ACCELERATION FEEDFORWARD CONTROL BASED ON ADAPTIVE IDENTIFICATION OF TRANSFER CHARACTERISTICS FOR HARD DISK DRIVES

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ABSTRACT

In this paper, acceleration feedforward control based on adaptive identification for hard disk drives is proposed. To realize adaptive identification, external disturbance is estimated by Disturbance Observer and used for identification. By this means, the feedfoward controller can be realized without indirect calculation as conventional methods. Some experimental results where a disk drive is shaken are shown to verify the effectiveness of the proposed method.

1 INTRODUCTION

Recently hard disk drives are used for various applications utilizing its high performance of density and capacity. In order to improve the performance of hard disk drives under vibration of the following mode, acceleration feedforward control is proposed. In the proposed method, we use the transfer characteristics between the accelerometer and the system disturbance directly. But in fact, since the system disturbance can't be observed, the estimated disturbance with Disturbance Observer is utilized. By this means, the feedforward controller can be realized without indirect calculation like conventional methods[1][2].

2 STRUCTURE OF SYSTEM

Block diagram of disturbance rejection control with feedforward input is drawn in Fig.1. The external acceleration a exerts bad influence to the system by the disk fluctuation and the head fluctuation through the transfer characteristics G. In the proposed method, feedforward controller $\hat{G}$ which characteristics is same as G can reject influence of the external disturbance. The transfer characteristics G is expressed by the general discrete transfer function with limited order as in (1).

$$d = G \cdot exacc = \frac{B(z^{-1})}{A(z^{-1})} \cdot exacc \qquad (1)$$

$$A(z^{-1}) = 1 + a_1 z^{-1} + a_2 z^{-2} + \cdots + a_{N_a} z^{-N_a}$$

$$B(z^{-1}) = b_1 z^{-1} + b_2 z^{-2} + \cdots + b_{N_b} z^{-N_b}$$

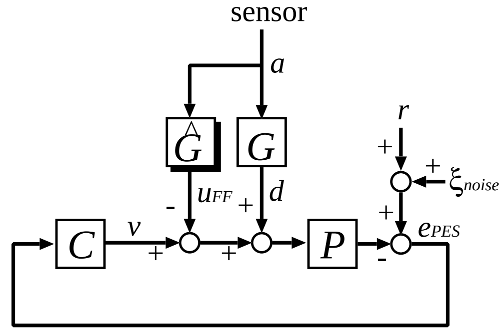


Fig.1: Block Diagram of Disturbance Rejection Control with Feedforward Input

3 IDENTIFICATION WITH DISTURBANCE OBSERVER

The general discrete transfer function in (1) is identified with Recursive Least Squares (RLS) algorithm and Fixed Trace (FT) algorithm.

$\hat{\boldsymbol{\theta}}(k)$ in (2) is the identified parameter and $\boldsymbol{\varphi}(k)$ in (3) is the input and the output signals of the identified transfer characteristics with Disturbance Observer in Fig.2.

$$\hat{\boldsymbol{\theta}}(k) = [\hat{a}_1, \cdots, \hat{a}_{N_a}, \hat{b}_1, \cdots, \hat{b}_{N_b}]^T \qquad (2)$$

$$\boldsymbol{\varphi}(k) = [-\hat{d}(k-1), \cdots, -\hat{d}(k-N_a), Q \cdot a(k-1), \cdots, Q \cdot a(k-N_b)]^T \qquad (3)$$

Using identified transfer characteristics, we can design the feedforward input u_{FF} in (4). As a merit of this method, feedforward input u_{FF} can be applied to the system without reconstruction of the system.

$$u_{FF}(k) = \hat{G} \cdot a(k) \qquad (4)$$

$$= \hat{b}_1 a(k-1) + \cdots + \hat{b}_{N_b} a(k-N_b) + \hat{a}_1 u_{FF}(k-1) + \cdots + \hat{a}_{N_a} u_{FF}(k-N_a) \qquad (5)$$

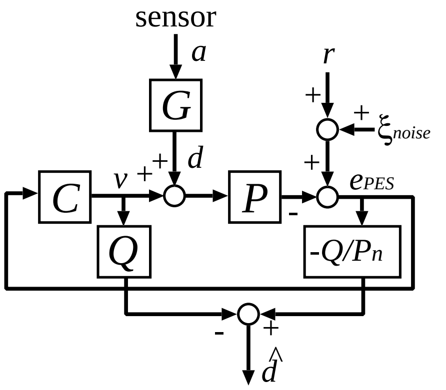


Fig.2: Block Diagram of Disturbance Observer to Estimate Disturbance

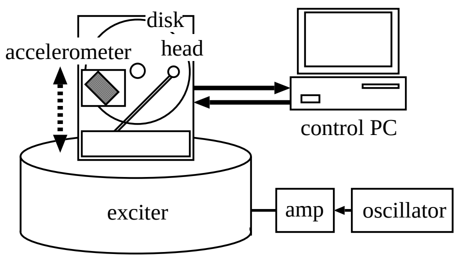


Fig.3: Configuration of Experimental System

4 EXPERIMENT WITH DISK DRIVE

Fig.3 shows the configuration of the experimental system. The accelerometer is mounted on the base of a hard disk drive to measure the external disturbance and the hard disk drive is shaken by the exciter in the direction, perpendicular to the spindle motor's axis by the sinusoidal wave.

Figs. 4 and 5 show the time series of position error signal under excitation. After applied the proposed method (500[ms]-), position error signal is remarkably reduced.

Fig.6 shows the 3σ of Position Error Signal in experiments in each frequencies of disturbance. 3σ expresses the possible maximum error statistically. By the comparison with the proposed controller and without the proposed controller, the proposed FF controller can remarkably suppress the vibration which is not possible for the conventional FB controller in all frequency of disturbance.

5 CONCLUSION

In this paper, we proposed a novel method for the acceleration feedforward control based on adaptive identification of transfer characteristics for hard disk drives. In the proposed method, transfer characteristics can be identified in a realtime manner due to the fast estimation of the disturbance by Disturbance Observer. In experiments PES is reduced by the proposed feedforward controller under vibration.

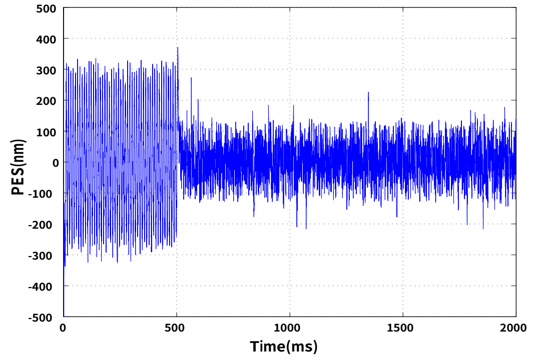
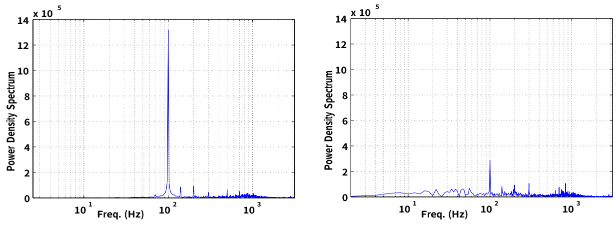


Fig.4: Time Series of PES under 100[**Hz**] vibration



(a) Without Proposed FF (b) With Proposed FF

Fig.5: Characteristics of Fourier Transform about PES under 100[**Hz**] vibration

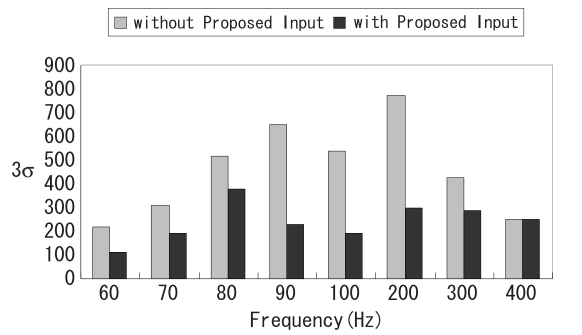


Fig.6: Comparison of 3σ of Position Error Signal with/without Proposed Feedforward Input

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