# Improved Performance of Turbo Codes using Iterative decoding with additional Convolutional Interleaver

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***Abstract*--** Turbo codes are most powerful channel codes which have very high decoding complexity. This paper adopts an improved model for Turbo codes by using additional interleaver in the system. The proposed additional interleaver considered here is Convolutional interleaver which can achieve better error rate performance than other interleavers with reduced number of iterations. Simulation results shows that the proposed model performance with and without additional convolutional interleaver in AWGN Channel.

***Keywords* — Convolutional interleaver, Iterative decoding, Frame size, Bit error rate.**

## I. INTRODUCTION

Turbo Codes are parallel concatenations of convolutional codes with significant interleaving. It was first discovered by Claude Berrou in 1993. Interleaving is used with turbo codes and essentially the additional gain accrues to a reduction in the nearest neighbor count by the depth of the interleaver. The interleaver used in Turbo codes plays a major role in the performance of Turbo codes [1,2,3,4,5].

Turbo codes have attracted many researchers because of its astonishing performance at low BER. Turbo codes are the channel coding scheme used in wireless cellular networks because they can reach near to Shannon limit. The interleaver and decoding techniques used in Turbo codes plays a major role in the performance of Turbo codes. Turbo Code design targets a data rate that is less than capacity, but perhaps just slightly less [6,7,8,9].

Fig.1 illustrates the proposed improvement model of Turbo code encoder-decoder through the additional interleaver namely convolutinal interleaver and de-interleaver to the encoder and decoder respectively of the standard system. Core interleaver used can be either block interleaver or Random interleaver. The performance comparison of Random Interleaver with Block interleaver for fixed number of iterations and fixed decoding algorithm is verified. Random interleaver has slightly superior performance with compared to Block interleaver. If number of iterations is increased then there is improvement in BER performance but system speed significantly reduces. Convolution interleaver has better BER performance with compared to block and random interleavers when number of iterations are less.

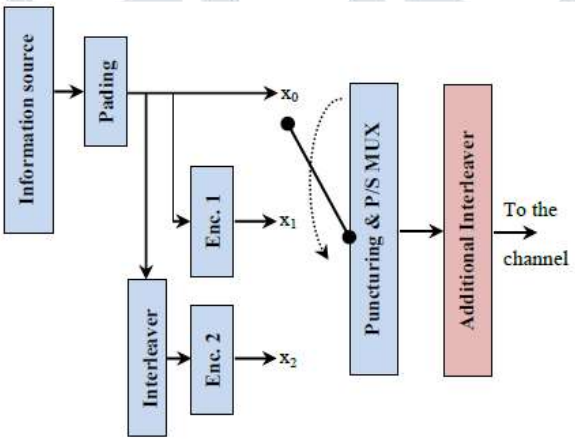


Fig.1a: Proposed model of Turbo encoder structure

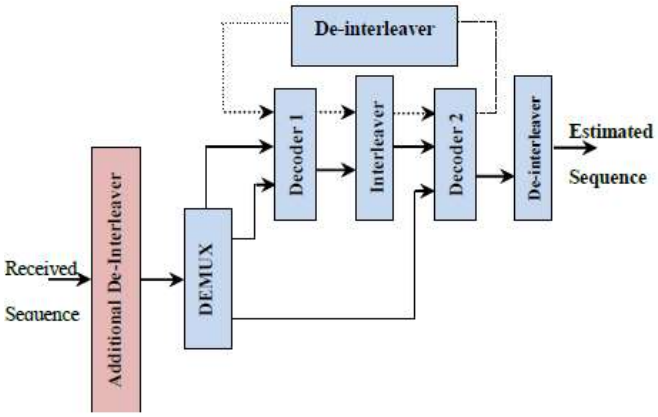


Fig.1b: Proposed model of Turbo decoder structure

## II. RESULT AND DISCUSSIONS

A common conclusion reached by many researchers is that increasing the number of iterations, to some extent reduces the BER significantly. This result was based on the block and random interleavers. We have considered this effect for our proposed model, where using additional Convolutional interleaver beside the normal system to improved its performance.

For many applications such as speech transmission, they require coding with short-frame length since it gives excellent results with Turbo coding having short-frame length (frame size FS = 128 or 512) gives better performance at different number of iterations.

Impact of various Frame/Interleaver size FS= 128, 512 on the performance of Turbo codes for 4 or 6 iterations and number of terminated frame errors =5 for log-map-decoder for AWGN Channel are shown by the following figures 2,3,4,5,6,7,8,9,10,11,12. Show how the performance of the Turbo code improved with using the additional interleaver with different frame length (FS) and interleaver type that used in the encoder and decoder.

Figures 2,5,6 and 9 show simulation results obtained when the additional and original interleavers are similar for AWGN channel and different frame length and 6 iterations. Figures 3,4,7 and 8 show simulation results obtained when the additional and original interleavers are different for AWGN channel and different frame length and 6 iterations

Figure 10 shows simulation results obtained when the additional and original interleavers are similar for correlated Rayleigh fading or Jack fading channel and frame length (FS=128) and 6 iterations. Figure 6 shows simulation results obtained when the additional and original interleavers are similar for uncorrelated Rayleigh fading channel and frame length (FS=128) and 6 iterations.

Finally, Turbo code exhibits better performance by using additional interleaver where the number of iterations is less than that in normal turbo codes. This can be seen in figure 12, where the same types of additional and original interleavers are used for AWGN channel and frame length (FS=128) and for 6 iterations (for normal turbo code) and 4 iterations (for improvement model of turbo code). Using the proposed model gives better results compared with other researches [5,10].

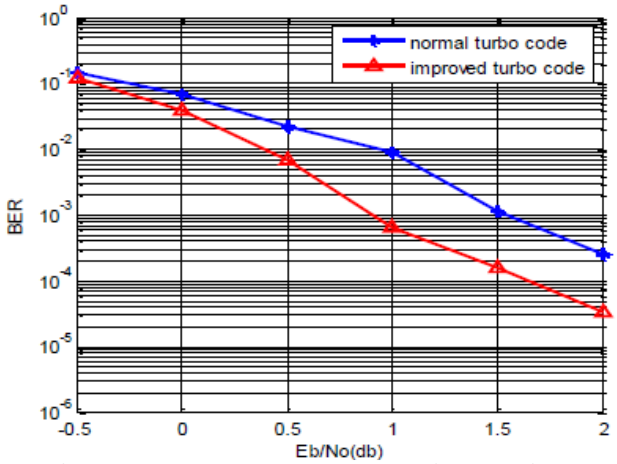


Fig . 2: Impact of Frame/ Interleaver size FS=128 on the performance of Turbo codes for 6iterations

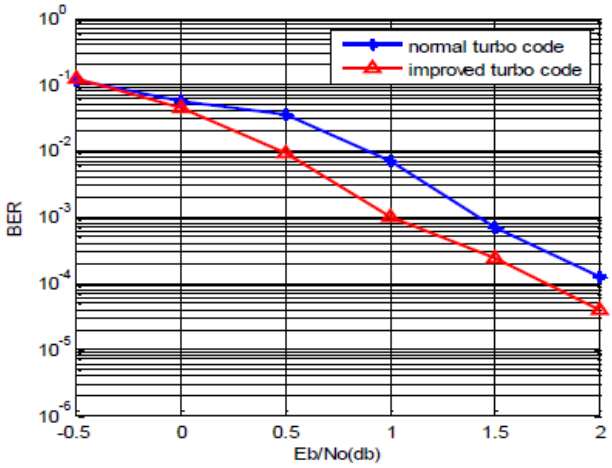


Fig. 3: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using block original interleaver and convolutional additional interleaver types

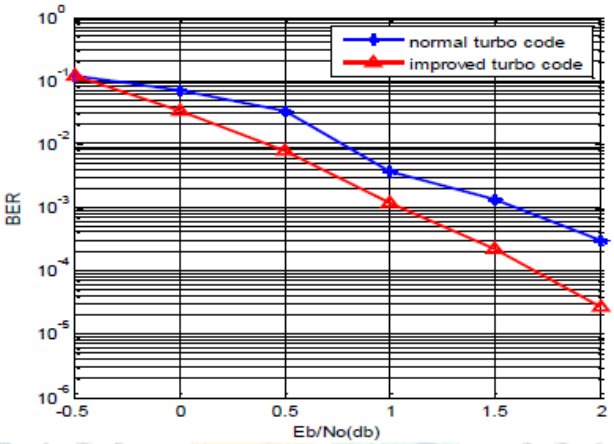


Fig. 4: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using random original interleaver and convolutional additional interleaver types

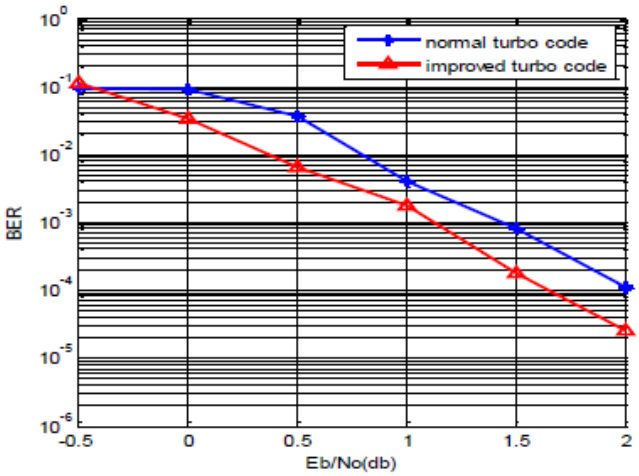


Fig. 5: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using random interleaver type for original and additional interleavers

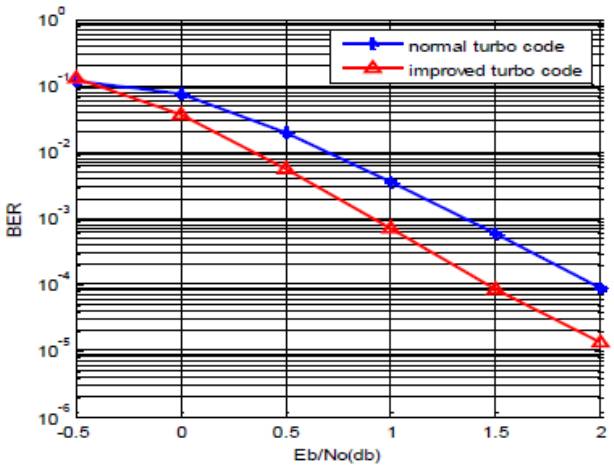


Fig. 6: Impact of Frame/Interleaver size FS=512 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using block interleaver type for original and additional interleavers

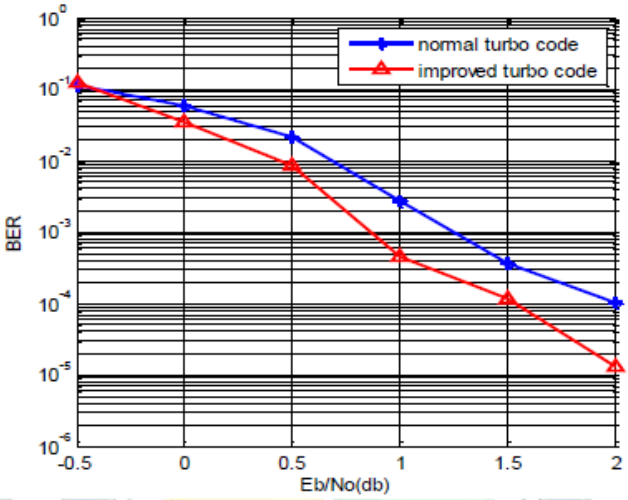


Fig. 7: Impact of Frame/Interleaver size FS=512 on the performance of Turbo codes for 5 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using block original interleaver and random additional interleaver types

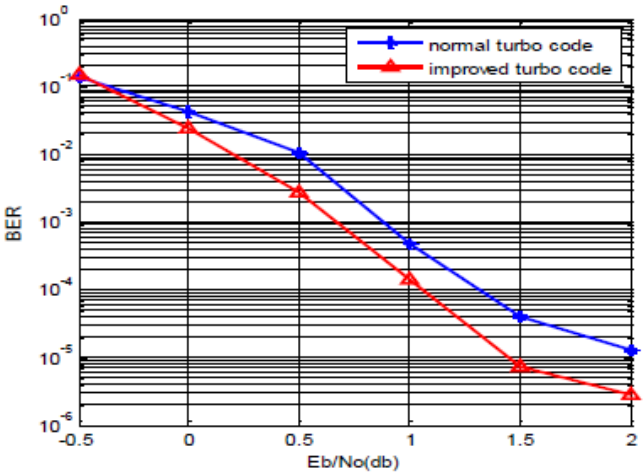


Fig. 8: Impact of Frame/Interleaver size FS=512 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using random original interleaver and block additional interleaver types

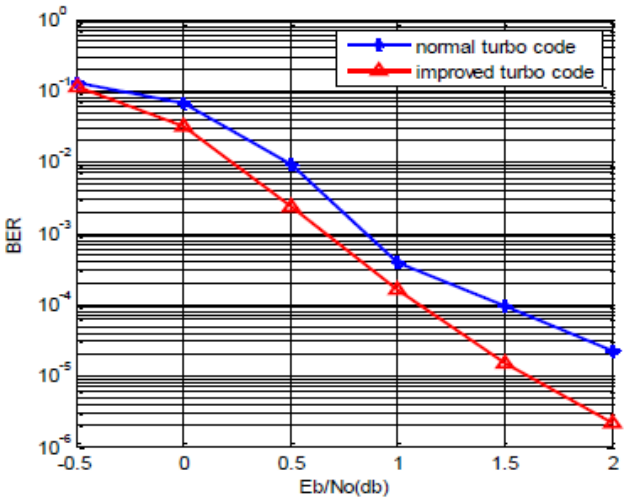


Fig. 9: Impact of Frame/Interleaver size FS=512 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for AWGN Channel for log-map-decoder using random interleaver type for original and additional interleavers

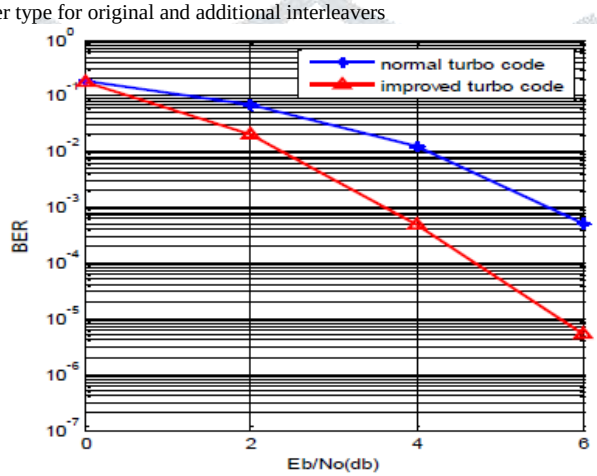


Fig. 10: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 5 iterations and number of terminated frame errors=5 for correlated Rayleigh fading or Jack fading channel for log-map-decoder using random interleaver type for original and additional interleavers

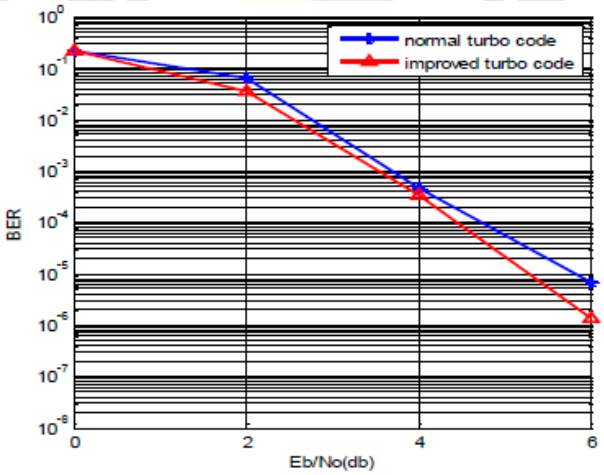


Fig. 11: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 6 iterations and number of terminated frame errors=5 for uncorrelated Rayleigh fading channel for log-map-decoder using convolutional interleaver type for original and additional interleavers

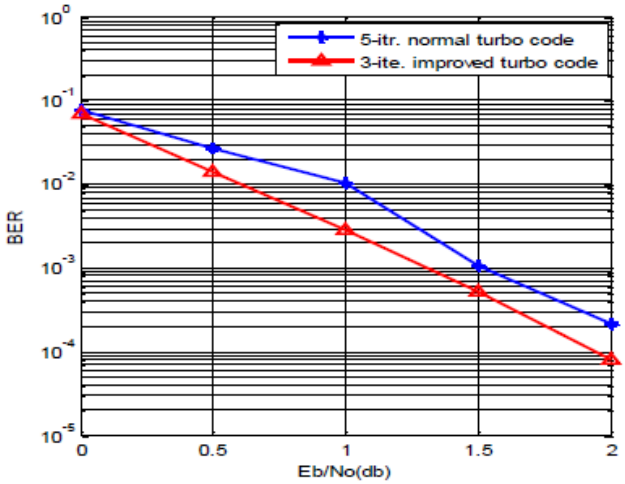


Fig. 12: Impact of Frame/Interleaver size FS=128 on the performance of Turbo codes for 5 iterations (for normal turbo code) and 3 iteration (for improvement model of turbo code) and number of terminated frame errors=5 for AWGN channel for log-map-decoder using convolutional interleaver type for original and additional interleavers

## III. CONCLUSIONS

In this paper the proposed model of building blocks of turbo codes has been described using additional convolutional interleaver. The reason for the focus on interleaving is that interleavers have a large influence on the free distance. When the free distance of a turbo code increases, the error floor performance improves.

The result of a proposed model of turbo product code has been given. The interleaver was replaced by a more general permutation and the results investigated. These codes were simulated in an AWGN.

The graphs of these experiments showed that the additional interleaver has better BER performance whether the additional interleaver the same or different type from the original interleaver and used 4 and 6 iterations to estimate the correct code words. These experiments were only performed on small (FS=128) and long (FS= 512) codes, and therefore the permutation possibilities are limited.

From the plot it is clear that Convolutional interleavers (original or addition interleavers) with different frame length (FS=128 or 512) gives better performance at number of iterations (4 or 6 iterations) compared with the standard Turbo codes system especially when the interleavers are the same. Another important result found was that the new model at 4 iterations gives better performance than the original model at 6 iterations.

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