EFFICIENT DIGITAL MODULATION AND ENCODING APPROACH USING TAPSK AND MULTILEVEL NON-COHERENT BLOCK CODES

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ABSTRACT

Non-coherent detection provides simple receiver architecture then coherent detectors because it does not require carrier phase tracking. Also since non-coherent detectors works differently than coherent it facilitates the application of multilevel non-coherent blockcoding which provides an effective error correcting capacity at higher coding efficiency. The further insight on Non-coherent system shows that the coding efficiency can be further improved by increasing the minimum non-coherent distance between the modulations symbols. This results the development of new modulation technique derived from MPSK and named as TAPSK (Twisted Amplitude Phase Shift Keying). The TAPSK may provide higher coding efficiency then traditional techniques for similar error correcting capacity when configured properly for specific block size and multilevel block codes. This paper presents the simulation and analysis of TAPSK with multilevel non-coherent blockcodes (NBC) for development of efficient digital communication technique. Finally the simulation result shows that properly designed TAPSK configured with multilevel non-coherent blockcodes (NBC) can achieve much better coding efficiency.

Keywords: TAPSK, Non-coherent detection, block coded modulation, multilevel coding.

1. INTRODUCTION

The non-coherent detection provides simple receiver architecture because it does not require carrier phase tracking hence it is preferred for the systems where the simpler receiver architecture are required. To improve the reliability non-coherent detection Non-coherent block codes techniques for the additive white Gaussian noise (AWGN) channel were also proposed in [2],[5], including non-coherent block-coded MPSK(NBC-MPSK) [4],[5], differentially encoded QAM(quadrature-amplitude modulation) without channel coding was proposed [1]. The authors of [1] derived a minimum energy constraint for enlarging the minimum non-coherent distance between the symbols.

The signal constellation considered for TAPSK (twisted amplitude and phase shift keying) is considered with two different amplitudes for successive symbols. In this paper only a limited numbers of MTAPSK (M = 8 and 16) is considered for convenience of presentation. However, the proposed non-coherent schemes can be easily extended to any possible value of M.

This paper deals with analysis and impact of different configuration parameters of TAPSK with multilevel non-coherent blockcodes (NBC) for development of efficient digital communication technique. In rest of paper the second section presents the briefliteraturereviewabout the TAPSK and multilevel non-coherent blockcodes (NBC). The third section presents the model of the simulated system followed by the simulation results and conclusion in fourth and fifth sections respectively.

2. LITERATURE REVIEW

A new non-coherent sequence detection algorithms for combined demodulation and decoding of coded linear modulations transmitted over additive white Gaussian noise channels, possibly affected by inter-symbol interference, are presented in [6]. The literature also proposed optimal sequence detection in the presence of random rotation of the signal phase based on proper approximations. These results a simple suboptimal detectionschemes based on the Viterbi algorithm, whose performance approaches that of coherent detection. In the proposed schemes [6], the tradeoff between complexity and performances is simply controlled by a parameter, referred to as implicit phase memory, and the number of states of trellis diagram. Besides being realizable, these schemes havethe convenient feature which facilitates to remove the constant phase assumption and encompass time-varying phase models. Ruey-Yi Wei et al [3] propose three non-coherent block-coded twisted amplitude and phase shift keying (NBC-TAPSK) schemes which are derived from non-coherent block-codedMPSK. The authors also proposed a new non-coherent detector and a corresponding non-coherent distance for non-constant-energy signal over the additive white Gaussian noise (AWGN) channel. At high data rates, NBC-8TAPSK has the best bit error performance among all non-coherent schemes. Further Results on Non-coherent Block-Coded MPSK is presented in [5]. The paper first focus on the rotational invariance (RI) of NBC-MPSK. Based on the RI property of NBC-MPSK with multistage decoding, a non-coherent near-optimal linear-complexity multistage decoder for NBC-MPSK is proposed; they also investigated a tree-search ML decoding algorithm for NBC-MPSK shown to have low complexity and excellent error performance. The authors also utilized the idea of the NBC-MPSK to design non-coherent space-time block codes, called non-coherent space-time block-coded MPSK (NSTBC-MPSK). Multiple-Phase Codes for Detection without Carrier Phase Reference in proposed by Feng-Wen Sun et al [4] in the paper authors consider the construction and analysis of linear block codes for M-array Phase-Shift Keying that can be decoded without carrier phase synchronization. Under these circumstances, the function that has a significant impact...
on performance is the non-coherent distance, analogously to the Euclidean distance for the coherent case. The major difficulty in constructing and analyzing such codes lies in the fact that the non-coherent distance is not a true metric. For this reason, prior work mainly relies on numerical approaches to search for good codes and to determine the corresponding minimum non-coherent distance. However, in this literature the author’s first present a theorem that links the non-coherent distance to different codewords, respectively. The information bits decide the power of the symbols with the energy of the symbols with energy normalization, the values of \( r_0 \) and \( r_1 \) should satisfy \( p_0 r_0^2 + (1 - p_0) r_1^2 = 1 \) where \( p_0 \) denotes the probability of transmitting the symbol with \( a = 0 \) which depends on the component code \( C_a \).

5. NON-COHERENT BLOCK-CODED TAPS K SCHEMES

To increase \( d_{nc,c} \) of NBC-8PSK, we propose to enlarge the energy of the symbols with \( a = 1 \) and reduce the energy of the symbols with \( a = 0 \), which becomes 8TAPSK. Hence, the bit in level 1 decides the power which the considered symbol should spend. \( \text{Definer} = r_1 / r_0 \). When \( r_1 = r_0 \), 8TAPSK is the same as 8PSK. For the energy normalization, the values of \( r_0 \) and \( r_1 \) (\( r_0 \leq 1 \leq r_1 \)) should satisfy \( p_0 r_0^2 + (1 - p_0) r_1^2 = 1 \) where \( p_0 \) denotes the probability of transmitting the symbol with \( a = 0 \) which depends on the component code \( C_a \).

6. MULTILEVEL BLOCK CODES (MLBC)

For \( M > 2 \)-ary digital transmission schemes like ASK, PSK, QAM or CPIM (incl. FSK) an efficient combining of channel coding and modulation is possible using multilevel-coding (MLC). Transmission schemes with high power and bandwidth efficiency can be designed by this method in various ways. MLC method is based on an iterative partitioning of the set of signal elements of the modulation scheme. The distance structure of MLC-schemes is in principle known as methods of generalized concatenated codes can be applied. Often, design of MLC-schemes is done according to the minimum Euclidean distance criterion.

A multilevel block code of \( L \) levels uses \( L \) block codes each of the same length \( n \), called component codes, over finite alphabets of possibly different sizes. A signal set \( S \), called the basic signal set, of dimension \( N \), has \( \lfloor \frac{N}{m_i} \rfloor m_i \) points, where \( m_i, i = 1, 2, 3, ..., L \) are the size of the alphabets, with each point labeled by an ordered \( L \)-tuple with one entry from each alphabet. With this labeling, a set of \( L \) codewords, one from each code, corresponds to a point in \( N L \) dimensions, with each coordinate of \( L \)-coordinate words choosing a point in \( S \). Multilevel coded signal sets with linear codes over GF (2) as component codes have been studied in [1]-[5] and in various general settings in [6]-[10]. Kschischang et al. [11] use linear codes over non-binary fields to construct multilevel signal sets and give algebraic structural properties of these codes. Multilevel codes for the purpose of unequal error protection have been discussed in [12] and [13]. Sub optimal multi stage decoding and performance analysis of multi level codes have been studied in [14]-[16]. This correspondence deals with two-level (\( L = 2 \)) group codes with the basic signal set consisting of points on a circle. The blockdiagram of a two-level block-coded modulation is shown in Fig. 2(a). When \( C_b \) and \( C_c \) are length \( n \).
Codes over alphabets $Y = \{y_1, y_2\}(m_1 = 2)$ and $X = \{x_1, x_2, x_3, x_4\}(m_2 = 4)$. Fig. 2(b) shows a labeling of $S$ consisting of eight points on the circle with $X$ and $Y$. For code words

$$a = (a_0, a_1, \ldots, a_{n-1}) \in C_s \text{ and } b = (b_0, b_1, \ldots, b_{n-1}) \in C_r$$

Each pair $(a_i, b_i)$, $i = 0, 1, \ldots, n - 1$ selects a point in $S$, and the pair $(a; b)$ specifies a point in $2n$ dimensions. The collection of all such points in $2n$ dimensions corresponding to all possible pairs of code words constitute the two-level block-coded modulation code (signal set) or signal space code. This correspondence concerns $Y$ and $X$ being $Z_m$ and $Z_M$ residue class integers modulo $2$ and $M$, respectively, and the basic signal set being a collection of $2M$ points on a unit circle matched to the dihedral group with $2M$ elements.

7. SIMULATION RESULTS
Figure 8: SNR vs. BER Comparison plot for minimum distance $(d) = 4$, $r = 0.2, 0.4, 0.6, 0.8$, Block Length = 127.

Table 1: Spectral Efficiency (bits/sym) Comparison

<table>
<thead>
<tr>
<th>Block Length</th>
<th>8PSK</th>
<th>8QAM</th>
<th>8TAPSK</th>
</tr>
</thead>
<tbody>
<tr>
<td>31</td>
<td>2.1935</td>
<td>1.5484</td>
<td>1.3871</td>
</tr>
<tr>
<td>63</td>
<td>2.5238</td>
<td>2.0952</td>
<td>2.0476</td>
</tr>
<tr>
<td>127</td>
<td>2.7244</td>
<td>2.4488</td>
<td>2.4488</td>
</tr>
</tbody>
</table>

Table 2: 8TAPSK Spectral Efficiency Comparison for Different Values of $r$.

<table>
<thead>
<tr>
<th>$r$</th>
<th>Spectral Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>1.3465</td>
</tr>
<tr>
<td>0.4</td>
<td>2.3386</td>
</tr>
<tr>
<td>0.6</td>
<td>2.5591</td>
</tr>
<tr>
<td>0.8</td>
<td>2.6142</td>
</tr>
</tbody>
</table>

8. CONCLUSION

The simulation performed for the 8PSK and 8TAPSK modulation techniques with multilevel NBC and AWGN channel conditions for non-coherent detection, shows that the 8TAPSK provides a lower BER at small spectral cost. The result also shows that 8TAPSK greatly outperforms the 8PSK and 8QAM for AWGN Channels while the increased Block Length can also be used to increase the spectral efficiency. Furthermore, the ratio "$r$" can be optimally set to get tradeoff between spectral efficiency and BER.

REFERENCES


