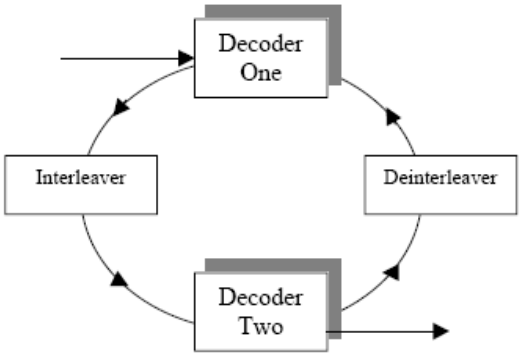

Figure 7: Turbo decoder

For turbo codes, the Soft Output Viterbi Algorithm (SOVA), and the Log-MAP decoding algorithm can be used as they produce soft-bit estimates. The Log-MAP decoding scheme is the modified version of the MAP decoding scheme and is computationally less complex than the original MAP decoding algorithm. However, due to the push for strikingly low bit error rates, the MAP or the Log-MAP has been most commonly used in turbo codes since they are based on the optimal decoding rule. In contrast, the SOVA is an approximation to the MAP sequence decoder and will have a slightly worse bit error performance. Though SOVA suffers from performance degradation as opposed to the Log-MAP decoding rules, it has much reduced complexity.

4. MAP Algorithm

To first understand the decoding of turbo codes, a preliminary understanding of the MAP algorithm is necessary. The idea was set out to estimate the posteriori probabilities of the states and transitions of a Markov sequence transmitted through a discrete memoryless channel. This work resulted in an algorithm that minimizes symbol error rates while trying to decode block and trellis codes. The aim of the MAP algorithm is to minimize the symbol error rate for the decoding of trellis and block codes. Therefore, after receiving the information through the channel, the job of the decoder is to determine the most likely input bits (original/uncoded information sequence), based on the received symbols. Since the input is over the binary alphabet, it is conventional to form a log-likelihood ratio (LLR) and base the bit estimates on comparisons based on magnitude of the likelihood ratio to a threshold. The log-likelihood ratio for the input symbol indexed at time t is defined as

$$\Lambda(x_t) = \ln \frac{P(x_t = 1 \mid r)}{P(x_t = 0 \mid r)}$$

In this expression, $P(x_t = i \mid r)$ is the a posteriori probability of the information bit, $x_t = i$, where i $\{0,1\}$, when the knowledge of the received data r is given. The decoder produces estimates of the information bits based on the values of the log-likelihood ratio. The magnitude of the log-likelihood ratio is defined as the soft output or soft value which can be passed after processing to the other decoder as a priori information. The estimator obeys the following rule

$$x_t = \begin{cases} 1 & if\ \Lambda(x_t) \geq 0 \\ 0 & otherwise \end{cases}$$

(A) Log-MAP Decoding

The Log-MAP decoding algorithm is used which in fact is based on the same idea as the MAP decoding algorithm with the benefit that it simplifies the computation by eliminating the multiplicative operations and the need to store small values for the probabilities by including the logarithm operator in the computation [6,9]. The multiplicative operation is computationally more expensive than the addition operator in terms of processing speed of a microprocessor. Also the requirement of large amount of memory to store the probabilities in the computation of the log-likelihood ratio makes the implementation of this algorithm complex. After defining all the entities required in the decoding process the complete decoder structure for Log-MAP algorithm is shown in Fig. 3

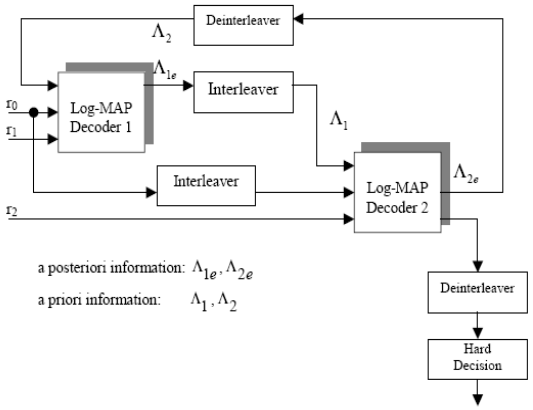

Figure 7: Log-MAP algorithm

(B) SOVA Decoding

The SOVA decoder also estimates the soft output information for each transmitted symbol in the form of the LLR. In order to calculate this LLR the algorithm relies on the reliability of the maximum likelihood (ML) chosen path [9]. At each node in the trellis the absolute difference between the surviving and the competing paths determines the reliability of the decision. The greater the difference between the survivor and the competing path, the more reliable is the survivor path. For this reliability calculation, it is assumed that the survivor path's accumulated metric is always better than the competing accumulated metric. Furthermore, to reduce complexity, the reliability values only need to be calculated for the ML survivor path and are unnecessary for the other survivor paths since they will be discarded. The structure of the SOVA decoding algorithm can be shown in Fig.4

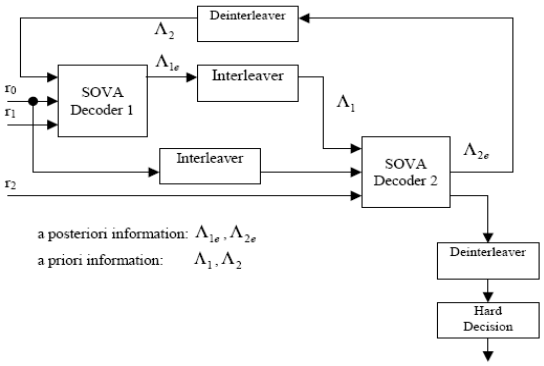

Figure 7: SOVA decoding

5. Simulation Results

The simulation results obtained by using both SOVA and Log- MAP decoding schemes for the additive white Gaussian noise channel are presented. The effect of puncturing is also studied by simulating the punctured scheme by using odd-even interleaving. The results for both punctured and unpunctured codes are obtained by simulating the schemes under identical parameters so that a fair comparison can be made [8].

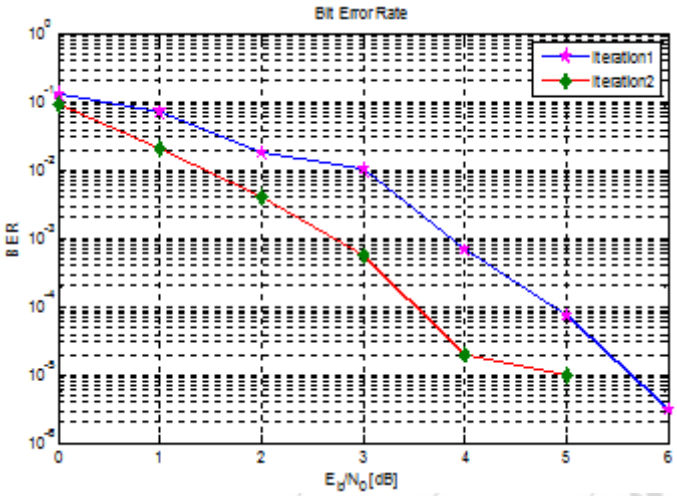

Figure 5: BER plot for log-map decoder: Punctured

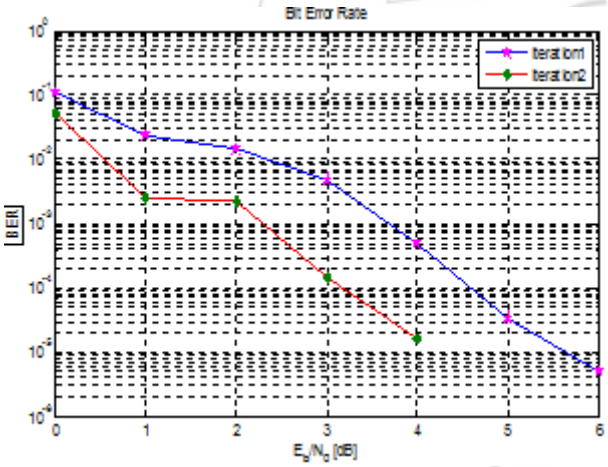

Figure 6: BER plot for log-map decoder: Unpunctured

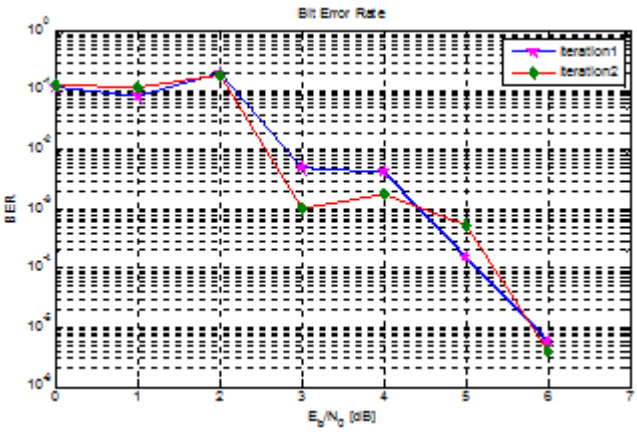

Figure 7: BER plot for SOVA decoder: Punctured

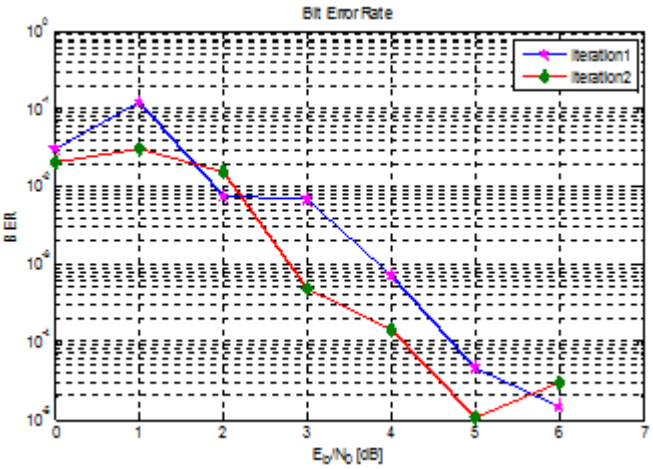

Figure 8: BER plot for SOVA decoder: Unpunctured

From Fig 5 and Fig 6 it is clear that for log Map decoder punctured code degrades the performance of the decoder as compared to unpunctured code. From Fig7- Fig8 it is clear that for SOVA decoder punctured code degrades the performance of the decoder as compared to unpunctured code. From the simulation results we observed that an increase in code rate (punctured case) degrades the performance of the decoder as compared to unpunctured code. From Fig5- Fig7 we also observe that log-MAP decoder gives better performance as compared to SOVA decoder for same parameters.

6. Conclusion

Turbo code, a very powerful error correcting coding scheme, which is formed by the parallel concatenation of two recursive non-systematic convolutional codes, is presented. The simulation results clearly depicts that the code has the capability of reaching very low bit error rates at even small signal to noise ratios with increasing iterations. The objective of the iterative process is to further reduce bit errors. However, the evaluation of the number of iterations necessary for optimal results has proven to be a difficult task. The SOVA decoding scheme has shown less performance than the Log-MAP algorithm and this was expected due to the fact that the SOVA decoder is an approximation to the MAP decoding scheme and hence suffers from performance degradation. Although SOVA has the disadvantage of performance degradation, it has the hardware implementation advantage as it does not require large memory size to store numbers, whereas Log-MAP algorithm despite its superior performance is prone to memory overflows.

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