Chapter 2

Iterative Codes in Magnetic Storage Systems

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The development of information technology has spurred enormous demand for vast and reliable data storage. In the past decade, the areal density of commercial hard disk drives has increased at an unprecedented rate of 60% compound annual growth, basically doubling the data storage density every 18 months. The goal of future hard disk drives is to realize storage densities of 1 Terabits/in$^2$ and higher. The storage capacity increase up to now has been primarily driven by the advances in head and media technologies; however, coding and signal processing are being increasingly recognized as cost-efficient means of improving storage capacity as advances in VLSI circuit technology are enabling increasingly sophisticated signal processing methods at negligible cost increases.

2.1 Introduction

Fig. 2.1 shows a block diagram of a read/write channel in a hard disk drive. Encoder and decoder are denoted as “Enc” and “Dec” respectively. In the write process, user data is organized into sectors of 4096 bits, appended with several bytes of cyclic redundancy check bits, and fed to a Reed-Solomon (RS) [1] encoder that operates on 8 or 10-bit symbols. The modulation code [2] is a high-rate code that imposes a run-length constraint to facilitate timing recovery and for perpendicular recording, also imposes a running-digital-sum constraint to reduce baseline wander. The modulation encoder is followed by a parity encoder that appends one or more parity bits to the modulation codeword. The parity bits allow detection and correction of certain type of error events [3, 4]. In order to alleviate the effect of the nonlinearities in the writing process, a write precompensation is employed. The major causes of these nonlinearities are bandwidth limitations in the write path and the demagnetizing fields in the magnetic medium. These nonlinearities will cause data pattern-dependent displacements of recorded transitions relative to their nominal positions. The write precompensation compensates for these displacements by
introducing data pattern-dependent compensating shifts into the signals. Digital information is stored on magnetic media by saturating the media in one of two magnetic directions. The recording is accomplished by alternating the direction of the current in the write head coil, which alternates the direction of the magnetic field emanating from the head while the magnetic media is in motion. The alternating head field magnetizes the medium accordingly, producing regions along the medium that are magnetized in either of two directions.

To retrieve data from the disk drive, the read head senses the transitions (i.e., changes) in the magnetization and converts the stored information back to an electronic waveform. The analog playback signal is amplified before feeding it to the read channel shown schematically in Fig. 2.1. A front-end low pass filter (LPF) is employed to suppress out-of-band noise and perform some preliminary equalization (e.g., pulse shaping). An analog-to-digital converter samples the analog signal from the LPF at the desired sampling phase that is adjusted by a timing recovery loop. The obtained symbol-rate-sampled signal is further shaped into a partial response (PR) signal [5] by the equalizer and fed to the channel detector. An optimal sequence detector for a parity-coded system is a Viterbi detector [6] that combines channel states and code states [4]. The decoder ensures that the states at the parity block boundary satisfy the parity constraint. A suboptimal decoding of a parity coded system begins with the detection of recorded bits using the Viterbi algorithm matched to the PR channel only. Then, a parity-based post processor (denoted as “Parity P.P.”) is employed to correct a specified number of the most likely error events at the output of the Viterbi detector by exploiting the parity information in the incoming sequence. The post processor produces the final estimate of the PR channel input sequence. This sequence is passed to the modulation decoder that delivers estimates of the modulation encoder input to the RS