Buletinul Ştiinţific al Universităţii Politehnica Timişoara

TRANSACTIONS on ELECTRONICS and COMMUNICATIONS

Volume 60(74), Issue 1, 2015

Performance of Turbo Encoders with 64-QAM Modulators Interfacing Systems in Fading Environment

Maria Kovaci[1] Horia Balta[1,2]

Abstract – This paper presents a study on the interfacing between the turbo encoder and modulator. The binary allocation of the bits from a turbo coded symbol towards the modulator symbol can be done in several ways. This study shows the performance of the allocation modes taking into account the quadrature amplitude modulation with 64 points and the Rice fluctuating transmission channel. The simulations presented show that the performance of the entire transmission system, measured in coding gain may be influenced by up to 1 dB by a suitable choice of the allocation method.

Keywords: fading channel, communication systems, mapping, quadrature amplitude modulation, turbo code

I. INTRODUCTION

One of the most used modulations in the current communications systems is undoubtedly the Quadrature Amplitude Modulation (QAM). QAM is among the specifications of communications standards. Under its different variants, QAM is used in digital cable television or wireless and cellular technology applications. The 64-QAM is a good compromise between spectral efficiency (6 bit/s/Hz) and performance of bit/frame error rate (B/FER) versus signal to noise ratio (SNR) [1]. 64-QAM gives a symbol error rate of 10^{-6} for a SNR of about 19 dB for uncoded system in non-fluctuating channel (i.e., Additive White Gaussian Noise channel – AWGN channel) and, practically, it cannot be used in fading channel. However, using a turbo code, a BER of 10^{-10} can be obtained at a SNR of 9 dB for the AWGN channel and at SNR of 13 dB for the pure fluctuant channel (Rayleigh channel). Obviously, the advantages are the spectral efficiency and the simplicity of the implementation. For these reasons, the square 64-QAM is the most frequently digital modulation encountered in applications. For example, in LTE is specified that such modulation techniques with Gray allocation can be used to minimize the BER [2].

Of course, there are also disadvantages. One of them is that constellations with QAM modulations Gray allocation does not protect equally all the bits of the modulator symbol. Neither the 64-QAM modulation constellations is no exception to this. The problem arising is to find the binary allocation variant between the coded symbol and the modulator symbol which optimizes the performance. Our previous studies have been dedicated to this question for QAM constellations [3], [4], [5], in AWGN channel. In the present paper we study the turbo coded bit allocation for the 64-QAM constellations in Rice fading environment. A similar study, for 16-QAM was done in [6]. In this study we used both the double binary turbo code (DBTC) of the DVB-RCS2 standard [7] and the single binary turbo code (SBTC) of the LTE standard [2].

The Rice channel to which we referred above is a model for the real channels in which the received signal is a mixture between the direct wave (Line of Sight– LOS) which is propagated directly from the transmitter to the receiver and the waves reflected by different objects.

In this paper, as in [5], we have analysed three locations for the placement of the information and parity bits generated by turbo coding in the symbol modulator. In the first case the information bit was placed in the best protected position, followed by two parity bits placed in less protected positions. In the second case the information bit is placed on the middle position, so that in the better and less protected positions are placed the parity bits. Finally, in the third case, the information bit appears on the poorly protected position. The results of simulations show a completely different behaviour in the performance of B/FER vs SNR of these allocation variants.

The structure of this work is organized as follows. In Section II are presented the turbo encoders used in this paper (single binary - SBTE and double binary - DBTE) in order to identify the bits to be allocated in the symbol modulator. Section III briefly describes the square 64-QAM with the same aim to identify positions from the modulator symbol that will be filled by turbo encoded bits, nominated previously. Section IV is dedicated to presenting allocation alternatives. Section V shows the simulation results and Section VI concludes the paper.

[1] Faculty of Electronics and Telecommunications, Communications Dept.
Bd. V. Parvan 2, 300223 Timisoara, Romania, e-mail: maria.kovaci@upt.ro
[2] Valahia University of Targoviste, 2 Avenue King Carol I, 130024, Romania, e-mail: horia.balta@upt.ro