CHAPTER-1

STORAGE DEVICES & INTERFACING.

Objective

➢ To understand the Recording techniques in storage devices.
➢ To understand the working of storage devices.

2.1 Recording Techniques: FM, MFM, RLL, perpendicular recording
2.2 Hard Disk construction and working.
2.3 Terms related to Hard Disk. Track, sector, cylinder, cluster, landing zone, MBR, zone recording, write pre-compensation.
2.4 Formatting: Low level, High level & partitioning.
2.5 FAT Basics: Introduction to file system, FAT 16, FAT 32, NTFS,
2.6 Hard Disk Interface: Features of IDE, SCSI, PATA, SATA, Cables & Jumpers.
2.7 CD ROM Drive: Construction, recording.(Block diagram)
2.8 DVD: Construction, Recording. (Block Diagram)
2.9 Blue-ray Disc specification.

History of Magnetic Storage

Before magnetic storage, the primary computer storage medium was punch cards (paper cards with holes punched in them to indicate character or binary data), originally invented by Herman Hollerith for use in the 1890 Census.

The history of magnetic storage dates back to June 1949, when a group of IBM engineers and scientists began working on a new storage device. What they were working on was the first magnetic storage device for computers, and it revolutionized the industry. On May 21, 1952, IBM announced the IBM 726 Tape Unit with the IBM 701 Defense Calculator, marking the transition from punched-card calculators to electronic computers.

Four years later, on September 13, 1956, a small team of IBM engineers in San Jose, California, introduced the first computer disk storage system as part of the 305 RAMAC (Random Access Method of Accounting and Control) computer. The 305 RAMAC drive could store 5 million characters (that’s right, only 5 MB!) of data on 50 disks, each a whopping 24 inches in diameter. Individual bits were stored at a density of only 2 Kb/sq. inch. Unlike tape drives, RAMAC’s recording heads could go directly to any location on a disk surface without reading all the information in between. This random accessibility had a profound effect on computer performance at the time, enabling data to be stored and retrieved significantly faster than if it were on tape.

From these beginnings, in just over 60 years the magnetic storage industry has progressed such that today you can store 3 TB (3000 GB) or more on tiny 3 1/2-inch drives that fit into a single computer drive bay.
How Magnetic Fields Are Used to Store Data

The read/write heads in a magnetic storage device are U-shaped pieces of conductive material, with the ends of the U situated directly above (or next to) the surface of the actual data storage medium. The U-shaped head is wrapped with coils or windings of conductive wire, through which an electric current can flow (see the figure below). When the drive logic passes a current through these coils, it generates a magnetic field in the drive head. Reversing the polarity of the electric current also causes the polarity of the generated field to change. In essence, the heads are electromagnets whose voltage can be switched in polarity quickly.

![Magnetic Read/Write Head](image)

The disk or tape that constitutes the actual storage medium consists of some form of substrate material (such as Mylar for floppy disks, or aluminum or glass for hard disks) on which a layer of magnetizable material has been deposited. This material usually is a form of iron oxide with various other elements added. Each of the individual magnetic particles on the storage medium has its own magnetic field. When the medium is blank, the polarities of those magnetic fields are normally in a state of random disarray. Because the fields of the individual particles point in random directions, each tiny magnetic field is canceled out by one that points in the opposite direction; the cumulative effect of this is a surface with no observable field polarity. With many randomly oriented fields, the net effect is no observable unified field or polarity.

When a drive’s read/write head generates a magnetic field (as when writing to a disk), the field jumps the gap between the ends of the U shape. Because a magnetic field passes through a conductor much more easily than through the air, the field bends outward from the gap in the head and actually uses the adjacent storage medium as the path of least resistance to the other side of the gap. As the field passes through the medium directly under the gap, it polarizes the magnetic particles it passes through so they are aligned with the field. The field’s polarity or direction—and, therefore, the
polarity or direction of the field induced in the magnetic medium—is based on the
direction of the flow of electric current through the coils. A change in the direction of the
current flow produces a change in the direction of the magnetic field. During the
development of magnetic storage, the distance between the read/write head and the media
has decreased dramatically. This enables the gap to be smaller and makes the size of the
recorded magnetic domain smaller. The smaller the recorded magnetic domain, the
higher the density of data that can be stored on the drive.

When the magnetic field passes through the medium, the particles in the area below
the head gap are aligned in the same direction as the field emanating from the gap. When
the individual magnetic domains of the particles are in alignment, they no longer cancel
one another out, and an observable magnetic field exists in that region of the medium.
This local field is generated by the many magnetic particles that now are operating as a
team to produce a detectable cumulative field with a unified direction.

The term flux describes a magnetic field that has a specific direction or polarity. As
the surface of the medium moves under the drive head, the head can generate what is
called a magnetic flux of a given polarity over a specific region of the medium. When the
flow of electric current through the coils in the head is reversed, so is the magnetic field
polarity or flux in the head gap. This flux reversal in the head causes the polarity of the
magnetized particles on the disk medium to reverse.

The flux reversal (or flux transition) is a change in the polarity of the aligned
magnetic particles on the surface of the storage medium. A drive head creates flux
reversals on the medium to record data. For each data bit (or bits) that a drive writes, it
creates a pattern of positive-to-negative and negative-to-positive flux reversals on the
medium in specific areas known as bit cells or transition cells. A bit cell or transition cell
is a specific area of the medium—controlled by the time and speed at which the medium
travels—in which the drive head creates flux reversals. The particular pattern of flux
reversals within the transition cells used to store a given data bit (or bits) is called the
encoding method. The drive logic or controller takes the data to be stored and encodes it
as a series of flux reversals over a period of time, according to the pattern dictated by the
encoding method it uses.

**Recording Technique**

The basic principle of writing data on the disk and reading data from the disk is
same as that of tape drive. In both the devices, there is a magnetic medium. Data is stored
on the magnetic medium by causing magnetization of particles on the media. The
magnetization is caused by passing current through a coil in the read/write head.
In both disk and tape, the head is stationary during the read/write operation. Only the media move. Presently, there are two standard formats for recording on a magnetic disk:

1. Frequency Modulation (FM) and
3. Run Length Encoding Technique (RLL)
4. Perpendicular recording (PMR)

**FM Recording Technique**

The FM format is known as single density format whereas the MFM method is known as double density format.

In the FM format, a clock pulse is written at the beginning of each bit cell. The data pulse is written at the centre of the bit cell. If the data is 1, the data pulse is present. If the data is 0, there is no data pulse. Each bit cell is of 4 ms duration for floppy disk. Figure shows FM recording format.

![FM Recording Format](image)

**MFM Recording Technique**

Modified Frequency Modulation, commonly MFM, is a run-length limited (RLL) coding scheme used to encode the actual data-bits on most floppy disks. It was first introduced in disk drives with the IBM 3330 hard disk drive in 1970. Floppy disk drive hardware examples include Amiga, most CP/M machines as well as IBM PC compatibles.

MFM is a modification to the original FM (frequency modulation) scheme for encoding data on single-density floppy disks and some early hard disk drives. Due to the minimum spacing between flux transitions that is a property of the disk and head design,
MFM, which guarantees at most one flux transition per data bit, can be written at higher density than FM, which can require two transitions per data bit. It is used with a data rate of 250 – 500 kbit/s (500 – 1000 kbit/s encoded) on industry standard 5¼” and 3½” ordinary and high density diskettes. MFM was also used in early hard disk designs, before the advent of more efficient types of run-length limited coding. Except for the steadily disappearing 880 kiB and 1.4 MiB floppy disk formats, MFM encoding is obsolete in magnetic recording.

**Method**

In the MFM format, the clock pulse is not present at the beginning of every bit cell. When the data is 1, there is no clock pulse. Only the data pulse is present at the centre of the bit cell.

![MFM recording Technique](image)

When the data is 0, following a 1 in the previous bit cell, neither clock pulse nor data pulse is written. But if the data is 0 both in the current bit cell and in the previous bit cell, then the clock pulse is written at the beginning of the current bit cell but no data pulse is written in the bit cell.

Figure shows the MFM recording format. In the FM recording, there are two flux changes per bit cell when 1’s are recorded in all bit cells. In the MFM recording, since the clock pulses are eliminated, there is only one flux change per bit cell, when 1’s are recorded in all bit cells. Hence the duration of the bit cell in MFM is reduced to 2 µs and the disk capacity is doubled in MFM.

Another technique which is more efficient than MFM (1.5 Times MFM to 3 Times FM) is the RLL (Run Length Limited) type of recording technique.

**Run Length Limited**

Run length limited or RLL coding is a line coding technique that is used to send arbitrary data over a communications channel with bandwidth limits. RLL codes are defined by four main parameters: m, n, d, k. The first two m/n refer to the rate of the code,
while the remaining two specify the minimum $d$ and maximum $k$ number of zeroes between consecutive ones. This is used in both telecommunication and storage systems which move a medium past a fixed recording head.

Specifically, RLL bounds the length of stretches (runs) of repeated bits during which the signal does not change. If the runs are too long, clock recovery is difficult — if they are too short, the high frequencies might be attenuated by the communications channel. By modulating the data, RLL reduces the timing uncertainty in decoding the stored data, which would lead to the possible erroneous insertion or removal of bits when reading the data back. Run-length limited codes were widely used in hard disk drives until the mid-1980s, and are still used in digital optical discs such as CD, DVD, MD, Hi-MD and Blu-ray. This mechanism ensures that the boundaries between bits can always be accurately found (preventing bit slip), while efficiently using the media to reliably store the maximum amount of data in a given space. Early disk drives used very simple encoding schemes, such as RLL $(0,1)$ FM code, but higher density RLL $(2,7)$ and RLL $(1,7)$ codes became the de facto industry standard for hard disks by the early 1990s.

**Method**

The RLL encoding or the Run Length Limited encoding is the most common encoding scheme used in the hard disk storage. This encoding scheme can be more accurately called as 2, 7 RLL encoding because in this scheme in a series or in a running in this length the minimum number of Os next to each other is two, and then maximum number of Os together can not be more than seven.

The RLL encoding scheme can store 50 percent more information than l encoding scheme on a given surface and it can store three times as much information as the FM encoding scheme.

The Run Length Limited name comes from the minimum number (Run Length and maximum number (Run Limit) of “no pulse” values allowed between pulses.

For the RLL encoding, an encoder/decoder (Endec) table is used to find the pulse signal to be used for different data bit groups.

The Endec table used by the IBM to convert bit information to the pulse signal.

<table>
<thead>
<tr>
<th>Data Bit</th>
<th>Pulse Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>NP NN</td>
</tr>
<tr>
<td>11</td>
<td>PN NN</td>
</tr>
<tr>
<td>000</td>
<td>NN NP NN</td>
</tr>
<tr>
<td>010</td>
<td>PN NP NN</td>
</tr>
<tr>
<td>011</td>
<td>NN PN NN</td>
</tr>
<tr>
<td>0010</td>
<td>NN PN NP NN</td>
</tr>
</tbody>
</table>
Example
To store 10001111 using different data encoding schemes, you need.
(i) PP - PN - PN - PN - PP - PP - PP - PP, i.e. total 13 pulses FM scheme.
(ii) NP - NN - PN - PN - NP - NP - NP - NP, i.e. total 7 pulses in MFM scheme.
(iii) NPNN NNNN PNNN PNNN°, 10 - 0011 - 11 ,
i.e. total 3 pulses in 2, 7 RLL scheme.

Summary
FM Recording Techniques:
It was the original data -encoding technique used for data storing on magnetic recording surface. It also called as “Single density recording”
Method of encoding:
In this method, clock pulse is present in the beginning of each bit cell. The data pulse is written in the middle of the bit cell.

- If data is 1, data pulse is present.
- If data is 0, data pulse is not present.
- In this recording technique, two flux changes in each bit cell.
- Each bit cell is 4μs duration for floppy disk.
  - 1 bit is stored in two pulses: Clock pulse, Data Pulse
  - 0 bit is stored in only one clock pulse and no data pulse is present

For:
- A binary digit 1 is stored as two pluses (PP)
- A binary digit 0 is stored as one pulse and one “No pulse” (PN)

Example:
Suppose we want to store a binary digit 110010110

1 1 0 0 1 0 1 1 0
(PP) (PP) (PN) (PN) (PP) (PN) (PP) (PN) (PN)

M F M Recording Technique:
✓ It is called “Double density Recording”.
✓ Clock pulse is not present at the beginning of each bit cell.
✓ Advantage of MFM recording technique is that, it read or writes fewer pulses.
✓ Disadvantage of MFM recording technique is more complex than MF.

Method:
✓ When data is 1, there is no clock pulse. Only data pulse is present at the center of the bit cell.
✓ When data is 0 preceded by 0, then the clock pulse is written at the beginning of the current bit cell, but no data pulse is written.
✓ When data is 0 preceded by 1, neither clock pulse nor data pulse is written.
✓ In MFM Recording, 0 and 1 are encoded as: 1 is always stored as (NP)
✓ 0 when preceded by another 0 is stored as (PN)
✓ 0 when preceded by 1, is stored as (NN)

For Example:

1 0 0 1
(NP) (NN) (PN) (NP)

RLL Recording Technique:
✓ Popular encoding scheme for HDD.
✓ It record data on disk twice then MFM and three times as much information of MF.
✓ It provide much faster data transfer as compare to the other encoding scheme.
✓ The names comes from minimum no (Run Length) And maximum no. (Run Limit) of “No pulse” valued allowed between two pulses.
✓ The RLL encoding combines group of bits into a generate specific patterns of flux reversals. For RLL encoding, an encoder/decoder table is used to find the pulse signal to be used for different data bit groups.

For example:
- Encode a Byte 100011
- The bit 10 is encoded as NP NN
- The bit 0010 is encoded as NN PN NP NN

Floppy Disk

Q. Explain the constructional details of floppy disk and list its typical storage capacity.

OR Explain with respect to floppy disk the following:
1) Tracks
2) Sectors
3) Write Protect Notch
4) Read Write Access

Ans. A floppy disk is used to store information or Data. Floppy diskettes are available in different sizes and capacities. This is reusable storage device. A floppy disk is used in floppy disk drive.
Floppy disk is has two major construction ie
   a. Outer jacket  
   b. Inner Media  

Floppy disk consist of a flexible plastic material(media) also called as MYLAR, coated with ferric oxide or magnetic oxide. As a material used is flexible, it is called floppy disk.

**Jacket**

The floppy disk is packaged or enclosed in a protective plastic jacket to prevent it from damage. The plastic jacket has slots for
   1. read write access,  
   2. a hole for in the center for mounting disk drive hub  
   3. a hole for index mark sensing and  
   4. write protect Notch.

The floppy disk rotates with the speed of 300-360 RPM. Floppy disk are available in different size for e.g.: 8 inches, 5¼-inches and 3 1/2 – inch with capacity varying from 120 Kb to 2.88Mb.

The size of the disk is nothing but the diameter of the media ie 5¼-inch floppy disk means diameter of the media is 5¼-inch

**Index Hole**

It is used to determine the beginning of sector, always data reading or writing is performed after sensing index hole.
**Write Protect Notch**

If this notch is covered with a transparent surface, data cannot be written on the disk i.e. write protected.

**Read Write Access**

The data can be written or read through this window. The is placed over this notch.

**Spindle Motor Hub Hole**

This hole is grooved with the drive motor and it causes the disk to rotate in the drive.

**Media**

The surface of floppy disk is divided into concentric circles called as tracks. Each track is further divided into number sectors depends on the density of floppy disk. Data is stored in sectors. Generally 512 bytes is stored per sectors.

**Q. Write the classification table for floppy disks.**

**Ans.**

\[
\text{Capacity} = \text{Tracks} \times \text{Sectors} \times \frac{\text{bytes/sector}}{\text{number of sides}}
\]

E.g.: Tracks = 80, Sides = 2, Bytes/sector = 512, Sectors = 15

\[
\text{Capacity} = 80 \times 15 \times 512 \times 2 = 1200 = 1\text{kb} = 1.2\text{ Mb.}
\]

<table>
<thead>
<tr>
<th>Size</th>
<th>Capacity</th>
<th>Tracks</th>
<th>Sides</th>
<th>Sectors per track</th>
<th>Bytes per sector</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 ¼ - inch</td>
<td>160 Kb</td>
<td>40</td>
<td>Single</td>
<td>8</td>
<td>512</td>
<td>Low</td>
</tr>
<tr>
<td>5 ¼ - inch</td>
<td>180 Kb</td>
<td>40</td>
<td>Single</td>
<td>9</td>
<td>512</td>
<td>Low</td>
</tr>
<tr>
<td>5 ¼ - inch</td>
<td>320 Kb</td>
<td>40</td>
<td>Double</td>
<td>8</td>
<td>512</td>
<td>Low</td>
</tr>
<tr>
<td>5 ¼ - inch</td>
<td>360 Kb</td>
<td>40</td>
<td>Double</td>
<td>9</td>
<td>512</td>
<td>Low</td>
</tr>
<tr>
<td>5 ¼ - inch</td>
<td>1.2 Mb</td>
<td>80</td>
<td>Double</td>
<td>15</td>
<td>512</td>
<td>High</td>
</tr>
<tr>
<td>3 ½ - inch</td>
<td>1.44 Mb</td>
<td>80</td>
<td>Double</td>
<td>18</td>
<td>512</td>
<td>High</td>
</tr>
<tr>
<td>3 ½ - inch</td>
<td>2.8 Mb</td>
<td>80</td>
<td>Double</td>
<td>36</td>
<td>512</td>
<td>Extra High</td>
</tr>
</tbody>
</table>
Q) What are the precautions to be taken while handling a floppy.
Ans. Precautions to be taken while handling floppies are:
(1) Protect from heat and direct contact of sunlight.
(2) Store the floppy disk in cool and dust free environment.
(3) Protect the floppies from magnetic field i.e. floppy disk shouldn’t be kept near or over the devices, which generate magnetic field for e.g.: Power supplies, T.V, Speaker, etc.
(4) Do not write with hard pens always use sketch pen for labeling the floppy disk.
(5) Do not blend or twist the floppies.
(6) Do not touch the read write area.
(7) Power supply of the system shouldn’t be switched off keeping the floppy disk in floppy drive.
(8) Do not keep the floppy disk in book.

Q. Explain the different Specifications used to describe a floppy or List different Classification of floppies.
Ans :- Floppies are classified in 4 different Ways.
1) Physical Size.
2) Number Of recording sides
3) Data Storage Capacity.
4) Recording density or recording technique.

1) Physical Size
   Depending upon physical size floppies are classified as : 8”, 5-1/4”, 3-1/2”. This size is diameter of circular disk.

2) Number Of recording sides
   Depending upon recording sides floppies are classified as :
   a) Single Sided floppies
   b) Double Sided
   ♦ In Single Sided floppies only one side is used to store data. Such floppies are marked as 1-3 or SS.
   ♦ In Double Sided floppies both sides are used to store data. In double sided floppies the floppy is marked as : 2s or DD-2, HD-2.

3) Data Storage Capacity
   Depending on data storage capacity floppies are classified as : 360 KB, 1.44MB, 1.2 MB, 2.88 MB & 720 KB.

4) Recording Techniques
Depending upon recording technique the storage density of floppy changes. Depending upon recording technique used the floppies are classified as: Low Density & High Density.

Low density floppy user frequency modulation technique (FM) & generally low density floppies has sectors maximum 9.

High density floppy used modified frequency modulation technique (MFM). High density floppies has sector above 15.

E.g.: Low Density: 360 KB, 720 KB.
     High Density: 1.2 MB, 1.4 MB.

5) Sectoring

Depending upon sectoring floppies are classified as:

1) Hard Sectored floppies
2) Soft sectored Floppies.

♦ In Hard sectored floppies there is one index hole for each sector identification & these floppies are sectored by manufacturing.
♦ In Soft sectored floppies there is only one index hole for sector identification. These floppies are sectored using software or DOS commands.

Advantage of Soft sector

1) Number of sectors can be changed by changing the software.
2) More flexible due to use of software.
3) Reliability is more & it is durable.

Disadvantages

1) Capacity of floppy disk is reduced because some space is required for storing the address of sectors.
2) Additional software is required.

Advantages of Hard sector

1) Capacity of floppy disk is more due to use of direct physical holes.
2) No use of software.

Disadvantages

1) Storing is constant & cannot be changed.
2) Low flexibility in use of sectors.

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Item/Features</th>
<th>5 ¼ inch 360KB</th>
<th>5 ¼ inch 1.2MB</th>
<th>3 ½ inch 720KB</th>
<th>3 ½ inch 1.44MB</th>
<th>3 ½ inch 2.88 MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Capacity(Formatted)</td>
<td>360KB</td>
<td>1.2MB</td>
<td>720KB</td>
<td>1.44MB</td>
<td>2.88 MB</td>
</tr>
<tr>
<td>2</td>
<td>Tracks/Sides</td>
<td>40</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>3</td>
<td>Sector/track</td>
<td>9</td>
<td>15</td>
<td>9</td>
<td>18</td>
<td>36</td>
</tr>
<tr>
<td>4</td>
<td>Bytes/sector</td>
<td>512</td>
<td>512</td>
<td>512</td>
<td>512</td>
<td>512</td>
</tr>
<tr>
<td>---</td>
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<td>-----</td>
<td>-----</td>
<td>-----</td>
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<td>5</td>
<td>Data Transfer Rate</td>
<td>250Kbs</td>
<td>500Kbs</td>
<td>500Kbs</td>
<td>500Kbs</td>
<td>500Kbs</td>
</tr>
<tr>
<td>6</td>
<td>Recording Format</td>
<td>MFM</td>
<td>MFM</td>
<td>MFM</td>
<td>MFM</td>
<td>MFM</td>
</tr>
<tr>
<td>7</td>
<td>Disk Speed</td>
<td>300 rpm</td>
<td>300 rpm or 360 rpm</td>
<td>360 rpm</td>
<td>360 rpm</td>
<td>360 rpm</td>
</tr>
<tr>
<td>8</td>
<td>Total Sectors</td>
<td>708</td>
<td>2371</td>
<td>1426</td>
<td>2847</td>
<td>5726</td>
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<tr>
<td>9</td>
<td>Common Technology</td>
<td>DSDD</td>
<td>DSHD</td>
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<tr>
<td>10</td>
<td>Track Width</td>
<td>0.330mm</td>
<td>0.160mm</td>
<td>0.115mm</td>
<td>0.115mm</td>
<td>0.115mm</td>
</tr>
<tr>
<td>11</td>
<td>Track Density(TPI)</td>
<td>48</td>
<td>96</td>
<td>135</td>
<td>135</td>
<td>135</td>
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<tr>
<td>12</td>
<td>Recording Density (BPI)</td>
<td>5876</td>
<td>9646</td>
<td>8717</td>
<td>17434</td>
<td>34868</td>
</tr>
</tbody>
</table>

**Hard Disk Drive - HDD**

**Introduction**

A hard disk uses round, flat disks called platters, coated on both sides with a special media material designed to store information in the form of magnetic patterns. The platters are mounted by cutting a hole in the center and stacking them onto a spindle. The platters rotate at high speed, driven by a special spindle motor connected to the spindle.

Special electromagnetic read/write devices called heads are mounted onto sliders and used to either record information onto the disk or read information from it. The sliders are mounted onto arms, all of which are mechanically connected into a single assembly and positioned over the surface of the disk by a device called an actuator.
A logic board controls the activity of the other components and communicates with the rest of the PC. Each surface of each platter on the disk can hold tens of billions of individual bits of data. These are organized into larger "chunks" for convenience, and to allow for easier and faster access to information.

Each platter has two heads, one on the top of the platter and one on the bottom, so a hard disk with three platters (normally) has six surfaces and six total heads. Each platter has its information recorded in concentric circles called tracks. Each track is further broken down into smaller pieces called sectors, each of which holds 512 bytes of information.

The entire hard disk must be manufactured to a high degree of precision due to the extreme miniaturization of the components, and the importance of the hard disk’s role in the PC. The main part of the disk is isolated from outside air to ensure that no contaminants get onto the platters, which could cause damage to the read/write heads.

constructional details of the hard disk drive / basic components of hdd
Following are the components of a typical hard disk drive (see Figure):

1. Disk platters
2. Read/write heads
3. Head actuator mechanism
4. Spindle motor
5. Logic board
6. Cables and connectors
7. Configuration items (such as jumpers or switches)
8. Bezel (optional)

**Disk Platter**

A hard disk has one or more platters, or disks. Platter are circular disk shaped, which are coated with the magnetic material. Hard disks for PC systems have been available in a number of form factors over the years. Form factor of the platter means size of the platter, which is expressed as the size of the platter. The following are the most common platter sizes used in PC hard disks today:

1. 5 ¼-inch (actually 130mm, or 5.12 inches)
2. 2 ½-inch
3. 3 ½-inch (actually 95mm, or 3.74 inches)
4. 1.8-inch

3 ½ inch and 2 ½ are the most popularly used platter sizes. Most of the HDD have two or more platters, but small size HDD have one platter. Vertical height of the HDD puts limitation on the number of platters in HDD.

Platters are generally made up of Aluminum alloy for strength and light weight. For smaller and higher density drives, platters are made up of Glass-ceramic (also called Memcor).
Companies manufacturing HDD are Seagate, Toshiba, Maxtor, Fujitsu, Areal Technology, HP Samsung.

**Recording Media**

The platters are covered with a thin layer of a magnetically retentive substance called media in which magnetic information is stored. Two popular types of media are used on hard disk platters:

- **Oxide media**
- **Thin-film media**

**Oxide media** is made of various compounds, containing iron oxide. A magnetic layer is created by coating the aluminum platter with a syrup containing iron-oxide particles. This media is spread across the disk by spinning the platters at high speed; centrifugal force causes the material to flow from the center of the platter to the outside, creating an even coating of media material on the platter. The surface then is cured and polished. Finally, a layer of material that protects and lubricates the surface is added and burnished smooth.

The oxide media coating normally is about 30 millionths of an inch thick. The color of platters are brownish or amber. This type of media is used since 1955.

**Thin-film** media is thinner, harder, and more perfectly formed than oxide media. Thin film was developed as a high-performance media that enabled a new generation of drives to have lower head floating heights, which in turn made possible increases in drive density. Originally, thin-film media was used only in higher-capacity or higher-quality drive systems, but today, almost all drives have thin-film media.

The coating is much thinner than can be achieved by the oxide-coating method. Thin-film media also is known as plated, or sputtered, media because of the various processes used to place the thin film of media on the platters.

**Thin-film plated** media is manufactured by placing the media material on the disk with an electroplating mechanism. The aluminum platter then is immersed in a series of chemical baths that coat the platter with several layers of metallic film. The media layer is a cobalt alloy about 3\(\mu\)-in thick.
**Thin-film sputtered** media is created by first coating the aluminum platters with a layer of nickel phosphorus and then applying the cobalt-alloy magnetic material in a continuous vacuum-deposition process called sputtering. During this process, magnetic layers as thin as 1 or 2 $\mu$-in are deposited on the disk.

**Read/Write Head**

Read/Write head is used to write any information on the disk surface and to read the written back, without any data loss. A hard disk drive contains one read/write head for each side of its platter.

All the head used in a disk drive system are connected together and moved in and out on the disk surface as a single unit.

Mechanically, read/write heads are simple. Each head is on an actuator arm that is spring-loaded to force the head into a platter. Each platter actually is “squeezed” by the heads above and below it.

Inside the hard disk, when the disk is at rest i.e. not spinning, then the head is in direct contact with the surface. As the disk starts to spin, because of its very high rotation speed, air pressure develops under the head. This pressure lifts the head from the disk surface and the head starts to floats on an air cushion, 3 to 10 $\mu$ inch (millionth of inch) above from the disk surface.

Different types of heads are used with the hard disk drives for read/write purpose, some of them are

1. Ferrite head
2. Metal-in-gap head
3. Thin-film head
4. Magneto-resistive head
The arm on which the read/write head of the disk drive is located is called the head slider. These sliders are made in a catamaran, sailboat shape the central portion of the slider carries the read/write head over the disk surface.

The head arms are thin pieces of metal, usually triangular in shape onto which the head sliders (carrying the read/write heads) are mounted. In a way, the idea here is similar to how the arm of a phonograph is used to move the stylus from the outside of a record to the inside (although of course the similarity ends there). There is one arm per read/write head, and all of them are lined up and mounted to the head actuator to form a single unit. This means that when the actuator moves, all of the heads move together in a synchronized fashion. Heads cannot be individually sent to different track numbers.

The arms themselves are made of a lightweight, thin material, to allow them to be moved rapidly from the inner to outer parts of the drive. Newer designs have replaced solid arms with structural shapes in order to reduce weight and improve performance. This is the same technique used to reduce weight in the construction of airplane wings, for example. Newer drives achieve faster seek times in part by using faster and smarter actuators and lighter, more rigid head arms, allowing the time to switch between tracks to be reduced.

**Logic board and Spindle motor**

The hard drive logic board (or "controller") is the brains of the hard drive. It directs the hard drive's activity and serves as the interpreter between the hard drive and the CPU. The processor talks to the hard drive through the hard drive controller circuit board installed in the hard disk drive. In some setups such as SCSI and/or RAID, the hard drive may also connect to a SCSI or RAID controller opposed to the hard drive being directly connected to the system motherboard itself.

Spindle motor is the main motor, which rotates the hard drive’s platters. This motor works on a feedback loop to automatically adjust the disk’s rotation speed. A hard disk platter rotates at around 3,600 to 7,200 RPM (Rotations Per Minute) or more. The logic board controls movement of spindle motor and the head actuator mechanism.
Air Filter

Most of the people think that inside the hard disk drive there vacuum. But this is not true, the hard disk drive will not work in a vacuum condition, because the read/write head needs to float on the disk surface. Most of the hard disk drive will have two air filters, one is called recirculating air filter and the second is called breather filter.

The recirculating air filter is used to filter any particles dislodged from inside the drive such as scrap of disk media. This filter does not circulate the external air to the inside of the disk drive.

The breather filter or the barometric filter is the only connection of the inside of the hard disk drive with the outside environment.

Head Actuator mechanism

The actuator is the device used to position the head arms to different tracks on the surface of the platter (actually, to different cylinders, since all head arms are moved as a synchronous unit, so each arm moves to the same track number of its respective surface). The actuator is a very important part of the hard disk, because changing from track to track is the only operation on the hard disk that requires active movement: changing heads is an electronic function, and changing sectors involves waiting for the right sector number to spin around and come under the head (passive movement). Changing tracks means the heads must be shifted, and so making sure this movement can be done quickly and accurately is of paramount importance. This is especially so because physical motion is so slow compared to anything electronic--typically a factor of 1,000 times slower or more.

More important than the heads, it is the mechanical system that moves them: the head actuator. This mechanism moves the heads across the disk and positions them accurately above the desired cylinder. Many variations on head actuator mechanisms are in use, but all of them can be categorized as being one of two basic types:

1. Stepper motor actuators
2. Voice coil actuators

The use of one or the other type of positioner has profound effects on a drive’s performance and reliability. The effect is not limited to speed; it also includes accuracy, sensitivity to temperature, position, vibration, and overall reliability. A drive equipped with a stepper motor actuator is much less reliable (by a large factor) than a drive equipped with a voice coil actuator.

A stepper motor drive has a slow average access rating, is temperature-sensitive during read and write operations, is sensitive to physical orientation during read and write operations,

**Stepper Motors:**

Originally, hard disk drives used a stepper motor to control the movement of the heads over the surface of the platters. A regular motor turns in a rotary fashion continuously; it can stop at any point in its rotation as it spins around, kind of like the second hand on a wind-up wristwatch. A stepper motor can only stop at predefined "steps" as it turns around, much the way the second hand turns on an electronic, quartz wristwatch.

A hard drive using a stepper motor for an actuator attaches the arms to the motor, and each time the motor steps one position clockwise or counterclockwise, the arms move in or out one position. Each position defines a track on the surface of the disk. Stepper motors are also commonly used for both turning the spindle and positioning the head on floppy disk drives. If you have a floppy drive, find one of its motors and turn it slowly with your hand; you will feel the discrete step-wise nature of its motion.

![Stepper Motor Image](image-url)
automatically above a save zone during power-down, and usually requires to realign the sector data with the sector header information due to mistracking.

Hence performance of the stepper motor mechanism is inferior to the voice coil mechanism. Some stepper motor drives feature automatic head parking at power-down.

![Stepper Motor Head Actuator](image)

**Fig. Stepper Motor Head Actuator**

A stepper motor is a motor that rotates in steps, when you rotate an ordinary motor, it will turn any angle of rotation, but a stepper motor turns a fixed angle with each step. The stepper motor is connected to the read/write head actuator using the following two methods:

(i) Split metal band mechanism
(ii) Rack and pinion gear mechanism

These mechanisms are used to convert the rotation motion of the stepper motor into the in-and-out motion required to move the read/write head over the disk surface.
A stepper motor actuator. The motor moves in steps, which you can feel if you move the motor shaft by hand. The shaft has two thin strips of metal wrapped around it, which are connected to a pivot that is rigidly attached to the actuator arms. As the motor shaft turns, one half of this "split band" coils onto the shaft and the other half uncoils. When the motor turns in the opposite direction the process reverses. As this occurs the pivot moves and in doing so, moves the actuator arms and the hard disk heads.

**Voice Coil Actuator**

A voice coil actuator is found in all higher-quality hard disk drives, including most drives with capacities greater than 40M and virtually all drives with capacities exceeding 80M. Unlike the blind stepper motor positioning system, a voice coil actuator uses a feedback signal from the drive to accurately determine the head positions and to adjust them, if necessary. This system has significantly greater performance, accuracy, and reliability than traditional stepper motor actuators offered.

**Voice Coils:** The actuator in a modern hard disk uses a device called a voice coil to move the head arms in and out over the surface of the platters, and a closed-loop feedback system called a servo system to dynamically position the heads directly over the data tracks. The voice coil works using electromagnetic attraction and repulsion. A coil is wrapped around a metal protrusion on the end of the set of head arms. This is mounted within an assembly containing a strong permanent magnet. When current is fed to the coil, an electromagnetic field is generated that causes the heads to move in one direction or the other based on attraction or repulsion relative to the permanent magnet. By controlling the current, the heads can be told to move in or out much more precisely than using a stepper motor. The name "voice coil" comes from the resemblance of this technology to that used to drive audio speakers, which are also basically electromagnets. All PC hard disk voice coil actuators are rotary, meaning that the actuator changes position by rotating on an axis.

A voice coil actuator works by pure electromagnetic force. The construction of this mechanism is similar to that of a typical audio speaker, from which the term voice coil is derived. An audio speaker uses a stationary magnet surrounded by a voice coil connected
to the speaker’s paper cone. Energizing the coil causes the coil to move relative to the stationary magnet, which produces sound from the speaker cone.

In a typical hard disk voice coil system, the electromagnetic coil is attached to the end of the head rack and placed near a stationary magnet. No contact is made between the coil and the magnet. As the electromagnetic coils are energized, they attract or repulse the stationary magnet and move the head rack. Such systems are extremely quick and efficient, and usually much quieter than systems driven by stepper motors.

Unlike a stepper motor, a voice coil actuator has no click-stops, or undesired positions; rather, special guidance system stops the head rack above a particular cylinder. Because has no problems, the voice coil actuator can slide the heads in and out smoothly to any position desired. Voice coil actuators use a guidance mechanism called a servo to tell the actuator where the heads are in relation to the cylinders and to place the heads accurately at the desired positions. This positioning system often is called a closed loop, servo-controlled mechanism.

Closed loop indicates that the index (or servo) signal is sent to the positioning electronics in a closed-loop system. This loop sometimes is called a feedback loop, because the feedback from this information is used to position the heads accurately. Servo-controlled refers to this index or the servo information that is used to dictate or control head-positioning accuracy.

This servo mechanism based systems is also called as “track following system” because the read/write head always follow the track or cylinder on the surface of the disk.

Bezel or face plate
The hard disk bezel is a passive component which holds the HDD when it is installed in the system. The front panel of the bezel holds the HDD activity LED which indicates the HDD access.

Some bezels feature a light-emitting diode (LED) that flickers when your hard disk is in use. The LED is mounted in the bezel; the wire hanging off the back of the LED plugs into the drive or perhaps the controller.

In some drives, the LED is permanently mounted on the drive, and the bezel has a clear or colored window so that you can see the LED flicker while the drive is accessed.

In systems in which the hard disk is hidden by the unit’s cover, a bezel is not needed.

Cables and Connectors

Hard disk drives have several connectors for interfacing to the system, receiving power, and sometimes grounding to the system chassis. Most drives have at least these three types of connectors:

• Interface connector(s)
• Power connector
• Optional ground connector (tab)

Interface connector

The interface connectors are the most important, because they carry the data and command signals from the system to and from the drive. In many drive interfaces, the drive interface cables can be connected in a daisy chain or bus-type configuration. Most interfaces support at least two drives, and SCSI (Small Computer System Interface) supports up to seven in the chain.

Some interfaces, such as ST-506/412 or ESDI (Enhanced Small Device Interface), use a separate cable for data and control signals. These drives have two cables from the controller interface to the drive. SCSI and IDE (Integrated Drive Electronics) drives usually have a single data and control connector. With these interfaces, the disk controller is built into the drive. For standard IDE 40 pin FRC is used as interface connector.

Power Connector

The power connector usually is the same type that is used in floppy drives, and the same power-supply connector plugs into it. Most hard disk drives use both 5v and 12v power, although some of the smaller drives designed for portable applications use only 5v power. The 12v power runs the spindle motor and head actuator, and the 5v power runs the circuitry.
Hard Drive Interfaces

Hard drives, like any other computer devices, have to be "connected" to the computer's operating system which controls hardware and software and makes them work. These connections are called interfaces and there are a number of interfaces which have been developed to connect hard drives to the computer system, itself.

Enhanced Integrated Drive Electronics (EIDE)

Most hard drives interface with the system (motherboard) via Enhanced Integrated Drive (or Device) Electronics, or EIDE. Two popular types of EIDE interfaces are Parallel Advanced Technology Attachment (PATA), which transmits data through parallel lines, and Serial Advanced Technology Attachment (SATA), which transmits data through a single line, 1.5 - 3.0 Gbits/sec. With ATA, there is connectivity for two hard drives per controller port.

Small Computer System Interface (SCSI)

A second interface is Small Computer System Interface, or SCSI, pronounced "scuzzy", used for more high-end applications of up to 15 devices. The multiple drives are attached to the SCSI bus. Depending on the SCSI interface in question, ranging from 2 MBs/sec to 320 Mbs/sec, however, the addition of more devices will overload the available bandwidth.

Serial Attached SCSI (SAS)

Then, there is Serial Attached SCSI, or SAS. SAS is incredibly scalable, supporting impressive storage topologies of over 16,000 devices. The serial transmission of data requires fewer connections and eliminates the SCSI bus. It still uses the very capable SCSI protocol. SAS performs at 3 – 12 Gbits/sec.

IEEE 1394 Firewire

Another interface is IEEE 1394, or Firewire which is popular in multimedia and entertainment applications. Firewire 400 performs at approximately 100 – 400 Mbits/sec; Firewire 800 at 400 – 3200 Mbits/sec; Firewire 1600 at 1.6 Gbits/sec; Firewire 3200 at 3.2 Gbits/sec; and future improvements are expected to raise the speed to 6.4 Mbits/sec. Firewire can connect 63 devices.

Fibre Channel

Then, there is Fibre Channel, another high-end interface which competes with SCSI and allows connection of up to 126 devices. Fiber channel performs at 2 – 4 Gbits/sec.

Cables and Connectors in Detail
Types of Hard Disk

Types of Drives:

Now that the basics have been covered, let's look at some different kinds of drives. There are two main types used by home PCs and laptops: IDE/EIDE and Serial ATA (SATA).

IDE (Integrated Drive Electronics):

The IDE interface standard has been around for a very long time. The term interface in this sense means how the drive connects to the motherboard. As improvements were developed it later was called EIDE for Enhanced IDE. And after even further developments it has also come to be known as ATA (Advanced Technology Attachment). These drives connect to the motherboard via a flat, 80-wire cable to an IDE connector. Two drives can be attached on one cable.
The speed of a hard drive is determined by how fast the connector can send data. Currently the primary drive rates are 100 MB/s and 133 MB/s - 133 MB/s being the maximum. These hard disks are commonly described by the abbreviation "ATA" followed by the speed of its connector (ATA 100, ATA 133).

IDE drive connectors use a parallel bus, meaning multiple bits are transmitted simultaneously. To distinguish between Serial ATA drives, IDE disks are also referred to as PATA (the "P" stands for parallel).

To make it a little less confusing, here are some different names for IDE:

- EIDE (Enhanced IDE)
- ATA (Advanced Technology Attachment)
- PATA (Parallel ATA)

Although there are still IDE drives around, Serial ATA is now the standard and is discussed next.

**Serial ATA (SATA):**

Today, SATA disk drives are the current standard and use a serial interface to transfer data, i.e. data is transmitted one bit at a time. Using a faster clock rate, sending one bit is faster than sending several with a slower clock, as with IDE. Data also travels along a single wire, reducing interference. With SATA, one path is used for sending and another for receiving. With PATA, data is sent and received on one path.
The original SATA standard has a transfer rate of 150 MB/s (SATA-150). Now SATA can transmit up to 300 MB/s (SATA II or SATA-300), and 6 Gb/s (SATA 3), far surpassing PATA's 133 MB/s. SATA uses a 7-wire cable for connecting to the motherboard.

SCSI Drives:
SCSI (Pronounced "scuzzy") stands for Small Computer Systems Interface, and was originally developed to replace IDE before SATA came about. In addition to hard drives, other devices can use SCSI. Because PCs use either IDE or Serial ATA drives, I am not going to go into a lot of detail about SCSI, but I do want you to know that it exists and a PC is capable of using a SCSI drive if it has a SCSI controller.

SCSI is much faster than IDE. Several types developed over time: Narrow, Wide, Fast, Fast Wide, and Ultra. These refer to how much and how fast data is sent for each standard. The only one in use today is Ultra, itself consisting of various types. 8 or 16 devices are supported on one cable, depending on which kind is implemented. SCSI devices are a little more troublesome to configure than IDE and SATA and generally tend to be more expensive.

External Drives:
Hard disk drives can connect externally to a computer. The drive is placed in a case called an enclosure that contains a port(s) on the back for connecting to the computer via a cable. For quite some time enclosures used USB or Firewire. Now, many support any combination of USB, Firewire, and External SATA (eSATA) ports on the same encasement. External SATA is far faster than USB and Firewire. To use it, a computer must also have an eSATA connector. If it doesn't, a card can be purchased with the interface on it. Enclosures are manufactured to match the form factor of particular drive.
Solid State Drives:
Solid State Drives, or SSDs, differ from traditional hard drives in that they contain flash memory rather than a motor, spinning platters, and a read/write head. A big advantage is that you do not have to concern yourself with drive failure due to some mechanical failure, and they require much less power to run.

Like standard drives they come as internal or external, IDE or SATA. Most are 2.5 inches.

A big disadvantage with solid state hard drives, however, is capacity and cost. Presently, most come in much smaller capacities than regular drives and are quite expensive. So you will have to decide if the cost is worth it.

Flash Drives:
Flash Drives are portable drives about the size of your thumb that use flash memory to store data. They replaced floppy disks years ago as the primary method of transporting data from place to place. The early ones only had a capacity of 8 or 16 MB megabytes. Now, storage is in the gigabytes which allows you to store large files such as music and pictures. They connect using a USB interface.
Sectors, Clusters, Tracks, and Cylinders

A typical hard drive is an electromagnetic device made up of a number of disk-shaped pieces called platters that are stacked on top of each other (see the figure below). Each platter can store data on both sides and has a read/write head that transfers data from the computer to the disk. To find information on these platters, drives are divided into a number of sections called Sectors, Clusters, Tracks, and Cylinders.

The following lists each type of section:

- **Sector** - A sector is the smallest unit of data that can be read or written from a disk. Typically, sectors are 512 bytes in size, but other sizes including 1024 and 2048 are common.
- **Cluster** - A cluster is the smallest unit of data that a file system can allocate for a file. Each cluster has a fixed size that is always a multiple of the sector size. Older file systems (FAT16) often allocated large cluster sizes of 32K or more, meaning that even small files of 1K would take up 32K of disk space. More modern file systems (FAT32 and NTFS) allow smaller cluster sizes. A file is stored optimally on disk as a series of contiguous clusters (clusters that are in order on disk). However, a file can be split into multiple clusters on different areas of the disk and this is called fragmentation.
- **Track** - A track is a concentric ring of sectors on a platter. A read/write head can read all the data from a certain track by moving to a position and then rotating the platter.
- **Cylinder** - A cylinder is a group of tracks in all the platters that are on top of each other.

http://www.mtsac.edu/~rpatters/CISB11/Chapters/Chapter_03/Chap03/LectureFrame.htm
Landing Zone

A 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.

Short for Landing Zone, lzone, or LZ is a setting used to specify the Landing Zone of the heads on a computer hard drive. Today, with new computers, the lzone is no longer required as most computer hard drives autopark. Setting the CMOS values to Auto will automatically allow the computer to define the Landing Zone.

However, for older computers and devices that require the Landing Zone to be defined or only have a "custom" or "user-defined" option that requires a numerical value defining the Landing Zone you can define the value as the number of cylinders plus one. For example, if you had 3924 cylinders for your hard drive you would set both the Landing Zone and the Write Precomp as 3925.

This setting specifies the cylinder to which the BIOS should send the heads of the hard disk when the machine is to be turned off. This is where the heads will "land" when they spin down. Modern drives (in fact, virtually every drive made in at least the last five or so years) automatically park the heads in a special area that contains no data when the power is turned off. Therefore this setting is meaningless and is typically ignored.

Most BIOSes set this value to be the largest cylinder number of the logical geometry specified for the disk when you autodetect. So if the drive has 6,136 logical cylinders, the landing zone will be set to 6,135. In any event a modern IDE drive will ignore this setting and autopark by itself.

Why Landing Zone and Head Parking is Needed

When the platters are not spinning, the heads rest on the surface. When the platters spin up, the heads rub along the surface of the platters until sufficient speed is gained for them to "lift off" and ride on their cushion of air. When the drive is spun down, the process is repeated in reverse. In each case, for a period of time the heads make contact with the surface of the disk--while in motion, in fact.

While the platters and heads are designed with the knowledge in mind that this contact will occur, it still makes sense to avoid having this happen over an area of disk where there is data. For this reason, most disks set aside a special track that is designated for being where the heads will be placed for takeoffs and landings. Appropriately, this area is called the landing zone. The process of moving the heads to this designated area is called head parking.

Most early hard drives that used stepper motors did not automatically park the heads of the drive. As a safety precaution, small utilities were written that the user would run before shutting down the PC. The utility would instruct the disk to move the heads to the
landing zone, and then the PC could be shut off safely. A parameter in the BIOS setup for the hard disks told the system which track was the landing zone for the particular model of hard disk. Usually, it is the next consecutive-numbered track above the largest-numbered one actually used for data.

Modern voice-coil actuated hard disk drives are all auto-parking. On some disks, a weak spring is attached to the head assembly that tries to pull the heads to the landing zone. When power is applied the actuator is able to overpower the spring and position the heads normally. When the power is shut off, the electromagnetic force from the voice coil abates, and the spring yanks the heads to the landing zone before the platters can spin down. Other disks use a different mechanical or electronic scheme to achieve the same goal. This means that modern hard disks will automatically park their heads—even in the event of a power failure—and no utilities are required. The BIOS landing zone parameter for modern drives is ignored.

Master Boot Record

Short for Master Boot Record, a small program that is executed when a computer boots up. Typically, the MBR resides on the first sector of the hard disk or diskette that identifies how and where an operating system is located so that it can be boot (loaded) into the computer's main storage or random access memory. The program begins the boot process by looking up the partition table to determine which partition to use for booting. It then transfers program control to the boot sector of that partition, which continues the boot process. In DOS and Windows systems, you can create the MBR with the FDISK /MBR command.

The Master Boot Record is also sometimes called the "partition sector" or the "master partition table" because it includes a table that locates each partition that the hard disk has been formatted into. In addition to this table, the MBR also includes a program that reads the boot sector record of the partition containing the operating system to be booted into RAM. In turn, that record contains a program that loads the rest of the operating system into RAM.

The master boot record (or MBR) is information that is normally stored in the first sector of the hard drive. This information is the data structure that identifies where an operating system (OS) files are located on the drive so that the OS can be loaded into the system’s memory (RAM) at the time of booting.

The MBR contains two elements;

1. executable code and
2. a partition table,
which identifies each partition residing on the hard drive. The MBR executable code or program begins the boot process by looking up the partition table to determine what partition holds the operating system.

This program looks for two hidden program files IO.SYS and MSDOS.SYS for DOS and executes IO.SYS program first. This program in turn loads MSDOS.SYS and COMMAND.COM into RAM to complete the process of booting.
From the above figure, you can see that a disk drive is composed of N sectors and each sector is of 512 bytes. Out of the N sectors, the first sector is assigned to the Master Boot record. The first 512 bytes of the BIOS is the Master Boot Record. MBR is composed of two components: a Bootstrapping program and the partition table. The code can be Windows loader, Unix loaders, or a virus.

Next, comes the partition table. The partition table is of 64 bytes and a 16 byte part which tells about the partition of the disk. The MBR is very small in size. Its machine code just helps to load that sector which is responsible for booting the associated partition.

**Write PreCompensation**

Older hard disks used the same number of sectors per track. This meant that older disks had a varying bit density as you moved from the outside edge to the inner part of the platter. Many of these older disks required that an adjustment be made when writing the inside tracks, and a setting was placed in the BIOS to allow the user to specify at what track number this compensation was to begin.

This entire matter is no longer relevant to modern hard disks, but the BIOS setting remains for compatibility reasons. Write precompensation is not done with today's drives; even if it were, the function would be implemented within the integrated controller and would be transparent to the user.

Write precompensation (abbreviated WPcom in the literature) is a technical aspect of the design of hard disks, floppy disks, and other digital magnetic recording devices. It is the modification of the analog write signal, shifting transitions somewhat in time, in such a way as to ensure that the signal that will later be read back will be as close as possible to the unmodified write signal. It is required because of the non-linear properties of magnetic recording surfaces.

A higher amount of precompensation is needed to write data in sectors that are closer to the center of the disk. In constant angular velocity (CAV) recording, in which the
disk spins at a constant speed no matter where the data is written, the sectors closest to the spindle are packed tighter than the outer sectors and so require a slightly different timing to write the data in the most reliable way. CAV recording is used by most floppy disk systems and by older hard disk systems; the term CAV is not applicable to non-circular media, such as magnetic tapes. On magnetic tapes, precompensation is usually constant throughout the tape.

In the past one of the hard disk parameters stored in a PC's CMOS memory was the WPcom number, a marker of the track where stronger precompensation begins, i.e. the transitions are shifted further in time. This was needed by the old MFM and RLL hard disk controllers in common use until the early 1990s. These controllers were usually housed on plug-in cards which could be plugged into the mainboard of the computer; in any case they were external to the actual drive and could deal with many different drives; thus they needed to be told some parameters about the particular drive type in use by the computer. One of these parameters was the WPcom number. This scheme allowed only two different precompensation strengths per disk, a lower one for the outer tracks and a higher one for the inner tracks, however this was enough for the simple low capacity drives of those days.

All hard disk types in common use after the early 1990s have a drive-specific controller built into the actual drive enclosure. This includes all IDE, SCSI, SATA, and SAS hard drive types, among others. Those internal controllers know everything they need to know about their specific drive, including which strengths of precompensation are needed on which parts of the disk.

Therefore they ignore any WPcom numbers stored in the computer's CMOS memory. Until the late 1990s, many PC BIOS setup programs still allowed the user to set WPcom numbers and other drive parameters for use with older hard disk types should the need arise; it wasn't always made very clear to the user that his more modern drive would almost certainly ignore the setting. Since then, the WPcom number is no longer even offered as a BIOS setting any more, as it is wholly obsolete now.

Floppy disk controllers still need to deal with precompensation, but since there have never been more than five or six common floppy drive types in use on PCs, all of which need the same kind of precompensation, there was never a need for a BIOS setting concerning precompensation on floppy disk drives.

**Sector Interleaving**
The way sectors are numbered on a hard disk. Created with a low-level format, the optimum interleave is determined by the speed of the drive. In a 1:1 interleave, sectors are one after the other (0,1,2,3, etc.). A 2:1 interleave alternates them (0,4,1,5,2,6,3,7).

With a 1:1 interleave, the disk controller must be fast enough to read sector 2 after it reads sector 1, otherwise the beginning of sector 2 will pass by the read/write head and require a full rotation to come under the head again. A 2:1 or 3:1 interleave provides more time to read sequential sectors in one rotation.

to arrange data in a noncontiguous way to increase performance. When used to describe disk drives, it refers to the way sectors on a disk are organized. In one-to-one interleaving, the sectors are placed sequentially around each track. In two-to-one interleaving, sectors are staggered so that consecutively numbered sectors are separated by an intervening sector.

The purpose of interleaving is to make the disk drive more efficient. The disk drive can access only one sector at a time, and the disk is constantly spinning beneath the read/write head. This means that by the time the drive is ready to access the next sector, the disk may have already spun beyond it. If a data file spans more than one sector and if the sectors are arranged sequentially, the drive will need to wait a full rotation to access the next chunk of the file. If instead the sectors are staggered, the disk will be perfectly positioned to access sequential sectors.

The optimum interleaving factor depends on the speed of the disk drive, the operating system, and the application. The only way to find the best interleaving factor is to experiment with various factors and various applications.

Memory can also be interleaved. See interleaved memory for more information.

The objective of sector interleaving is to provide an efficient way of files organization with optimum access time of records and minimum idle time. The exact interleave factor should be decided by considering the CPU speed and the diskette rotation speed.

**Zone Recording**

Zoned-bit recording (ZBR) is a method of physically optimizing the utilization of a hard drive by placing more sectors in the outer tracks than in the inner tracks. This technique is also known as zone-bit recording, zone recording, zone-density recording, or multiple-zone recording.
All hard drives consist of several disks called platters. In each platter, the data is physically placed in concentric circles called tracks. Each track consists of several sectors. The maximum possible number of bits per sector is a constant. As the distance from the center of the platter increases, the circumference of the tracks increases in direct proportion. In early hard drives, all tracks had the same number of sectors. All tracks were arcs with identical measure in angular degrees. Thus, sectors near the edge of the platter were physically longer than those near the center, and the magnetized regions representing data bits were spaced farther apart near the edge of the platter than near the center. As a result, the medium near the outside of each platter was underutilized.

In order to equalize the physical separation between magnetized regions representing bits, sectors should all have the same linear measure, not the same angular measure. In the ideal arrangement, the number of bits, and therefore the number of sectors, per track should vary in direct proportion to the track radius. Zoned-bit recording approaches this ideal by grouping the tracks into sets called zones. Tracks in the inner zones contain the fewest sectors, and tracks in the outer zones contain the most sectors. In this way, the magnetic medium of each platter is utilized as effectively near the outside as near the inside.
A graphical illustration of zoned bit recording. This model hard disk has 20 tracks. They have been divided into five zones, each of which is shown as a different color. The blue zone has 5 tracks, each with 16 sectors; the cyan zone 5 tracks of 14 sectors each; the green zone 4 tracks of 12 sectors; the yellow 3 tracks of 11 sectors, and the red 3 tracks of 9 sectors. You can see that the size (length) of a sector remains fairly constant over the entire surface of the disk (contrast to the non-ZBR) If not for ZBR, if the inner-most zone had its data packed as densely as possible, every track on this hard disk would be limited to only 9 sectors, greatly reducing capacity.

**Effect of Zone Bit Recording**

One interesting side effect of this design is that the raw data transfer rate (sometimes called the media transfer rate) of the disk when reading the outside cylinders is much higher than when reading the inside ones. This is because the outer cylinders contain more data, but the angular velocity of the platters is constant regardless of which track is being read (note that this constant angular velocity is not the case for some technologies, like older CD-ROM drives!) Since hard disks are filled from the outside in, the fastest data transfer occurs when the drive is first used. Sometimes, people benchmark their disks when new, and then many months later, and are surprised to find that the disk is getting slower! In fact, the disk most likely has not changed at all, but the second benchmark may have been run on tracks closer to the middle of the disk. (Fragmentation of the file system can have an impact as well in some cases.)