Experimental Evaluation of Writing Process Induced EMI/EMC in Magnetic Recording System

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Abstract—This paper presents recent works on experimental evaluation of the writing process induced EMI/EMC to the reading process in a magnetic recording system. Both the time domain and frequency domain methods have been applied. The EMI/EMC effects due to the writing process with high current have been studied within the frequency range of 30 MHz to 1 GHz, and found to be frequency dependent. The observed information is essential for implementation of two-dimensional magnetic recording technique (TDMR), in order to achieve a higher data capacity and data access in future storage system.

I. INTRODUCTION

Demands of a storage device with higher data capacity and data access (e.g., with a multiple Tb/in² areal density) require the hard-disk industry and research community to constantly explore some new technologies for their realizations. Recently, two-dimensional magnetic recording (TDMR) [1-3] has found to be a novel architecture for the areal density towards multiple Tb/in² in the magnetic recording systems.

For applying the TDMR, the recording bits in the adjacent tracks are preferably to be aligned properly, and the synchronization of writing/reading bits is necessary. This results in a requirement to activate the reading activity, while the writing is in process, i.e. the reader has to reproduce reference signals during the writing processes. In the current magnetic recording system, the power of writing process is around 1000 times higher than that of the reading process. The reader could pick up some strong writing signals from the writing process, through electromagnetic interference and coupling (EMI/EMC) [4] at the various section of suspension flexure in a magnetic recording system. The induced EMI/EMC needs to be investigated and evaluated accurately for the purpose of EMC/EMI suppression.

In this paper, experimental investigation and evaluation of the writing process induced EMI/EMC to the reading process of a magnetic recording system will be reported. The EMI/EMC effects in the frequency range of 30 MHz to 1 GHz will be analysed. Both the frequency domain and time domain methods were applied in order to understand the EMI/EMC effect more properly.

II. BACKGROUND OF THE STUDY

A. Device Under Test

The device under test (DUT) in this study is a suspension flexure with slider suspension electrical bonding points inside the magnetic recording system as shown in Fig. 1. As shown in Fig. 1, the prototype of a suspension flexure with indications of differential writer (W+: positive bonding point [BP], W-: negative BP) and reader (R+: positive BP, R-: negative BP) trace pairs are shown in Fig. 1(a), and Fig. 1(b) presents two samples (with/without terminations) used in this study.

B. Measurement Setups

The main purpose of this study is to investigate the electromagnetic power coupled into the reader trace pair when the writing is in process (i.e., there is a high current applied to the writer trace pair). A probe station is therefore used to fix the samples with proper electrical contact for pumping in the electromagnetic power. Fig. 2(a) shows the experimental setup on a probe station in order to study the EMI/EMC effect
at the interesting portions of flexure on suspension. The contact of a microprobe with the writer trace pair viewed from a microscope is shown in Fig. 2(b).

![Image](image1)

(a) Setup on a probe station

![Image](image2)

(b) View of 1 microprobe within the microscope

Fig. 2 Experimental setup on a probe station with microprobes

**III. MEASUREMENT RESULTS AND ANALYSIS**

**A. Impedance Measurement of Reader/Writer Traces at Flexure on Suspension Using Time-Domain Technique**

In order to evaluate the setup for EMI/EMC measurements as shown in Fig. 2, a Time-Domain Reflectometry (TDR) technique is used to check the contact of the microprobe with the Reader/Writer traces at the flexure on suspension, through measuring the characteristic impedance of connector, cable and Reader/Writer traces.

Theoretically, the characteristic impedance along the trace is 5 Ohm for the writer pair and 15 Ohm for the reader pair, if both the pairs are properly terminated/loaded. Fig. 3 shows the TDR setup for impedance measurements, where a sampling oscilloscope with TDR generator is used.

![Image](image3)

Fig. 3 The setup for TDR measurements of characteristic impedance

Fig. 4 shows the measured impedances of the writer and reader traces along the flexure on suspension using TDR technique, for a properly terminated sample as shown in Fig. 4(a), and for two samples without terminations as shown in Fig. 4(b). The measured impedance when the probe tip is open (i.e., no contact and not terminated) is also shown in Fig. 4 as a reference (blue line).

![Image](image4)

(a) Impedance for writer and reader traces on same sample with termination

![Image](image5)

(b) Impedance for writer traces on different samples without termination

Fig. 4 Measured impedances of the writer/reader traces along the flexure on suspension using TDR technique

The measured value after the probe tip indicates the trend of impedance variation along the traces at the flexure on suspension. For a terminated sample in Fig. 4(a), the impedance become stable after 41.5 ns roughly and the measured values are very close to the theoretical values of the writer trace (i.e., 5 Ohm) and the reader trace (i.e., 15 Ohm) under design.

Moreover for a further evaluation of the measurement system, the characteristic impedances for two samples without terminations have also been measured and shown in Fig. 4(b). It is clearly found that after the signal propagates along the Reader/Writer traces, the signal reaches the open end (around 40 ns). Similar characteristic impedance curves as that (blue line) for an open-ended probe tip has been observed.

From both the observations in Fig. 4, it can be concluded that the setup on the probe station with microprobes as shown in Fig. 2 is proper and meets expectations for evaluating the EMI/EMC effect induced by the writing process.
B. Electromagnetic Interference and Coupling (EMI/EMC)

In this work, EMI/EMC effect induced by the writing process to the reader trace pair has been experimentally evaluated within the frequency range of 30 MHz to 1 GHz (more specifically 30 MHz, 100 MHz, 500 MHz, and 1 GHz), using the setup shown in Fig. 5. As shown in Fig. 5, a signal generator is connected to the microprobe which is in contact with the writer trace pair on the suspension flexure, through a coaxial cable. The coupled electromagnetic power into the reader trace pair is monitored using a real-time spectrum analyzer which is connected to another microprobe in contact with the reader trace pair.

![Image](image1.png)

Fig. 5 The complete configuration for EMI/EMC measurements using the setup on a probe station with microprobes as shown in Fig. 2(a)

Typical measurement results from two different samples using the configuration in Fig. 5 are shown in Fig. 6. From Fig. 6, it is clearly observed that for different samples, very similar EMI/EMC effects have been induced by the writing process to the reader trace pair. Generally, the electromagnetic coupling increases when the frequency decreases, except for 500 MHz which needs to be investigated further. The slight difference in the measured coupled power on the reader trace pair for the two samples could be due to the variations of microprobe contacts with the traces as shown in Fig. 2(b).

Moreover, good linearity has also been observed on the coupled power at the receiver trace pair (R+ R-) when the electromagnetic power input onto the writer trace pair (W+, W-) varies from -70 dBm to +10 dBm. This indicates that EMI/EMC effects are very obvious which can decrease the signal-to-interference ratio (S/I), when implementing the TDMR architecture for the areal density towards multiple Tb/in² in the magnetic recording systems. Therefore, proper design (e.g., packaging) of the suspension flexure becomes important for synchronization of the writing/reading bits.

IV. CONCLUSIONS

In this paper, we reported some recent works on experimental evaluation of EMI/EMC effects in the magnetic recording system induced by the writing process with high current. The measurement setup with the microprobes was firstly evaluated using the TDR technique in time domain, and found to be suitable for EMI/EMC measurements.

The later measurements in frequency domain indicated that the EMI/EMC effects induced by the writing process are very significant and needed to be carefully addressed for implementing the TDMR architecture.

![Graph](image2.png)

Fig. 6 Measured power in the reader trace pairs when the writer trace pair is active

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