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# EFFICIENCY OF CONCATENATED CODE ON THE BASIS OF MULTITHRESHOLD DECODER

In the article concatenated code, consisting of the convolutional orthogonal codes decoded with multithreshold decoders, and such codes, as the parity check code and the short convolutional code decoded with the Viterby decoder are considered.

By transmission of a digital data on a noisy channel always there is a probability of that received data will contain errors. Error-correcting coding is usually applied to decrease of a bit error rate (BER). For today some methods of the error correction, permitting to work near to the channel capacity are known [1]. Among them it is possible to select multithreshold decoders (MTD) [2] developed by the Russian technicians, which program versions even at a large noise level fulfil on two order smaller number of operations, than other algorithms.

On fig. 1 bit error performance of MTD over a channel with additive white gaussian noise (AWGN) represented in case of usage of binary phase shift keying (BPSK) for self-orthogonal codes (SOC) with a code distance d=9, selected according to minimization of error propagation effect. The given model of a channel has been selected because it enough precisely describes real satellite and some other types of channels. At obtaining the represented relations it was used about 10 decoding iterations. For matching in a figure by dashed lines represented a graphics of relation of BER for optimal decoding of the codes. As follows from the represented schedules, application MTD for decoding of codes with small error propagation provides practically optimal decoding that allows to get a coding gain more than 7 dB at Pb=10–5. In the given figure of a curve «MTD PLIS» characteristics PLIS MTD of the convolutional code, developed by leading experts also represented in the field of error-correcting coding.

On fig. 1 for matching characteristics of classical decoder Viterby for a convolutional code with constraint length K=7 and code rate 1/2 and 2/3 represented. It is visible, that MTD in data conditions it appears much better practically sold decoder Viterby, and with rise of code rate the difference in efficiency becomes more and more impressive.

From the coding theory it is known, that concatenated codes in which the information is sequentially encoded with the several methods, have essentially the best efficiency, than codes used for their construction [3]. Therefore for the further rise of efficiency from coding it is obviously possible to use MTD in a structure of various concatenated codes. Thus together with MTD it is desirable to use the most simple methods of an error correction

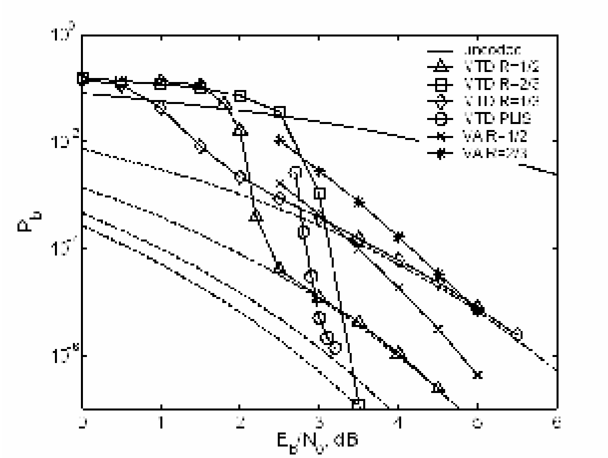


Fig. 1. Efficiency of multithreshold decoders over an AWGN channel

(the parity check code, a short convolutional code) for saving a simplicity of practical implementation of the resulting coding scheme.

For research of concatenated codes on the basis of MTD the software have been developed, permitting to determine BER at a preset signal to noise ratio over an AWGN channel. Distinctive feature of the program is possibility of represent BER performance as plots.

On fig. 2 are shown BER performance over the above described model of a channel for various codecs. In the given figure the curve «MTD (R=1/2, d=9)» reflect efficiency of usual MTD for SOC with code rate R=1/2 and a code distance d=9.

The curve «MTD (R=1/2, d=9) + PCC» on fig. 2 shows characteristics of the concatenated code [3] consisting of the parity check code length n1=25 and same SOC, as at obtaining «MTD (R=1/2, d=9)» curve. It is necessary to mark, that at obtaining the given relation the parity check code was used on several iterations of decoding, thus as though "helping" to MTD at decoding internal SOC. As follows from matching characteristics of MTD and a concatenated code with PCC on its basis, last allows to reduce in 10 and more times BER in comparison with ordinary MTD, that allows to receive an additional coding gain about two or even three decibel. Also we shall mark, that the concatenated code consisting of the Reed-Solomon code and a convolutional code with code rate R=1/2 and constraint length K=7, decoded with the optimal algorithm Viterby, even at smaller common code rate (R~0,437) strongly yields to a cascade circuit on base MTD and PCC at Pb>10–6. Unfortunately, the given way of cascading allows to improve characteristics MTD only in the field of its effective work.

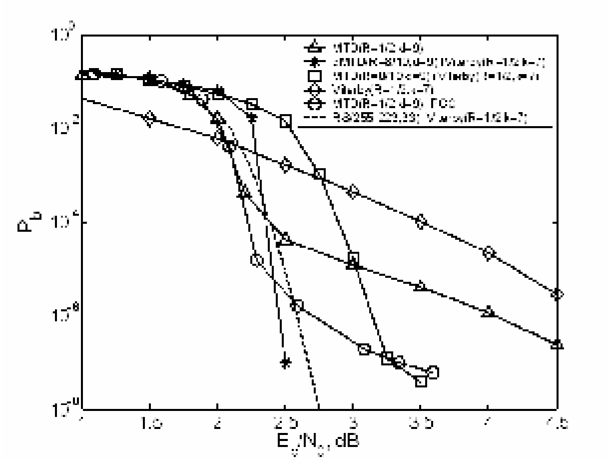


Fig. 2. Simulation results of the concatenated codecs on base MTD over an AWGN channel

The probability of a bit error of the concatenated code consisting from SOC with code rate R=8/10 and a code distance d=7, decoded with MTD, and a convolutional code with R=1/2, K=7, decoded with algorithm Viterby, represented on fig. 2. curve «MTD (R=8/10, d=7) + Viterby (R=1/2, K=7)». From matching given a graphics with the efficiency of decoder Viterby for the component code (a curve «Viterby (R=1/2, K=7)») it is visible, that the cascade circuit appears better, since signal-to-noise ratio about 2,8 dB. Matching of the given code with a cascade circuit on base MTD and PCC shows, that last it appears better approximately on 0,7 dB for BER greater than 10–7. At smaller BER efficiency of these codes is approximately identical.

Essentially best results on efficiency are shown with the concatenated codes consisting from q-ary SOC [4] for Q=256, decoded with qMTD, and a convolutional code decoded with algorithm Vuterby. The BER for the given concatenated code represented on fig. 2 curve «qMTD (R=8/10, d=7) + Viterby (R=1/2, K=7)». As transition to q-ary codes follows from the analysis of the represented schedules has allowed to increase coding gain approximately on 0,8 dB. It speaks that, that errors on an output of decoder Viterby are usually bunched in packages, each of which, in case of usage q-ary codes, distorts only one or two q-ary symbols.

In addition it is necessary to mark, that characteristics of the concatenated code consisting from q-ary SOC and a short convolutional code appear approximately on 0,2 dB better characteristics of widely used concatenated code consisting of the Reed-Solomon code and a convolutional code, decoded with algorithm Viterby (characteristics of the given concatenated code represented on fig. 2. curve «RS (255, 235, 256) + Viterby (R=1/2, K=7)»). We shall underline, that increasing of the coding gain even on 0,1 dB is already considered serious achievement. One more very important advantage of the given cascade circuit is the simplicity of its implementation. The concatenated codecs is much easier, than the concatenated code consisting of the Reed-Solomon code and codec Viterby.

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