3GPP TSG RAN WG1#10 **Tdoc R1-(00) 0078**
China, Beijing
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Agenda Item: Ad Hoc 1

Source: Siemens

Simulation Results for TDD Cell Parameter Cycling

1. Introduction

This working paper provides performance simulations of the TDD system with both intra-cell and inter-cell interference present. In the simulations both the midamble sequence and scrambling sequence are changed to examine the influence upon performance with different sequences. Simulations are presented of the average coded and uncoded bit error rate on the downlink.

In the simulation two signals are generated, each composed of K individual users signals. The scrambling codes and midamble basic sequences applied to each signal are selected from a set of 128 such sequences. A different scrambling sequence and different midamble sequence is applied to each signal. The ratio of the power per code in each signal is varied in the simulation and different pairs of scrambling sequences/midamble sequences are chosen. The simulations have been performed on the downlink with Joint Detection performed in the receiver.

2. Performance dependence upon scrambling sequence Choice

The dependence on the uncoded bit error rate with the choice of scrambling sequence is shown below in Figure 1 when only a single user is present in each signal. It would be expected that the largest dependence upon the scrambling sequence would be observed with only a single user present in each signal.

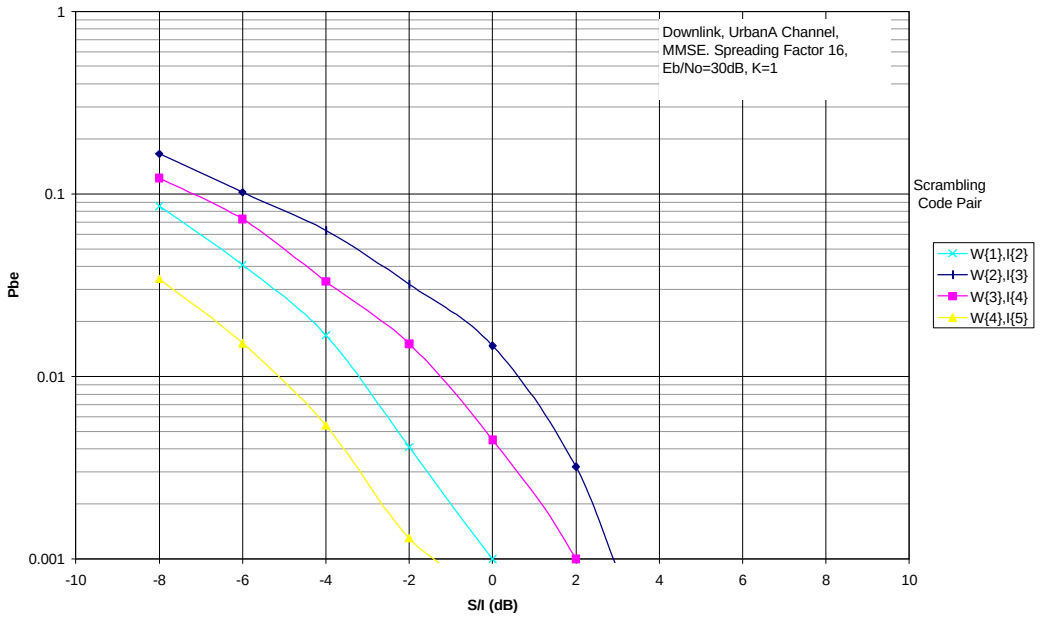

Figure 1 Inter-Cell Interference Performance Dependence Upon Scrambling Sequence (K=1)

The results show that there is a considerable dependence upon performance due to the choice of scrambling code, and a 6dB variation in the tolerance to inter-cell interference can be seen for one code pairing against another code pairing at an uncoded bit error rate of 1%. Over the entire set of 128 scrambling sequences, and considering all spreading sequences the dependence between codes may be greater.
When the number of users present in each signal increases, the dependency upon the choice of scrambling sequence would be expected to diminish, because different cross-correlations exist between each of the users signals within the wanted and inter-cell interfering signals. Simulation results are presented in Figure 2 for the case where 4 users are present in each signal.

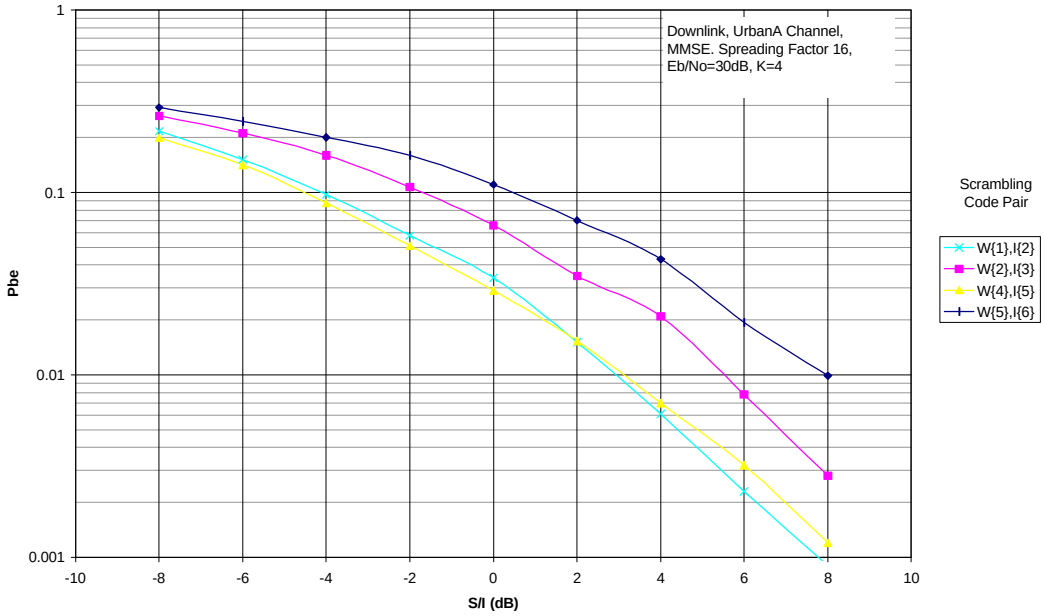

Figure 2 Inter-Cell Interference Performance Dependence Upon Scrambling Sequence (K=4)

The results show that despite an increase in the number of users there is a still a strong dependency upon the scrambling code sequence. The bit error rates shown are an average across the bit error rate obtained for each user. There is some variation in the bit error rate for individual users. The overall degradation in performance with 4 users present in both wanted and interfering signals compared to just a single user present is partly accounted for by the fact that 4 times the interference power is present.

Changing the scrambling sequence on a frame by frame basis from a set of scrambling sequences will reduce the performance dependency with the choice of scrambling code. The average bit error rate seen for each user should be the same independent of the spreading code chosen, with a fixed scrambling code this is not the case. If the inter-cell interfering signal uses a different ordering or set of scrambling sequences the same average bit error rate should result, independent of the ordering or set of sequences chosen (providing the number of scrambling sequences in the set is large enough). Simulations have been conducted for 1 and 4 users where the scrambling sequence used in each frame is selected from a set of 2, 4 sequences. The ordering of the selection is different for the wanted and interfering signal. The results are shown below in Figure 3 and Figure 4 when the scrambling sequence is selected from a set of two.

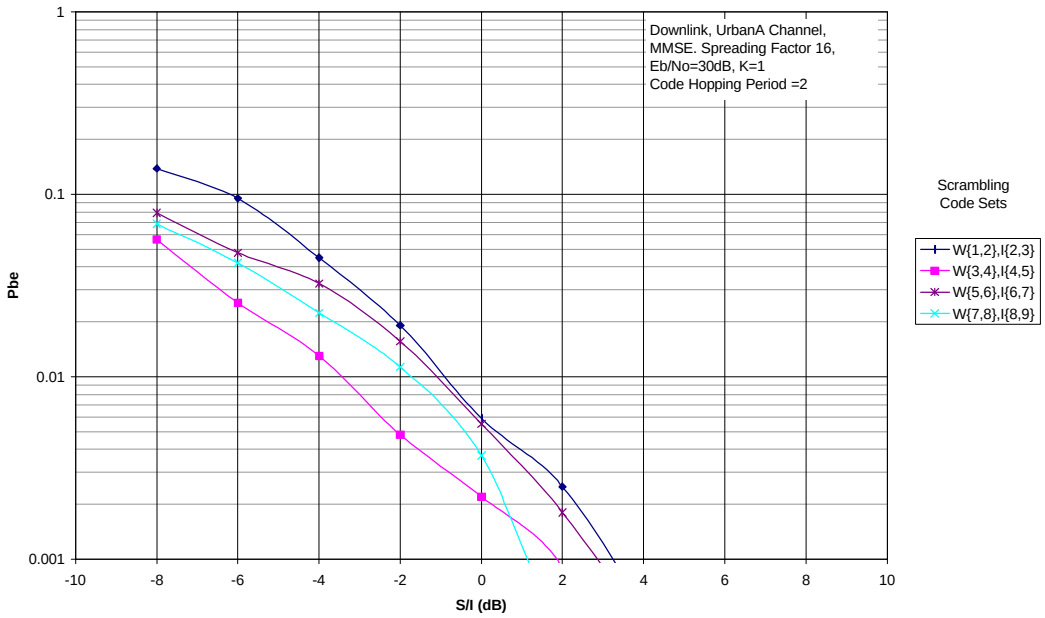

Figure 3 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis (K=1, Period =2 Frames)

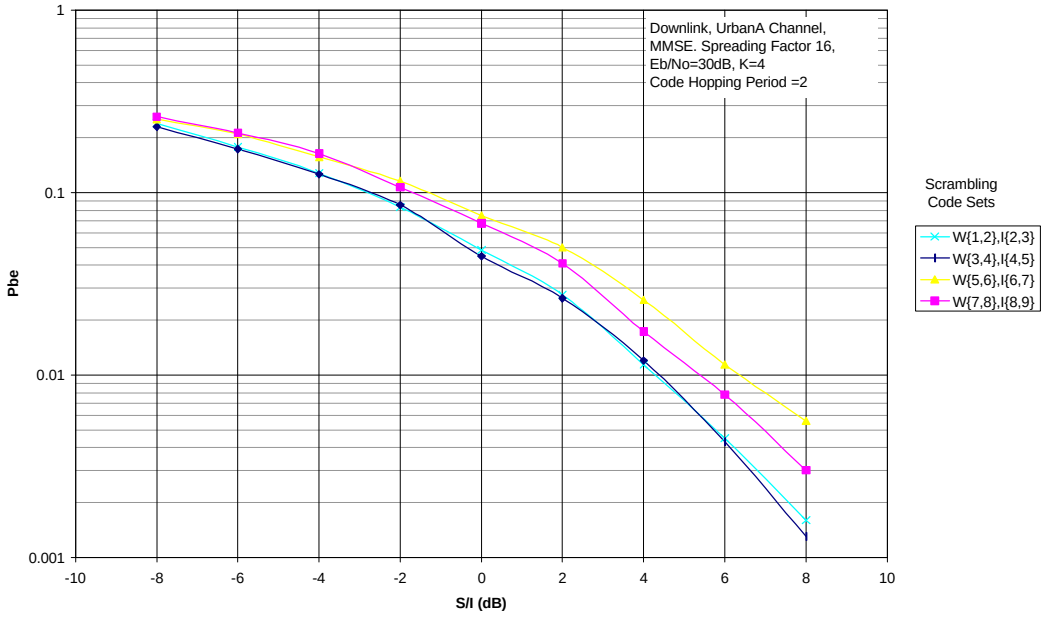

Figure 4 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis (K=4, Period =2 Frames)

Comparing the results of Figure 3 and Figure 4 with those of Figure 1 and Figure 2 shows that with the scrambling sequence changed on a frame by frame basis over a period of two frames the dependence of the inter-cell interference performance upon the choice of sequence is reduced by approximately half (in decibel terms). It should be noted that the overall variation could be greater if the entire set of scrambling sequences is considered. The effect of changing the scrambling sequence over a four frame period is examined in Figure 5 and Figure 6.

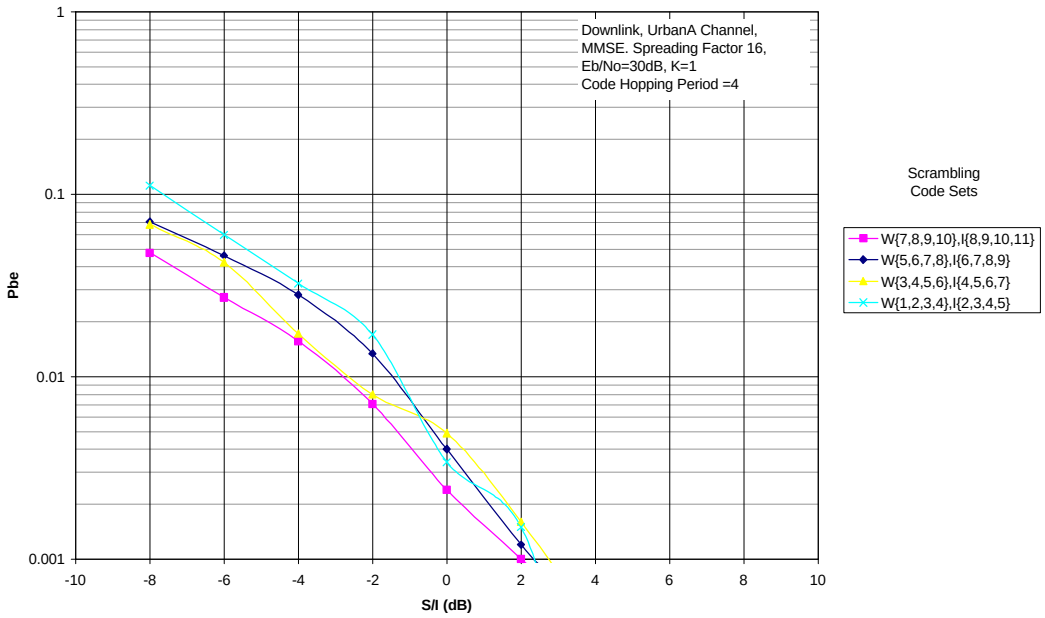

Figure 5 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis (K=1, Period =4 Frames)

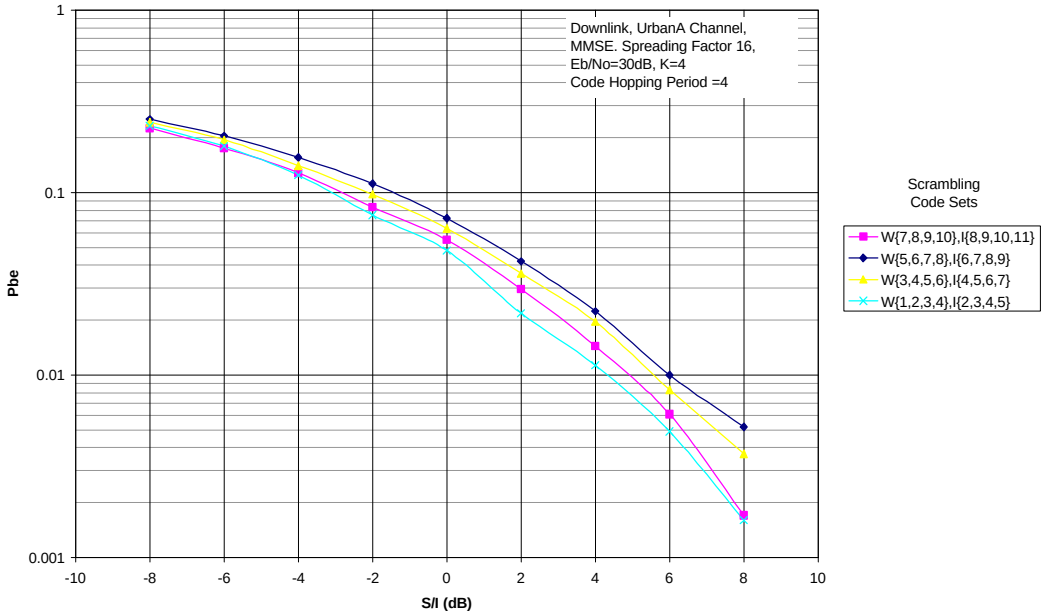

Figure 6 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis (K=4, Period =4 Frames)

The results of Figure 6 show that only a small further reduction in the performance dependence upon the scrambling sequence set is obtained when the set extends over 4 instead of 2 frames. The performance dependence is still significant amounting to about 2dB variation at a bit error rate of 2%.
Further increasing the number of sequences over which the scrambling sequence is changed will reduce the performance variation due to the choice of scrambling sequence. With a much larger number of sequences over which the scrambling sequence is cycled the performance dependence upon the choice of sequence should become negligible.

The application of interleaving and error correction coding over more than one frame has also been examined. In the results of Figure 7, Figure 8 and Figure 9 a 1/3 rate convolutional code is applied to the data and

interleaving performed over two frames. The period over which the scrambling sequence is changed is 1, 2 and 4 frames.

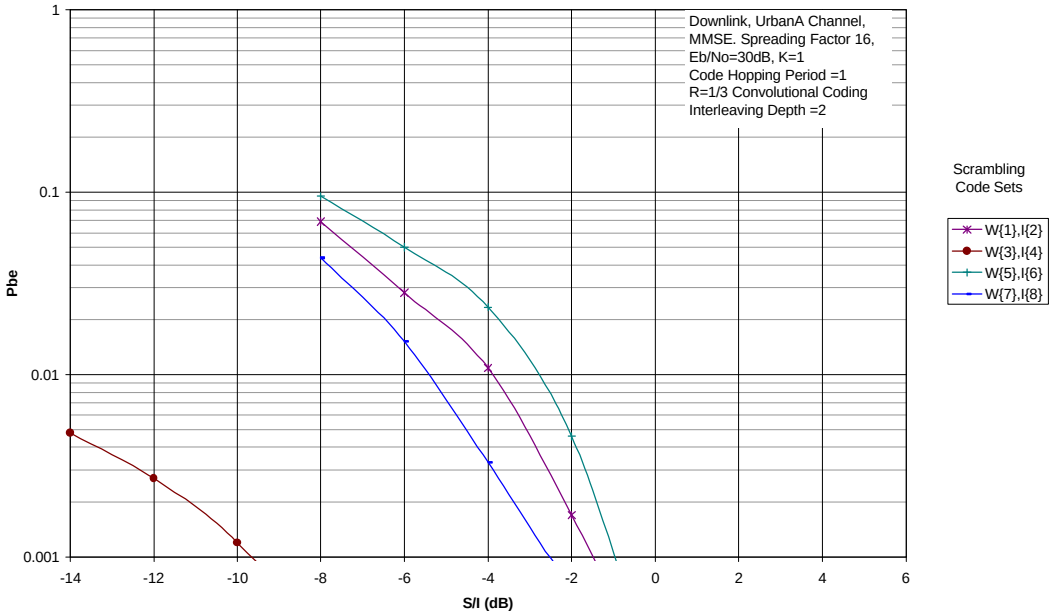

Figure 7 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis, 1/3 Rate Convolutional Coding and Interleaving (K=1, Period =1 Frames)

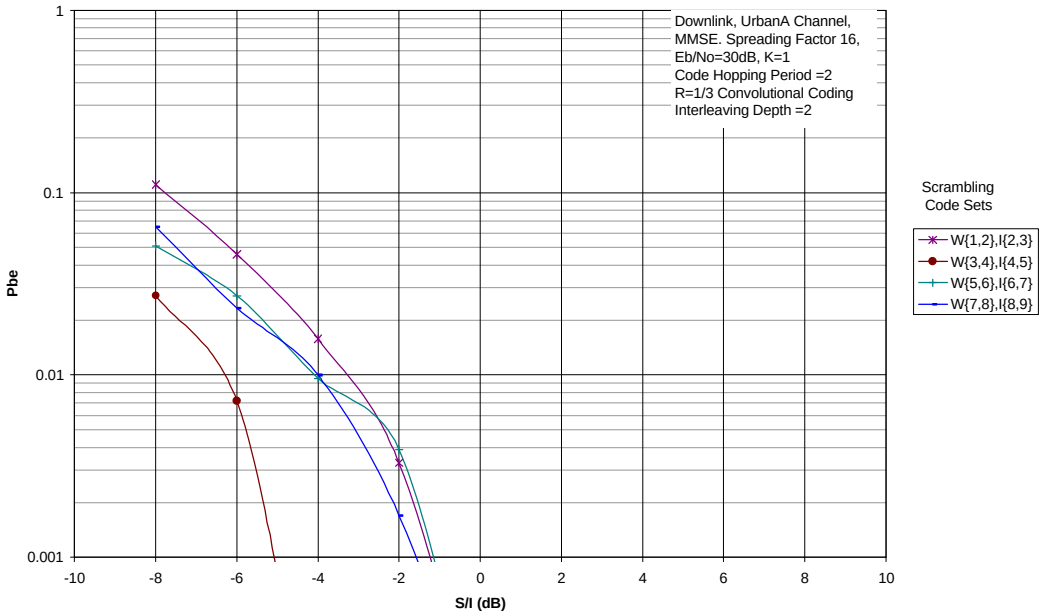

Figure 8 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis, 1/3 Rate Convolutional Coding and Interleaving Depth 2(K=1, Period =2 Frames)

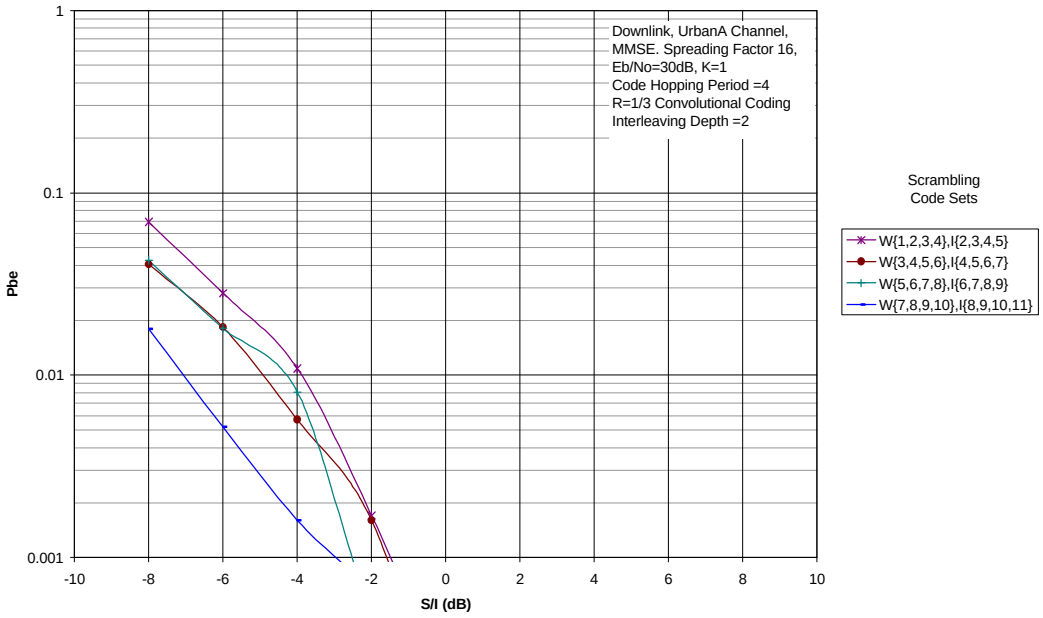

Figure 9 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis, 1/3 Rate Convolutional Coding and Interleaving Depth 2(K=1, Period =4 Frames)

The results of Figure 7, Figure 8 and Figure 9 show that the performance dependance upon scrambling sequence is not reduced by the use of interleaving and error correction coding.
Results are presented below in Figure 10 for the situation where the scrambling sequence is changed over a two frame period and where the interleaving is performed over 4 frames.

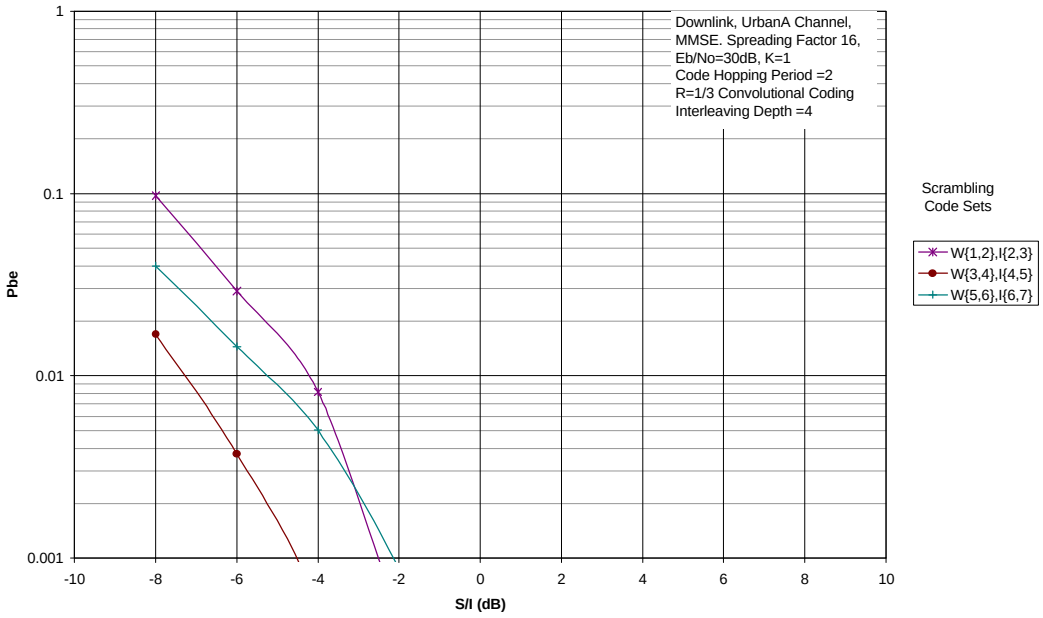

Figure 10 Inter-Cell Interference Performance with Scrambling Sequence Changed on a Frame by Frame Basis, 1/3 Rate Convolutional Coding and Interleaving Depth 4(K=1, Period =4 Frames)

Comparing the results of Figure 8 with those of Figure 10 indicate that the interleaving depth has little influence in reducing the performance dependence upon the scrambling code.

3. Conclusion

To avoid significant performance differences with inter-cell interference due to the choice of scrambling sequence, and midamble sequence it is recommended that both scrambling sequence and midamble sequence are cyclically varied on a frame by frame basis. The simulation results show that cell parameter cycling is beneficial in order to avoid a strong impact of the choice of the cell parameters on the performance. The period over which the sequences are changed should be as long as possible.

Cyclically changing the scrambling sequence and midamble sequence can have an impact upon the initial synchronisation process. With the period equal to two frames it is possible for the mobile having detected the SCH to determine the order in which the midamble and scrambling sequence are changed. This would have minimal impact upon the synchronisation process. From a performance viewpoint a two frame period is insufficient. Ideally a much longer period is required. However, considering the periods of two and four frames only, the performance difference is only moderate.