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# Improved Upper Bounds on the Decoding Error Probability of Parallel and Serial Concatenated Turbo Codes via their Ensemble Distance Spectrum

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## Abstract

The ensemble performance of parallel and serial concatenated turbo codes is considered, where the ensemble is generated by a uniform choice of the interleaver and of the component codes taken from the set of time varying recursive systematic convolutional codes. Following the derivation of the ensemble weight enumeration functions of random parallel and serial concatenated codes, improved upper bounds on the bit and block error probabilities of these ensembles of codes are derived and the influence of the interleaver length $N$ and the memory length of the component codes $m$ are investigated. The improved bounding technique proposed here, which is based on the tangential-sphere bound, is compared to the conventional union bound and to a recent alternative bounding technique by Duman & Salehi which incorporates modified Gallager bounds. The advantage of the derived bounds is demonstrated for a variety of parallel and serial concatenated coding schemes with either fixed or random component codes, and it is especially pronounced in the region above the cutoff rate, where the performance of turbo codes is most appealing.