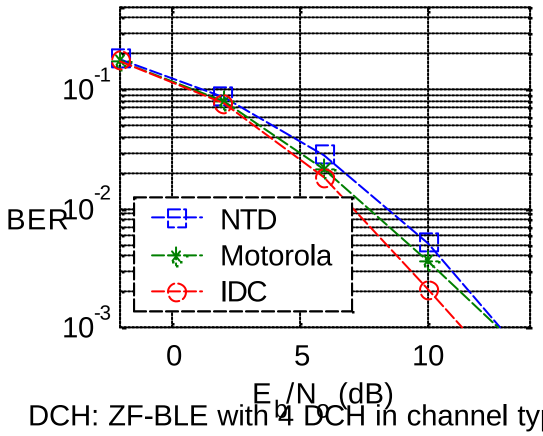
DCH: ZF-BLE with 7 DCH in channel type PB



DCH gain at 10%
Motorola: -0.17 dB
IDCC: -0.06 dB

DCH gain at 1%
Motorola: -1.52 dB
IDCC: -0.59 dB

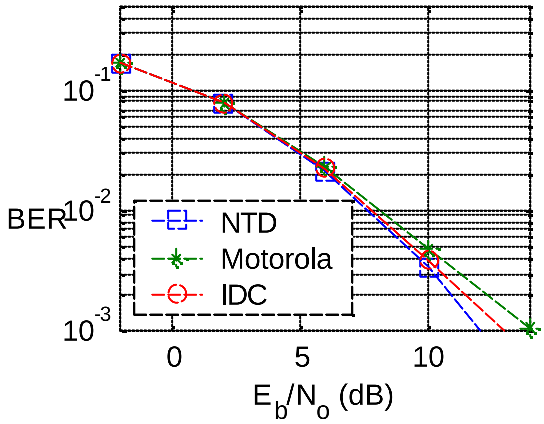
BCH: ZF-BLE with 4 DCH in channel type VA



BCH gain at 10%
Motorola: 0.41 dB
IDCC: 0.57 dB

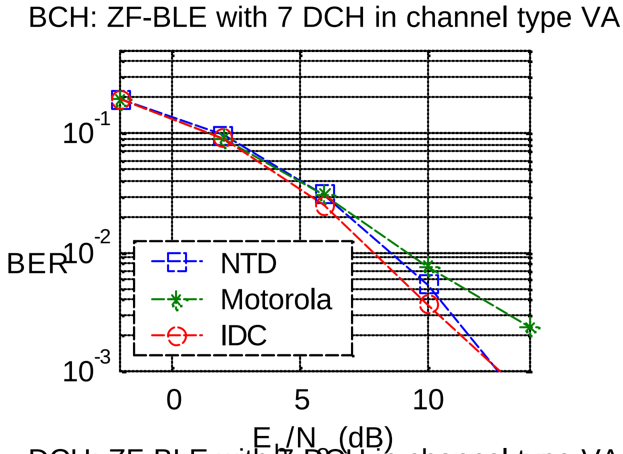
BCH gain at 1%
Motorola: 0.67 dB
IDCC: 1.33 dB

DCH: ZF-BLE with 4 DCH in channel type VA



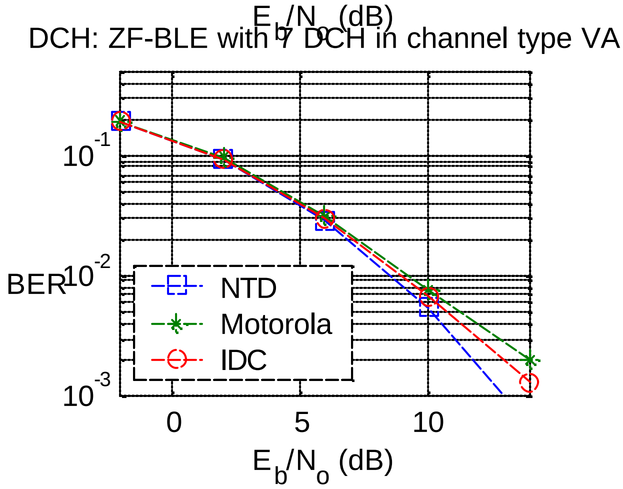
DCH gain at 10%
Motorola: -0.02 dB
IDCC: 0.01 dB

DCH gain at 1%
Motorola: -0.44 dB
IDCC: -0.16 dB



BCH gain at 10%
Motorola: 0.19 dB
IDCC: 0.39 dB

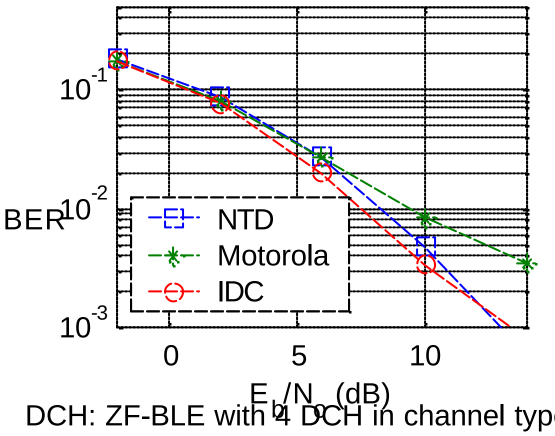
BCH gain at 1%
Motorola: -0.63 dB
IDCC: 0.68 dB



DCH gain at 10%
Motorola: -0.08 dB
IDCC: -0.02 dB

DCH gain at 1%
Motorola: -0.72 dB
IDCC: -0.38 dB

BCH: ZF-BLE with 4 DCH in channel type VB

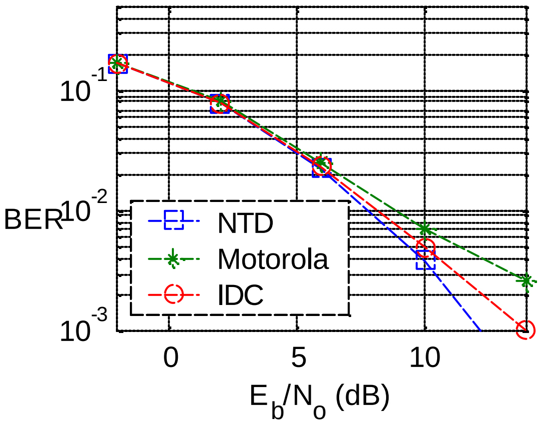


BCH gain at 10%
Motorola: 0.44 dB
IDCC: 0.69 dB

BCH gain at 1%
Motorola: -1.07 dB
IDCC: 0.75 dB

BCH gain at 7%
Motorola: 0.26 dB (0.5 dB)
IDCC: 0.57 dB

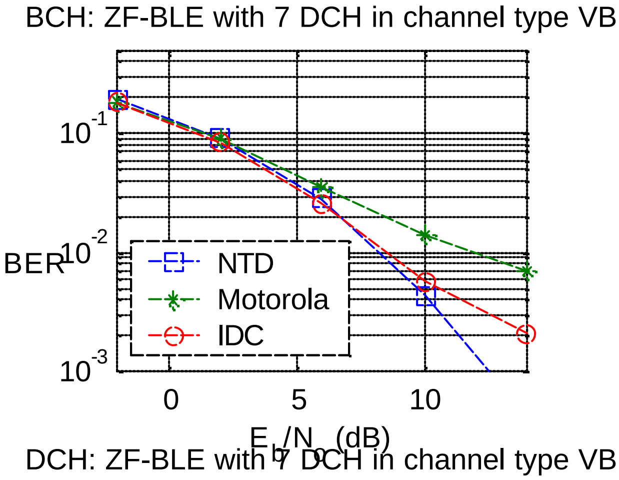
DCH: ZF-BLE with 4 DCH in channel type VB



DCH gain at 10%
Motorola: -0.09 dB
IDCC: -0.01 dB

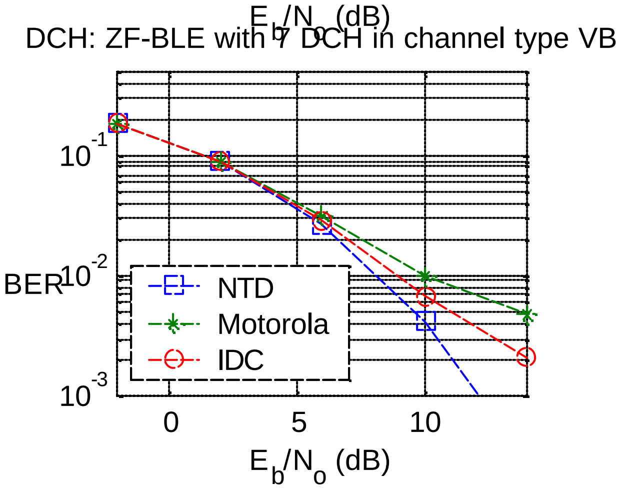
DCH gain at 1%
Motorola: -1.12 dB
IDCC: -0.37 dB

DCH gain at 7%
Motorola: -0.12 dB (-0.1 dB)
IDCC: -0.03 dB



BCH gain at 10%
Motorola: 0.02 dB
IDCC: 0.45 dB

BCH gain at 1%
Motorola: -3.76 dB
IDCC: -0.29 dB



DCH gain at 10%
Motorola: -0.17 dB
IDCC: -0.04 dB

DCH gain at 1%
Motorola: -1.88 dB
IDCC: -0.84 dB