MEASURING THERMAL GRADIENT IN HAMR WITH PSEUDORANDOM BIT SEQUENCES

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I. INTRODUCTION

The downtrack thermal gradient is a key metric characterizing the performance of heat assisted magnetic recording (HAMR) heads and can limit performance by determining the achievable transition width and hence linear density. A robust and accurate method for measuring the downtrack thermal gradient is consequently of great importance for evaluating HAMR head performance. Here we describe a method for determining the downtrack thermal gradient by measuring the shift in write location caused by an abrupt step in laser current while writing a series of pseudorandom bit sequences (PRBS's). The technique works for small perturbations of the laser current, operates at realistic linear densities, and can correct for several artifacts that affect the accuracy of thermal gradient measurements.

II. PRBS THERMAL GRADIENT

When a HAMR head's laser power is increased, the thermal spot size produced on the disc becomes larger, increasing the track pitch and shifting the write location in the downtrack direction (see Fig. 1). This shift in write location produces a measurable phase jump in the read signal. If we increase the laser power by a controlled amount and measure the resulting shift in the write location, then we can approximate the downtrack thermal gradient using the equation

$$dT/dx = (T_w - T_a)A_{\%}/\delta \quad (1)$$

where T_w is the write temperature, T_a is the ambient temperature, $A_{\%}$ is the fractional change in laser power, and δ is the shift in write location in nm [1,2].

We measure the shift δ using time-domain correlation of PRBS periods written before and after a laser power step. PRBS's are chosen for this measurement because 1) PRBS's provide minimal cross-correlation except when they overlap exactly, 2) they provide a long time base for the measurement (e.g., 127 or 255 bits), and 3) they simulate user data more accurately than single tones. The true period of the PRBS patterns is determined by finding the period that maximizes the average cross-correlation between different periods. Then the periods before the laser power step are averaged together to remove electronic and media noise. The periods after the step are also averaged. Then the correlation between the two average PRBS's is calculated as a function of the relative time delay between them. The delay maximizing the correlation is then used to calculate δ using the linear velocity.

This PRBS thermal gradient measurement technique can address a number of sources of error in thermal gradient measurements. First, equation (1)'s derivation involves truncation of Taylor series in $A_{\%}$ to first order only. The second-order term introduces an error of ~5% under typical measurement conditions. Averaging the transition shift δ measured for positive and negative laser current steps, however, makes the error due to this second-order term cancel. Second, changes in the response of the head/media system with changing laser power (e.g., curvature) can produce a change in the odd part of the dibit response which introduces a spurious transition shift in addition to that produced by the increasing thermal spot size. We can extract the dibit response from the PRBS signals before and after the laser power step using the methods of Ref. [3] and exactly determine this shift and so correct the thermal gradient calculation. Third, the PRBS method places no constraints on the linear velocity or data rate used, which is important—our measurements indicate that the thermal gradient of typical HAMR heads depends

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significantly on data rate.

III. RESULTS AND CONCLUSIONS

We used the PRBS-based technique to measure the thermal gradient of HAMR heads under a variety of recording conditions. The measurements correlate well with corresponding results from similar techniques [1] and provide insight into how to optimize the performance of HAMR. As expected, the thermal gradient varies significantly with laser power, but it also changes with data rate, perhaps due to the frequency dependence of head field. The dibit response correction to the thermal gradient mentioned earlier can be as large as several percent.

REFERENCES

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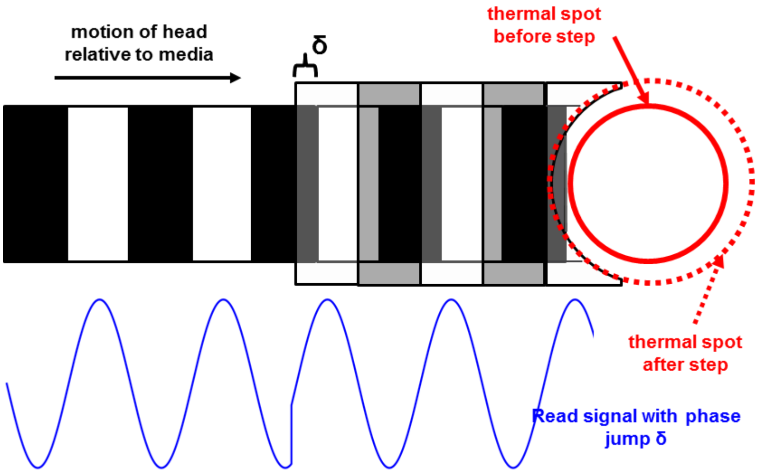

Fig. 1 The effect of increasing laser power on track width and write location.

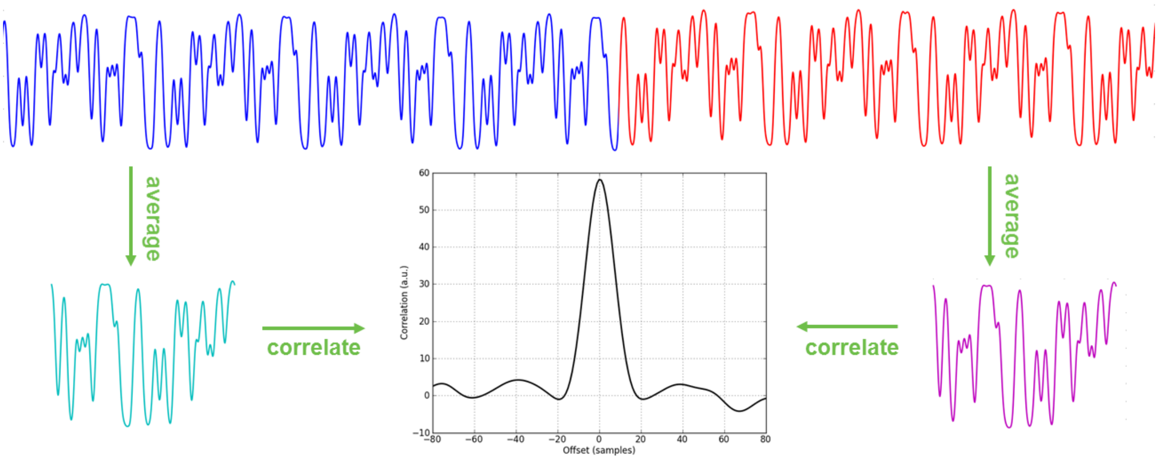

Fig. 2 Schematic of the process for calculating the downtrack thermal gradient from PRBS signals.