Chapter 14

Design of a Hard Disk Drive Servo System

14.1. Introduction

HARD DISK DRIVES (HDDs) provide important data-storage medium for computers and other data-processing systems. In most hard disk drives, rotating disks coated with a thin magnetic layer or recording medium are written with data, which are arranged in concentric circles or tracks. Data are read or written with a read/write (R/W) head, which consists of a small horseshoe-shaped electromagnet. Figure 14.1.1 shows a simple illustration of a typical hard disk servo system. The two main functions of the R/W head positioning servomechanism in disk drives are track seeking and track following. Track seeking moves the R/W head from the present track to a specified destination track in minimum time using a bounded control effort. Track following maintains the head as close as possible to the destination track center while information is being read from or written to the disk. Track density is the reciprocal of the track width. It is suggested that on a disk surface, tracks should be written as closely spaced as possible so that we can maximize the usage of the disk surface. This means an increase in the track density, which subsequently means a more stringent requirement on the allowable variations of the position of the heads from the true track center.

The prevalent trend in hard disk design is towards smaller hard disks with increasingly larger capacities. This implies that the track width has to be smaller leading to lower error tolerance in the positioning of the head. The controller for track following has to achieve tighter regulation in the control of the servomechanism. Current hard disk drives use a combination of classical
control techniques, such as lead-lag compensators, PI compensators, and notch filters. These classical methods can no longer meet the demand for hard disk drives of higher performance. So many control approaches have been tried, such as LQG and/or LTR approach (see e.g., [61] and [133]), and adaptive control (see e.g., [92]) and so on. Although much work has been done to date, more studies need to be conducted to use more control methods to achieve better performance of the hard disk drives.

The purpose of this chapter is to use the result of the robust and perfect tracking (RPT) control method of Chapter 9 to carry out a design of a hard disk drive servo system. We will first obtain a model of the VCM actuator and then cast the overall servo system design into an RPT design framework. A first order dynamic measurement feedback controller is then designed to achieve robust and perfect tracking for any step reference. Our controller is theoretically capable of making the $L_p$-norm of the resulting tracking error with $1 \leq p < \infty$ arbitrarily small in faces of external disturbances and initial conditions. Some trade-offs are then made in order for the RPT controller to be implementable using the existing hardware setup and to meet physical constraints such as sampling rates and the limit of control of the system. The implementation results of the RPT controller are compared with those of a PID controller. The results show that our servo system is simpler and yet has faster seeking times, lower overshoot and higher accuracy. The results of this chapter were reported earlier by Goh et al. [59].