Performances of Convolutional Encoders Trellises Termination Methods, Components of MNBTCs

Horia Balta[1, 2], Radu Lucaciu[1], and Janos Gal[1]
[1] Electronics and Telecommunications Faculty, University Politehnica Timisoara, Timisoara, Romania
[2] Electrical Engineering, Electronics and Information Technologies Faculty, Valahia University Târgoviste, Târgoviste, Romania
e-mail: horia.balta@upt.ro

***Abstract*—The closure/termination of convolutional encoders (CE) trellises can be achieved through several strategies, each offering advantages and disadvantages compared with the others. Because multi-non-binary turbo codes (MNBTCs) operate with shorter lengths of blocks of data than other families of turbo codes (TC), the strategy of terminating component CE trellises has a stronger influence on the encoding rate, and, implicitly, on the bit/frame error rate (B/FER) performance. This paper compares the performance of B/FER versus signal to noise ratio (SNR) for the main strategies for terminating the CE trellises, components of MNBTCs.**

Keywords— bit error rate; communications systems; multi-non-binary convolutional codes; trellis termination; turbo codes.

I. INTRODUCTION

Turbo codes **[1]** segment sequences of information due to the need to perform the interleaving. Obviously, the length of data blocks, which is the length of interleaving, should be greater to be able to benefit from the correction potential of the convolutional code. But a great length of interleaving also means a large delay. This is a disadvantage for real-time transmissions. A good compromise in this respect is represented by MNBTCs **[2]**. Due to the more compact structure of data blocks used to operate, MNBTCs offer, compared to single binary turbo codes (SBTC) or double-binary turbo codes (DBTC), for the same number of bits, a lower latency.

The segmentation of the information sequence in TCs brings for component convolutional encoder a new task: the termination of trellises. This task does not exist, or basically did not matter, outside the context of TCs, as the Viterbi decoder accepted semi-infinite sequences and, as such, the "*end effect*" (i.e., of terminating the trellis) had a negligible contribution to the bit/frame error rate (B/FER) performance. Moreover, for a simple convolutional code (non concatenated), trellis termination can be used in zero padding, with a very low degradation of the coding rate for the same reasons, i.e. the great length of the data block. In the context of TCs, however, terminating the trellis may significantly affect the error rate. In addition, due to the interleaving between TC component encoders, the zero padding technique can be used for a second component CE, with some compromises. Thus, practical applications have adopted and used virtually all known termination strategies. For example, in the LTE **[3]** and the CCDS recommendation for deep space communications **[4]**, the uninterleaved dual termination is used, and DVB-RCSs **[5]** use the circular termination technique (tail-biting).

The smaller the length of interleaving, the more consistent the effect of terminating CE trellises, components of MNBTCs, on the BER performance. It is therefore expected that larger differences appear between the different strategies of interleaving for MNBTCs. This paper compares the performances of B/FER versus signal to noise ratio (SNR) of different interleaving strategies tailored for MNBTCs.

The structure of the paper is the following. The next section briefly describes the MNBTC. The general layout of a MNBTC and that of a component multi-non-binary convolutional encoder (MNBCE) are presented. Section III describes the methods for terminating MNBCEs trellises and the termination strategies for the investigated MNBTCs. Simulation results are given in Section IV, and Section V is reserved for some conclusions.

II. MNBTC – OVERVIEW

This section makes a brief presentation of MNBTCs, needed to introduce some terms that are used to describe methods of trellis termination. A more detailed presentation of MNBTCs is found in **[2]**.

A. The Structure of a MNBTC

The layout of a MNBTC is shown in Fig. 1. A block of data $u = [u_R \; \dots \; u_2 \; u_1]$ is a vector of R symbol sequences with $u_r = \left[u_r^0 \quad u_r^1 \quad \dots \quad u_r^{N-1}\right]$, $1 \le r \le R$. This block is encoded by the MNB C1 encoder, which generates the symbol sequence $x_1 = \left[x_1^0 \quad x_1^1 \quad \dots \quad x_1^{N-1}\right]$, and by the MNB C0 encoder, after a preliminary interleaving performed by block π. In turn, the C0 encoder generates the second redundancy sequence $x_0 = \left[x_0^0 \quad x_0^1 \quad \dots \quad x_0^{N-1}\right]$. So, the output of the turbo encoder is $x = [x_{R+1} \dots x_2 \, x_1 \, x_0]$, where $[x_{R+1} \dots x_2] = [u_R \dots u_2 \, u_1]$ is the