International Journal of Research (IJR) Vol-1, Issue-9 October 2014 **ISSN 2348-6848**

Overview and study of New Channel Coding Methods for Satellite Communication

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Abstract:
This paper deals with the new progressive channel coding methods for short message transmission via satellite transponder using predetermined length of frame. The key benefits of this contribution are modification and implementation of a new turbo code and utilization of unique features with applications of methods for bit error rate estimation and algorithm for output message reconstruction. The mentioned methods allow an error free communication with very low Eb/N0 ratio and they havebeen adopted for satellite communication, however they can be applied for other systems working with very low Eb/N0 ratio.

Keywords:
Turbo code, coding, interleaving, MAP, bit error rate, satellite communication.

1. Introduction:

The signal transmitted via satellite transponder is affected by many factors. Satellite links are usually designed with extremely low margin of link budget. Therefore low *Eb/N0* ratios at the point of receiver are typical and define the basic feature of satellite communications. There are some ways with successful and reliable data message transmission in spite of these adverse conditions. The fundamental method for achievement of reliable message decoding from the signals with very low *Eb/N0* ratio is effective channel coding methods. The turbo codes represent an optimal technique due to their unique properties.

2. Turbo Codes:

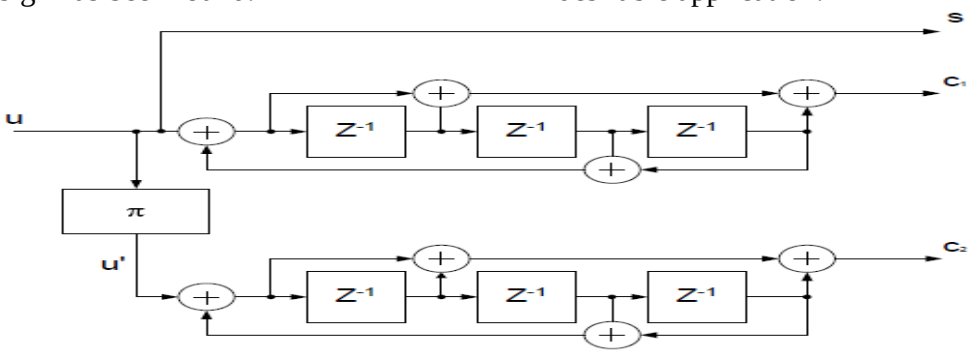
The turbo codes were introduced first in 1993. At the present time, they are implemented in many modern communication systems above all thanks to their excellent efficiency or more precisely to their high code gain. Therefore they can reach low bit error rates (BER) in the course of extremely low *Eb/N0* ratios. The crucial advantage is the fact that turbo codes do not have any marked limit for bit error rate reducing. The principle of an iteration decoding is applied and increasing number of iteration steps allows practically unlimited reduction of bit error rate.

In spite of many advantageous properties of turbo codes, they have a few of disadvantages that complicate their implementation. The fundamental handicap of turbocodes is presented by their high latency due to iteration decoding process and relatively complicated decoding algorithm SISO (Soft Input Soft Output). Moreover a setting of optimal parameters for encoder and decoder is practically

insolvable. The project of proper parameters is indeed difficult because the enormous number of combinations of parameters for turbo code design can be applied and it depends on the implementation of given turbo code and objective requirements. Till this time no mathematical tool for turbo code design has been found.

A number of algorithms and architectures for turbo codes have been proposed for specific applications.

In consequence this, the compromise between turbo code complexity and efficiency is the basic task of turbo code designing with the optimal features for desirable application.

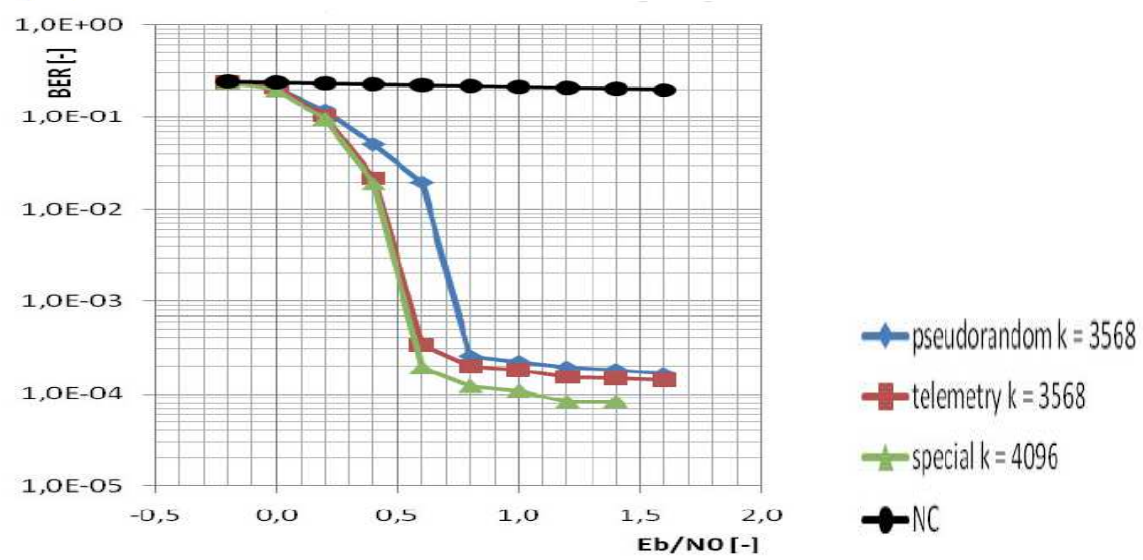


Fundamental architecture of turbo coder

In case of time-uncritical application (off-line systems) or utilization of efficient computing system, the error free detection of message can be reached even for channel with strong noise and jamming. This idea is very important for the implementation of system for short data message service (SMS) that is under consideration. Because SMS system does not need to work in real time and certain latency is sufferable, the turbo code can be used like a primary component for free error detection of signals affected by very low *Eb/N0* ratio.

3. Turbo Code Modification:

Various requirements on turbo code properties are demanded for given application of communication system. The telemetry turbo code has been chosen for short data message transmission like a base code. The telemetry turbo code is determined for short data transmission and it can work with very low *Eb/N0*. Therefore it is possible to suppose that a modification of this code is suitable for the development of a proper code for short data message service via satellite transponder. The modification consists in the implementation of an optimum interleaver with appropriate data block length *k* and code ratio *R*. The basic operation of the interleaver is a generation of sequences with the smallest mutual correlations. An efficiency of interleaver is given by its proposed parameters. The interleaver quality is pivotal because this E lement affects in principle the efficiency of turbo code and the approaching to Shannon limit.



Resulting BER for various types of turbo codes with data block lengths 3568 and code rate *R* = 1/4.

Three types of interleavers (telemetry , pseudorandom and edge effect elimination interleaver) have been implemented in the telemetry turbo code with code ratios *R* = 1/2, *R* = 1/3, *R* = 1/4 and *R* = 1/6. These standard code ratios are used also in other communication systems. The turbo code has been tested with different data block lengths *k* =1024, 1784, 3568, 4096, 7136, 8464, and 9216 bits, in dependence on interleaver type. The turbo code for special edge effect elimination interleaver, code ratio *R* = 1/2 and block length *k* = 4096 bits reached the best results. This modified turbo code attains the smallest bit error rate in comparison with other modifications, e.g. BER = 1.9·10–4 for *Eb/N0* = 0.8 dB. The codes with *R* = 1/6 achieve even lower bit error rate but they produce too high redundancy. Therefore the mentioned variant (*R* = 1/4, *k* = 4096) of turbo code has been chosen for the proposed system.

4. BER Estimation:

The BER cannot be simply determined in real systems without auxiliary pilot signal or training message. However the knowledge of BER is needful for a control of the iteration decoding process and an effective BER estimation method for unknown received message is prerequisite.

BER estimation methods presented in the next sections are based on applied methods in publications. These methods have been modified for applications using turbo decoders and they result from the classical turbo code decoding theory.

4.1 The BER Estimation Based on APP:

The first method for the BER estimation is based on a posteriori probability (APP). Probabilities *APPi*(+*A*) and *APPi*(-*A*) can be determined in the output of the turbo decoder for each transmission bit *xi*. Than the BER estimation can be described by the equation

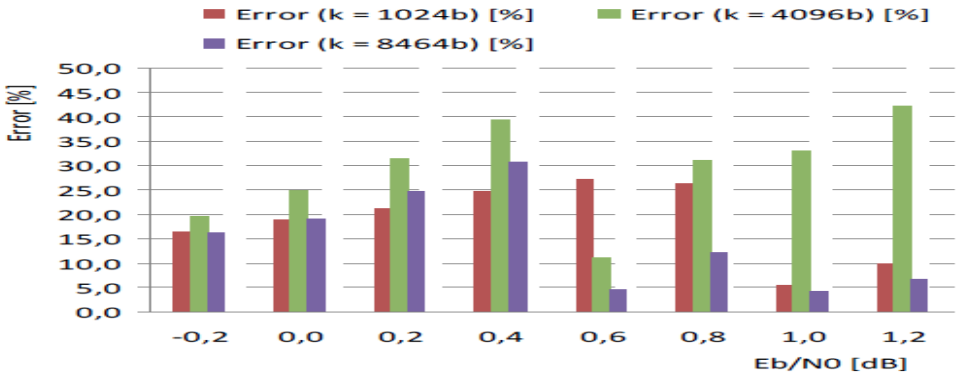
$$BER = \frac{1}{N} \cdot \sum_{i=1}^{N} \min(APP_i(-A), APP_i(+A))$$

$$APP(+A) = \frac{1}{1+e^{-LLR}},$$

$$APP(-A) = \frac{1}{1+e^{+LLR}}.$$

The resulting BER estimation can be expressed by the equation

$$BER = \frac{1}{N} \cdot \sum_{i=1}^{N} \frac{1}{1+e^{|LLR_i|}}.$$



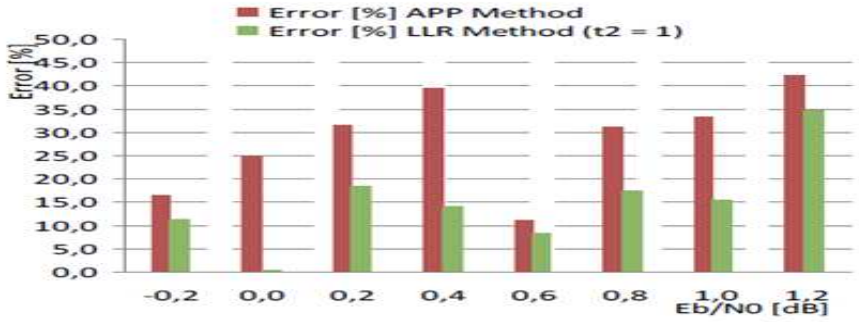
Errors of BER estimations based on APP for various lengths of blocks

The BER estimation method based on *a posteriori* probability (APP) gives relatively correct results. Comparison of BER estimation errors by APP method for block length k = 1024, 4096 and 8464 bits is presented in Fig. The error of BER estimation is not too high but the highest error is for block length k = 4096 bits, which has been chosen for short data message transmission system.

4.2 Comparison of BER Estimation Methods:

Two BER estimation methods have been applied. The first method described in uses a posteriori probability (APP), the second one, which is based on theory in, applies LLR values.

Both methods yield very good results and they are applicable for BER estimation. However, the modified method is more accurate for the threshold $t2 = 1$. Maximal deviation is 34.6% only for the residual error rate value BER = 8.3·10-5. The deviation for BER in range (10-2 ÷10-3) is max. 17.5%.



Comparison of BER estimation methods.

The result of the BER estimation is depending on threshold value $t2$ as mentioned above. The accuracy of Parameter $t2$ is not critical and for the high-precise BER estimation can be set in the interval $1 \leq t2 \leq 1.5$.

5. Conclusion:

The new progressive channel coding methods for short message transmission via satellite transponder have been developed. The key benefit of this contribution is design and implementation of new modified turbo code with unique features resulting from application of estimation methods for bit error rate and final forming of the output message. The mentioned methods allow error free communication for very low *Eb/N0* ratios and they are suitable for satellite communication however also for other systems working with limiting *Eb/N0* ratios.

6. References:

[1] SRIPIMANWAT, K. *Turbo Code Applications*. Netherlands: Springer, 2005. ISBN 10 1-4020-3686-8.

[2] GIULIETTI, A., BOUGARD, B., PERRE, L. *Turbo Codes: Desirable and Designable*. United States of America: Kluwer Academic Publisher Group, 2004. ISBN 1-4020-7660-6.

[3] VUCETIC, B. *Turbo Codes. Principles and Applications*. Netherlands: Springer, 2000, 386 p. ISBN 0-7923-7868-7.

[4] HAGENAUER, J., OFFER, E., PAPKE, L. Iterative decoding of binary block and convolutional codes. *IEEE Transactions on Information Theory*, March 1996, vol. 42, no. 2, p.429-445.

[5] BENEDETTO, S., MONTORSI, G. Unveiling turbo codes: some results on parallel concatenated coding schemes. *IEEE Transactions on Information Theory*, March 1996, vol. 42, no. 2, p.409-428.

[6] BENEDETTO, S., MONTORSI, G. Design of parallel concatenated convolutional codes. *IEEE Transactions on Communications*, May 1996, vol. 44, no. 5, p. 591-600.

[7] SOLEYMANI, M., GAO, Y., VILAIPORNSAWAI, U. *Turbo Coding for Satelite and Wireless Communications*. Netherlands: Kluwer Academic Publisher, 2002, 214 p. ISBN 1-4020-7197-3.