2

Storage Devices & Its Interfacing

Data Encoding Techniques used in Hard Disk

1) Frequency Modulation (FM)
2) Modified Frequency Modulation (MFM)
3) Run Length Limited.(RLL)
4) Perpendicular Encoding

FM Encoding:

- One of the earliest techniques for encoding data for magentic storage is called Frequency modulation encoding.
- Sometimes called Single Density Encoding.
- Used mostly in Floppy Disk Drives.
- FM encoding no longer used.
- In this FM method of data recording a 1 bit is stored as two pulses(one clock pulse and one data pulse.) and 0 bot is stored as a one pulse and one gapor no pulse(1 clock pulse and one “no pulse” to show that it is a 0 bit).
- A binary digit 1 is stored as two pulses(PP)
- A binary digit 0 is stored as one pulse and one “no pulse”(PN)

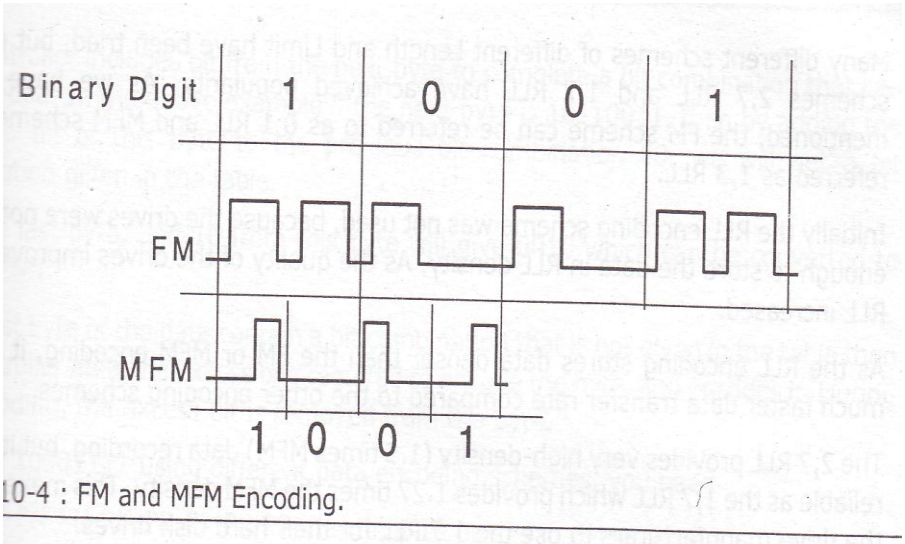
For example a binary number 1011 will be stored as
PP PN PP PP

MFM Encoding Scheme

Modified Frequency Modulation method of data storage, by reducing the number of pulses is able to store more data without any data and synchronisation loss.
In MFM recording the 0s and 1s are encoded as given below:

- 1 is always stored as a no pulse and a pulse (NP)
- 0 when preceded by another 0 is stored as apulse and no pulse(PN)
- 0 when preceded by a 1 is stored as two no pulses (NN)

If you store 1001 on the disk surface using the MFM storage method it would be stored as NP NN PN NP



10-4 : FM and MFM Encoding.

RLL Encoding Scheme

This encoding scheme can be more accurately called as 2,7 RLL encoding because in this scheme in a series or in a running length the minimum number of 0s next to each other is two and the maximum number of 0s together can not be more than seven.
The RLL encoding scheme can store 50 percent more infomration tham MFM encoding scheme on agiven surface and it can store three times as much information as the FM encoding schemes.
The Run Length limited name comes from the minimum number(Run Length) and maximum number(Run Limit) of “no pulse” values allowed between two pulses.

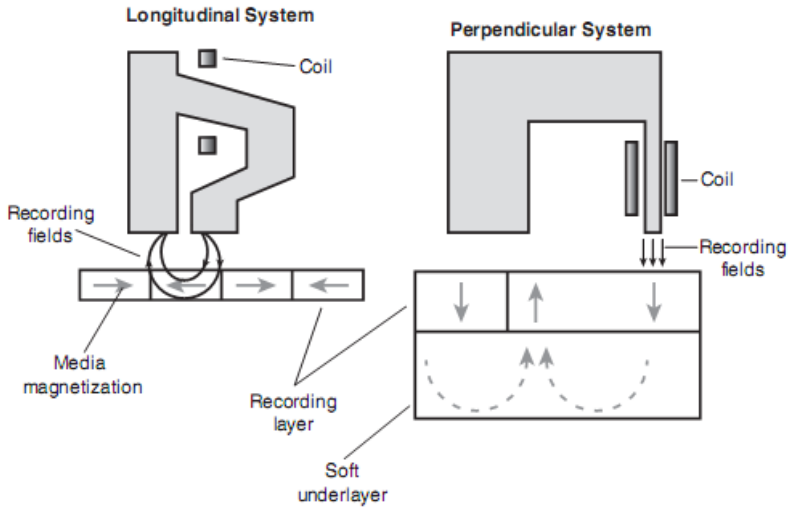
Data bit	Pulse Encoding
10	NPNN
11	PNNN
000	NNNPNN
010	PNNPNN
011	NNPNNN
0010	NNPNNPNN
0011	NNNNPNNN

For eg encode a byte 10 0011 00 to proper RLL Signal then the
Bit 10 can be encoded as NPNN
Bit 0011 can be encoded as NNNNPNNN
Finally when you look into the table you will find that there is no information given about how to convert the remaining bit 00.
In this type of situation one must remember that the RLL controller is not used to encode single byte of information instead it converts the entire collection of bytes to be sent to the hard drive.
The controller includes bit from the next byte to complete a bit combination that can be encoded. In the above example if the next byte is 10110011 then by adding the first two bit of this byte to the previous bit combination 00, we will get a bit combination given in the table.
00 from last byte and 10 from this byte will give 0010 which can be converted to NNPNNPNN.
If the last byte of the data contain a bit combination that is not given in the table then the controller adds the excess bits required to encode the byte and encodes it. During the decoding the excess bit is removed from the byte.
To store 10001111 using different data encoding schemes you need

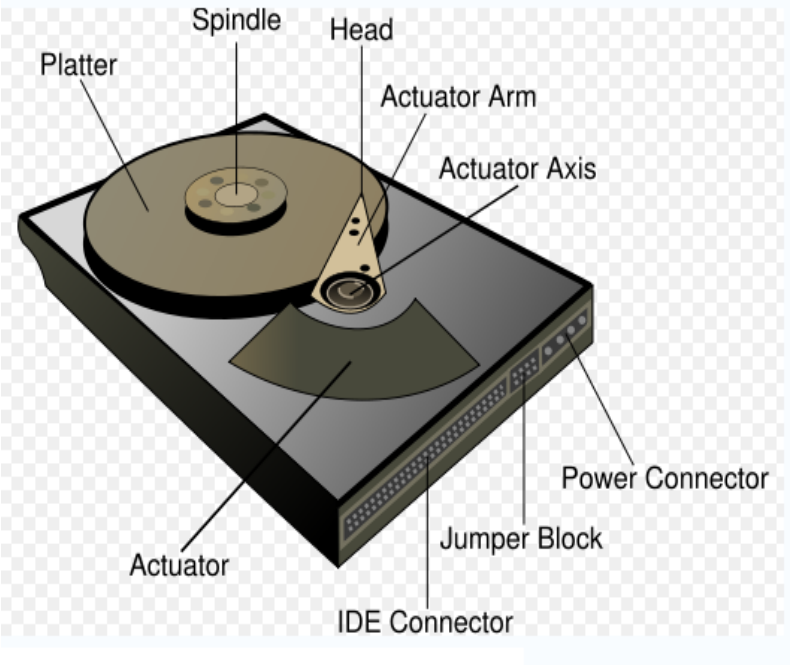
- PP-PN-PN-PP-PP-PP-PP ie total 13 pulses in FM Scheme
- NP-NN-PN-PN-NP-NP-NP-NP ie total 7 pulses in MFM Scheme
- NPNN-NNNNPNNN-PNNN ie total 3 pulses in 2,7 RLL Scheme.

Perpendicular Encoding

- Virtually all hard drives record data using longitudinal recording which stores magnetic bits horizontally across the surface of the media.
- However perpendicular recording which aligns magnetic signals vertically on the media surface has the potential to achieve higher data intensities because vertically oriented magnetic bits use less space than longitudinally stored bits.



Hard Disk Construction



Hard Disk Drive

A hard disk drive is made up of several physical components

1) Disk platters
2) Read/write heads
3) Head actuator mechanism
4) Spindle motor
5) Logic board
6) Cables and connectors
7) Bezel / Front Plate
8) Air Filter

The platters, spindle motor, heads and head actuator mechanisms usually are contained ina sealed chamber called the hard disk assembly(HDA) and is treated as single components. Other external parts are logic boards, bezels or mounting hardware.

1) Hard Disk Platters(Disks)

- The platters stores information. It comes in varying sizes like 5.12", 3.14",0.85" etc. The physical size of a drive is expressed as the size of the platters
- Most hard disk have two or more platters
- Platters were originally made from an aluminium/magnesium alloy which provides bothe strangth and light weight
- All modern drives use glass or glass ceramic plates.

2) Read/Write Heads

- A hard disk drive usually has one read/write head for each platter surface(meaning that each platter has two sets of read/write heads-one for top side and one for bottom side
- These heads are connected on asingle movement mechanism so heads across the platters in unison.
- The HDD uses various types of heads for read/write purpose.
    - Ferrite head
    - Metal-In-Gap Head
    - Thin Film Head
    - Magneto Resistive Head
    - Giant Magento Resistive Head

3) Head Actuator Mechanism

- This mechanism moves the heads across the disk and positions them accurately above the desired cylinder.
  Two basic Categories are used
  i) Stepper Motor Mechansim
  ii) Voice Coil Actuator
  Stepper Motor actuators were commonly used on hard drives made during the 1980s and early 1990s with capacities of 100MB or less
- Floppy disk drives position their head by using a stepper motor actuator
- All hard disk drives being manufactures today use voice coil actuator.
  Voice Coil Actuator
- The two main types of voice coil positioner mechnisms are
  - Linear Voice Coil Actuators
- Rotary Voice Actuators

4) Spindle Motor

- The spindle motor spins the platters connected to spindle. The motor is directly connected to the spindle of platters. These platters revolve at exactly 3600 rpm to 1500 rpm. The speed of motor has to be controlled very precisely.
- Normally a feedback loop is employed in the control electronics to monitor the speed. The speed control is fully automatic.

5) Logic Boards

- A disk drive will have a board containing the electronics that control the drive's spindle and headactuator systems These are calledlogic boards.
- They present data to the controller in aplanned format.
- They may be removed and replaced to rectify a logic board problem.

6) Cable and Connectors

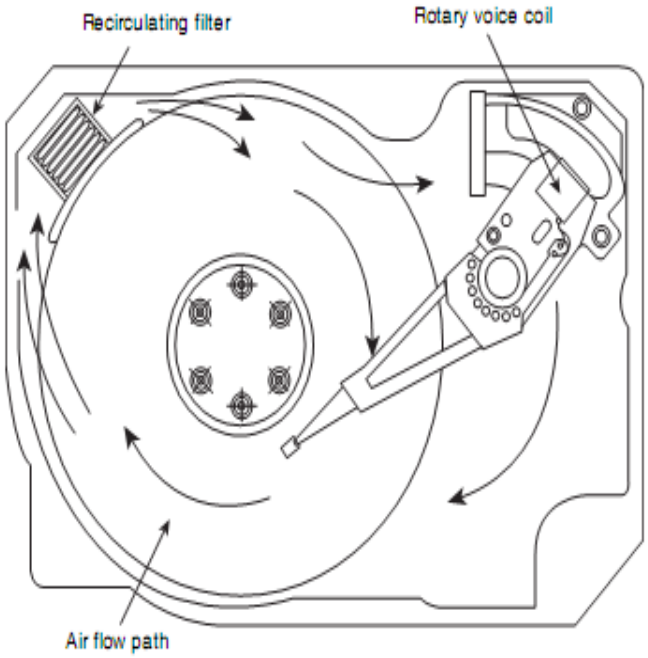
- Cable and connectors are used to connect HDD to the main computer system.
- All hard disk drive contains connections for
    - Data/Control interface connector
    - Power connector

7) Bezel/ Front Faceplate

Bezel is the front faceplate provided on most of the hard disk drives.

8) Air Filters

- Nearly all hard disk drives have two air filter. One is called the recirculating filter and the other is called either a barometric or breather filter.
- These filters are permanently sealed inside the drive and are designed never to be changes for the life of the drive.
- A hard disk on a PC system does not circulate air from inside to outside the HDD or vice versa.
- The recircualting filter permanently installed inside HDA is designed to filter only small particles. Scraped off platters during head takeoffs and landings.
- The HDD is vented through a breather filter element that enables pressure equalization(breathing) between inside and outside of drive HDA in hard disk is sealed but not airtight.



Air circulation in a hard disk.

Servo Techniques

Three Servo mechanism designs have been used to control voice coil positioners

- Wedge Servo
- Embedded Servo
- Dedicated Servo
- The three designs are slightly different but they accomplish the same basic task-
- They enable head positioner to adjust continuously so it is precisely positioned above a given cylinder on the disk.
- All servo mechanisms rely on special information ie written to the disk when it is manufactured. This information is usually in the form of special code called gray code
- The main difference between these servo designs is where the gray code information is actually written on the drive
- This system enables the head to easily read the information and quickly determine its precise position.
- At the time of manufacture, a special machine called a servo writer writes the servo gray code on the disk.

Wedge Servo:

- Early servo controlled drives used a technique called a wedge servo.

- In these drives, the gray code guidance information is contained in a “wedge: slice of drive in each cylinder immediately preceding the beginning of each track.
- The problem is that servo information appears only one time every revolution, which means that the drive often needed several revolutions before it could accurately determine and adjust the head position.
- Because of these problems the wedge servo was never a popular design it no longer is used in drives

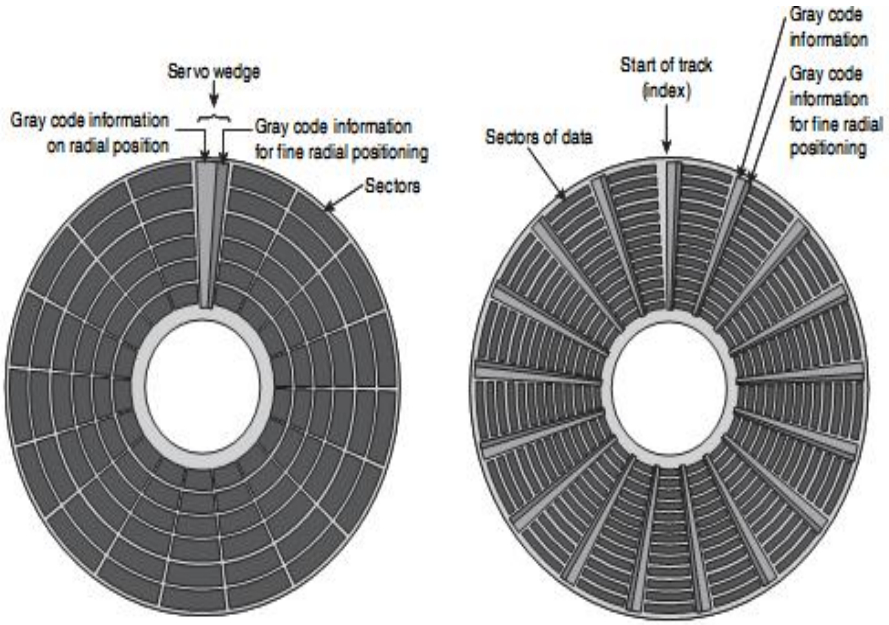
Embedded Servo

An embedded design writes the servo information before the start of each sector

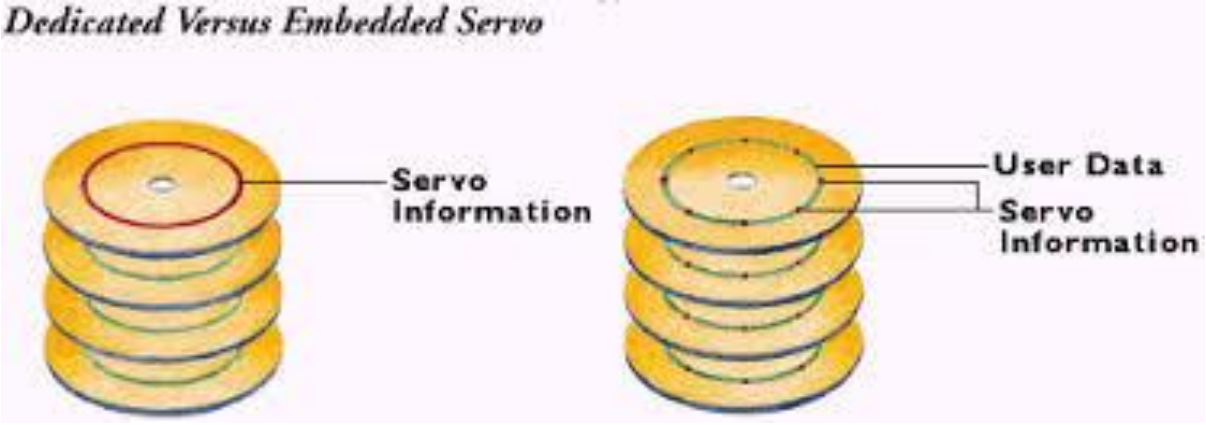
- This arrangement enables positioner circuits to receive feedback many times in a single revolution making the head positioning much faster and more precise.
- Another advantage is that every track on the drive has its own positioning information so each head can quickly and efficiently adjust position to compensate for any changes in platter or head dimensions especially for changes due to thermal expansion or physical stress.
- Most drives today use an embedded servo to control the positioning system

Dedicated Servo

- A dedicated servo is a design in which the servo information is written continuously throughout the entire track rather than just one per track or at the beginning of each sector
- Unfortunately if this procedure were used on the entire drive no room would be left for data.
- The term dedicated comes from the fact that this platter side is completely dedicated to the servo information and can’t contain any data
- The drawback to a dedicated servo is that dedicating an entire platter surface for servo information is wasteful.



10 A wedge and an embedded servo.



Terms Related to Hard Disk:

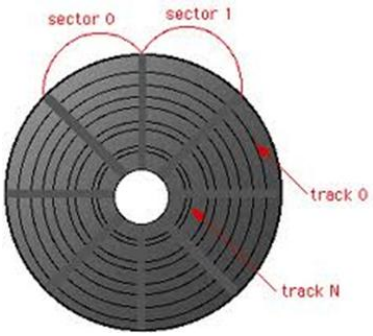
Track

- The read/write area of the hard disk is divided into concentric circles called tracks. The tracks are numbered from zero starting at outside and increasing as you go inside.

Sectors

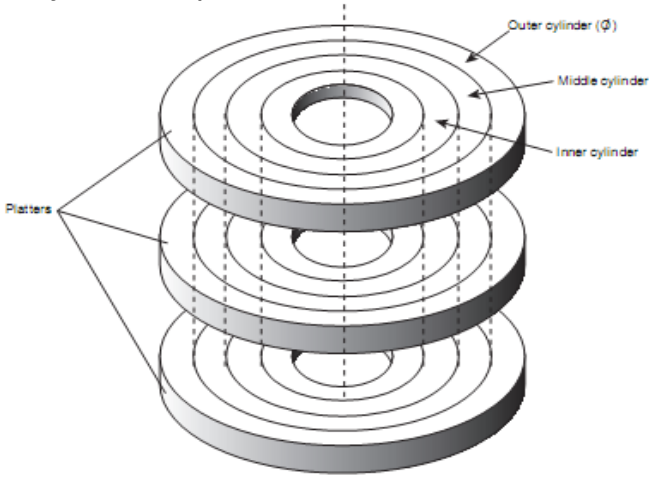
The track in a disk are divided into sectors.

Each sector is able to hold 512 bytes of data

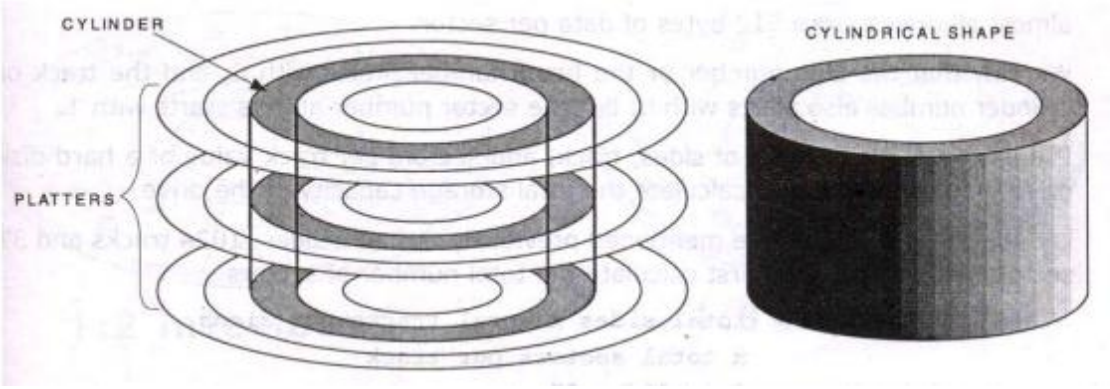


The sectors represent are shaped pieces of the track

- Cylinder
  - In a hard disk, same tracks of different platters form an imaginary structure called a cylinder.
  - Data is stored in the disk cylinder by cylinder. All tracks on a cylinder are written and then the R/W head moves to the next Cylinder.
  - This reduces movement of R/W head and increases the speed of read and write operation.



Hard disk cylinders.



Cluster

- When OS writes some information on the hard disk, it does not allocate the space sector wise, instead uses a new unit of storage called “Cluster”
- A cluster can be made up of one or more sectors.
- Cluster is the basic unit in DOS.
- **Clusters are the minimum space allocated by DOS when storing any information on the disk.**

Landing Zone

- It is the non-data space on a computer's hard disk where the read/write heads rest, or park, when the computer's power is turned off.

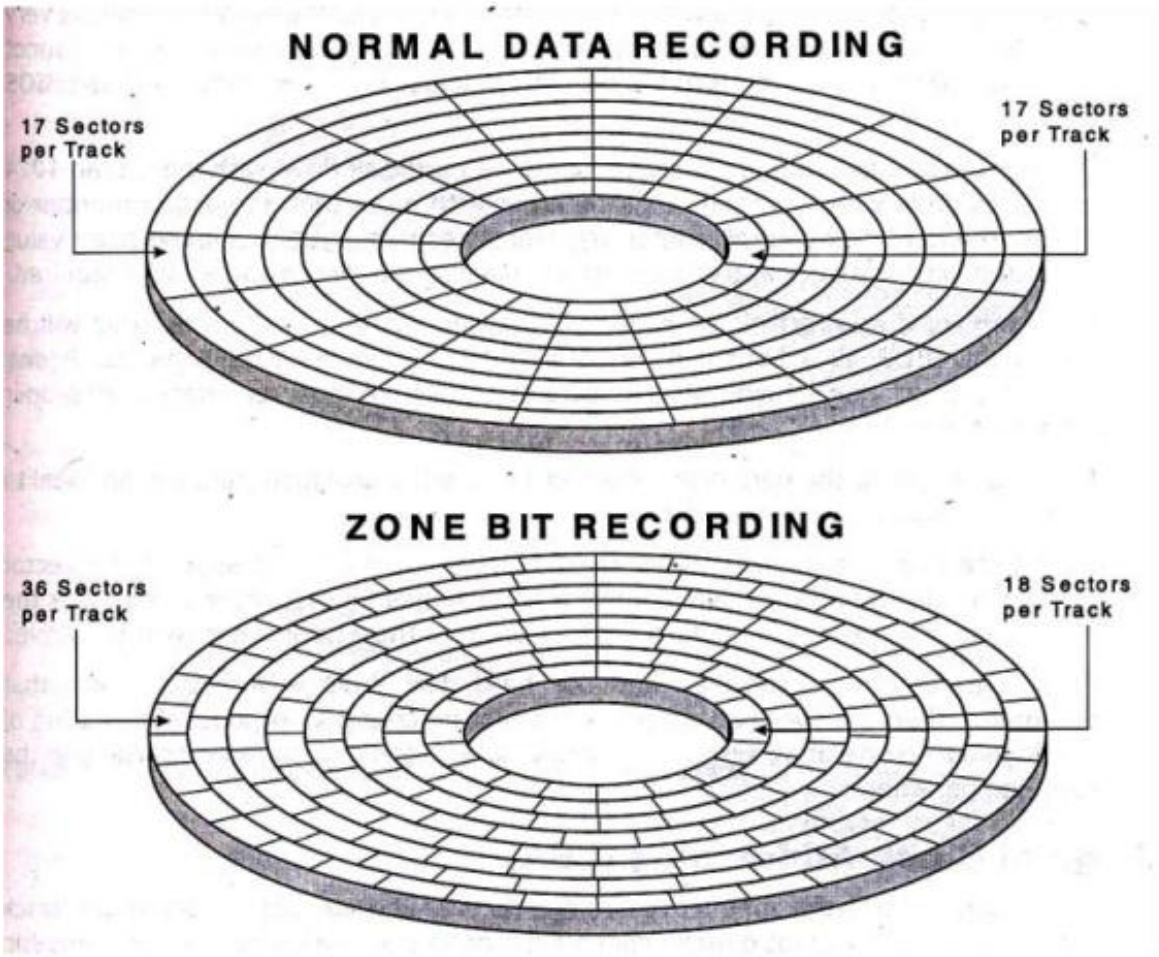
MBR (Master Boot Record)

- The MBR or master boot Record contains a small program to load and start the active/bootable partition form the HDD.
- This area also contains information about all four primary partitions on the HDD their starting sector ending sector, size etc in a partition table record.

Zone Bit Recording

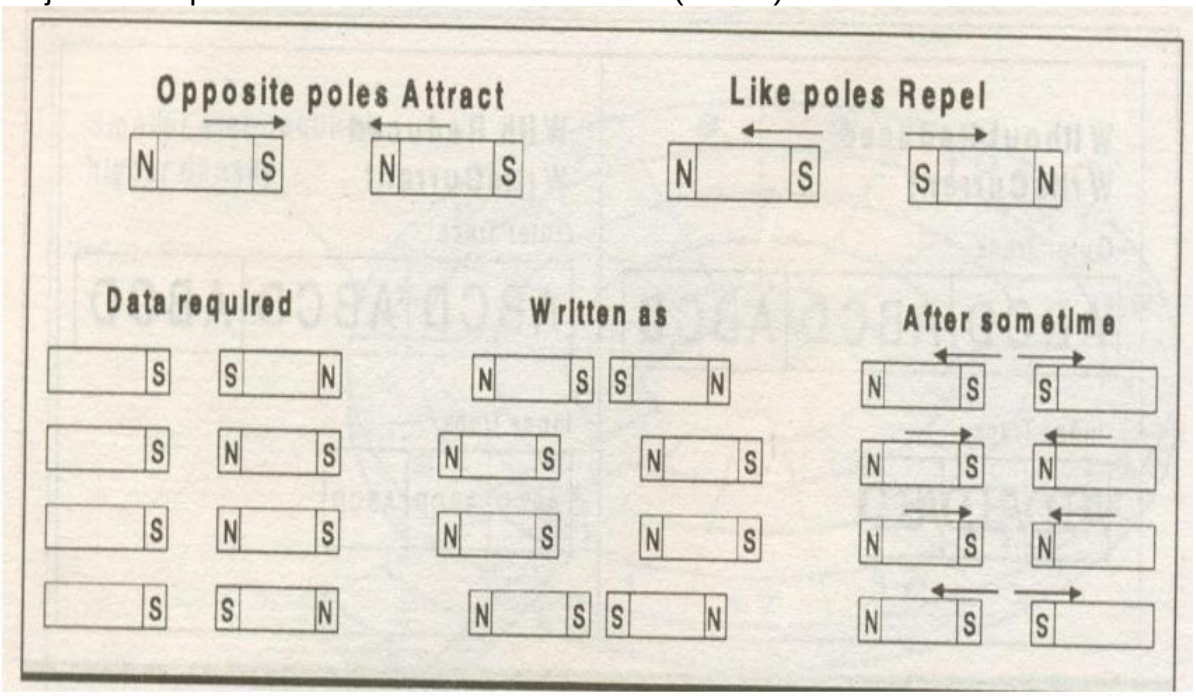
- This is a scheme is used by current high capacity IDE and SCSI HDDs to store more sectors in outer track compared to the number in the inner track.
- In this method, the platter is divided into number of zones, each zone will have a fixed number of sectors / track
- The controller used with the drive has one additional job of converting the odd number of sectors/ track in different tracks into standard no. of sectors/track.
- One way to increase the capacity of a hard drive during the low level format is to create more sectors on the disks.
- Outer cylinders than on the inner ones. Because they have a larger circumference the outer cylinders can hold more data.

- Drives that use zoned recording split the cylinders into groups called zones, with each successive zone having more sectors per track as you move outward from the centre of disk.



Write Precompensation

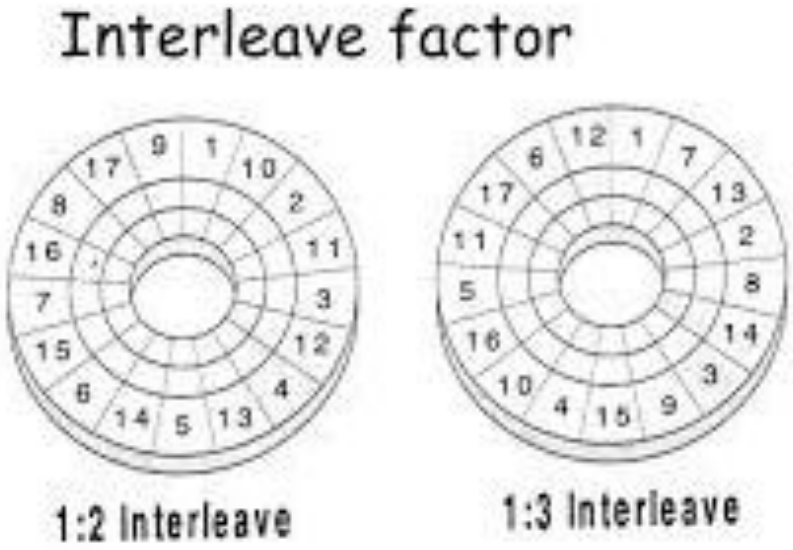
- It is useful for drives using standard track, sector format Drives using zone bit recording do not require any write pre- compensation
- The magnetic particles used to write on the disk surface have north and south poles
- Like poles repel and unlike poles attract
- In outer surface of hard disk platter, magnetic particles are far apart to be affected by the attraction and repulsion of magnetic particles
- In the inner tracks of the disk drive, the density of the magnetic are very high and adjacent particles start to attract and repel.
- This will force to change the information written on the disk
- To compensate for this shift of data particles due to attraction and repulsion, the drive can write the data apart or closer than the required position
- The particles will slowly shift to the required position because of attraction and repulsion
- This process of writing the data closer or farther to compensate for attraction or repulsion of magnetic particles is called Write pre-compensation



Interleave and Interleave factor

All modern drives are formatted with no interleave sometimes expressed as 1:1 interleave ratio.

Interleave factor- the number of sectors that pass beneath the read/write heads before the next numbered sector arrives eg 1:3



- It is process to prepare blank hard disk for data storage.
- It puts magnetic marks of tracks and sectors on the platter surface (low level formatting).
- FAT and root directory are also put on the platter.(high level formatting).
- Hard Disk requires a low level formatting and a high level formatting to make it useful for data storage.

  Types of formatting:-

  1) Physical or Low Level formatting

  2) High Level Formatting

  1) Physical or Low-Level Formatting
- It is done at the factory level performed by the manufacturer and cannot be technically performed by end user.

- It magnetically divides the disk into tracks and sector.
- Basic addressing information is written to each sector of each cylinder.
- It checks for bad sectors and maps them out.

2) High level Formatting

- Performed by the end user
- During the high level format, the operating system writes the structures (FAT and Root Directory) necessary for managing files and data on the disk.
- **File System**
- The file system in storage devices starts with FAT (File allocation Table).

1. FAT refers to a data table that holds information about how and where files are stored in any partition
2. It is a kind of index used by operating system to keep track of information stored on the hard disk

- The common file systems are used by PC operating are:
    - FAT16
    - FAT32
    - NTFS

FAT (File Allocation Table)

- Developed by Microsoft for MS-DOS, MS-Windows 95,98,Me
- FAT located in MBR sector of bootable disk
- 2 Important Functions of FAT;

1) contains allocation information (in the form of linked list)
2) Indicate which allocation units are free.

It is simple and reliable. Two identical copies of FAT are used.

Structure of FAT

Partition Boot Sector	**FAT 1**	**FAT 2 (Duplicate)**	**Root Folder**	**Other Folders and All Files**

FAT 16:-

- Uses 16 bit binary number to hold cluster
- Max 65526 Clusters are possible
- Used for HD of size 16 MB to 2048 MB(2 GB)

FAT32:-

- Most popular and nearest FAT supported by Windows 95,98, Me , 2000
- From 32 bits -28 bits is cluster number and 4 bits are recovered.
- It permits 268 Millions of clusters i.e. HD size of 2 TB

NTFS (New Technology File System) Structure

Partition Boot Sector	**Master File Table**	**System File**	**File Area**

- Used by Windows NT, XP, 2000 , Server 2003, Server 2008, Windows Vista
- NTFS provides better performance, security compatibility and extendibility than FAT
- Read, Search, Write, Recovery are done fast.
- Master File Table (MFT) contain information about all files and folders. First file on NTFS volume.
- Partition Boot Sector Start at Sector 0 to 16. First Info on an NTFS volume.

Features:

1. It allows you to encrypt files and automatically decrypt them as they are read.
2. Supports long file names upto 255 characters
3. Supports File Size upto 2 TB

4. For keeping track of clusters it uses a B- tree directory
5. Reliable File System as compared to FAT
6. Allows Large partition sizes i.e more than 4 GB
7. Built-in file compression facility
8. Improved Security And access control deciding who can perform what sorts of operations on various data within the file system

NTFS vs FAT

Criteria	**NTFS**	**FAT32**	**FAT16**
Operating System	Windows NT Windows 2000 Windows XP Windows 2003 Server	DOS v7 and higher Windows 98 Windows ME Windows 2000 Windows XP	DOS All versions of Microsoft Windows
Max Volume Size	2TB	2TB for some OS	2GB for all OS.
Max Files on Volume	Nearly Unlimited	4194304	65536
Max File Size	Limit Only by Volume Size	4GB minus 2 Bytes	2GB (Limit Only by Volume Size)
Max Clusters Number	Nearly Unlimited	4177918	65520
Max File Name Length	Up to 255	Up to 255	Standard - 8.3 Extended - up to 255
Built-In Security	Yes	No	No
Recoverability	Yes	No	No
Fault Tolerance	Max	Minimal	Average

Partitioning

- Partitioning is a procedure which divides the hard disk into multiple sections or logical parts or drives.
- Need of partitioning:-

1. Different operating systems may be stored on different partitions.
2. To segregate data as per user choice.
3. To create separate memory space for back up.
4. Maximize Hard disk utilization.

HDD Interface Types

Interfacing means connecting the hard disk drive to the main computer system.

1) PATA Parallel Advanced Technology Attachment(IDE)

IDE stands for integrated Drive/Device Electronics

Features

- Proven and reliable technology integration
- Upto 133 MB/s interface transfer rate
- PATA allows cable lengths upto 18 inches(46 cms)

- Designed for desktop PCs and Notebook PCs with usage in entry servers and consumer electronics as well

2) SCSI(pronounces as scuzzy) Small Computer System Interface

Features

- Fast and wide Data Path
- Supports upto 7 peripheral Devices such as CD-ROM, Scanner that can attach to a single SCSI port
- Faster than the average parallel interface
- It will allow data transfer upto 100 MB/s to 160 MB/s
- SCSI is now plug and play in nature such as automatic SCSI ID assigning and termination

3) SATA (Serial Advanced Technology Attachment)

- Is a computer bus primarily designed for transfer of data between a computer and mass storage devices such as hard disk drives and optical drives.

Features

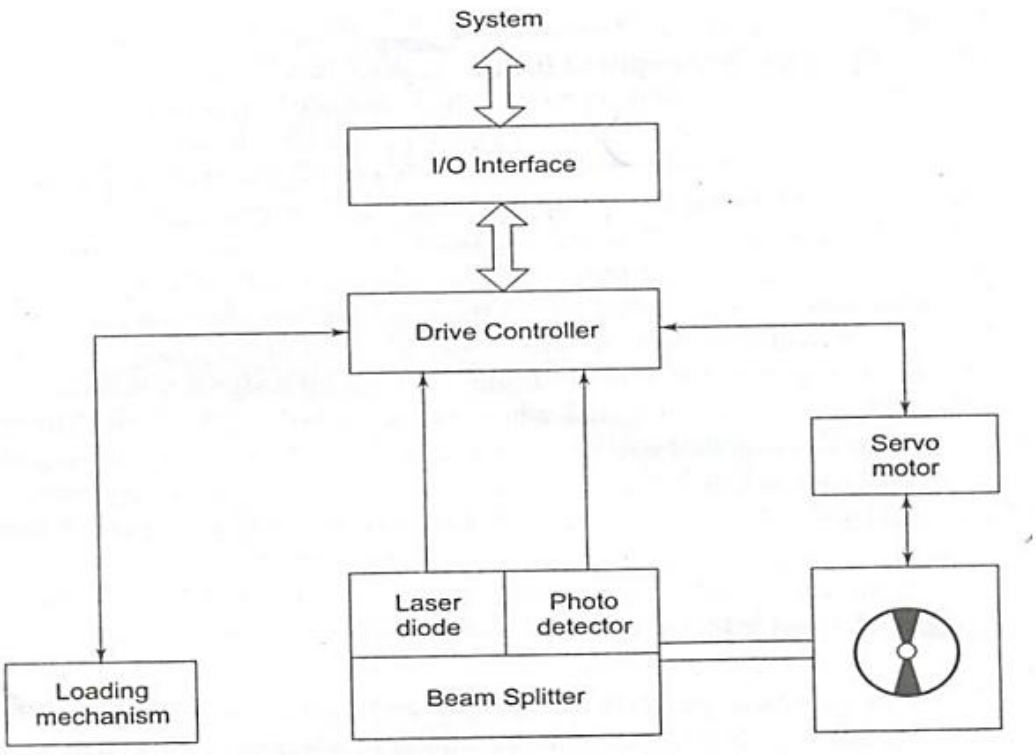
- SATA is better more efficient interface than the dated PATA standard.
- It supports hot swapping
- Serial ATA uses only 7 conductors while PATA uses 40.
- Data Transfers at the rate of 1.5 Gbit/s, 3 Gbit/s and 6 Gbit/s

CD ROM-Construction and Recording

-Can be connected to the computer via an IDE(ATA),SCSI, SATA, firewire or USB interface

-1x CDROM gives a data transfer rate of 150 KB/s

Block Diagram of CD-ROM



Construction of CDROM Drive:
A CD drive consists of
1. Optical head which contains laser diode, photo detector and beam splitter
2. Drive controller
3. Loading mechanism
4. Servo motor (Turn Table)
5. I/O interface

Working of CD-ROM Drive

The optical head contains:

1. Laser diode, which generates the laser beam
2. A lens system to focus the laser beam on the disc and to direct the reflected beam on to the photo detector.
3. The beam splitter sends the reflected beam towards a different lens for focusing.
4. Servo motors that control the position of laser and lenses to ensure correct tracking and focusing
5. Photo detector that detects the reflected light and converts it into electric pulses.
6. Drive controller is the overall controller of the CD drive. It controls the speed of rotation and processes the signals coming from the optical head
7. The information coming from the photo detector is in the encoded form (8 to 14 Modulation) (EFM).
8. The decoding of data is done by the microprocessor on the controller.
9. The decoded data is sent to the I/O interface, which makes it available to the system

DVD(Digital Versatile/Video Disc)

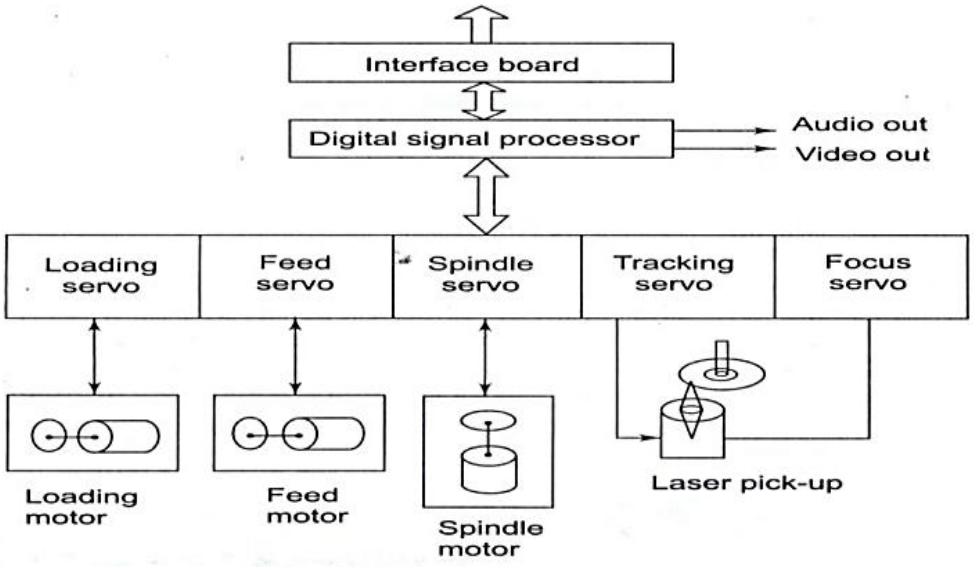
- Optical storage media for storing data
- Uses primary for movies softwares and data backup purpose
- DVD holds about 7 times more data than CD Data

DVDs can store more data than CDs for a few reasons:

- Higher-density data storage
- Less overhead, more area
- Multi-layer storage

Construction of DVD Drive

- Internal Mechanism of CDROM and DVD Drive is same
    - Drive Motor
    - Laser and Lens System
    - Tracking Mechanism (Loading Mechanism)



Blu –Ray Disc **Blu ray also known as Blu-ray Disc(**BD is a next generation optical disc format jointly developed by members of the **Blu-ray Disc Association(BDA)** – a group of the world's leading consumer electronics, personal computer and media manufactures (including Apple, Dell, Hitachi, HP, JVC, LG, Mitsubishi, Panasonic, Pioneer, Philips, Samsung, Sharp, Sony, TDK and Thomson)

- The format was developed to enable recording, rewriting and playback of High Definition Video (HD) as well as storing large amounts of data.
- A blue laser is used to read the media. Blue light has a shorter wavelength than red used by previous technologies. This makes it possible to read data with greater precision.

Specification	Value	Specification	Value
Capacity (Single Layer)	23.3 GB/25 GB/27 GB	**Tracking Pitch**	0.32µm
Capacity (Dual Layer)	46.6 GB/50 GB/54 GB	**Shortest pit length**	0.160/0.149/0.138 µm
Laser Wave Length	405 nm (blue-violet)	**Recording Density**	16.8/18.0/19.5 Gb/sq.in
Lens Numerical Aperture	0.85	**Data transfer Rate**	36 Mbps
Disc Diameter	120 mm	**Recording format**	Phase Change Recording
Disc thickness	1.2 mm	**Tracking format**	Groove Recording
Optical Protection Layer	0.1 mm	**Video Format**	MPEG2