INTERLACED MAGNETIC RECORDING CHANNEL SIGNAL PROCESSING FOR MITIGATING INTER-TRACK INTERFERENCE

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I. INTRODUCTION

Magnetic recording industry are intensely exploring technologies for continuing the enhancements of recording density in a cost-effective way such as two-dimensional magnetic recording (TDMR) without major modifications in the media or recording physics [1]. Likewise, recently proposed interlaced magnetic recording (IMR) shows potential areal density capability (ADC) gain by the write strategy change that recording tracks in the interlaced orders with controlled linear densities [2]. Consequently, the tracks are partitioned into two groups depending on the squeeze state, and the overall ADC can be improved based on the separate customization of the track and linear densities, particularly for the non-squeezed tracks with an aggressive linear density scaling. On the other hand, the squeezed tracks suffer from severe inter-track interference (ITI), and may limit the extra ADC gain by the poor off-track performance.

In this study, a novel ITI mitigating signal processing scheme is proposed for IMR channel, where severed ITI in the squeezed track is suppressed based on the effectively synchronized ITI estimation and subsequent filtering. Note that the block-wise ITI cancellation (ITIC) for magnetic recording discussed for shingled recording with negligible frequency offsets [3] cannot be applied for the asynchronously recorded IMR channel due to the intentional frequency offsets between neighboring tracks. In the proposed ITI mitigation scheme, effective synchronization can be addressed by the oversampling of the squeezed track with the baud-rate of side tracks, which dynamically adjusts the relative timing difference between asynchronously recorded tracks. Figure 1 shows a block schematic of the read channel signal processing for IMR with the proposed ITI mitigating scheme. As illustrated, tracks are recorded by the interlaced order, for example odd ones first with a linear density L_s and even ones later with an L_n, $L_n > L_s$, which forms squeezed and non-squeezed track groups, respectively. During read-back, the squeezed track signal is 1) over-sampled by a factor of $\gamma = L_n / L_s > 1$, denoted by $\mathbf{x}_{\gamma\mathrm{x},si}$, 2) processed for the ITI error signal estimation, $\mathbf{e}_{\mathrm{iti},\gamma\mathrm{x},si}$, with the extracted ITI response and the saved track data of both sides, 3) filtered to subtract the ITI contribution in the over-sampled domain, and 4) re-sampled to its baud-rate, $\mathbf{x}_{1\mathrm{x,c},si}$, by the interpolated timing recovery (TR) [4].

II. RESULTS

The proposed ITI mitigating signal processing scheme is numerically evaluated with the micro-pixelated magnetic channel model [2] with the IMR of near 1 Tb/in^2 scenario. The widths of writer and reader are set to 60 and 45 nm, respectively and head electronics SNR (HESNR) is accounted up to 30 dB. The bit error rate (BER) performance is investigated by the partial response (PR) equalizer and Viterbi detector for the baud-rate samples with and without ITI mitigation. Figure 2 (a) shows the on-track BER of the squeezed track as a function of HESNR with the track density of 529.2 kTPI with the set of linear densities L_s = 2,080 and L_n = 2,600 kBPI, yielding γ = 1.25. The BER can be reduced by the proposed ITI mitigation for IMR, for example from $10^{-1.01}$ to $10^{-1.48}$ under 30 dB HESNR. In addition, the ITI suppression is also effective at the off-track locations, and Fig. 2 (b) shows the BER scanning results with read offsets along the cross-track direction. As illustrated, the bathtub shape curve can be deeper and wider by the proposed ITI mitigation, for example, the width at the target BER of $10^{-1.0}$ is broadened from 6.8 to 31.0 nm. For comparison, similar on-track performance can be achieved without the ITI mitigation at the lower density of 488.5 kTPI, L_s = 2,000, and L_n = 2,500 kBPI. As expected, the proposed ITI mitigation enhances the squeezed track BER performance significantly in the IMR channel, and can provide extra ADC push on top of the original IMR gain by enabling higher track density channel operation.

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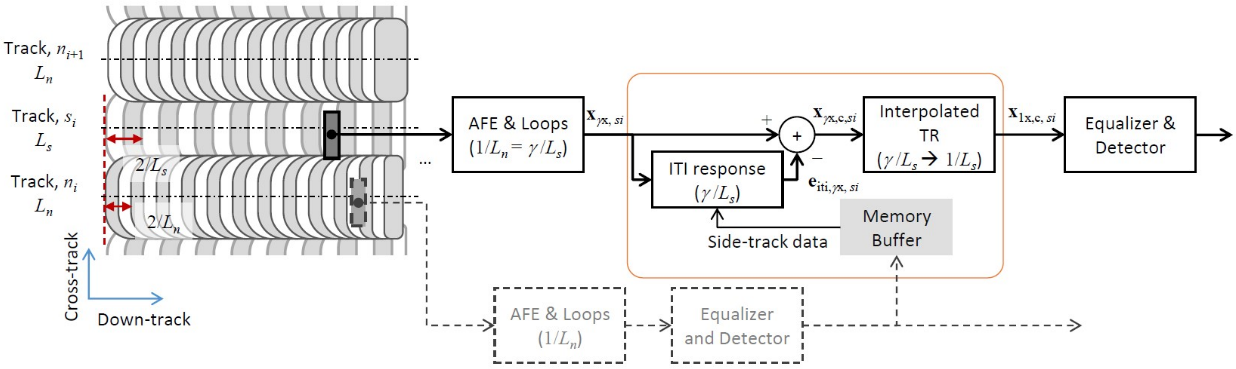

Fig. 1 Schematic of the read channel signal processing blocks of IMR with the proposed ITI mitigating scheme.

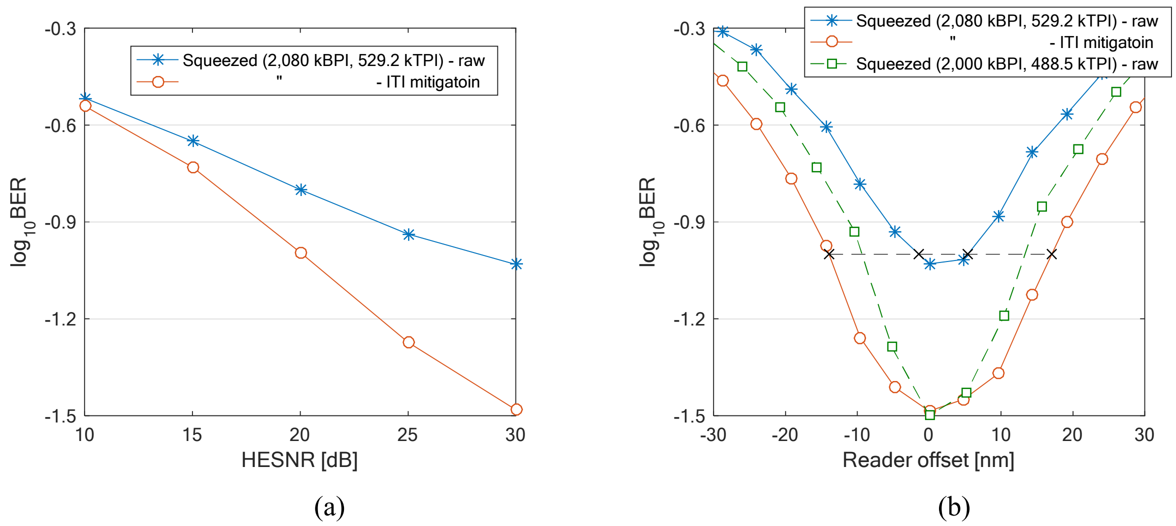

Fig. 2 BER performance of the IMR with the proposed ITI mitigating scheme (a) as a function of HESNR at on-track location with 529.2 kTPI, L_s = 2,080 and L_n = 2,600 kBPI, and (b) bathtub curves at HESNR=30dB with the previous condition, and with 488.5 kTPI, L_s = 2,000 and L_n = 2,500 kBPI for comparison.