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On the Probability of Error for Triangular Quadrature Amplitude Modulation

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Abstract

We compute the exact value of error probability per symbol (SER) for triangular quadrature amplitude modulation (TQAM) scheme in the case of AWGN channel. The results show that the exact value of SER follows the behavior of the known upper bound [2]. Hence a simple modification of the upper bound can be used in practice for evaluating the SER.

Keywords: TQAM, symbol error probability, AWGN channel

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1 Introduction

One of the most popular modulation in commercial communication systems is square quadrature amplitude modulation (SQAM). SQAM scheme with its simple detection procedure is easy for implementation and demonstrates a good performance.

Recently, the triangular quadrature amplitude modulation (TQAM) was proposed. In TQAM constellation the signal points are vertexes of a lattice of equilateral triangles and the constellation is symmetric with respect to the origin. The comparison of TQAM with SQAM given in [3] shows that the former is more power efficient while preserves the low detection complexity of the latter. In [4] a general formula for calculating the average energy per symbol of the TQAM is derived and approximate values of symbol error rate (SER) and bit error rate (BER) of the TQAM in the presence of additive white Gaussian noise (AWGN) are given.

In the next section we give a brief description of TQAM. In Section 3 we derived the exact value of SER for 2^{2m}-TQAM constellations, uncoded case. In the last section we compare the obtained results with the upper bound given in [2].

2 TQAM constellation

In this paper we consider TQAM constellation of $M = 2^{2m}$ signal points placed in $L = 2^m$ rows parallel to real axis with L signal point in each row. The points form a lattice of equilateral triangles and the constellation is symmetric with respect to the origin. An example of 64-ary TQAM is given in Fig. 1.

The power gain of M-ary TQAM over M-ary SQAM in decibels [4] is

$$10 \log_{10} \left(\frac{8M - 8}{7M - 4} \right) \xrightarrow[M \to \infty]{} 0.5799 \text{ dB}$$

3 The SER in uncoded case

The L^2−TQAM constellation can be separated into seven types of detection regions $D_1, D_2, \ldots, D_7$. In this section we will calculate the probability of correct detection q_i for each of the regions D_i, $i = 1, \ldots, 7$. The number of detection regions of each type for L^2-TQAM is given in the next table.