SYMBOL DECODING BASED ON SIGNAL SUBSPACE DECOMPOSITION IN MSK

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ABSTRACT

The availability of fast processors with architectures tailored to meet the computational demand of digital signal processing algorithms is widely applied to demodulation and decodification of CPM signals in some scenes: Mobiles, AWGN channels,... In this application the number of floating point operations executed by each processed symbol is a critical parameter to be designed, this is to be minimized. In this paper a method that reduces significantly the number of operations (until 80%) by symbol for CPM signals is presented. The decodification stage is performed from the rank reduced signal subspace obtained by means of an orthogonal decomposition of the signal [1].

I. INTRODUCTION

For digital transmissions over band limited channels, the need of bandwidth efficient constant envelope signaling schemes has developed the Continuous Phase Modulation (CPM) signaling scheme. The simplest binary signaling scheme is the called Minimum Shift Keying (MSK), which is considered as starting point of a new point of view in decoding: the orthogonal signal decomposition. Starting of the most common decoding algorithms, we will apply the orthogonal signal decomposition in order to achieve a better performance in computational cost with a low lost in error probability.

A description of most common decoding algorithms, the Maximum Likelihood (ML) [2] criteria and the Viterbi algorithm [3] is presented in next section. In section III will be described the orthogonal decomposition and how to carry through it. In section IV will be applied the orthogonal decomposition to the common decoding algorithms described in section II, explaining what kind of improvement could be expected. Finally, some simulation results and the most important conclusions are presented in section V.

II. ML AND VITERBI

The received signal has been processed before the demodulation stage. This means that it has been band_pass filtered, down translated to an I-Q base band signal and analog to digital converted. The signal to be demodulated, x(n), is shown in (1) as a burst of N symbols, sampled to a Ns samples/symbol rate. The pulse form p(n) is rectangular of limited duration, equal to one symbol period.

$$x(n) = s(n) + n(n) = \sum_{k=0}^{N-1} x_k(n) \cdot p(n - k \cdot Ns) \quad (1)$$

where $$\underline{x}_k = e^{j\theta_k} \cdot e^{j\frac{\pi}{2} \cdot \alpha_k \cdot \underline{q}} + \underline{n}_k \quad (2)$$

$\underline{x}_k$ is the received signal and contains already the noise terms represented by the vector $\underline{n}_k$, θ_k is the memory phase term necessary to get a continuous phase in time, h represents the modulation index (which in MSK take the value 0.5), α_k is the transmitted symbol $\{+1, -1\}$ in the k symbol period, q(n) is a function that "smoothes" the phase transition, in Full Response MSK [4] $\underline{q}$ corresponds to $\underline{q}$ = $(0,1,...,(Ns-1)/Ns)^T$ and n(n) is the noise term.

$\underline{x}_k$ can be also expressed as:

$$\underline{x}_k = e^{j\theta_k} \cdot \begin{Bmatrix} \underline{S}^{(+1)} \\ \underline{S}^{(-1)} \end{Bmatrix} + \underline{n}_k \quad (3)$$

where $\begin{Bmatrix} \bullet \\ \bullet \end{Bmatrix}$ means that there are two possibilities: $\underline{S}^{(+1)} = e^{+j\frac{\pi}{2} \cdot \underline{q}}$ and $\underline{S}^{(-1)} = e^{-j\frac{\pi}{2} \cdot \underline{q}}$ (corresponding to the symbol +1 and -1 respectively). This vectors are called Trellis vectors. In order to achieve a better understanding, the phase evolution of the signal is shown in a Trellis diagram: