PRINCE OF SONGKLA UNIVERSITY

FACULTY OF ENGINEERING

Final Examination : Semester 2 **Academic Year : 2010**

Date : 18 February 2010 **Time : 9.00-12.00**

Subject 210-783 SP (HARD DISK DRIVE TECHNOLOGY) **Room : Robot**

ชื่อ-นามสกุล ..... รหัสนักศึกษา ..... ตอนเรียนที่ .....

หมายเหตุ

1. ข้อสอบมีทั้งหมด .....4..... ข้อ ในกระดาษคำถาม .....7..... หน้า
2. ห้ามการหยิบยืมสิ่งใด ๆ ทั้งสิ้น จากผู้อื่น ๆ เว้นแต่ผู้คุมสอบจะหยิบยืมให้
3. ห้ามนำส่วนใดส่วนหนึ่งของข้อสอบออกจากห้องสอบ
4. ผู้ที่ประสงค์จะออกจากห้องสอบก่อนหมดเวลาสอบ **แต่ต้องไม่น้อยกว่า 30 นาที** ให้ยกมือขออนุญาตจากผู้คุมสอบก่อนจะลุกจากที่นั่ง
5. เมื่อหมดเวลาสอบ ผู้เข้าสอบต้องหยุดการเขียนใด ๆ ทั้งสิ้น
6. ผู้ที่ปฏิบัติเข้าข่ายทุจริตในการสอบ ตามประกาศคณะวิศวกรรมศาสตร์ **มีโทษ คือ ปรับตกในรายวิชาที่ทุจริต และพักการเรียน 1 ภาคการศึกษา**
7. ให้นักศึกษาสามารถนำสิ่งต่อไปนี้เข้าห้องสอบได้

   ☐ ตำรา ☐ หนังสือ

   ☐ เครื่องคิดเลข ☐ กระดาษ A4 ..... แผ่น

   ☐ พจนานุกรม

   ☐ อื่น ๆ .....
8. ให้ทำข้อสอบโดยใช้

   ☐ ดินสอ √ ปากกา

ผู้ออกข้อสอบ ..เกริกชัย ทองหนู.....

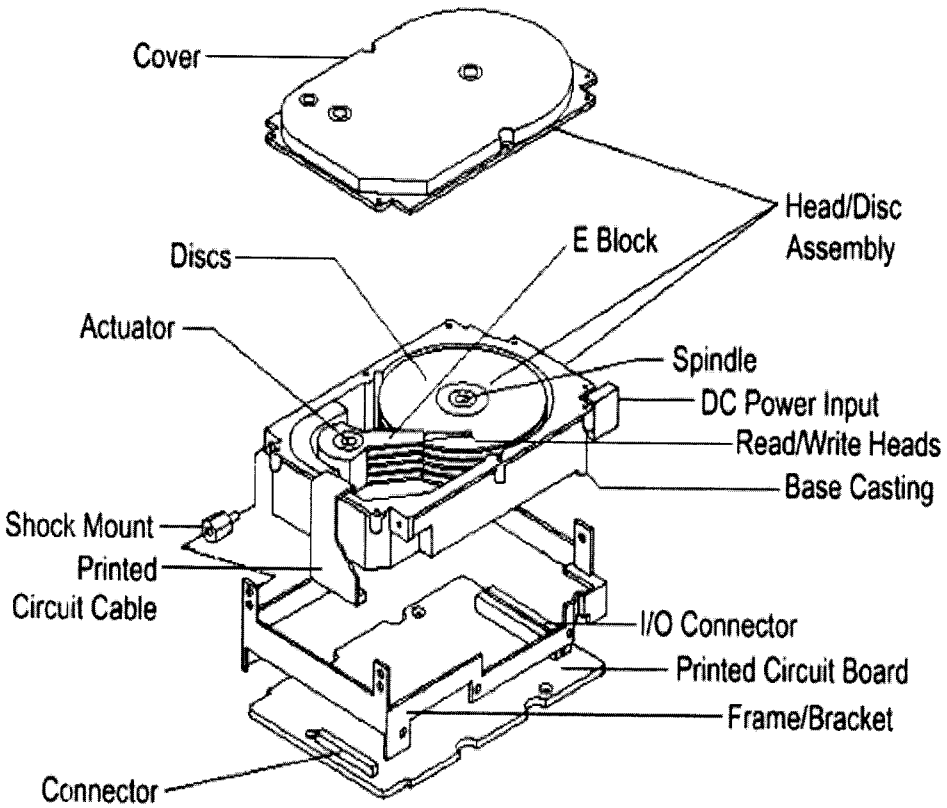
นักศึกษารับทราบ ลงชื่อ .....

"ท่านสามารถ Download แบบฟอร์มปกข้อสอบได้ที่ Web Site คณะวิศวฯ หน้าแรก"

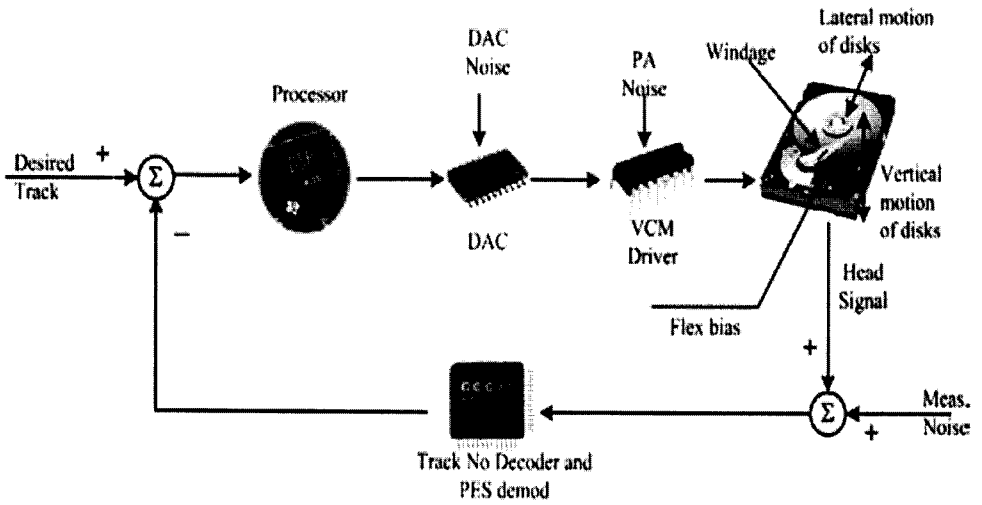
Attempt all questions.

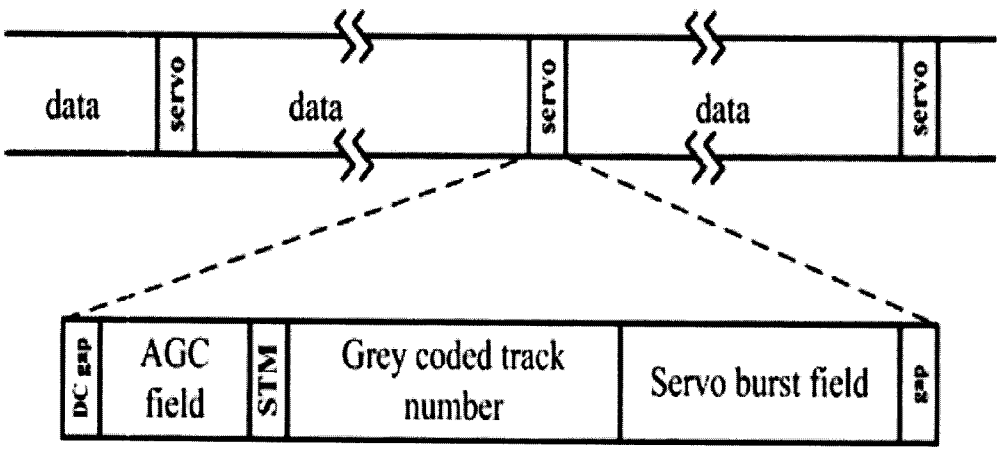
1. Give a brief description of the following parts of a typical modern hard disk drive depicted below. (10)

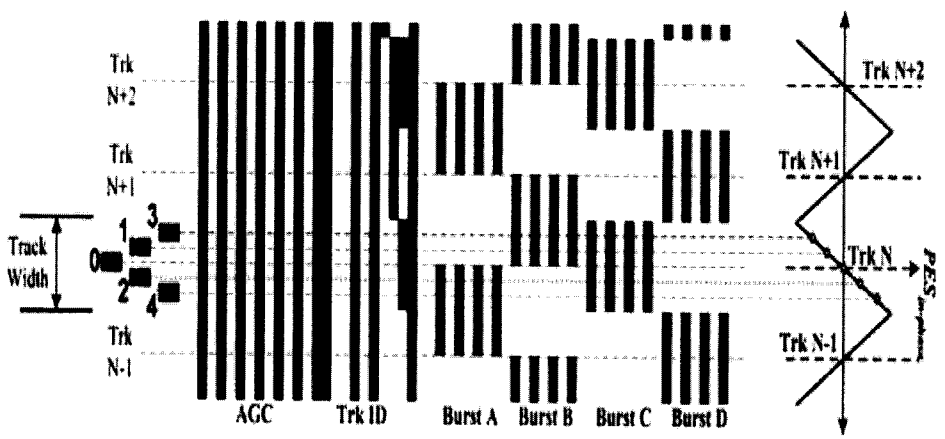
- DISK
- ACTUATOR ASSEMBLY
- HEAD/SUSPENSION ASSEMBLY
- SPINDLE AND MOTOR ASSEMBLY
- ELECTRONICS CARD



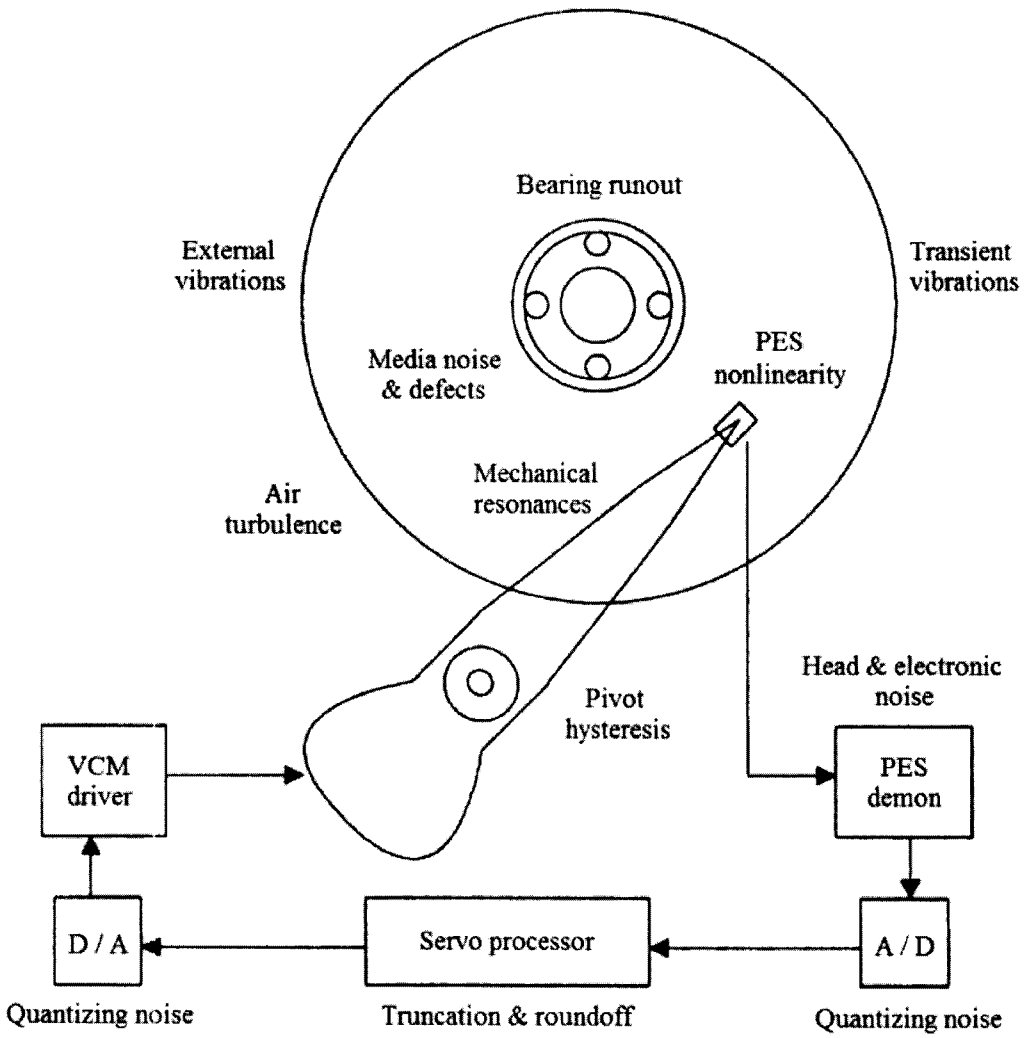
2. With the information provided in the pictures below, describe how a closed loop head positioning servomechanism work. (10)







3. Describe causes and effects of ten of the various sources of disturbances and errors in a typical disk drive servo channel indicating in the picture below. (10)



4. In spite of a slow change in the basic design of hard disks over the years, accelerated improvements in terms of their capacity, storage, reliability and other characteristics have been made. In what follows, highlight the various trends (See more information in the document attached). (20)

- BIT DENSITY
- CAPACITY
- SPINDLE SPEED
- FORM FACTOR
- PERFORMANCE
- REDUNDANT ARRAYS OF INEXPENSIVE DISKS (RAID)
- RELIABILITY
- INTERFACES

Analyzing the Trends in the Enterprise Hard Disk Drive Industry

Executive Summary

Surviving in the hard disk drive (HDD) industry is no easy feat. With the requirements of the marketplace constantly evolving, there is a continual demand for HDD products featuring greater storage capacity and higher performance, all within a shrinking form factor. Hard disk drive manufacturers are kept on their toes developing solutions that will successfully accommodate these growing needs. This whitepaper focuses on the emerging trends within the Enterprise HDD sector of the business, and how they are benefiting the industry.

Serial Technology

One of the biggest stories during the last couple of years has been the launch of the new interface for Enterprise hard disk drives, Serial Attached SCSI (SAS). The need to transition to Serial technology became evident when it was no longer possible to improve upon data transfer speeds based on the existing interface, Parallel SCSI.

SAS brings numerous benefits to the table, among them:

- *Higher performance.* With SAS, the data transfer rate improves to 3Gb/s, and is expected to double to 6Gb/s in the near future. In addition, Fujitsu has been able to demonstrate system throughput performance of up to 1.7 GBps using multiple SAS hard disk drives.
- *Increased bandwidth scalability.* With expander hardware used as a switch, each SAS hard disk drive has its own dedicated connection to the host. As a result, when adding multiple hard disk drives to a system, latency is reduced and the performance improvement scales with each additional drive.

FUJITSU

THE POSSIBILITIES ARE INFINITE

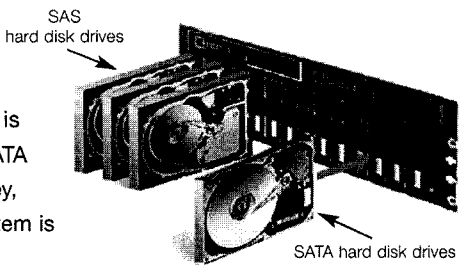


Figure 1

- *Enhanced flexibility.* With a SAS backplane, the option is available to swap in higher capacity, lower cost Serial ATA (SATA) hard disk drives. This interoperability feature is key, as it allows customers to make a choice on how the system is configured even after installation. (Figure 1)
- *Improved reliability.* Lower power hard disk drives coupled with improved interface error detection ensures that the SAS HDDs have a longer life and fewer undetected failures.

SAS products are already in demand by original equipment manufacturers (OEMs), and are readily available in the channel. In addition, numerous hardware vendors are utilizing SAS technology in their storage systems and enclosures. SAS is continuing to gain momentum in the marketplace and will be widely adopted in the industry by the year 2007.

Compactness

The availability of SAS hard disk drives combined with the new small form factor (SFF) has revolutionized the industry. Fujitsu has helped champion this effort by launching the industry's first 2.5" SAS hard disk drive back in March 2005. (Figure 2)

With 2.5" Enterprise hard disk drives, solution providers can pack in four times the number of HDDs compared with the 3.5" models. As a result, total storage capacity increases and input/output (I/O) performance improves dramatically, all without a change in the footprint. In addition to the greater space efficiency, SFF hard disk drives use less power, generate less heat and noise, and have less mechanical vibration.

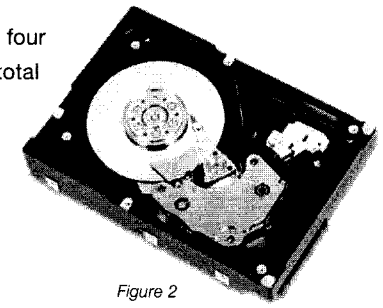


Figure 2

Storage Capacity

Improving storage capacity has been an ongoing development throughout HDD history. In order to accomplish this, it is necessary to increase the tracks per inch (TPI) or bits per inch (BPI) — or ideally, both at the same time. The fact that capacity continues to double with each new generation of hard disk drives is phenomenal. This has been possible due to a number of factors.

Hard disk drive manufacturers are continuing to research ways to improve servo track writing technology so that TPI can be improved. Servo bursts, while a necessary component to help guide the magnetic head, take up valuable space on an already dense platter. Fujitsu has developed a couple of methods to address this issue. With media servo track writing, multiple disks are stacked on a spindle and the servo bursts are written simultaneously. The disks are then mounted separately into the drive. The second method, a newer technology known as magnetic printing, involves imprinting the servo pattern magnetically on the media to correspond to the grooves on the master disk. As a result, a consistent pattern can be written without any disturbances caused

by the spinning disk (Figure 3). Both of these servo track writing technologies have successfully increased HDD recording density.

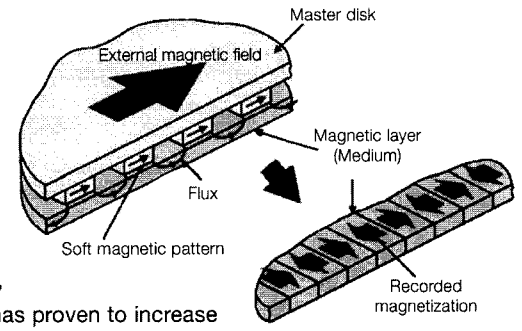


Figure 3

Due to improved performance from both giant magnetoresistive (GMR) and tunneling magnetoresistive (TMR) heads, manufacturers have been able to increase the BPI on the disks. In addition, a specific technology designed by a Fujitsu-led team has proven to increase stored data capacity. Called Current Perpendicular to Plane (CPP), this architecture reorients current flow, enabling the read element to be physically smaller. Consequently, the bits written on the media surface can be smaller, allowing a greater number to be packed on, resulting in a higher density hard disk drive.

Perpendicular magnetic recording (PMR) is an exciting new recording technology that will also significantly increase the amount of bits that can fit into a square inch of space. In order to keep up with the trend of increasing areal density, it is essential for all hard disk drive vendors to switch over to this technology. To successfully take on this challenge, the manufacturer is required to be vertically integrated. For this, three different components are required: the read head, the write head, and the media, all of which must be tightly integrated together and developed using the latest technology. Further, it is unlikely that all of these components will be available in the open market.

With its superior media, Fujitsu has been able to continue development of its current generation of Enterprise hard disk drives using the current longitudinal recording technology. Fujitsu expects to launch its first PMR mobile hard disk drives this year, while Enterprise products featuring the new technology are expected to debut by late 2007.

Speed

Mission critical applications such as large-scale storage systems and servers require the high-performance that only Enterprise HDDs can deliver. Hard disk drive manufacturers have been challenged to keep up with the demand for greater performance, and have succeeded on several levels.

Rotation speed has continued to improve over the years, with speeds of 10K RPM and 15K RPM being the standard for 3.5" hard disk drives. The industry's transition to Fluid Dynamic Bearing (FDB) motors has helped to increase spindle speed, in addition to allowing for higher recording density, lower vibration and lower acoustics. In addition, optimization of the shroud and spoiler has resulted in the reduction in the amount of internal vibration caused by air turbulence, which affects the hard disk drives' ability to position on the target track accurately.

Media data transfer speeds have also continued to escalate, with rates for 15K RPM Enterprise products reaching 150 MB/s. Recent technology has focused on increasing the recording density through TPI, rather than linear recording density or BPI. The result has been a data transfer speed increase of approximately 25% for each new generation.

High-speed access can be measured in a number of ways. Generally, this has been defined by the average seek time (the amount of time it takes to locate the head on

the track) and the average rotational latency (the amount of time it takes to locate a piece of data around the track). Fujitsu hard disk drives boast an industry leading seek time of 3.3ms for its 15K 3.5" Enterprise products. Another method to consider is how commands are reordered to achieve the most effective access time. The newest trend being employed is Native Command Queuing (NCQ), which allows for faster execution of operation commands. Finally, the cache can also improve access performance by temporarily storing data, which can then be more efficiently accessed by the system. For the current generation of Fujitsu SAS hard disk drives, the cache buffer has doubled to 16MB.

RoHS Compliance

A final trend worth mentioning is the movement of the industry towards complying with the European Union's Restriction of Hazardous Substances (RoHS) directive. Enacted in 2003, this calls for the elimination of certain hazardous materials in the development of electrical and electronic equipment. The Fujitsu family of hard disk drives is already in full compliance with the RoHS initiative, well before the requested July 2006 deadline.

Summary

Customer demand for storage products with ever-higher capacity and performance presents a daunting challenge to the hard disk drive industry. However, HDD vendors have stepped up to the task, as evidenced by the numerous technological advancements that have been introduced to the marketplace. Products featuring Serial technology, a more compact form factor, and perpendicular recording technology are just some of the breakthrough achievements. With the industry continuing to rapidly evolve, one can only imagine what trends are in store for the future.

About Fujitsu Computer Products of America, Inc.
Fujitsu Computer Products of America, Inc. is a subsidiary of Fujitsu Limited, a leading provider of customer-focused IT and communications solutions for the global marketplace. FCPA provides innovative solutions for the U.S. marketplace. Current product and service offerings include high performance hard disk drives, Magneto-Optical drives, scanners and scanner maintenance, palm vein recognition technology, 10Gb Ethernet switches and degaussers.

Fujitsu Computer Products of America, Inc.
www.fcpa.fujitsu.com

1255 East Arques Avenue, Sunnyvale, CA 94085-4701. (800) 626-4686 (408) 746-7000 info@fcpa.fujitsu.com

FUJITSU

THE POSSIBILITIES ARE INFINITE

Printed in the U.S.A. Qty. 3M WP11000406