A NEW CODING APPROACH TO DIGITAL MAGNETIC RECORDING

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Normally the readback signal of a digital magnetic recording system contains, due to the inherent differentiation, three levels (i.e., the plus peak, zero and minus peak), although the recorded data is binary and is represented by two opposite saturation states on the magnetic surface. This observation leads us to treat a magnetic recording channel as a linear system that possesses an inherent factor (1-D) in its transfer function, where D represents a unit time delay. Such a system is equivalent to the so-called partial-response channel which is widely used in high speed data communication systems.[1]

In our earlier paper[2] it has been shown that the conventional NRZI method of recording is equivalent to the precoding corresponding to the channel (1-D) which eliminates the error propagation. This new viewpoint has led to several important results:

(1) An algebraic method of error detection and correction has been developed which is applicable in both amplitude and peak detection methods. The proposed error detection scheme[2,3] takes full advantage of the redundancy inherent in the readback signal (see Figure). In this system the detector (either amplitude or peak detection type) reduces the continuous analog waveform into a sequence of signals with three levels. This hard decision output is then fed to an inverse filter 1/(1-D) and a decoder $[1-D]_{\text{mod } 2}$. If any detectable error exists in this sequence, it can always be detected by tracking the existence of any illegitimate level in the inverse filter output sequence. This algebraic approach has been extended to a more general decision schemes,[3] in which the quantizer makes a soft decision including ambiguity zones (again either in amplitude or in the peak shift). Most of digits in the ambiguity levels are replaceable by correct values using the redundancy of the sequence. We develop in this paper an optimum design of such a decoder, when the amplitude detection is employed, based on Chow's earlier work on an optimum decision rule with a rejection option.[5] Both analytical and simulation results on the performance of the proposed scheme are presented. Furthermore, an asymptotic expression for the decoding error rate is derived in closed form as a function of the channel signal-to-noise ratio, and is compared with the conventional bit-by-bit detection method and the maximum likelihood decoding method recently studied.[4]

(2) Precoding and the error control methods developed for binary saturation recording is generalizable to the case of multilevel recording. A precoder is now characterized by a transfer function $[1/(1-D)]_{\text{mod } m}$ which is a non-linear mapping in the ordinary sense but is linear in a residue class ring modulo m.

(3) A novel method of high-density recording, named "Interleaved NRZI" has been proposed.[1] This recording method is obtained by molding an ordinary recording channel into a partial-response channel characterized by a transfer function $(1-D^2)$. This recording method results in a potential increase of about 50% in information density. The error control method developed above is equally applicable to the proposed recording method. An extension to multi-level signalling is also shown.

References

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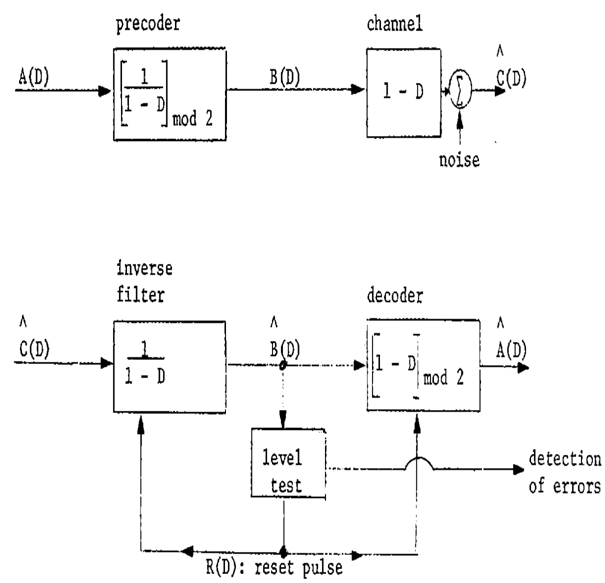

Figure. A Partial-response System Representation of the NRZI recording System and Error Control Method.