Data Recovery

Introduction to Hard Disk Chapter 1

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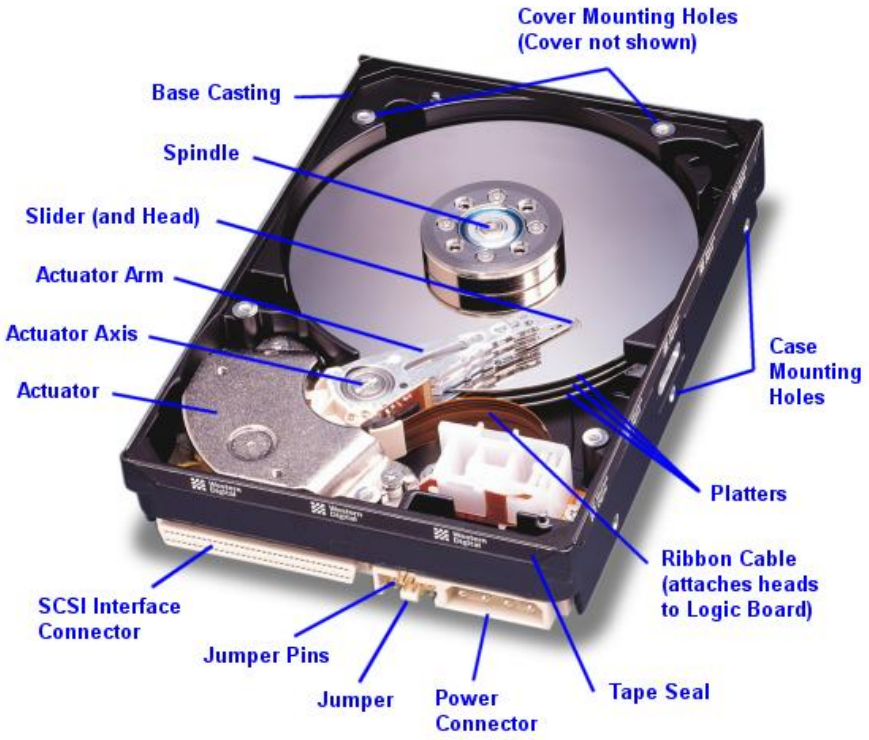
Introduction to the Hard Disk

- The hard disk is mounted into a physical enclosure.
- The internal environment has to remain free from dust.
- If dust enters between the read/write heads and the platters it will cause a head crash



Introduction to the Hard Disk

- The bottom of the disk is called the base casting.
- The drive mechanics are placed into the base casting.
- A rubber gasket is placed between the base and cover to ensure a tight seal.
- The drive is closed with a number of small screws and a center screw to stabilize the spindle motor shaft and secure the axis of the actuator assembly

Hard Disk Assembly

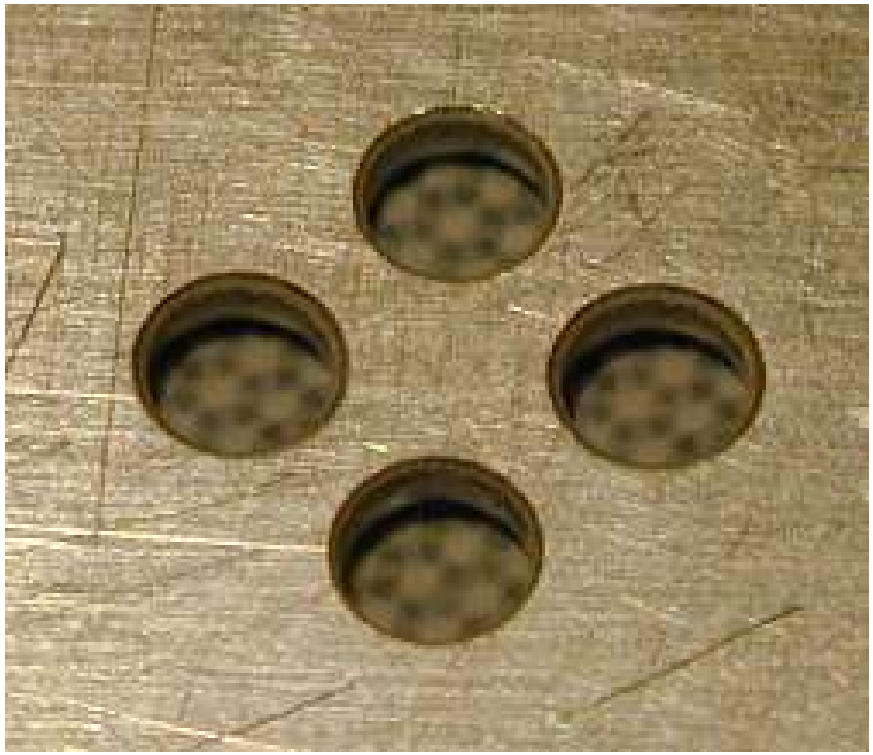
- The entire base and covered chamber including the heads, platters, and actuator is called the hard disk assembly.
- The drive should never be opened in an uncontrolled environment outside a clean room.

Logical Board and Heads

- The logic board is mounted on the bottom of the base casting. The card is separated from the base casting with foam.
- The heads are linked to the PCB through a ribbon cable or a set of pins that goes through a hole in the base casting mating to a special connector inside the head assembly to connect the heads.

Drive Breath Holes and Filters

- Hard disks are not sealed because they have to pass air from the inside of the drive to the outside.
- The drives breath holes are covered with a breather filter to let air pass through slowly but no dust or dirt

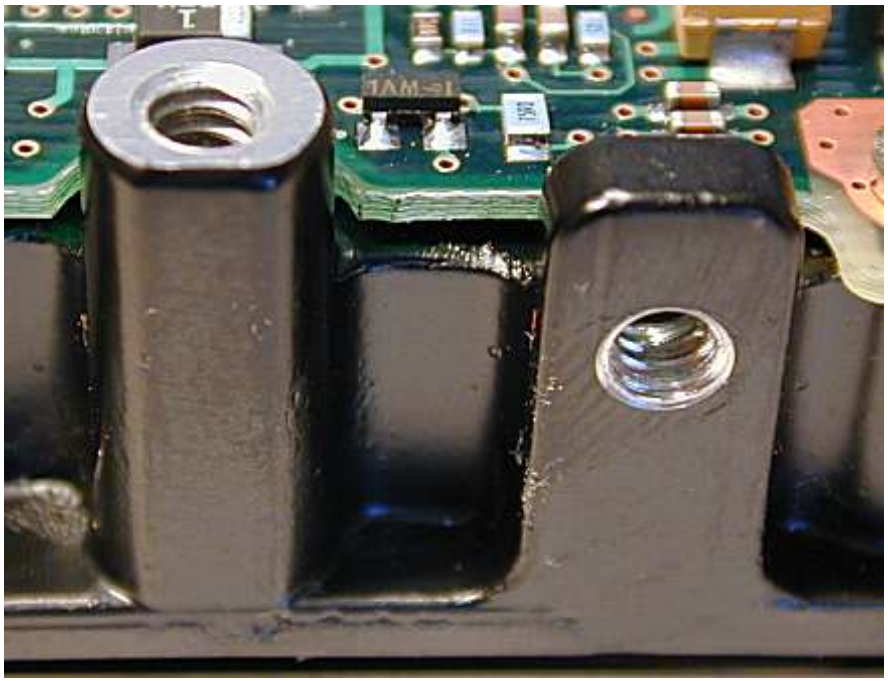


Internal Air Flow and Filters

- HD have an internal air flow within the sealed chamber
- The air flow continuously filters the air .
- Inside the chamber is a small re-circulating filter for added security

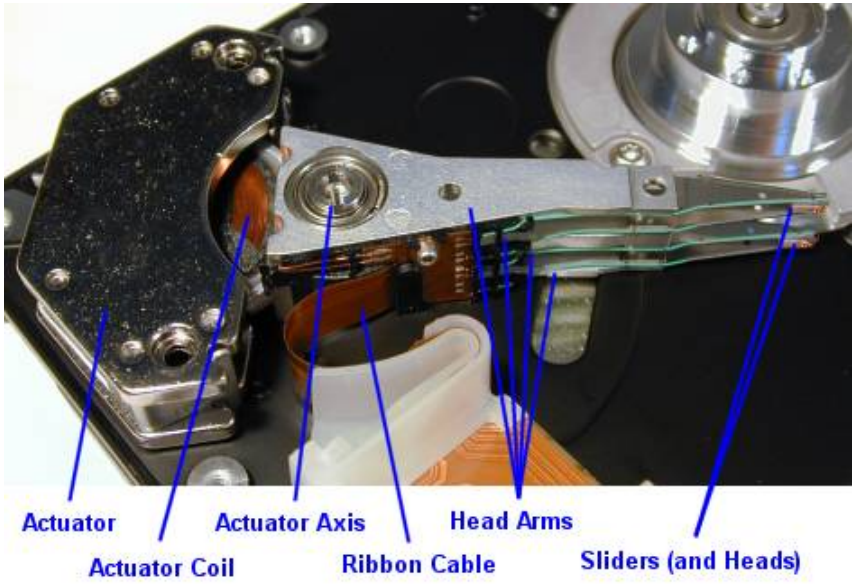
Housing Screw Holes and Connectors

- Screw holes are built into the aluminum base of the disk
- Different connectors and jumpers are used to configure the HDD to the rest of the system
- The connectors vary from ATA (IDE), SCSI, USB and SATA



Read Write Heads

- Platters are accessed for read/write operations using the read/write heads
- Heads are mounted between the surface of each platter
- Heads are mounted on a head assembly or actuator assembly

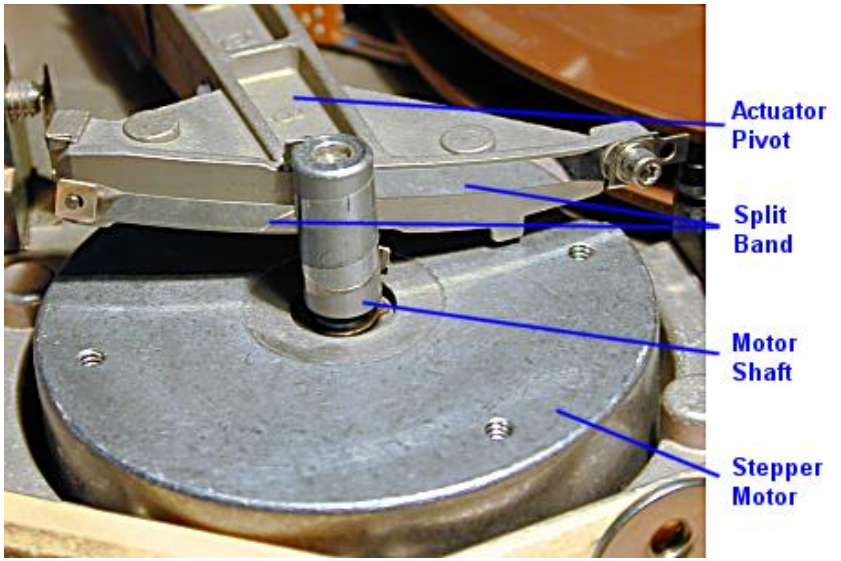


Read Write Heads

- Heads are mounted on head sliders.
- The sliders are suspended over the surface of the disk at the ends of the head arms.
- Heads are moved around the surface of the disk by the actuator.
- Sliders, arm, and actuator design are critical to improving the seek time of a hard disk.

Stepper Motor and Actuator

- The actuator positions the head arms to different tracks on the surface of the platters
- The actuator is a very important part of the HDD. Changing from tract to track is the only operations that requires active movement



Stepper Motor and Actuator

- Head changing is an electronic function
- Changing sectors involves waiting for the right sector number to spin around and come under the head
- Changing tracks the heads must be shifted making sure this can be done accurately is extremely important.
- There are two types of head actuators

Stepper Motor and Actuator

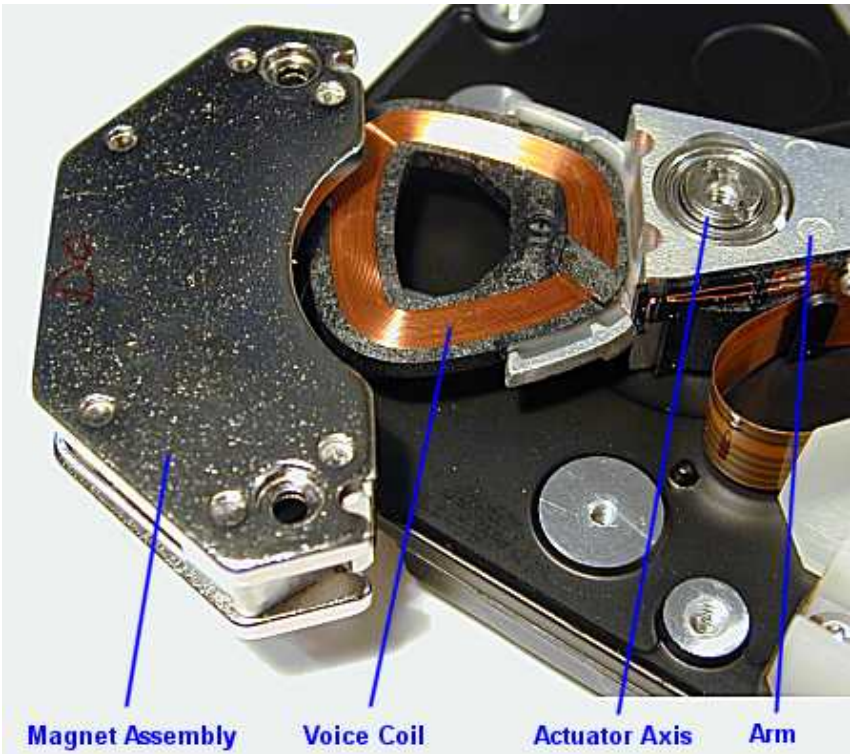
- Before HD used stepper motors to control the movement of heads over the surface of the platters.
- The motor turns in a rotary fashion and can stop at any time in its rotation
- Stepper motors can only stop at predefined steps as it turns around the disk

Stepper Motor and Actuator

- Stepper motors used for actuators attaches the arms to the motor and each time the motor steps one position the arms moves in or out one position.
- Each position defines a track on the surface of the disk.
- Stepper motors are used for both turning the spindle and positioning the head on floppy disk drives.

Voice Coil and actuator

- The actuator in modern drives use a voice coil to move the head arms in and out over the surface of the platters
- A closed loop feedback system called a servo system dynamically position the heads over the data tracks.



Voice Coil and actuator

- The voice coils work using electromagnetic attraction and repulsion.
- The coil is wrapped around a metal protrusion on the end is the set of head arms
- This is mounted within an assembly containing a strong permanent magnet
- When current is fed to the coil an electromagnet field is generated that cause the heads to move one director or the other relative to the permanent magnet.

Voice Coil and actuator

- By controlling the current the heads can be told to move in or out more precisely than using a stepper motor.
- All HDD voice coil actuators are rotary meaning the actuator changes position by rotating on an axis
- The difference between the two design the stepper motor is an absolute positioning system

Difference Between Stepper Motors and Voice Coils

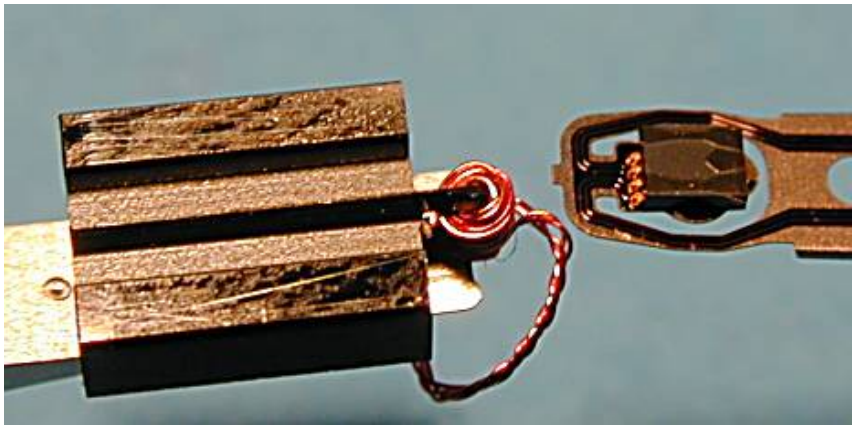
- The voice coil is a relative positioning system
- Stepper motors are no longer used in HDD but are still used to drive floppy disks
- All modern HDD today use voice coil actuators
- Voice coil actuators positioning is dynamic and is based on feedback from examining the actual position of the tracks

Head Arms and Sliders

- Head arms are thin metal and usually triangular in shape where the head sliders are mounted.
- There is one arm for read/write heads and all of them are lined up and mounted to the head actuator to form a single unit

Sliders

- Sliders have a special shape to allow them to ride precisely over the platters
- Two rails or runners on the outside that support the slider at the correct flying height over the surface of the disk

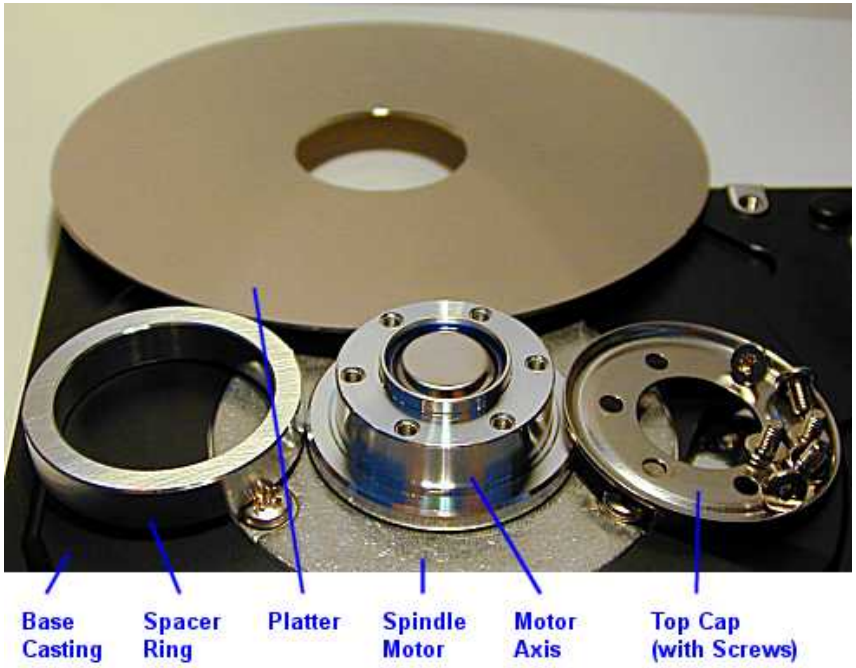


Sliders

- In the middle the read/write heads are mounted, sometimes on another rail
- Read/Write heads have been shrinking in size and the sliders need to be smaller in order to carry them.
- The main advantage of using smaller sliders it that it reduces the weight that must be yanked around the disk surface of the platters and it improves positioning speed and accuracy.

Spindle Motors

- Spindle motors are configured for direct connection
- There are no belts or gears used in spindle motors
- The spindle the platters are mounted to is attached directly to the shaft of the motor



Spindle Motor

- The platters are machines with the exact size hole as the spindle
- Platters are placed on the spindle with separator rings or spacers between them
- Platters are placed at a precise distance to allow room for the head arms
- The entire assembly is secured with a head cap and torx screws

Spindle Motor

- Spindle motor bearings are precision components that are placed around the shaft of the motor to support the spindle motor and ensure that the spindle turns smoothly without wobbling or vibration
- Many issues such as noise and heat that is created by the motor are related to the bearings
- Most hard disk use ball bearings which are placed in a ring around the shaft

Platters

- Traditional platters were made of light aluminum alloy and coated with a magnetizable material such as ferrite compound that is applied in liquid form and spun evenly across the platter or thin metal plating

Platters

- Newer technology uses glass or ceramic platters because they can be made thinner and more efficient at resisting heat.
- The magnetic layer on the platter has tiny domains of magnetization for storing information transferred through the read/write heads
- Most drives have at least 2 platters which are magnetized on each side so a drive with 2 platters has 4 side to store data on

Landing Zone

- Landing zone is usually near the inner diameter (ID) where no data is stored.
- The areas is called “Contact Start/Stop (CSS) Zone”
- In case of power loss HDD are designed with a spring to park the heads.
- In such cases the spindle motor temporarily acts as a generator providing power to the actuator

Landing Zone Spring Tension

- Spring tension from the head mounting constantly pushes the heads towards the platter
- When the platters spin the heads are supported by an air bearing and experience no physical contact or wear
- In CSS drives the heads are designed to survive a number of landings and takeoffs from the media surface

Landing Zone

- Manufactures design the sliders to survive 50,000 contact cycles before the chance of damage on startup rises
- Heads literally drag along the disk's surface until the air bearing is established
- Seagate Barracuda 7200.10 are rated to 50,000 start-stop cycles which means that no failures attributed to the head-platter interface were seen before at least 50,000 star-stop cycles during testing.

Load / Upload

- Load/Upload technology relies on the heads being lifted off the platters into a safe location eliminating the risks of wear and stiction
- Modern HDD use ramp loading to load/unload the heads. The ramps are plastic and placed near to the outer disk edge.

Inside of the HDD

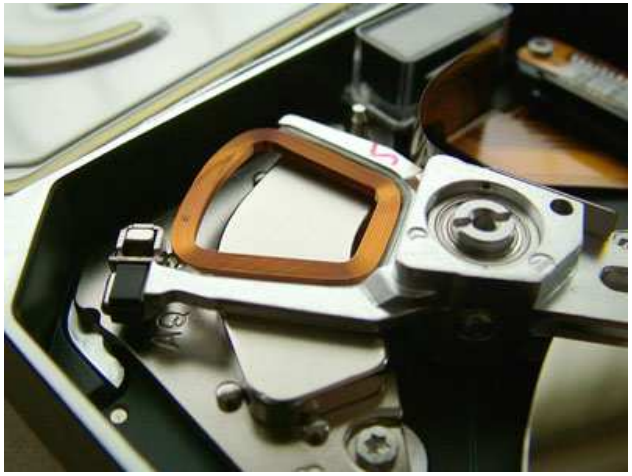
- A hard disk drive with the platters and spindle motor hub removed showing the copper colored motor coils surrounding a bearing at the center of the spindle motor
- Removing the platter motor is tricky - you have to give the spindle sticking out underneath the drive a tap using a hammer and a center punch.

Inside of the HDD

- Here is the platter motor removed from the drive casing.
- Here is a close-up of the platter motor coils. The coil, itself, is shaped rather like an arrowhead, and made of doubly-coated copper magnet wire.

Inside of the HDD

- This is a particle catcher. Its purpose it to catch any small particles tossed off the disk as it rotates. On a good drive this will be clean but sometimes you find small metal particles on it when the drive has suffered a head crash.
- This is the actuator that controls the read/write heads and moves them across the drive.

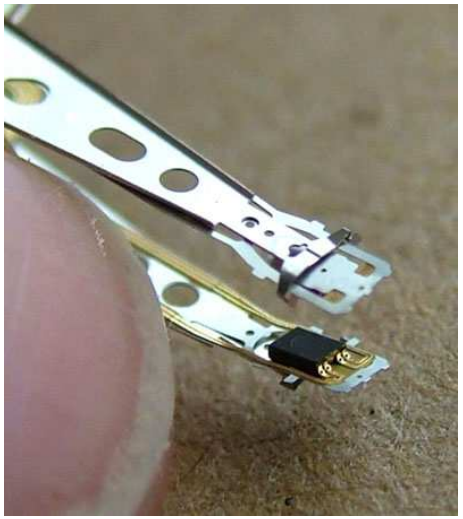


Inside of the HDD

- To undo the actuator you undo the screw holding it. However, you also need to undo the platters at the same time.
- Un-doing the platter screws use TORX No. 6.

Inside of the HDD

- Platters removed along with the actuator and read/write heads.
- This is the read/write head that writes data to the platters and reads it off - if they touch the platters when operating they will smash the delicate magnetic coating or even themselves, rendering the drive scrap

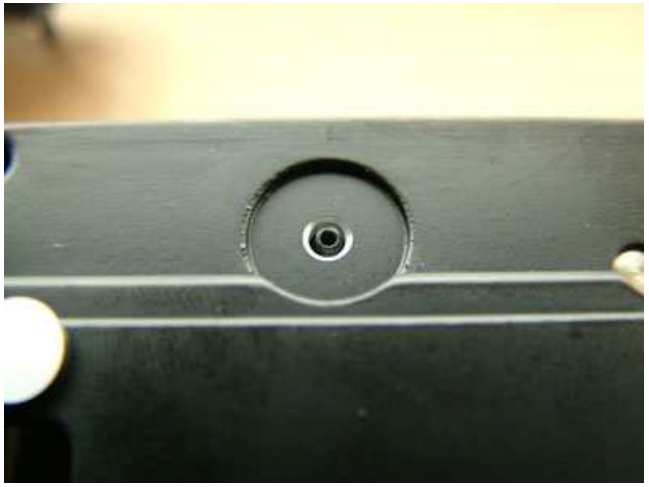


Inside of the HDD

- This is the ultra-strong magnet powering the motor for the actuator arm
- Filter that cleans the air entering the drive. A drive isn't airtight, instead it allows the pressure to be equalized in the drive but the air coming into the drive has to be clean.

Inside of the HDD

- The vent hole on the exterior cover of the drive
- Parts that are inside the hard drive



Determine LBA of a Hard Drive

- To determine the LBA of a HDD you must multiply number of cylinders x number of heads x number of sectors x number of bytes (most commonly 512)
- Drives with ATA interface and 8 gigabytes or more behave as if they were structured into 16383 cylinders, 16 heads, and 63 sectors
- The C/H/S counts reported to the CPU by ATA drives are no longer actual physical parameters because the actual number of sectors varies by zone.

ATA Interface

- **AT Attachment (ATA)** and **At Attachment Packard Interface (ATAPI)** are interface standards fro connecting storage devices
- Western Digital original Integrated Drive Electronics interface resulted in near synonyms fro ATA/ATAPI including abbreviations such as IDE which is still a common informal abbreviations.
- Introduction to serial ATA in 2003 the original ATA was renamed to Parallel ATA (PATA)

IDE and ATA-1

- The first ATA/ATAPI interface was developed by Western Digital under the name of Integrated Drive Electronic IDE
- The IDE drives present themselves to the computer as an array of 512-byte blocks with a relative simple command interface.
- This relieved the software in the host computer from stepping the disk head arm as it had one in the earlier drives

EIDE and ATA-2

- In 1994 WD introduced drives under a new name “Enhanced IDE (EIDE) which included most of the features of the forthcoming ATA-2
- ATA-2 was the first to note that devices other than hard drives could be attached to the interface
- With ATA-2 any device may be placed on the ATA interface provided it adheres to this standard

ATAPI

- Small Form Factor designed the ATAPI “ATA Packet Interface” which was actually a protocol allowing the ATA interface to carry SCSI commands and responses.
- All ATAPI devices are actually speaking SCSI other than their electronic interface
- Early device the SCSI commands and responses were embedded into packets for transmission on the ATA cable.

Serial ATA

- The Serial ATA (SATA) computer bus is a storage interface for connecting host bus adapters to mass storage devices.
- Host adapters and devices communicate via high-speed serial cable
- Serial ATA advantage is the reduced cable-bulk and cost, faster and more efficient data transfer, and the ability to remove or add devices while operating (hot swapping)

Access Time

- Access time is the time delay or latency between a request to an electronic system and the access being completed or the requested data returned.
- In disk drives the access time is the time required for a computer to process data from the process and then retrieve the required data from a storage device.
- Hard drive access time is determined by the sum of the spin-up time, seek time, rotational delay and transfer time

Access Time

- Spin-up time – is the time required to accelerate the disk to operating speed
- Seek Time – is the time for the access arm to reach the desired disk track
- Rotational delay – the delay for the rotation of the disk to bring the required disk sector under the read-write mechanism
- Transfer time – time during which data is actually read or written to medium with a certain thoughput

Average Seek Time

- The seek time of the hard disk measures the amount of time required for the read/write heads to move between tracks over the surface of the platters,
- Switching between tracks requires the head actuator to move the head arms physically which take a specific amount of time.
- The amount of time to switch between two tracks depends on the distance between the tracks.
- There is a certain amount of overhead involved in track switching so the relationship is not linear

How Seek Time is Measured

- Average: represents the average seek time from one random track (cylinder) to any other
- Track-to-Track: the amount of time required to seek between adjacent tracks
- Full Stoke: the number is the amount of time to seek the entire width of the disk from the innermost track to the outermost.