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Bounds on the Error Probability of ML Decoding for Block and Turbo-Block Codes

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Abstract

The performance of either structured or random turbo-block codes and binary, systematic block codes operating over the Gaussian channel, is assessed by upper bounds on the error probabilities of maximum likelihood (ML) decoding. These bounds on the block and bit error probability which depend respectively on the distance spectrum and the input-output weight enumeration function (IOWEF) of these codes, are compared, for a variety of cases, to simulated performance of iterative decoding and also to some reported simulated lower bounds on the performance of ML decoders. The comparisons facilitate to assess the efficiency of iterative decoding (as compared to the optimal ML decoding rule) on one hand and the tightness of the examined upper bounds on the other.

We focus here on uniformly interleaved and parallel concatenated turbo-Hamming codes, and to that end the IOWEFs for Hamming codes and these turbo-Hamming codes are calculated by efficient algorithms derived here. The usefulness of the bounds is demonstrated for uniformly interleaved turbo-Hamming codes at rates considerably beyond the cutoff rate, where the results are compared to the simulated performance of iterative decoding with different types of interleavers. We consider also the ensemble performance of RA (repeat and accumulate) codes, a family of uniformly interleaved and serially concatenated turbo-block codes, introduced by Divsalar, Jin and McEliece. Although, the outer and inner codes possess a very simple structure: a repetitive and a differential encoder respectively, our upper bounds indicate impressive performance at rates beyond the cutoff rate, as is also evidenced by simulations of the performance of iterative decoding algorithms for a particular structured interleaver.