WRITER SYSTEM OPTIMIZATION USING TAU-MODEL

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Ⅰ. INTRODUCTION

In order to increase the areal density of Hard Disk Drive, high jump-up by HAMR, MAMR, or TDMR is required, but the current system optimizations such as head shape optimizations or write-current wave form optimizations are also required. Though LLG (Landau–Lifshitz–Gilbert equation) simulator is preferable for these optimizations, computation resource still tends to be huge to calculate SNR, fringe properties or BER (Bit Error Rate). In this paper, our newly developed FEM (Finite Element Method)-model called tau-model is proposed, which model can calculate time-dependent write field from write heads several ten times faster than LLG and can trace the LLG behavior.

Ⅱ. MODELING METHOD

Basic equations of tau-model are shown as follows.

$$rot(\nu_0 \cdot rot\vec{A}) - \nu_0 \cdot rot\vec{M} - \vec{J} = 0 \qquad (1)$$

$$\vec{M} + \tau \cdot \frac{d\vec{M}}{dt} = \chi \cdot \vec{H} \qquad (2)$$

(A: vector potential, M: magnetization, J: write current, ν: magnetic resistivity, χ: magnetic susceptibility)

The equation (1) is Maxwell equation and (2) provides the magnetizaion with phase delay. The damping parameter "tau" in this equation is derived from the magnetic transmission line model[1][2]. Tau model calculates these equations in coalition with FEM technique. Figure 1 shows magnetization time delay of write head's main poles by using LLG and the tau-model. The horizontal axis of this figure shows the distance from ABS. The legend indicates yoke length of the write heads. Time delay calculated by tau-model is in good agreement with the result of LLG. This dependency was same for different writer models with several different yoke shapes. Every models were used by the same tau-value=0.6nsec. This fact means that this model can well trace LLG model results without changing the tau-value for minor changes of head shapes.

Ⅲ. CALCULATION RESULTS

Figure 2 shows time delay of yoke magnetization depending on coil shapes by the tau-model. The time delay of a toroidal coil shape is faster than a pan-cake shape's by around 10%. It is well known that the toroidal coil has fast responses but the reason is generally supposed to be its lower electrical impedance. As this model does not include the impedance effect, the good performance of the toroidal coil causes only from the relative position relationship between the yoke and the coil. This result suggests the possibility for more optimization of the coil shape or the position. Tau-model can easily evaluate such dynamic performances of the writer.

Figure 3 shows BER depending on the write current wave forms using the tau-model. Each point of BER in this figure uses 34000 random bit pattern. The tau-model can be so fast as to make it possible to do

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such large scale calculation.

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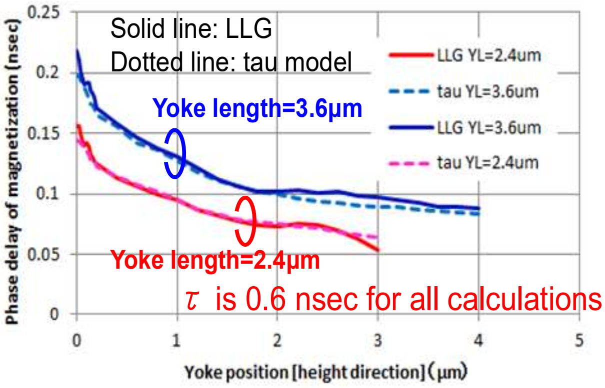

Fig. 1 Time delay of yoke magnetization comparison between tau-model and LLG

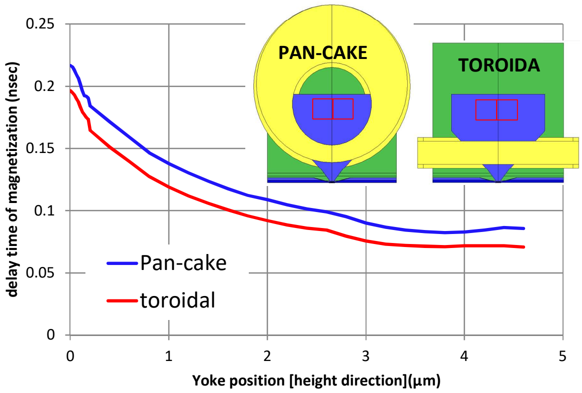

Fig. 2 Time delay of yoke magnetization depending on the coil shape.

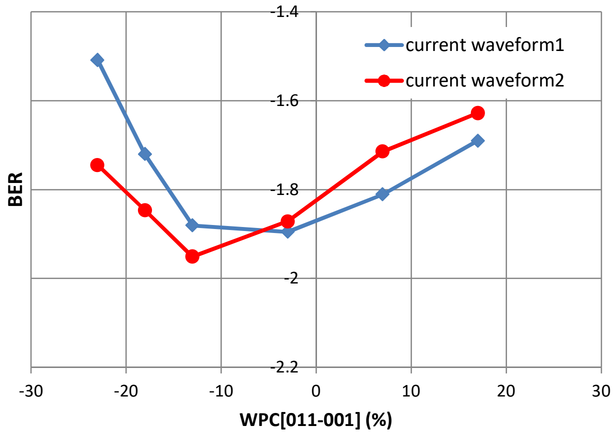

Fig. 3 BER depending on the write current wave form using tau-model 36000 random bits are used for each point.