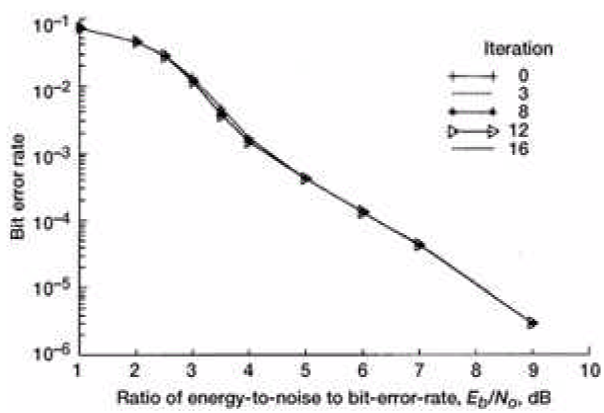
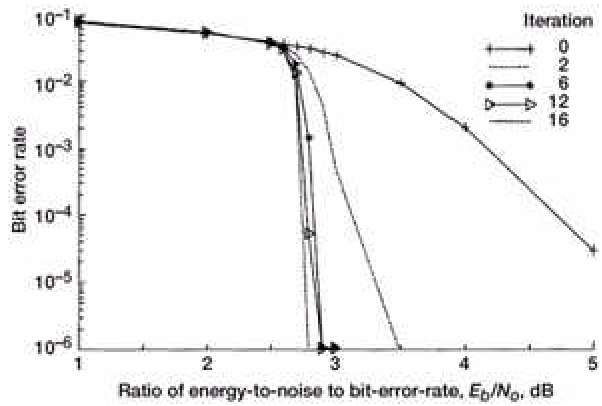
High-Performance, Low-Complexity Codes Researched for Communication Channels

NASA Lewis Research Center's Communications Technology Division has an ongoing program in the development of efficient channel coding schemes for satellite communications applications. Through a university grant, as a part of this research, the University of Toledo is investigating the performance of turbocodes, which use parallel concatenation of nonsystematic convolutional encoders with an interleaver. The error-correcting capacity of these codes is close to the Shannon limit. The research emphasis is on the development of low-complexity, but higher rate (greater than one half), turbocodes and on the iterative decoding of block codes.

Results of extensive computer simulations of higher rate turbocodes (2/3, 4/5, 5/6, 10/11, and 15/16) show that their performance is greatly affected by the proper selection of code polynomials, the puncturing pattern, and the interleaver selection. In addition, some types of turbocodes tend to have flares or flooring in the energy-to-noise versus bit-error-rate (E_b/N_o versus BER) curve. Research shows that, for the same code polynomials selected, puncturing with the extended puncturing period exhibits significant coding gains since more diverse positions are selected. The graphs show this gain for a 5/6 turbocode. Investigations of flares (or flooring) show that there are two important parameters related to the interleaver design. The first is the degree of uniformity. A nonuniform (pseudorandom) interleaver improves performance because it can make the weight distribution of a code similar to that of a random code that has a performance close to the Shannon limit. The other aspect is the interleaver size. Results show that higher rate turbocodes with a large size random interleaver do not exhibit flare. Additional research showed that an interleaver block size of 64 by 64 is optimum for a bit error rate of 10^{-6}.



Performance of (23,31) turbocode. Rate, 5/6; conventional puncturing pattern.



Improved performance of the turbocode with the extended puncturing period.

Another part of the research is on the application of the "turbo" concept to the block codes. The method of iterative decoding based on the Maximum a Posteriori Probability (MAP) algorithm, can be used to improve the performance of a simple block code to close to the theoretical limit. Results show that comparable performance with turbocodes can be achieved if a two-dimensional product code is used whose component codes are binary linear block codes such as the (15,11) extended Hamming code.

For more information, visit the Communications Technology Division at http://ctd.grc.nasa.gov/.

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