A STUDY OF TDMR FOR MAGNETIC TAPE SYSTEMS

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I. INTRODUCTION

Magnetic tape systems are widely used for data backup and archiving applications because of their low cost, stability of recording media for long-term data retention, and reliability of information retrieval and reproduction. In order to achieve higher areal recording density, the track density can be further increased since the bit aspect ratio of current tape systems is approximately 27 [1], which is larger compared to current HDD by an order of magnitude. Technologies for tape transport have been studied and demonstrated [2], [3] to achieve aggressive track density scaling. In this work, the application of a two-dimensional magnetic recording (TDMR) scheme to a magnetic tape system was studied to further extend track-tolerance budget for track misregistration..

II. EXPERIMENTAL SETUP

In order to evaluate the performance of TDMR using a conventional single-reader tape head, the waveform data captured at different tape scans asynchronously was synthesized by software processing method. The position of the reader was moved toward the cross-track direction gradually; at the same time, signals from the data-reader element and servo-reader element were captured simultaneously. The position of the data-reader element relative to the servo-track on tape can be identified using the servo information decoded from the captured servo-signal. Hence, the two-dimensional readback signal image as shown in Fig. 1 can be synthesized. In this example, a 300 nm wide data-reader which is narrower compared with recent commercial tape drives [1], was used for signal acquisition to obtain a high cross-track resolution image.

To evaluate the performance of TDMR, repeating 63-bit and 255-bit pseudorandom binary sequences were written to commercial 15 TB tape media alternately in a shingling manner using a commercial tape head mounted on a reel-to-reel tester and read back by 300 nm wide reader. The written track pitch was set to 500 nm, and the linear density was set to 510 kbpi, which corresponds to the bit aspect ratio of approximately 10. Even under the utilization of the servo-signal, the timing jitter due to tape speed variations among different tape passes occurring within the servo sub-frame remains. A reference directed interpolative timing recovery scheme was utilized to compensate for this issue.

III. SIGNAL PROCESSING ARCHITECTURE AND SIMULATION RESULTS

The performance of the proposed signal processing scheme was evaluated in terms of signal-to-noise ratio (SNR) after extended partial-response class 4 (EPR4) equalization before the detector input. Fig. 2 depicts the signal processing architecture used for the experiment. By using two sets of signals in the synthesized image as shown in Fig.1, each representing the readback waveform from different cross-track locations of the two different readers, the performance of two-dimensional EPR4 equalization was evaluated. The result was compared with a conventional one-dimensional equalization scheme in terms of SNR cross-track profile, as shown in Fig. 3. It is clear that the performance gain of two-dimensional equalization strongly depends on the relative position of the two readers. When the reader pitch (RP) of the two readers was set to the appropriate value, approximately 230 nm in this case, the effective tracking margin was extended by nearly 150%. Here, the effective tracking margin was defined as the width of the region where SNR exceeded 7 dB. On the other hand, when the two readers were set closely together, an increase in SNR around the center of the track profile was confirmed possibly due to the off-track mitigation effect by the usage of the dual reader.

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IV. CONCLUSION

The TDMR gain in a magnetic tape system was studied under the condition where the bit aspect ratio is approximately 37% compared with current tape systems. The performance was evaluated in terms of SNR track profile utilizing a two-dimensional readback signal synthesized from the conventional single reader output. The results show that the effective track profile can be extended by nearly 150% compared with a conventional one-dimensional equalizer when the dual reader positions were set properly. An additional gain in SNR was also confirmed at the center of the track profile when the two readers were set closer together, indicating that the introduction of two-dimensional equalization scheme to current tape systems is effective to further increase track density.

REFERENCES

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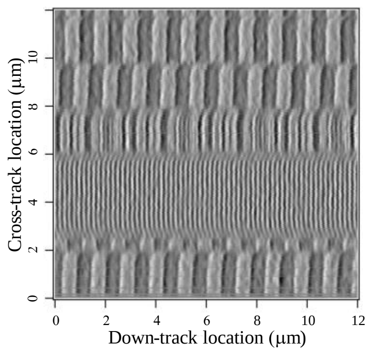


Fig. 1 Synthesized two-dimensional readback waveform image of tape media.

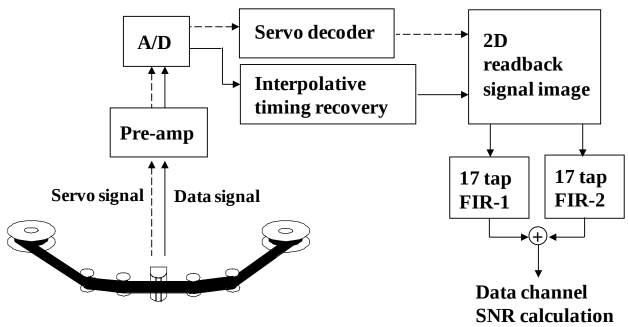
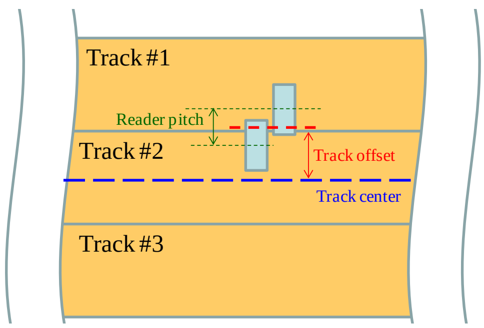
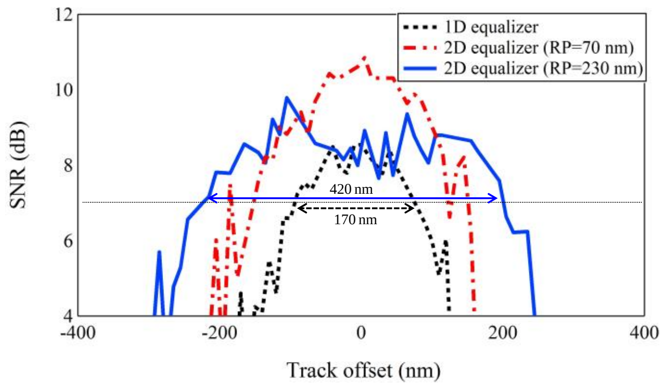


Fig. 2 Block diagram of signal processing.



(a)



(b)

Fig. 3 (a) Track profile evaluation scheme. (b) SNR track profile of two-dimensional equalizer output at different RP compared with that of conventional one-dimensional equalizer.