

Practical 8: Study of Physical and Logical Components of Hard Disk and SSD and Their Interfaces

A computer stores data permanently using storage devices like **Hard Disk Drives (HDDs)** and **Solid State Drives (SSDs)**.

Both devices store data, but their internal structure, working, speed, and technology are very different.

This practical explains:

- Physical components
- Logical components
- Working
- Interfaces (how they connect to motherboard)

2.Hard Disk Drive (HDD)

A **Hard Disk Drive** is an electromechanical storage device that stores data using magnetic platters.

2.1 Physical Components of HDD

1. Platters

- Circular metal disks coated with magnetic material.
- Data is stored magnetically on these surfaces.
- A hard disk usually has 2–8 platters.

2. Spindle

- Central shaft that rotates the platters.
- Speed measured in RPM (5400, 7200, 10000).

3. Read/Write Heads

- Positioned slightly above platter surface.
- They read or write data using magnetic pulses.
- One head for each platter surface.

4. Actuator Arm

- Moves read/write heads to correct track.
- Very fast & precise movement.

5. Actuator (Voice Coil Motor)

- Controls the movement of the actuator arm.
- Works like a speaker coil—high precision.

6. PCB (Printed Circuit Board)

- Controls all HDD functions.
- Manages data transfer, motor speed, cache memory.

7. Head Parking Area

- Safe zone where heads rest when disk is off.

8. Disk Enclosure

- Protective casing to prevent dust and damage.

2.2 Logical Components of HDD

1. Sectors

- Smallest addressable storage unit (usually 512 bytes or 4096 bytes).

2. Tracks

- Concentric circles on a platter.

3. Cylinders

- Tracks aligned across multiple platters.

4. Clusters

- Group of sectors used by OS to store files.

5. File System

- Helps OS manage data.
- Examples: NTFS, FAT32, exFAT.

6. LBA (Logical Block Addressing)

- HDD uses LBA numbers instead of physical location to access data.

2.3 Working of Hard Disk

1. Platters rotate continuously.

2. Actuator arm moves heads to required track.
3. Heads read or write data as magnetic patterns.
4. Data moves through PCB to computer using interface.

2.4 HDD Interfaces (Connections)

1. SATA (Serial ATA)

- Most common in desktops/laptops.
- Speed: 6 Gbps (SATA III).
- Uses **SATA Data Cable + SATA Power Cable**.

2. PATA/IDE (Old)

- Used before SATA.
- 40-pin ribbon cable.

3. SAS (Serial Attached SCSI)

- Used in servers.
- Very fast & reliable.

3. Solid State Drive (SSD)

SSD is a storage device that uses **flash memory chips** instead of spinning disks. It is much **faster, lighter, cooler, and shock-resistant**.

3.1 Physical Components of SSD

1. NAND Flash Chips

- Stores the actual data.
- Works electronically, no moving parts.

2. SSD Controller

- The “brain” of the SSD.
- Manages data flow, wear leveling, bad block management.

3. DRAM Cache (Some SSDs)

- Temporary memory for fast operations.

4. Capacitors (in enterprise SSDs)

- Protect data during sudden power failure.

5. PCB (Circuit Board)

- Holds NAND chips, controller, and other circuits.

6. Enclosure

- Protects the internal components.

3.2 Logical Components of SSD

1. Pages

- Smallest unit of data (4–16 KB).

2. Blocks

- Group of pages (128–512 pages).

3. Over-Provisioned Space

- Reserved space to increase endurance.

4. Wear Leveling

- Controller distributes writes to extend life.

5. TRIM Command

- Helps SSD delete unused blocks to maintain speed.

6. Logical Block Addressing (LBA)

- SSDs use logical addresses just like HDDs.

3.3 Working of SSD

1. Data is written electronically into NAND flash cells.
2. Controller manages addressing, speed, and data integrity.
3. No physical movement → Instant access & high speed.
4. Very low power consumption.

3.4 SSD Interfaces (Connections)

1. SATA SSD

- Looks like 2.5-inch HDD.
- Uses SATA III cable (6 Gbps).
- Slower than NVMe but affordable.

2. M.2 SATA SSD

- Stick-type SSD.
- Uses SATA protocol but smaller form factor.

3. M.2 NVMe SSD

- Uses PCIe lanes.
- Very fast (3500–7000 Mbps).

4. PCIe SSD

- High-performance SSD using PCIe card slot.

5. U.2 SSD

- Used in servers, very fast & reliable.

4. Comparison of HDD and SSD

Feature	HDD	SSD
Speed	Slow	Very fast
Moving Parts	Yes	No
Heat	More	Less
Shock resistance	Low	High
Lifespan	Magnetic wear	Limited write cycles
Cost	Cheaper	Costly
Noise	Audible	Silent