ITU - Telecommunication Standardization Sector   <u>Temporary Document</u> RN-090

STUDY GROUP 15   <u>Original</u>: English

Red Bank, New Jersey, 21 - 25 May 2001

Question: 4/15

SOURCE[1]: VOCAL Technologies Ltd. (http://www.vocal.com)

TITLE: G.gen.bis: G.dmt.bis: G.lite.bis: G.vdsl: General structure to support Trellis Code Modulation in the fast path, and a programmable Trellis Code Modulation, Multi-level and Full turbo code in the interleaved path of the transmitter of G.992.1 and G.992.2 with low computational burden and use the advantages of each technique in different environments

ABSTRACT

The present paper relates to a technique for implementation of a Trellis Code Modulation for the fast path and a configurable encoder, that allows the use of Trellis Code Modulation, Full Turbo code (FTC) or Multi-Level Turbo Code (MTC) for the interleaved path. Interleaver sizes are chosen as an integral number of DMT symbols. The assignment of parity/information bits for a better protection is also included.

1.   Introduction:

This contribution presents a General structure to support Trellis code Modulation in the fast path, and a programmable Trellis Code Modulation, Multi-level and Full turbo code in the interleaved path of the transmitter of G.992.1 and G.992.2 with low computational burden and use the advantages of each technique in different environments.

The use of Multi-level and Full turbo codes does not have any considerable complexity increase in the transmitter. From the receiver point of view all the resources for one technique can be use for the other with a difference of the time needed for the processing.

The present paper relates to a technique for implementation of a general configurable encoder that allows the following modes of operation: Trellis Code Modulation (TCM), Full Turbo Code (FTLC), Multilevel Turbo Code (MTLC), using 8 or 16 state convolutional encoders, interleaver sizes as an integral number of DMT symbols, and assignment of parity/information bits for better protection with QAM modulations in a DMT system.

With this technique it is possible to choose in the interleaved path:

How many bits will be encoded (0, 1, 2,…all)

Which bits are more protected (parity or information bits)

How many states used in the convolutional encoder (8 or 16)

How many DMT symbols is the size of the interleaver (1 to n).

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2. Description

Figure 1 shows the structure of the fast and interleaved data paths. The fast path, is presented in Figure 2.
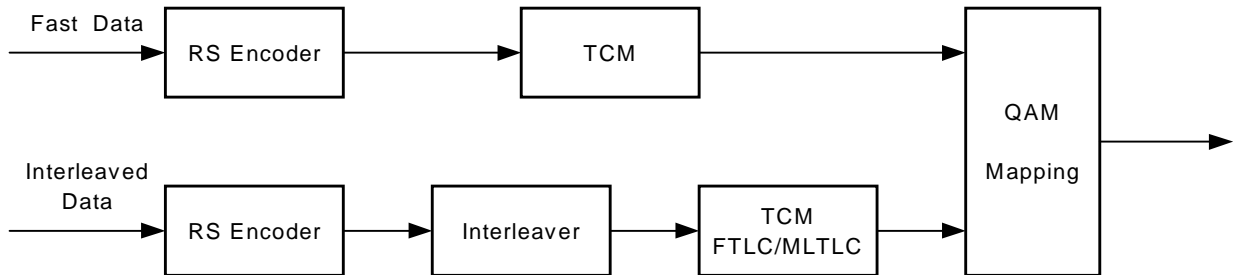

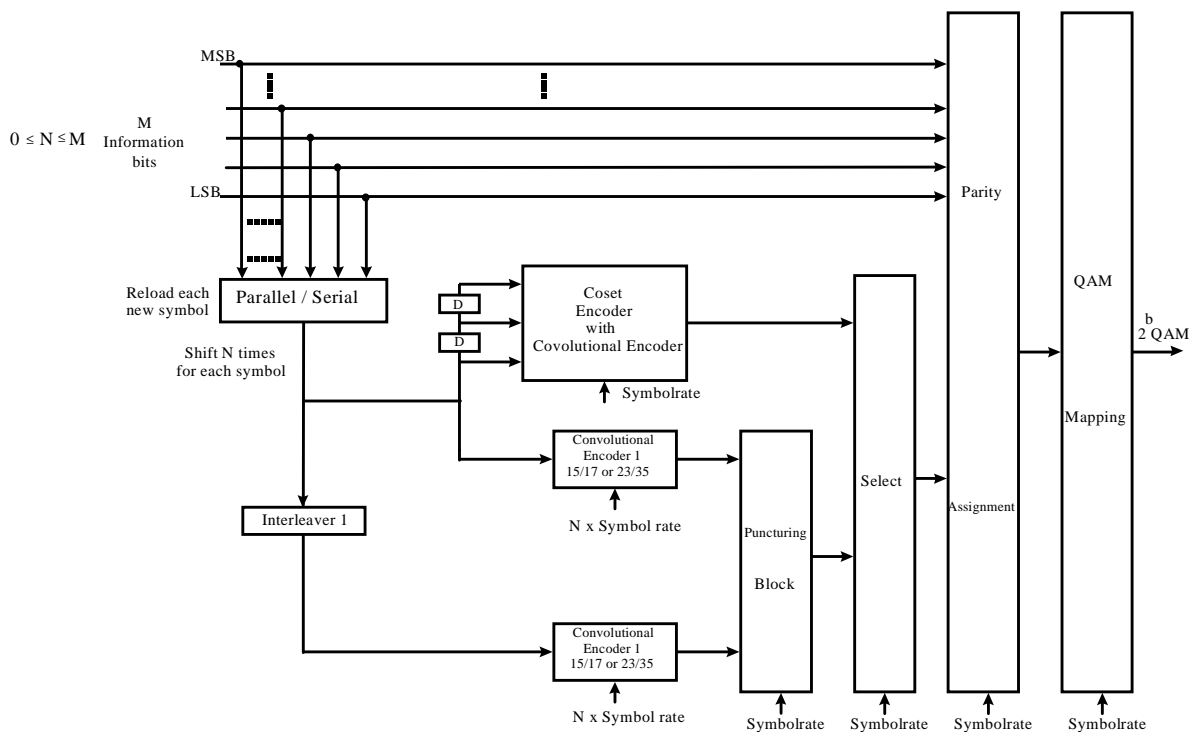Figure 1. Structure of the fast and interleaved data path

Figure 2. Block Diagram for the interleaved data path

In the block diagram of Figure 2, the bits are sent to the Parallel/Serial block every symbol. The Coset encoder, that includes its Convolutional Code defined in G.992.1, runs at symbol rate and produces the cosets bits defined in G.992.1.

The Convolutonal Encoders run at N times the symbol rate, where N is the number of information bits been encoded, and produce the parity bits. These parity bits go to the Puncturing block that decides which parity bits are used.

The Select block decides which encoder scheme is used (TCM, FTC, MTC) assuming that all encoders run for each symbol, such as in a hardware implementation. An alternative technique for selecting which encoder scheme is used is to operate those required, such as will be done in a software implementation. .

The Parity Assignment block decides which bits are more protected, depending of the application. Providing more protection to the information bits, means that in the mapping, the probability of the information bits having an error is lower than the probability of the parity bits having an error. Providing more protection to the parity bit(s), means that in the mapping, the probability of the parity bit(s) having an error is lower than the probability of the information bits having an error. Figure 3 shows the performance in an Impulse Noise Environment of Trellis Code Modulation, Full Turbo Codes with more protection to the parity bits, Full Turbo Codes with parity bits least protected and Multi-level Turbo Codes for a rate 4/6 64 QAM and a S-type interleaver size of 1088.

For the fast path the transmitter always uses TCM. For the interleaved path, the receiver decides which technique to use. If the impulse noise level is very low, or the computational burden is critical, the interleaved path may use TCM. If the impulse noise is the more important impairment and the application wants to works error free, the full turbo code with more protection to the parity bits may be the best option. If the intention is to have the best performance in all the environments, the Full Turbo Code with more protection to the information bits may be the best option. If the application needs to reduce the computational burden and does not need to work in an Impulse noise environments, the Multi-level Turbo code may be the best option. The QAM mapping block maps the bits to the transmitted symbol. The Puncturing, the Select, the Parity assignment and the QAM mapping blocks run at the symbol rate. For lower order constellations, such as 4 and 6 bits, the use of 16 states convolutional encoder can provide an extra coding gain of 1.8 dB.

1088 S-type Interleaver size. Latency <<< 10 ms
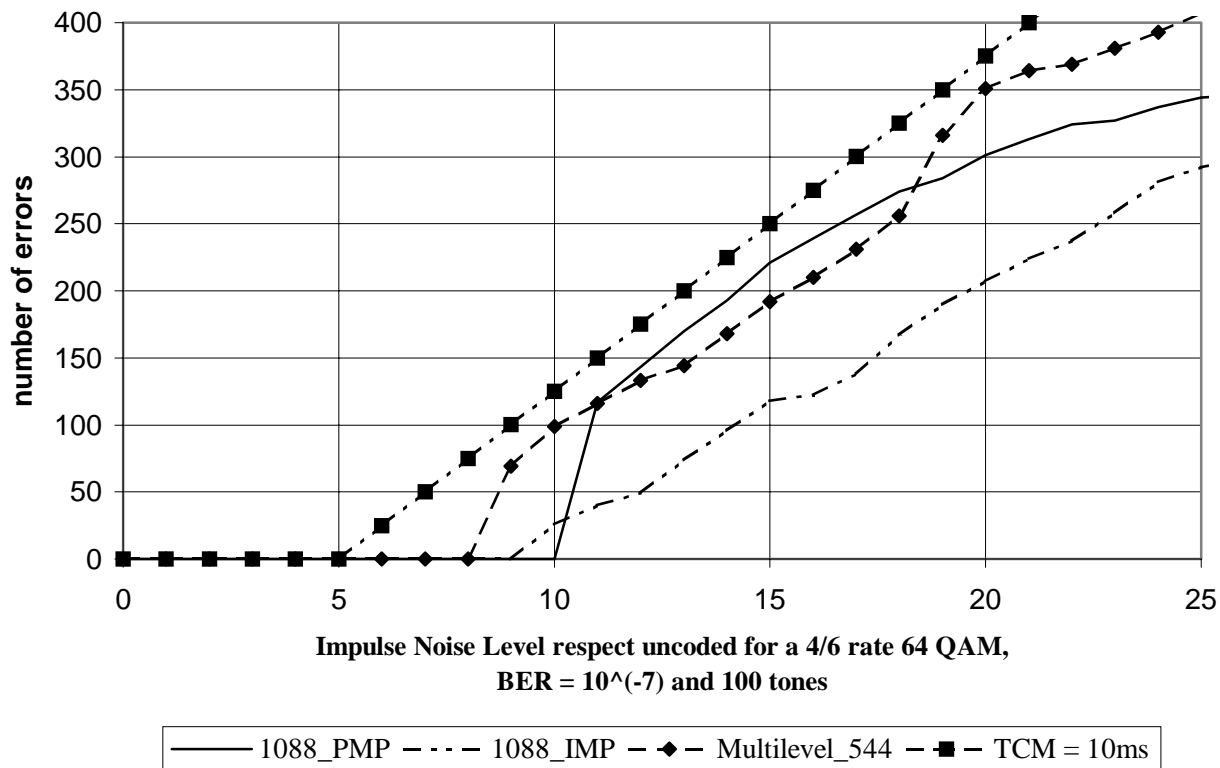

Figure 3. Simulation results in presence of Impulse noise for a rate 4/6 64 QAM and S-type interleaver sizes of 4096

3. Summary

The present paper relates to a technique for implementation of Trellis Code Modulation for the fast path, and a general configurable encoder in the interleaved path, that allows the following modes of operation: Trellis Code Modulation (TCM), full turbo code (FTLC), multilevel turbo code (MTLC), using 8 or 16 state convolutional encoders, interleaver sizes as an integral number of DMT symbols, and assignment of parity/information bits for a better protection with QAM modulations in a DMT system.

1. Agenda Item: G.992.1.bis issue 4.6 and G.992.2.bis issue 10.14. G.vdsl issue 11.17
2. Expectations: The committee accepts the technique described in this paper.