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An Iterative TMR Mitigation Method Based on Readback Signal for Bit-Patterned Media Recording

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Off-track condition or track misregistration (TMR) is one of the most significant problems in the extremely high-density bit-patterned media recording (BPMR) system, since a track pitch becomes narrower. Typically, the TMR can be detected and handled by a servo system; however, it requires some special data to be inserted in the tracks so as to estimate the amount of head offset. Nonetheless, this paper proposes an iterative TMR mitigation method for BPMR systems based on the readback signals. First, we design several pairs of the 2-D asymmetric target and its corresponding 2-D equalizer that match the BPMR channel for each TMR level. Then, we exploit the three adjacent data tracks obtained from the low-density parity-check decoders to estimate the TMR level. Last, a pair of the 2-D asymmetric target and its corresponding 2-D equalizer that is best fit to the estimated TMR level will be used to alleviate the TMR effect in the readback signal for the next global iteration. Simulation results indicate that the proposed system can effectively estimate the TMR level and performs better than the conventional system without a TMR mitigation method, especially when the TMR level is high and/or the position jitter is large.

***Index Terms*—2-D equalization, bit-patterned media recording (BPMR), intertrack interference, track misregistration (TMR).**

I. Introduction

TRACK misregistration (TMR) is one of the major problems in the extremely high-density bit-patterned media recording (BPMR) system [1], [2] because a track pitch or a spacing between the adjacent tracks becomes narrower. This can easily cause the read head to position away from the center of the main track, as illustrated in Fig. 1. For example, this could happen when the disk rotation speed is suddenly increased for high transfer rate and access time, while the read head moves to read the data on the main track [3]. In general, the TMR can cause a devastating impact on the data recovery process, because it will enhance the interference from the adjacent tracks, i.e., intertrack interference, thus degrading the quality of the readback signal. Moreover, the TMR effect may lead to the mismatch between the readback signal and the design of the target and its corresponding equalizer, which in turn causes the detector to perform unreliably.

Although the servo system can be used to handle the TMR effect [3], [4], it requires some special data to be inserted in the tracks so as to estimate the amount of head offset. However, it is normally difficult to approximate the behavior of the read-head movement when the TMR occurs beyond its limitation [3], [5]. Alternatively, Myint and Supnithi [6] introduced the TMR detection method from the readback signals, based on the observation of the 2-D equalizer coefficients, and then adjusted the 2-D target and the 2-D equalizer to be asymmetric so as to handle the TMR-affected readback signal. Nevertheless, we found that this method can only perform well when the TMR is not high (e.g., $\leq$10%) and an areal density (AD) is moderate (e.g., $\leq$2 Tb/in^2).

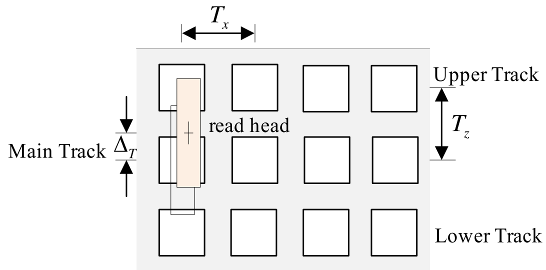

Fig. 1. TMR or a head offset, Δ_T, in BPMR systems.

To solve the TMR problem, we propose an iterative TMR mitigation method to alleviate the TMR effect based on the readback signals. We first design several pairs of the 2-D asymmetric target and its corresponding 2-D equalizer that match the BPMR channel for each TMR level. Next, we utilize the three adjacent data tracks obtained from the output of the low-density parity-check (LDPC) decoders to estimate the TMR level. Hence, a pair of the 2-D target and its corresponding 2-D equalizer that is best fit to the estimated TMR level will be employed to cope with the TMR-affected readback signal during the next global iteration.

The rest of this paper is organized as follows. Section II describes the BPMR channel model, and Section III explains the proposed TMR mitigation method. Simulation results are given in Section IV. Finally, the conclusion is drawn in Section V.

II. BPMR Channel Model

Consider a discrete-time BPMR channel model [7], [8] in Fig. 2. An input data sequence $u_{l,k} \in \{0, 1\}$ of length 3640 b with a bit period T_x is encoded by a rate-8/9 LDPC code [9] to obtain a sequence $x_{l,k} \in \{\pm 1\}$ of length

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