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Ståhl, Per; Anderson, John B; Johannesson, Rolf

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The Effect of the Tailbiting Restriction on Feedback Encoders

Per Ståhl
Lund University
P.O. Box 118
SE-221 00 LUND, Sweden
e-mail: per.stahl@it.lth.se

John B. Anderson
Lund University
P.O. Box 118
SE-221 00 LUND, Sweden
e-mail: anderson@it.lth.se

Rolf Johannesson
Lund University
P.O. Box 118
SE-221 00 LUND, Sweden
e-mail: rolf@it.lth.se

Abstract It is shown that for short and moderate relative tailbiting lengths and high signal-to-noise ratios systematic feedback encoders have better bit error performance than nonsystematic feedforward encoders. Conditions for when tailbiting will fail are given and it is described how the encoder starting state can be obtained for feedback encoders in both controller and observer canonical form.

I. SYSTEMATIC VERSUS NONSYSTEMATIC TAILBITING ENCODERS

Comparing the bit error performance between tailbiting codes encoded by systematic and nonsystematic encoders [1] shows that for a bad channel systematic encoders, feedforward or feedback, give the best performance. Simulations also show that the best encoders to use when the channel quality is unknown are the systematic feedforward ones. In a good channel we show that the type of encoder having the best bit error performance depends on the relative tailbiting length, i.e., the tailbiting length/memory. For a good channel, ML-decoding, and a rate $R = b/c$ tailbiting code of length $L$ an upper bound on the bit error probability can be expressed as $P_e \leq \frac{1}{2} \sum_{d=1}^{L} b_d P_d$, where $b_d$ is the sum of all bit errors for all codewords of weight $d$ and $P_d$ is the probability that a word of weight $d$ is chosen instead of the all-zero word. For a given length $L$ and memory $m$ the encoder giving the lowest bit error probability in a good channel is the one with as large minimum distance as possible and the smallest $b_{min}$ as possible. For rate $R = 1/2$ a search has been made for these encoders at various lengths and encoder memories. We can identify three regions where different encoder types give the best performance. For very short relative tailbiting lengths the best feedback encoders are systematic and give the same bit error probability as the best systematic feedback encoders. For short and medium relative tailbiting lengths, systematic feedback encoders are typically a factor of 1.5-2 better than the feedforward ones. For long relative tailbiting lengths feedforward encoders give typically a factor of 2 better performance than the systematic feedback encoders. The explanation for this lies in the type of codeword which leads to the minimum distance. We show that this in turn depends on the relative tailbiting length.

II. TAILBITING FAILURE

A rate $R = b/c$ feedback convolutional encoder of memory $m$ can be viewed as consisting of $b$ linear feedback shift registers (LFSRs), where the longest shift register has length $m$. For a

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REFERENCES


