

SESSION THB7

BLOCK CODING

SOFT BINARY BLOCK DECODERS BASED ON A GENERALIZED WAGNER RULE

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According to a result of Wagner, soft decision decoding of a binary linear rate $(n-1)/n$ block code is achieved by complementing a single, least reliable, bit of the binary sequence, which is the output of a hard limiter applied to the entries of the received sequence. A generalization of this rule for binary linear block codes with multiple (λ) check-bits is presented. Maximum likelihood decoders with significantly reduced computational complexity are attainable for a few mid and high rate codes by efficient implementation of the generalized Wagner rule.

The original Wagner rule, as well as the trivial soft decoding rule for rate 1 codes, were recently utilized by several authors (Conway and Sloane, Be'ery and Snyders, Forney) for deriving soft decoders with reduced computational complexity for codes that contain a subcode which is related to a single, respectively zero, check-bit code. The generalized Wagner rule is also applicable, in a similar fashion, to codes that contain a subcode related to a λ check-bit code. It is demonstrated that maximum likelihood decoders with increased computational efficiency are obtainable, for some mid rate codes, with the aid of the generalized rule.

ALGEBRATIC DECODING AND THE SAMPLING THEOREM

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The formulation of the algebraic decoding of cyclic codes from the transform domain point of view is a established approach that puts the decoding of error control codes into the more general context of signal processing techniques. In this paper, this transform domain point of view is explored further and it is shown that the decoding problem is entirely analogous to a classical situation in the field of Digital Signal Processing.

SOFT ERROR-TRAPPING DECODING OF CYCLIC CODES

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The error-trapping (ET) decoding technique is very simple and is normally applied in conjunction with hard-decision decoding of cyclic codes. It is most efficient for codes with rate $R <$

$1/t$, where t is the maximum number of errors to be corrected. Modified ET decoders have been proposed which partially circumvent this limitation for codes not satisfying $R < 1/t$.

This paper describes an ET decoder which effectively uses the softly-quantised demodulator output levels as an integral part of the decoding process. This soft ET decoder operates on multi-level symbols, which are Galois field elements, used to represent the quantised demodulator output levels of a communication system. The procedure described stands in contrast to the approaches to soft-decision decoding which employ conventional hard-decision decoders where, as separate items, the reliability measures of the digits are used in an ad-hoc fashion.

ON THE COMPLETE DECODING OF KERDOCK CODES

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The Kerdock code $K(m)$, m even, is a nonlinear code consisting of the Reed-Muller code $R(1, m)$ and $2^{m-1}-1$ cosets of $R(1, m)$ in $R(2, m)$. Thus $K(m)$ has length 2^m , cardinality 2^{2^m} and minimum distance $d = 2^{m-1} - 2^{m/2-1}$.

In this paper it is shown that a definition of $K(m)$ as systematic code allows instantaneous encoding and the application of different complete decoding strategies. In particular two decoding criteria are discussed; the first one is the traditional maximum likelihood decision criterion and the second one is defined to correct all error patterns of weight less or equal to $\lfloor (d-1)/2 \rfloor$ and otherwise to accept the information bits unmodified. Decoding algorithms for both rules are described.

Finally the code performance on the Binary Symmetric Channel for $K(4)$ are evaluated, both theoretically and by simulation.

SUB-OPTIMUM SOFT-DECISION DECODING OF BLOCK CODES USING THE ZERO-NEIGHBORS ALGORITHM

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A simple soft-decision decoder for linear binary block codes over the AWGN channel is presented which is based on the Zero-Neighbors Hard Decision Algorithm and on the Generalized Minimum Distance Bound. The complexity of the algorithm is essentially equivalent to that of the Zero-Neighbors HD Algorithm but its performance for short block codes is significantly improved, although slightly inferior to that of the optimum Maximum Likelihood Soft-Decision Decoder. Performance for block codes of moderate length is presently under investigation.