CPM Reception Combining Complexity Reduction Techniques for Schemes on Minimum Euclidian Distance Upper Bound and MSK

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Abstract — **The paper shows that some continuous phase modulation (CPM) schemes have some properties that allow a near optimum reception with very low complexity. The proposed reception method applies simultaneously three techniques for complexity reduction of CPM receivers, which have been previously object of separate analysis with additive white gaussian noise (AWGN). These techniques are: first-quadrant metrics calculus on a *F*-dimensional Walsh space, derivation of the other quadrant metrics using a no loss derivation algorithm and finally the use of constrained complexity maximum likelihood sequence detection (MLSD) using the *M*-algorithm. The cumulative effect on total performance loss is negligible and no more than the sum of the partial losses due to the Walsh space and the *M*-algorithm, known to be negligible when observing the respective standalone rules for the complexity reduction limits.**

I. Introduction

Continuous phase modulation (CPM) signals are insensible to non-linear amplitude amplification. Phase continuity allows good spectral performance and implies a code gain. These properties have motivated the common use of GMSK (gaussian MSK - minimum shift keying). The use of others schemes more spectrally and power efficient was restrained owing to excessive detection complexity. It requires a large bank of matched filters and the number of phase states can also be very large [1,2].

II. The Receiver And Suitable Schemes

It is proposed a new family of CPM receivers resulting from an intervention on three stages of the optimum receiver for signals corrupted by AWGN: initially, the bank of matched filters is replaced by a system of projections into a signal space resulting from the spanning of very few Walsh functions [3,4]. Afterwards, a processor calculates metrics using matrix algebra [4, 5]. Secondly it is applied an algorithm and a data structure that, jointly, consent to obtain all the metrics keeping in memory only 1/8 of the phase transitions, and allow to obtain their total number from just 1/4 of the metrics [4,5]. The method is valid for a subclass of schemes having a number of states S=0 mod 4 (which comprehend the best ones), where phase transitions have certain symmetry relations which can be translated to relations between positions of a table. Thirdly, MLSD is made with the M-algorithm propagating B states (the letter M is reserved for the M-arity) [4,6].

To test the receiver we used h=1/2 full response M-ary schemes for M=2 (MSK), 4, 8 and 16, taking advantage of them having just S=4, in spite of being catastrophic. The schemes with h=0.45=9/20 are the best 4-ary and 8-ary full response schemes in terms of power gains within the region of useful spectral efficiencies and having an acceptable S=40, being examples of rare schemes with a minimum normalized squared Euclidean distance (MNSED) on their upper bound [1,2,6,7,8].

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III. Results And Conclusions

The receivers are defined by F=M and B=M, observing the rules found in [4] on a standalone basis. The optimum receiver simulation confirms the expected gains for the h=9/20 schemes: 2.6 dB for M=4 and 4.3 dB for M=8. When combining the given techniques the receiver remains quasi-optimum with a power loss of only ≈0,1 dB for the quaternary scheme and ≈ 0.3 dB for M=8 scheme, which is about the sum of partial losses [4]. It was also tested a "decreasing M-algorithm" for the 8-ary scheme until a 0.5 degradation would be found. The search ended at B=4 with a 0.4 dB power loss. The MSK sub-optimum receiver is only 0.4 dB away from the optimum one, although attained with a rather simple receiver. Fig. 1 also includes the BER curves for ideal antipodal modulation (MNSED=2) and for MNSED=1.7, proposed by [9] to describe real MSK.

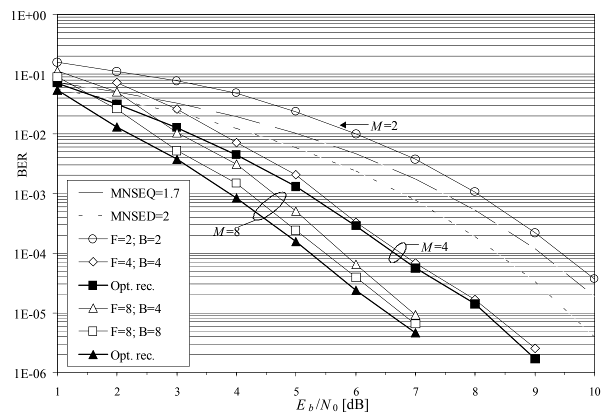

Figure 1: BER for 1REC, h=9/20, M=8 and M=4 and MSK.

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