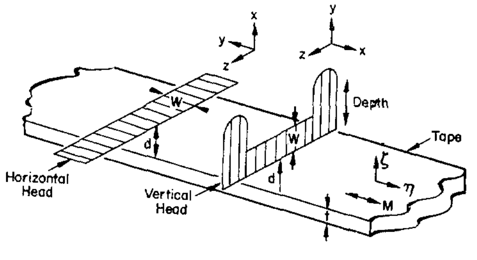

Fig. 1. Two MRT geometries.

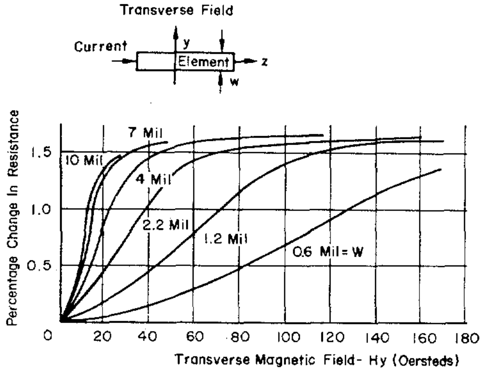

Fig. 2. ΔR versus transverse field.

mA. The device was deposited onto a polished glass substrate and sandwiched with a second polished piece of glass for protection. At the peak in wavelength response (2 mils), an rms output of about 25 mV was achieved. The response vanished into wideband tape noise for a wavelength below 50 μin. A maximum rms signal-to-rms tape noise of about 66 dB was observed. An applied bias field of about 60 Oe was required to linearize the device. Measured distortion characteristics of the head are comparable to ring head technology.

References

[1] J. Smit, *Physica*, vol. 16, p. 612, June 1951.
[2] R. L. Wallace, *Bell Syst. Tech. J.*, p. 1145, October 1951.

Noise-Whitening Filters For Digital Recording

E. WONG, MEMBER, IEEE, AND J. C. MALLINSON

A major limitation to high-density tape recording of digital data is that of intersymbol interference. It has recently been shown, however, that provided certain physical conditions are met during the recording process, the overall waveform is the superposition of the individual pulses. Thus, for a random sequence of bits, the interference due to pulse crowding can be viewed as another source of additive noise. This interference noise is shown to be approximately Gaussian under high-density conditions and to have a power spectral density which is identical in shape to the spectrum of a single pulse. Therefore, the problem of detecting a single pulse in the presence of both intersymbol interference and additive white Gaussian noise is reduced to a detection problem with additive Gaussian nonwhite noise. The problem can be further reduced to one of detecting a signal in additive white noise by the use of a noise-whitening filter. The overall optimal detector then has the form of a noise-whitening filter followed by a matched filter followed by a sampler and quantizer. We note that the noise-whitening filter is always a pulse compression filter. It is satisfying that the conflict between a matched filter which improves the peak signal-to-noise ratio (SNR) but broadens the pulse and a pulse compression filter which alleviates intersymbol interference but degrades the SNR is naturally resolved in our formulation of the problem. By seeking an optimal detector in the presence of both intersymbol interference and additive white noise, we have found an optimal structure containing features of both pulse compression and matched filtering. We conclude with several simple realizations of noise-whitening filters designed for a tape recorder operating at 15 000 bit/in.

Paper 12.6, presented at the 1970 INTERMAG Conference, Washington, D. C., April 21–24. This work was supported in part by the Jet Propulsion Laboratory under Contract 951785.

E. Wong is with the University of California, Berkeley, Calif.

J. C. Mallinson is with the Ampex Corporation, Redwood City, Calif.

The Influence of Data Codes on Peak Shift

B. BIRCH

The set of self-clocking digital recording codes is comprised of subsets characterized by the maximum permitted number of consecutive missing transitions or zero string length [1]. This zero, string length affects the decoding timing stability and discrimination, and peak shift effects also become more severe as the number of consecutive transition absences is increased. The familiar phase encoding method is an example of single absence coding but, by virtue of a further coding constraint, it is not representative of the general case and benefits from reduced pulse crowding problems.

Linear superpositioning of two Gaussian curves has been used to predict the extent of peak shifting for decreasing transition separation [2]. The results obtained are only applicable to the worst case nonreturn-to-zero error, and a more general approach, taking account of other neighboring transitions, is required for a wider investigation.

In the present case the analytic expression used to define the characteristic pulse was $[(1 + t^2)^{-1} - a]$, with the constant a such that a good theoretical–experimental fit for the replay amplitude-versus-reversal density curve was obtained for a particular flying head disk system. From this curve is obtained a plot of resolution, the ratio of full- to half-frequency replay amplitudes, against reversal density. For resolutions down to 40 percent this curve indicated the need to consider three reversal positions on each side of the transition being investigated. The resulting 64 possible reversal patterns are described by two-digit octal numbers; the more significant digit specifies the three-position reversal pattern to the left of the subject pulse, while the 8° digit defines the pattern to the right of this pulse.

A program was written to calculate the effect of these six possible reversals on both amplitude and peak position of the center pulse for increasing reversal density. The ratio of peak amplitudes for patterns 77 and 22 gives, of course, the resolution as a function of reversal density, and this result can be used to relate peak shift and resolution. The tabulated results may then be used as a reference table from which, the peak shift for reversal patterns of any length can be determined.

Peak shift problems manifest themselves in a system by modifying the relative lengths of the permitted cell intervals, thereby reducing the ability of the system to discriminate between these various cells. This change in length is given by the relative shifts of the two transitions demarcating the cell, and it may be determined from the tables by algebraically adding the shifts for the patterns specifying these transitions. Worst case conditions are obtained by considering

Paper 12.7, presented at the 1970 INTERMAG Conference, Washington, D. C., April 21–24.

The author is with International Computers Ltd, Kidgrove, England.