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**Source:** Siemens

**Title:** **Simulation results of TFCI coding performance for TDD**

**Document for:** Discussion

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## Abstract

This document shows simulation results of the performance of the proposed Transport Format Combination Indicator (TFCI) coding schemes and their influence on the services for TDD. These results were requested on the last TSG-RAN WG1 meeting.
The results show that the proposed TFCI coding schemes are well suited in terms of required gross-bit capacity and the influence of the BER of different services, this means that the increase of BER of the services is negligible or zero.
The simulations results show also that the needed TFCI coding performance for TDD can be achieved, when the TFCI decoding is done by combining two TFCI words, that means combining over two frames.


## Introduction

In document [1] TFCI coding proposals for UTRA TDD systems are introduced. The following simulation results show the performance of the proposed coding schemes. A biorthogonal block code is used for coding, if the number of TFCI net bits exceeds 2.
Since in TDD the TFCI is transmitted in one slot (625 µs) only, the TFCI is more susceptible to fading than the TFCI transmission in FDD, where the coded TFCI bits are spread over the whole frame (10ms). Therefore it is obvious, that the decoding of the TFCI will fail more often when using the bits from one slot only and resulting in an influence on the service BER.
In [1] five different TFCI coding schemes are proposed depending on the number of TFCI net bits. Simulation were done for four cases.

| Case | TFCI coding scheme | TFCI net bits | TFCI gross bits | TFCI coderate |
|---|---|---|---|---|
| **C1** | (32,6) biorthogonal coding | 6 | 32 | 0,19 |
| **C2** | 2 * (16,5) biorthogonal coding | 7 .. 10 | 32 | 0,22 .. 0,31 |
| **C3** | (16,5) biorthogonal coding | 3..5 | 16 | 0,19 .. 0,31 |
| **C4** | Repetition(* 4) (8,2) | 2 | 8 | 0,25 |
| **C5** | Repetition (*4) (4,1) | 1 | 4 | 0,25 |

Table 1 TFCI coding schemes

In order to determine the impact of the TFCI coding on a service, simulations were done in conjunction with the speech service for four TFCI coding schemes.
The simulations were performed with vehicular channel model and for the outdoor/indoor and pedestrian environment.
In the last part of this paper the TFCI coding performance for the different cases is shown as a function of the raw BER. With this graph it is possible to determine if TFCI coding is sufficient in conjunction with other services requiring different BERs.

**Simulation results**

**Simulation Case 1**
**Evaluation of TFCI decoding over 1 frame and combined decoding over two frames**

In a first step it was evaluated, how the TFCI decoding will perform using TFCI code words from one single frame in comparison with combining over two frames. This is done for the vehicular environment in conjunction with the speech service for the TFCI(32,6) coding scheme.
In Figure 1 it can be seen, that the degradation of the service at BER $1*10^{-3}$ due to TFCI decoding errors is about 1,6 dB. This is not acceptable.

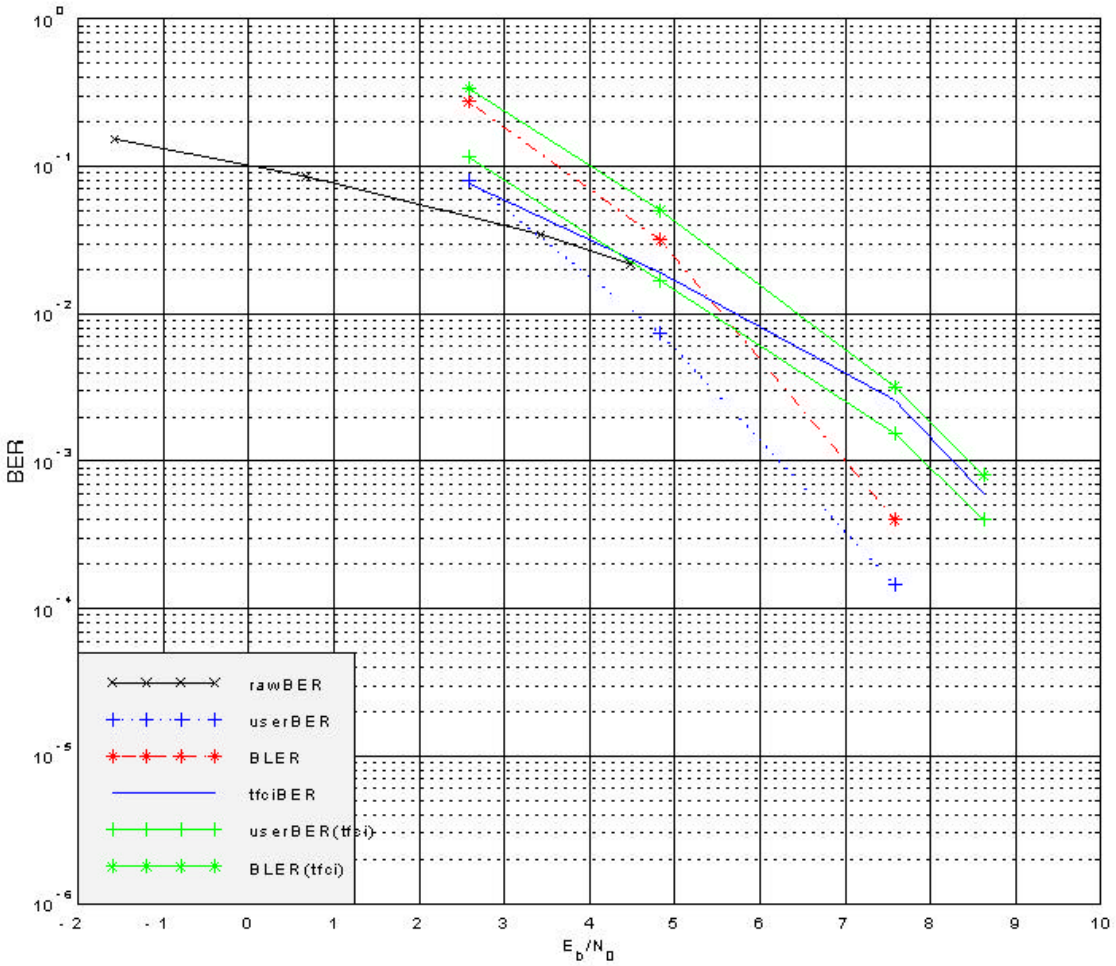


Figure 1: TFCI (32,6), speech service, vehicular A (120 km/h), decoding over one frame

In case of combining two TFCI words in the way, that the TFCI word with the highest probability is taken (selection combining), the BER of the user service is not affected. This simply way of combining has a low complexity. If a more sophisticated combining scheme is applied (maximum likelihood or maximum ratio), a further improved TFCI performance can be expected.

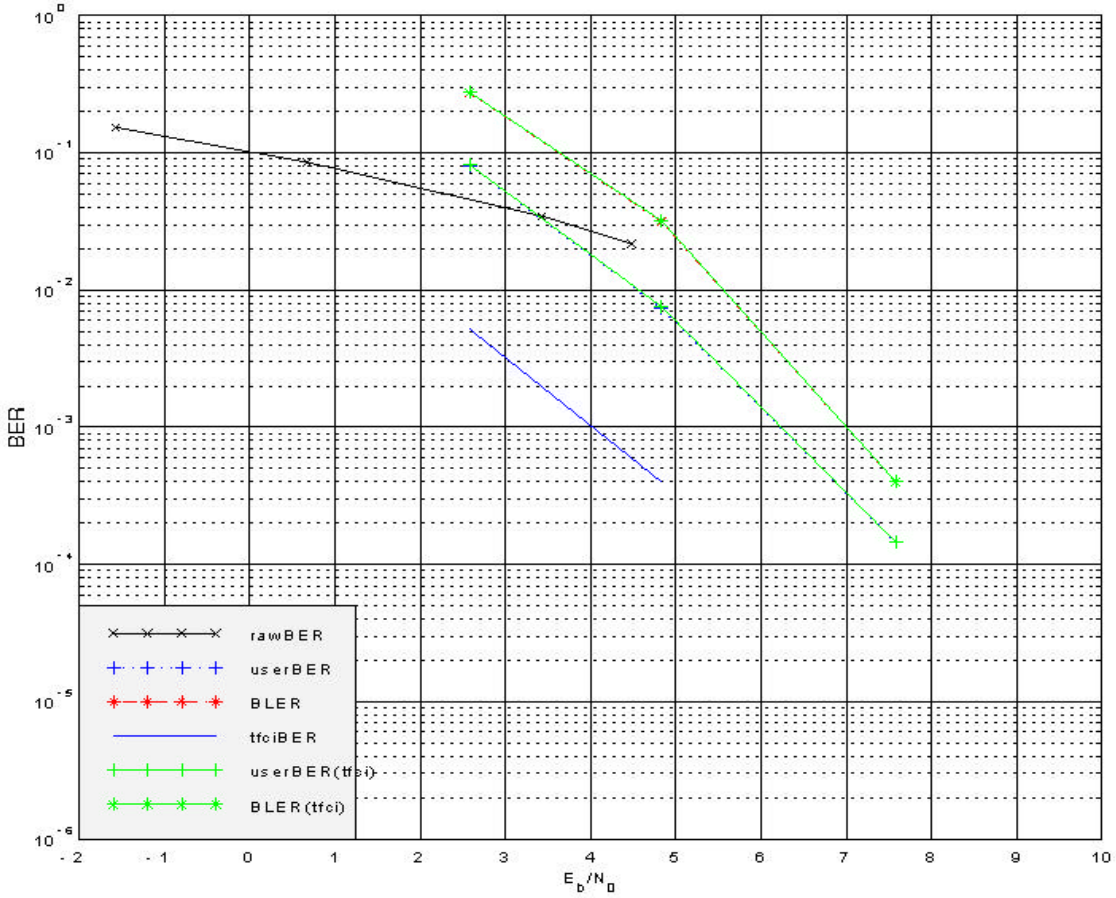


Figure 2: TFCI(32,6), speech service, vehicular A (120 km/h), decoding over two frames

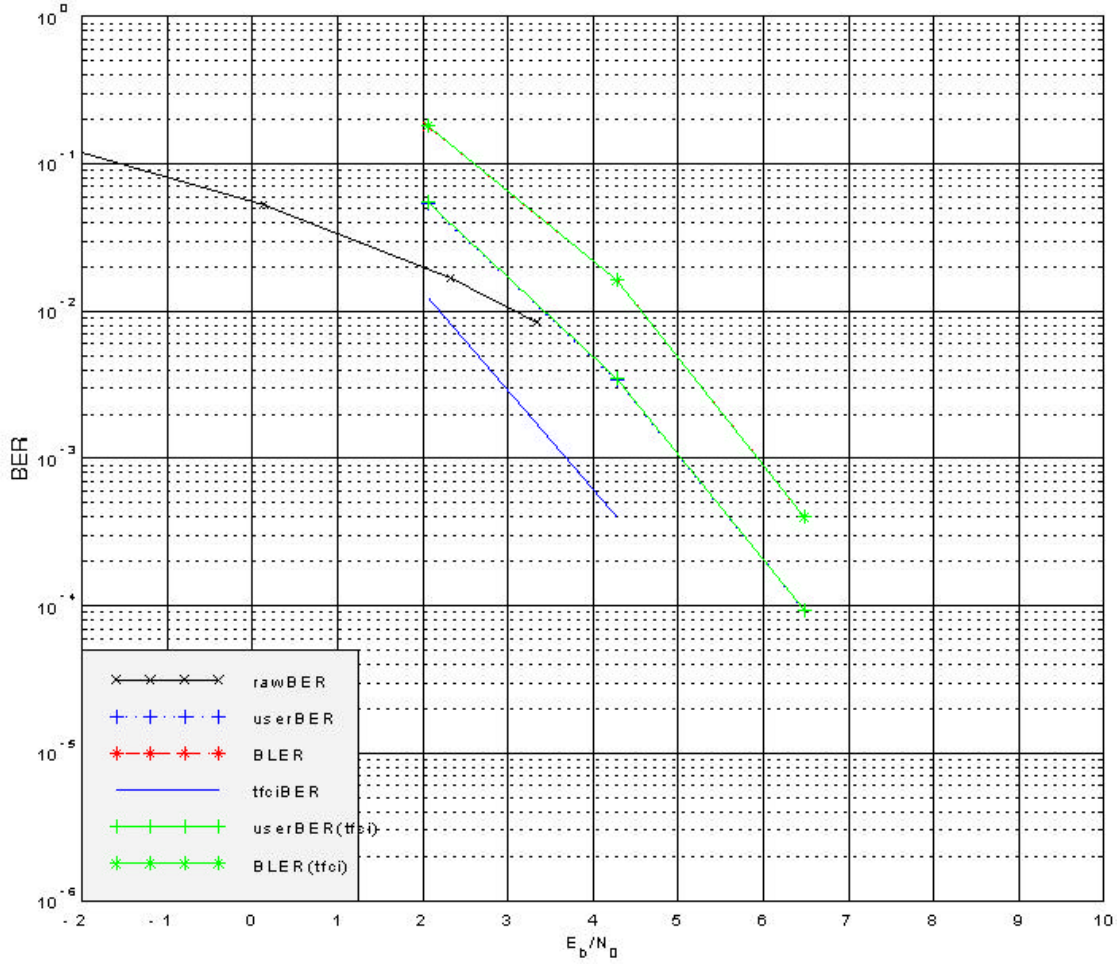


Figure 3: TFCI(32,6), speech service, indoor to outdoor/pedestrian (3 km/h), decoding over two frames

It can be seen, that the BER of the TFCI and the service are lower for the indoor to outdoor/pedestrian channel model as for the vehicular channel model. The following simulations results are shown for the vehicular channel model as a worst case consideration.

| Conclusion Simulation Case 1<br>When doing a combined decoding of the TFCI code words over two frames for TDD, the TFCI word error rate drops to a lower level, having no or or a very small influence on the BER of the service. |
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**Simulation case 2**
**TFCI coding performance for the different TFCI coding schemes (combined decoding over two frames) in conjunction with the speech service**

- TFCI decoding 2 * (16,5)

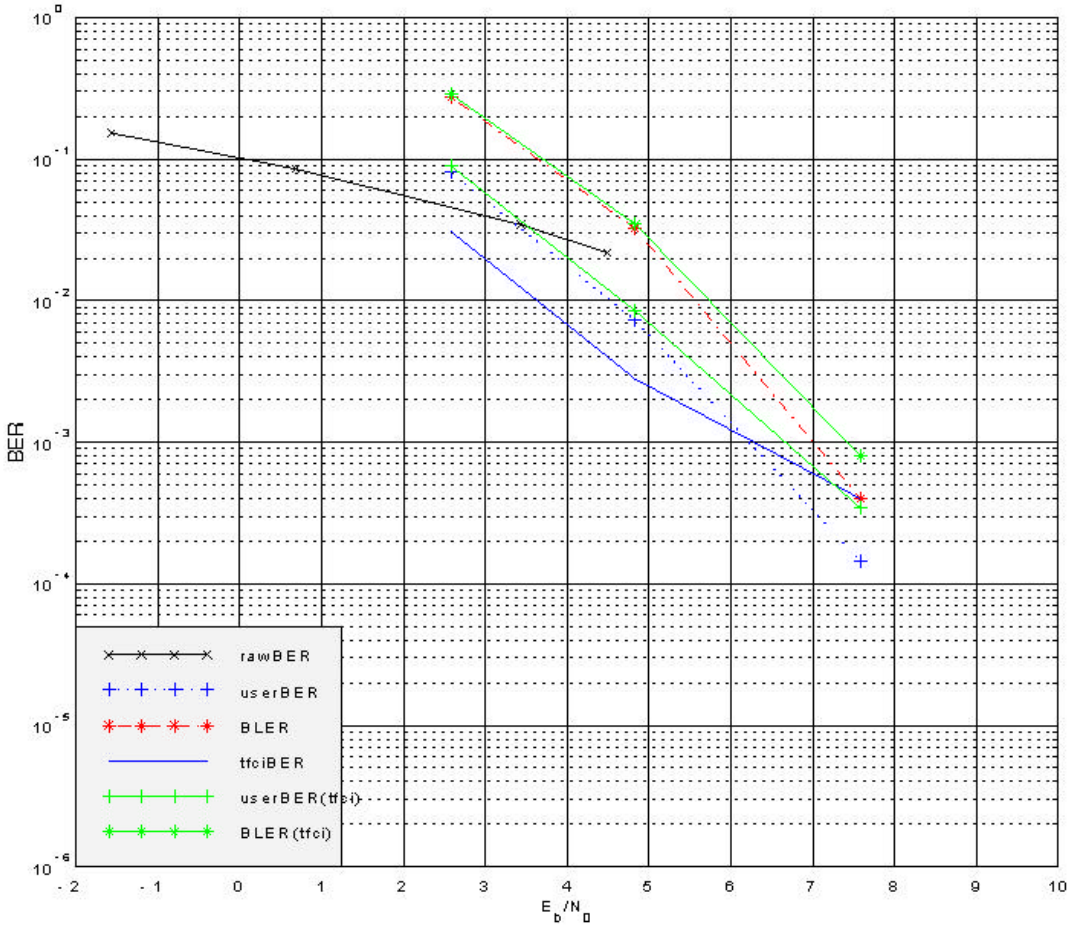


Figure 4 : TFCI 2 * (16,5), speech service, vehicular A (120 km/h), decoding over two frames

The TFCI 2 * (16,5) coding has the highest coderate (0,3125) and therefore the worst coding performance. For the speech service there is a degradation of about 0,4 dB for a service BER of $10^{-3}$ due to the TFCI word error rate of about $10^{-3}$ at this point.

- TFCI decoding (16,5)

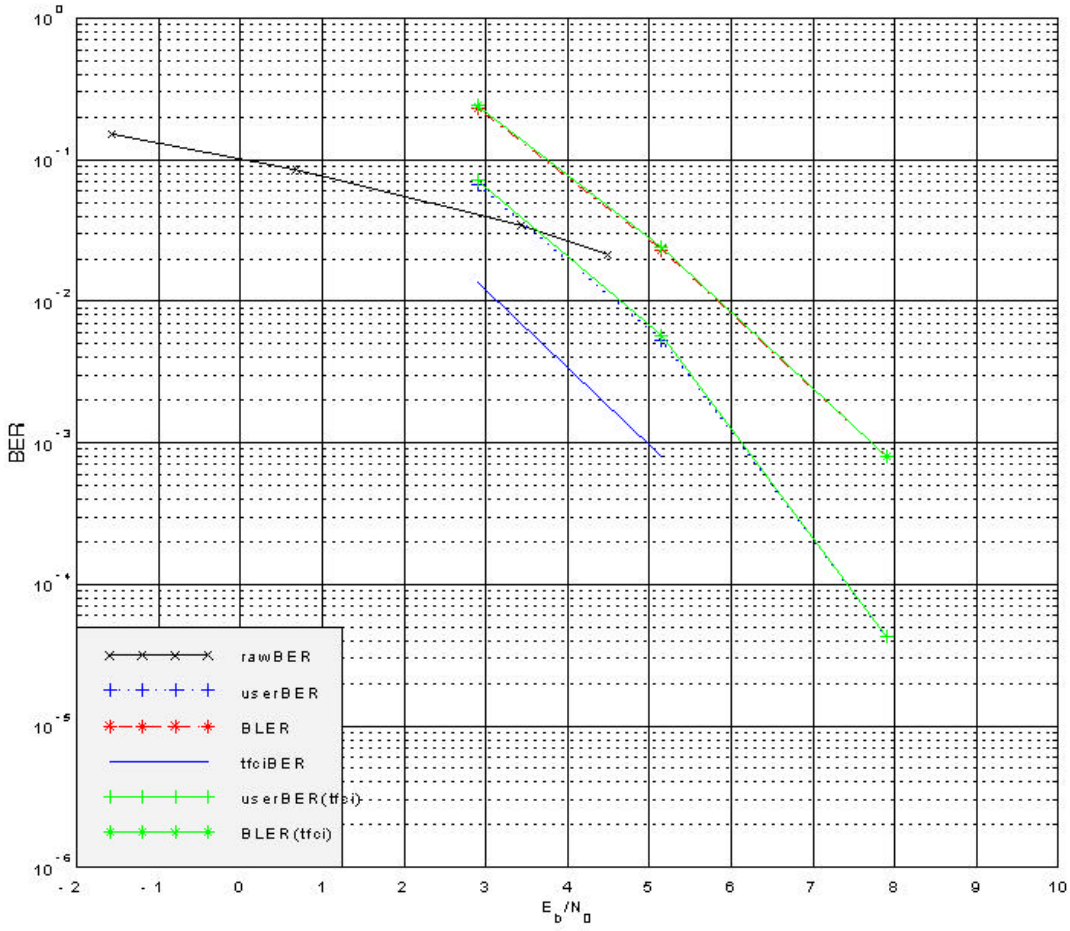


Figure 5 : TFCI(16,5), speech service, vehicular A (120 km/h), decoding over two frames

With the TFCI(16,5) coding the BER of a speech service is not affected.

- TFCI coding (8/2)

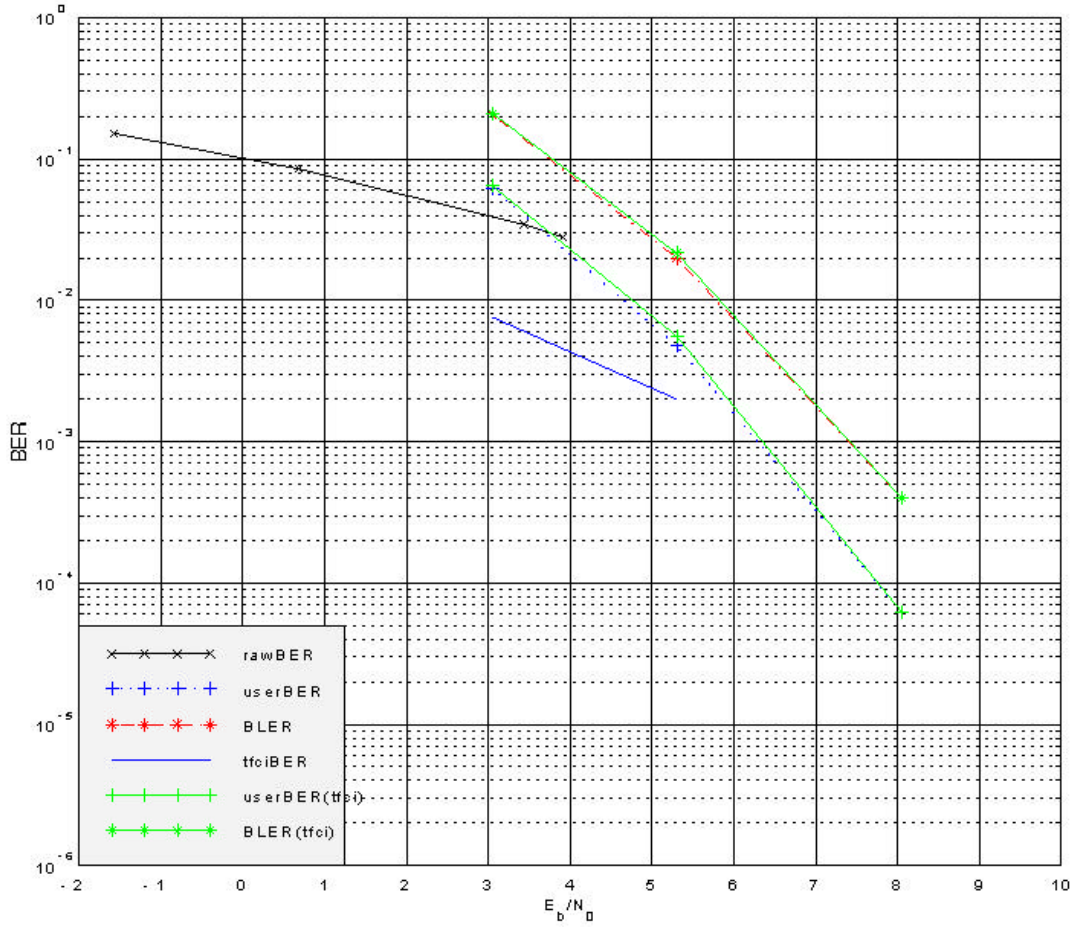


Figure 6 : TFCI (8/2), speech service, vehicular A (120 km/h), decoding over two frames

The speech service BER is practically not influenced by the TFCI(8/2) coding.

| Conclusion Simulation Case 2<br>The TFCI coding is sufficient for all cases in conjunction with a speech service. The user BER is not affected for the most TFCI coding schemes, only for the TFCI(15,5) * 2 coding (10 TFCI net bits) is a small but acceptable degradation. |
|---|

**Summary of TFCI coding performance**

The simulation results have shown, that a sufficient low error rate for the TFCI words can be achieved, when the decoding is done over two frames. The following figure shows the TFCI word error rates for the different TFCI coding schemes versus the raw BER.
The raw BER is a suitable parameter for determining the impact of TFCI on different services.
For example, as determined from simulations, the target value BER $10^{-3}$ for speech service can be achieved with a raw BER of about $5{,}5*10^{-2}$ (vehicular). Moreover, the following figure shows, that the (16,5)*2 TFCI coding will have an influence on the BER speech service as also shown in figure 4. The other TFCI codes have a negligible influence.

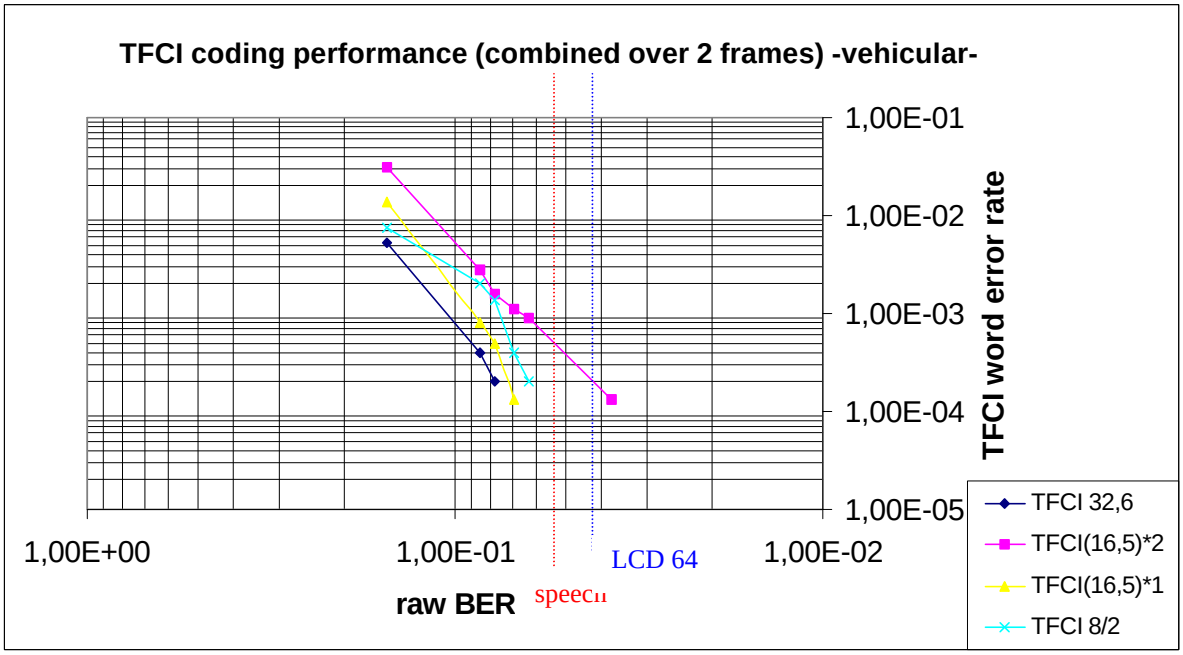


Figure 7 : TFCI coding performance, vehicular A (120 km/h), decoding over two frames over raw BER

The hardest requirement for the TFCI coding performance is the combination with a service with a target BER of $10^{-6}$, like the long interleaved and turbo-encoded LCD services. For those services most of the TFCI coding schemes are sufficient, because the target BER for LCD is reached for a little bit lower raw BER than for a speech service. Although the TFCI word error rate decreases significantly with a slightly decreasing raw BER (Figure 7), especially the TFCI word error rate of the TFCI(16,5)*2 code will not reach values of about $10^{-6}$ when the LCD service BER reaches $10^{-6}$. This would result in a not acceptable degradation of the LCD service. Like proposed for FDD in [3], repetition should be applied in this case for further reduction of the TFCI word error rate.

| Conclusion TFCI coding performance for different services<br>The performance of the TFCI coding schemes is also sufficient for services, which require a target BER of $10^{-6}$. If necessary, repetition is applied to the TFCI code words for further reduction of the TFCI word error rate, like also done in FDD. |
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## Conclusion

The TFCI coding schemes have no or a small influence on the BER of the service, when the TFCI decoding is done combined over two frames, needing an acceptable small amount of the gross bit capacity.
Therefore the Transport Format Combination should not change faster than every two frames.
Furthermore, the applied method of combined detection, the simple selection combining, also exhibits a sufficient performance while needing a low hardware complexity.
In case of services with a target BER of $10^{-6}$, for some TFCI coding schemes repetition should be applied to the TFCI code words for having also a small influence on the BER of the service.

## References

[1] 3GPP (S1.22) V1.0.x 1999-04; 3GPP TDD WG1 Multiplexing and channel coding (TDD)
[2] 3GPP TSGR1#5(99)611 ‘TFCI Coding Proposal for UTRA TDD’, Source: Siemens
[3] Tdoc SMG2 UMTS L1 568/98 ‘Downlink performance with TFI detection errors’, Source: Nokia