The Study of Testing Techniques for Positioner of Servo Track Writer

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Abstract

Positioner is the one of important components for servo track writer (STW) of hard disk drive. The good positioner should be able to move a read-write head on a specified track and write the servo signal on magnetic disks accurately. The verification of accuracy for read-write head moving on any track controlled by positioners is presented in this paper. The test strategies is categorized into two parts; to investigate the moving step of read-write head and the dynamic response in seek mode using dSPACE DS1104 controller board for detecting the position from encoder of the positioner. With these experiments, good and bad positioners can be identified in servo track writing process.

Keywords: HDD, Positioner, Servo track writer (STW), Seek and track following modes.

Introduction

High-density recording requires improvement in positioning accuracy on the data track. The track pitch of current hard disk drives (HDDs) is from 220 to 250 nm. The track pitch will continue to be reduced in future as the recording density of HDDs increases.

The magnetic head is positioned on the data track by the servo based on servo positioning information (servo pattern) (Test Engineering Department, 1999) recorded magnetically on the disk, and the quality of this information greatly affects the positioning accuracy of the HDD.

Servo pattern written in the servo track writer (STW) process, can be classified into two writeing as shown in Table 1(Yamada et al., 2006). The push-pin of the STW method is considered in this paper as displayed in Figure 1 (Uematsu and Fukushi, 2001). This method is mounted with a large STW actuator (positioner) to support the push-pin. The STW must be inside a clean room, because there must be holes in the drive covers for the push-pin.

There are three important requirements in STW: high quality, high productivity, and low equipment costs. The quality strongly depends on the following point regarding the accuracy of the servo track:

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1) Circularity of the servo track, which is Repeatable RunOuts (RROs) (Yange et al., 2001).

2) Position accuracy relative to the adjacent track.

3) Linearity of the demodulated position error signal to the track offset.

4) Noise in the demodulated position error signal, which is Non-Repeatable RunOut (NRRO) (Yange et al., 2001).

This paper introduces the testing techniques for positioner of STW push-pin. The testing consists APC test and dynamic response test in seek mode using dSPACE DS1104 controller board. The testing results are analyzed to identify good and bad positioner.

Table 1. Classification of servo track writing methods.

Writing method	Positioning	STW method
External writing	External positioning	Media STW Magnetic printing
Internal writing	External positioning	Push-pin, Mirror-on Non-contact push-pin
	Internal positioning	Rewrite STW Self STW

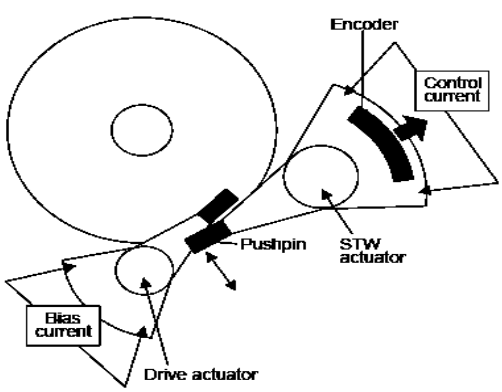


Figure 1. Push-pin STW.

Figure 2. Positioner and Beak.

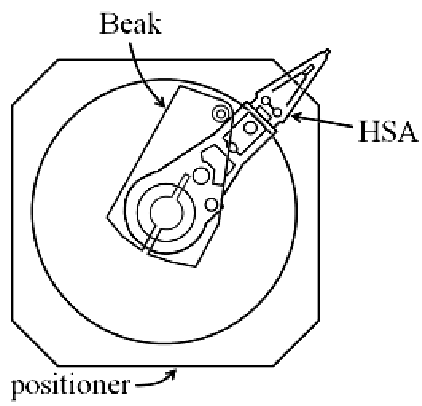


Figure 3. Beak position on positioner for controlling HSA.

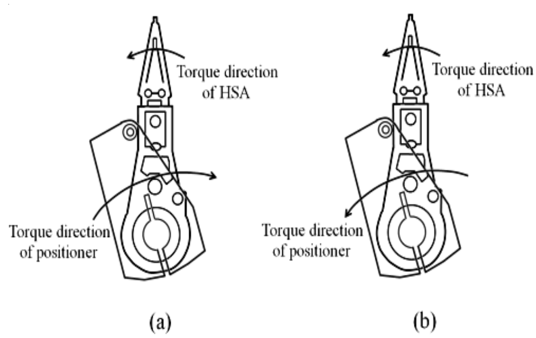


Figure 4. (a) Positioner and HSA moving for seek servo staring track.

(b) Positioner and HSA moving is anti-clock wise direction.

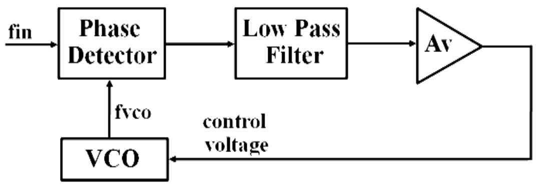


Figure 5. Phase Locked Loop (PLL) principle.

Servo track writer

A. Servo track writer

Servo track writer is an important mechanism for writing servo signal on hard disk drive. Two significant factors of STW can be mainly considered as head stack assembly (HSA) and timing of servo signal for writing on all tracks.

At present, positioner as shown in Figure 2 is an important device of STW for controlling servo motor. Since it is highly accurate, angle range moving and moving limit in short range. Positioner is driven with low speed and low torque, which is different from the other servo operation in many industries.

Minimum angular displacement controlled is equal to 0.003906 arcsec,1085 to 1,000,000,000 of 1 degree or 0.947 nm at linear position.

B. HSA control

HSA is controlled in order to move to the target position in servo signal (pattern) writing process. The direction of this moving can be considered in 2 forms:

1) In clockwise (cw) direction, the torque of HSA created by bias current of voice coil motor (VCM) is in anti-clockwise (acw) direction. Then, the torque of position is also created and controlled in cw direction to seek the servo starting track (track 0). Because of the position torque more than HSA torque, the resultant torque is in cw direction as shown in Figure 4(a). Firstly servo start point based on the detail of HDD, center point of disk and HSA, is calculated. The position of HSA detected from the encoder of positioned will operate in the feedback control configuration.

2) In acw direction, though the principle is same as the cw direction, the torques of HSA and positioner have acw direction, acw.as shown in Figure 4(b).

C. Timing control of servo pattern

Timing of servo signal writing on each track should be equal to other utilizing. This scheme is used for control of servo signal writer Phase Locked Loop (PLL). With the frequency control of PLL, output frequency can be equal to input frequency. Firstly, STW write clock signal, some reference signal, on outer disk (OD) at the zone, on which the servo signal is not written. Then clock signal is also generated by clock head in STW. The clock signal was read and fed back to PLL circuit as shown in with the operation, block diagram, in Figure 5. Without PLL, the error on writing the servo signal is occurred.

D. Laser Rotary Encoder

As Figure 6 in the diagram, laser beams are applied to two points equidistant from the grating disc's center of revolution. One diffraction beam is positive first order (+1) and the other is negative first order (-1). For each 1 pitch that the grating disc revolves, the ±1 diffraction light will change each phase by $\pm2\pi$. Reflecting the ±1 diffraction light into respective mirrors and then reapplying it to the grating disc changes the phase by $\pm4\pi$. In this way, each time the grating disc revolves 1 pitch, the brightness interference signals for 4 cycles can be obtained, making highly accurate angle sensing possible.

Positioner test

In this section, the positioner test procedures are described to investigate good and bad positioners some known good and bad positioners are chosen to be the device under test for experiment with the following methods:

A) APC Test for checking efficiency, error and value offset (MV) of positioners

For servo signal writing, we need a HSA moving with constant movement and always on the target,which is confirmed with APC. We denote The desired value of APC test by V_{APC} and distance between servo track by Track picth (T_P). Figure 7 is shown APC structure and APC variable.

In the section we show that both V_{APC} and (T_P) are estimated using (1) and (2):

$$V_{APC} = \frac{V_A + V_B}{V_B} = \frac{A+C}{B} \qquad (1)$$

and

$$T_p = W_W + W_r\,(1 - APC) \qquad (2)$$

where $\{W_W\}$ *and* $\{W_T\}$ are the constants, respectively.

the Position Error signal (PES). The algorithm is represent by the following

$$PES = \frac{\frac{1}{2}(V_A + V_C)}{(2V_B - V_A - V_C)} \qquad (3)$$

Figure 8 is shown APC and positioner step. The line A in APC results are fixed boundary from data average, it is between ± 8%. If the data (line B) jump over the line A it is mean bad positioner.

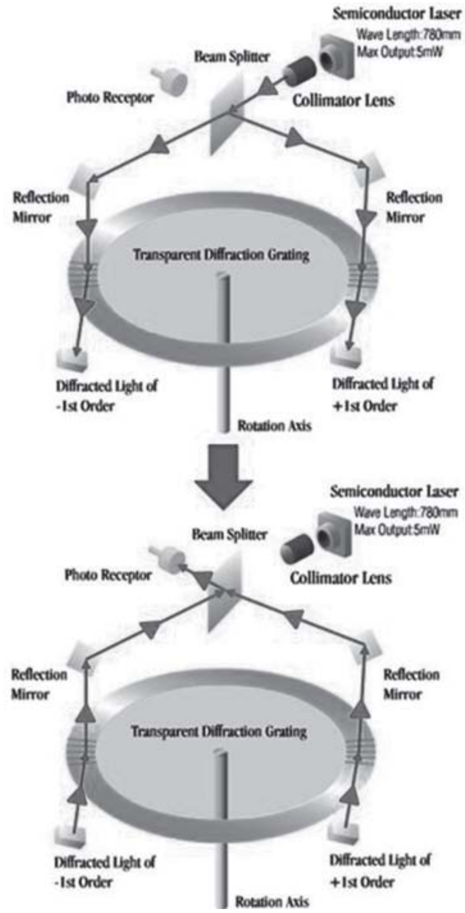


Figure 6. Laser Rotary Encoder operation.

B) Dynamic response analysis of servo track writer in moving track mode using the detection of signal from encoder of positioners

The equipment employed in these experiments are good positioner, bad positioner, servo track writer machine and dSPACE DS1104 controller board for detecting the position from encoder of the positioner.

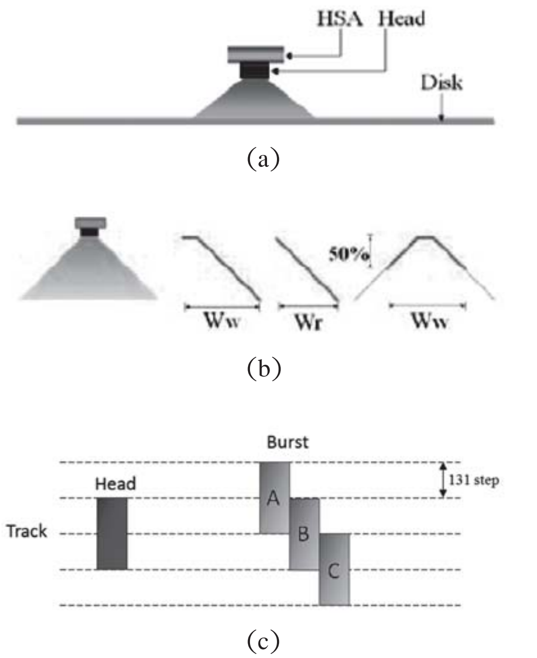


Figure 7. APC structure and APC variables (a) distance between HSA and disk surface (b) W_W ,W_T constants (c) relation between HSA and APC signal.

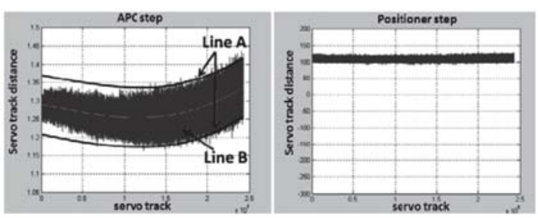


Figure 8. APC and Positioner Step.

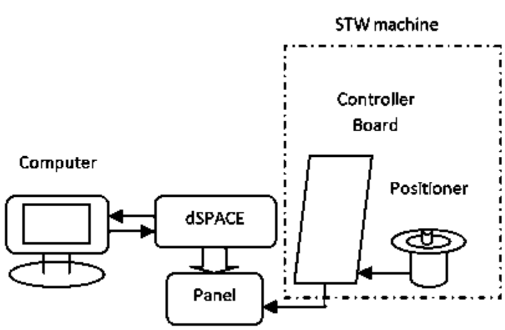


Figure 9. Block diagram of the test setup.

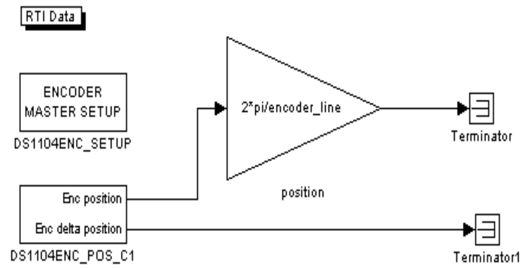


Figure 10. Simulink model for the test.

In our test setup, encoder phase A and B pulses are measured from the test points on controller board of servo track writer machine. Also, these signals are interfaced via in dSPACE DS1104 controller board for detecting the position from encoder

of the positioner to monitor the dynamic response of the positioned in moving track mode. Block diagram of the test setup and The created simulink model for the test is shown in Figure9 and 10 respectively.

Experimental results

In this section, experimental results are presented to identity the tested positioners.

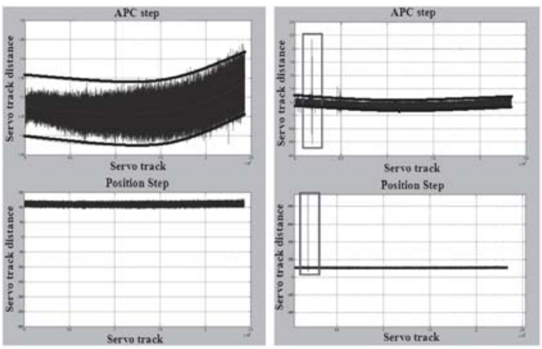
A) APC test

In Figure 11, the results of APC test are plotted on MATLAB. The good positioners are moving with constant distance and APC

values are still in fixed boundary, comparing with bad positioners. This guarantees that positioners move without overwrite in servo track writing process.

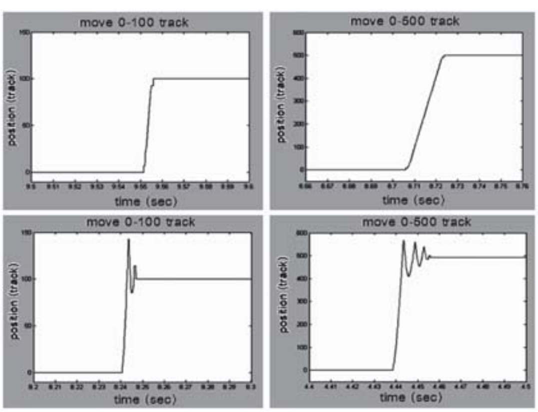
B) Test dynamic response in seek mode using a real-time interface card.

Obviously, phase A and phase B pulse from encoder of positioners, both good and bad are different. These pulse are converted to the dynamic response of the position in moving from 0-100, 0-500 track and plotted on MATLAB as shown in Figure 12. From Figure 12(a), dynamic response of good positioner. For the test in moving from track 0-100, the results aim to the test in moving track 0-500 as shown in Figure12(b). we can guarantee good performance with higher accuracy, no overshoot, compared with bad positioner.



(a) (b)

Figure 11. APC step and positioner step (a) good positioner and (b) bad positioner



(a) (b)

Figure 12. Dynamic response (a) positioners move 0- 100 track and (b) positioners move 0- 500 track

Conclusions

In this paper, we proposed the testing methods for the positioner of STW. To identify good and bad positioners, we performed APC test and dynamic response test in seek mode using dSPACE DS1104 controller board. Both of test provide sufficient performance to detect errors from positioners. APC test gives the results, which can guarantee the good positioners with constant moving and always on the target. Dynamic response test in seek mode using dSPACE DS1104 controller board provides the results, which can confirm good positioners with no overshoot and high accuracy.

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