

# Module 6

## Device Subsystems

### Part 1

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# What is a Storage Device?

- According to Oxford Dictionary

*A piece of computer equipment on which information can be stored.*

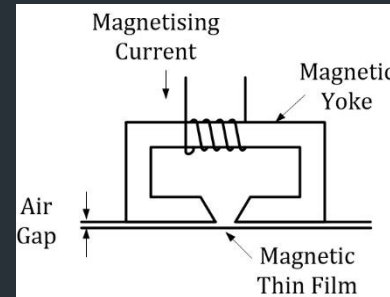
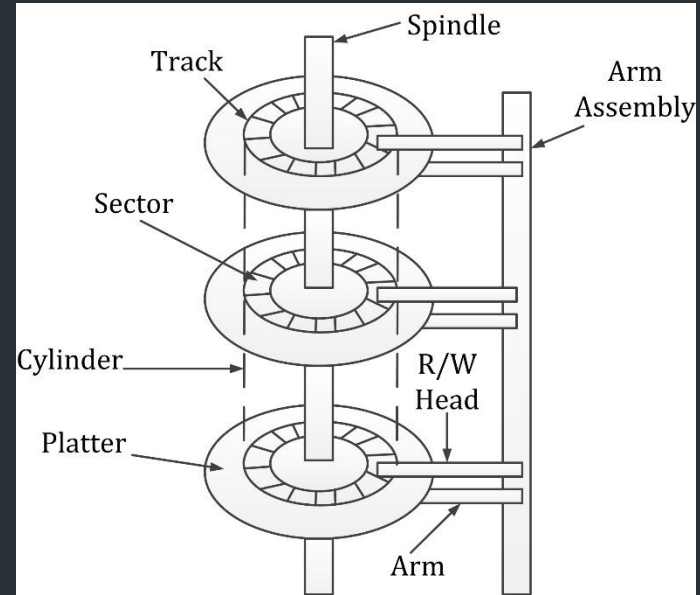


# External Storage Systems

- The Semi-conductor memories (Flash, RAM, EEPROM) are limited to small capacity storage.
- Secondary storage -> Store large amount of data.
- Secondary storage devices included:-
  - Magnetic Disk (Hard Disk).
  - CD, DVD (Optical Drive).
  - Magnetic Tapes.

# Magnetic Disk

- Several disks are placed in a spindle.
- Magnetic film is coated on both sides of the disk.
- The rotary drive is used in which the disk is placed.
- The read write head is in closed proximity with the surface of the disk.
- The head consists of the magnetic yoke and coil.

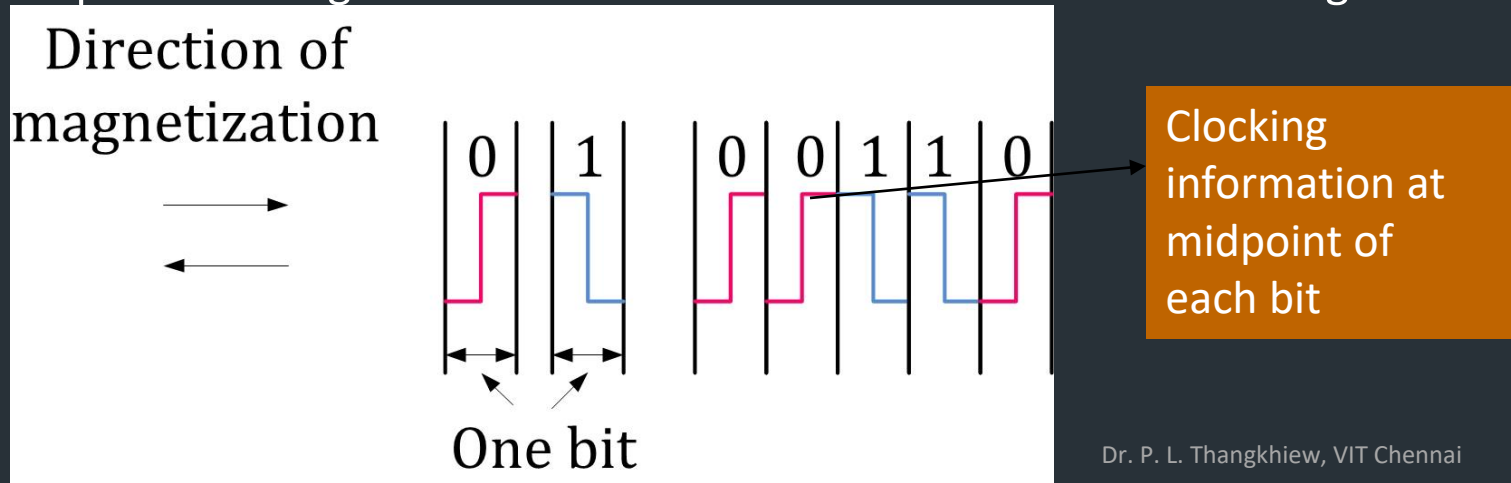


# Magnetic Disk

- A pulse of electric current of suitable polarity is applied to the coil to store digital information.
- Upon applying the current, the film is magnetized and switch its direction parallel to the applied field.
- The change of magnetic field between the head and the movement of the film causes a voltage in the coil, thus the coil acts as a sensing agents.
- A control circuit monitored the polarity of this voltage.

# Magnetic Disk

- The voltage is caused in the head only when the transitions of 0-1 or 1-0 occurs.
- Clock is used for synchronization to read information of long bit stream. Clocking information is combine with the data.
- Example: Encoding schemes such as Phase or Manchester encoding.



# Winchester Hard Disk

- It is a sealed unit that is developed by IBM in Winchester (USA).
- It consists of more platter.
- When the disk is spinning, the head is not contact with the surface.
- A very small gap is maintained between the disk and the head.
- When power is switched off the head rest gently on the disk,
- Robust.
  - Error Correction is automated.
  - Remapping of bad sectors

# Advantages

- It is used widely.
- Price is cheap.
- The speed is relatively fast as compared to its predecessor.
- The size is getting larger with times.
  - 1TB and 2TB is relatively prevalent nowadays.

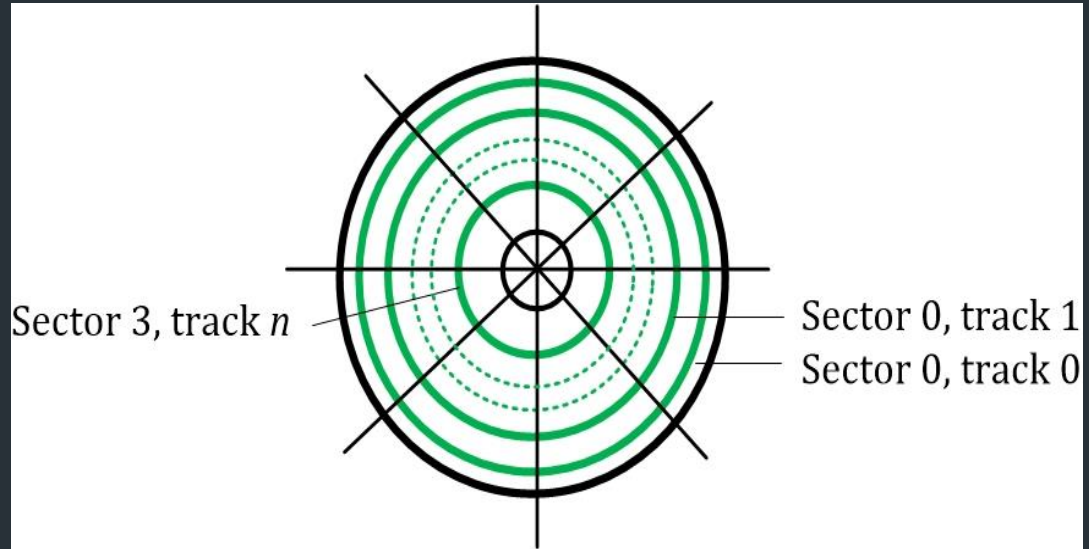


# Parts of the disk system

- Disk Platter – The disk itself.
- Disk drive – This is used to spin the disk and moves the R/W heads.
- Disk Controller
  - Circuit to handle the operation of the disk.
  - Can be implemented as a separate module.

# Organization

- Division is as follow
  - Surface -> Concentric Track -> Sectors
- Logical cylinder
  - Disk stacks together -> set of the corresponding tracks.
- Data accessed
  - Which surface? Surface Number
  - Which Track? Track Number
  - Which Sector? Sector Number
- Initially the R/W starts at the boundaries of the sector.

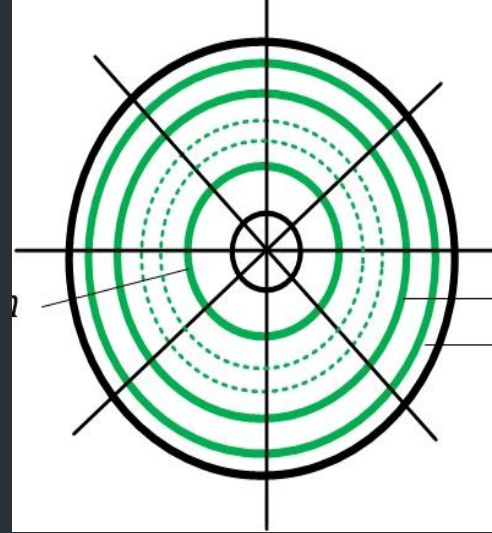


# Sector Head & Error Code Checking

- Storage of bits- Serially on each track. Sector size ~ 512 bytes.
- **Sector header includes:**
  - Identification information.
  - Sector header – Used to go to the intended sector on the track.
- **Error checking code (ECC)-**
  - Error detection and correction.
  - Initially the disk is unformatted and has no information in it.
  - Upon Formatting:-
    - The disk is divided into track and sectors.
    - The bad sectors on tracks are identified by the disk controller to keep such records.

# Organization

- Disk -> Logical partitions
  - Primary partition
  - Secondary partition
- Same number of sectors on each track.
- Which mean all track have same capacity of storage.
- Inner track is more densely packed.



# Access Time

- The two parameters are used to calculate the time elapse to receive an address and the starting of the data transfer.
- Seek time – The total time required for the head to move to the desired track. (Average ~ 5 to 8 ms).
- Rotational delay / Latency time - The time taken to be in the address sector after the R/W head is placed in the right track.  
(Av. ~ Half Rotation of the disk).
- Access Time = Seek Time + Latency

# Problem 1 : Capacity

- A disk has the following specification
  - # of Surface (S)= 8
  - # of Tracks on each surface (T)= 64 T/S,
  - # of Sectors on each tracks (Sec)= 128 Sec/T
  - # of Bytes on each sector (B) = 512 B/Sec.
- Total Capacity =  $S * T * \text{Sec} * B$ 
$$= 8 * 64 * 128 * 512$$
$$= 2^3 * 2^6 * 2^7 * 2^9$$
$$= 2^{25} \text{ Bytes} = 32 \text{ MB}$$

# Problem 2: Data Transfer Rate

- Consider

- Disk is rotating at 3600 rpm
- $S_u = 8$  surfaces
- $T = 64$  tracks per surface,
- $Sec = 128$  sectors per track
- $B = 512$  bytes per sector.

- Data Transfer Rate

= # of Head \* Total Capacity of a track \* # of rotations in 1 sec.

- Number of Heads = Number of Surface = 8
- Capacity of one track =  $Sec * B = 128 * 512$
- Number of rotation in one sec =  $(3600 / 60)$  rotations per sec.
- 60 rotations/sec
- Data Transfer Rate =  $8 * (128 * 512) * 60$  bytes/sec
- $2^3 * 2^7 * 2^9 * 60$  bytes/sec.
- $2^{19} * 2 * 30 = 30$  MBps

# Problem 3: Average Access Time

- Consider
  - Rotational speed = 1800 RPM.
  - Seek time (ST) = 5.5 ms.
- Av. Access Time.
  - Time reqd. for a full rotation.
    - $(60/1800) = (1/3) = 0.0333 = 33.33 \text{ ms.}$
  - Av. rotational Time
    - $\frac{1}{2} * \text{Time reqd. for a full rotation}$
    - $\frac{1}{2} * 33.33 \text{ msec} = 16.665 \text{ ms.}$
  - Av. Access time = Av. ST + Av. rotational time
    - = 5.5 ms + 16.665 ms
    - = 22.165 ms



# Problem 4: Average Access Time

- Consider
  - Rotational speed = 1800 RPM.
  - Seek time = 5.5 msec.
  - Amount of Data to be transferred = 1 Kbytes
  - Data Rate = 80 KB/sec
- Time taken for one full rotation =  $(60/1800) = 0.0333 \text{ sec} = 33.33 \text{ ms}$
- Av. Rot. Delay =  $\frac{1}{2} * \text{time taken for one full rotation} = \frac{1}{2} * 33.33 = 16.665 \text{ ms}$
- Transfer time =  $(1 \text{ KB} / 80 \text{ KB/sec}) = 12.5 \text{ ms}$ .
- Av. Access Time = Av. Seek Time + Av. Rot. Delay + Transfer time
  - =  $5.5 \text{ ms} + 16.665 \text{ ms} + 12.5 \text{ ms}$
  - =  $34.665 \text{ ms}$


# Data Buffer or Data Cache

- The disk drive is coupled to other components of the computer using connection type such as SCSI or SATA
- This scheme enables faster transfer rate of as compared to which the data can be read from the disk.
- This is achieved by using a data buffer. It is a semiconductor storage device.
- Cache mechanism

# Disk Controller

- The disk controller circuit is responsible for controlling the operation of the disk drive.



- Same communication as IO interface is used between OS and disk controller.
- Transfer of Data : Controller used DMA scheme
  - Disk  Main Memory

# How does the transfer works?

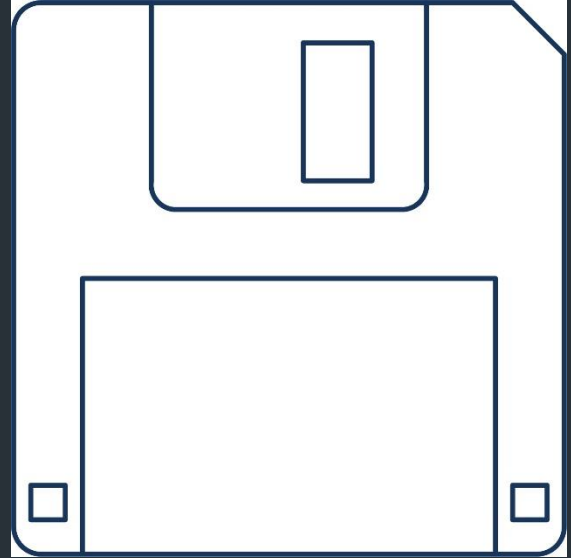
- The buffer in the disk controller holds the data to be written/read to other/itself.
- OS -> transfers by issuing R and write request.
- Controller registers are loaded with the necessary addressing and control information.
  - Address of 1<sup>st</sup> main memory of the block required to transferred.
  - Disk address- Sector location containing the initial of the intended blocks of words
  - Words count – Amount of words required to transferred.

# Disk Controller Major Functions

- Seek – The read write head -> intended track.
- Read- Starts a read operation. The data from disk are put in the buffer for transfer in the main memory. The word count kept track of the number of words to be transferred.
- Write- Transfers data to the disk
- Error Checking – Computes Error checking codes (ECC)

# Floppy Disks

- Shutter – opens when inserted in the computer.
- Write protect can be enable by opening the notch
- Tracks – closed concentric circle
- Sectors- wedge shaped sections on the disk.



# RAID Disk Arrays

- University of California-Berkeley first proposed to use multiple disks operating in parallel to reduce access time
- It is called as Redundant Array of Inexpensive Disks (RAID).
- Basic configuration -> RAID 0 -> Data stripping -> large files into number of pieces spread across different disks
- RAID 1- storing identical copies -> improve reliability.

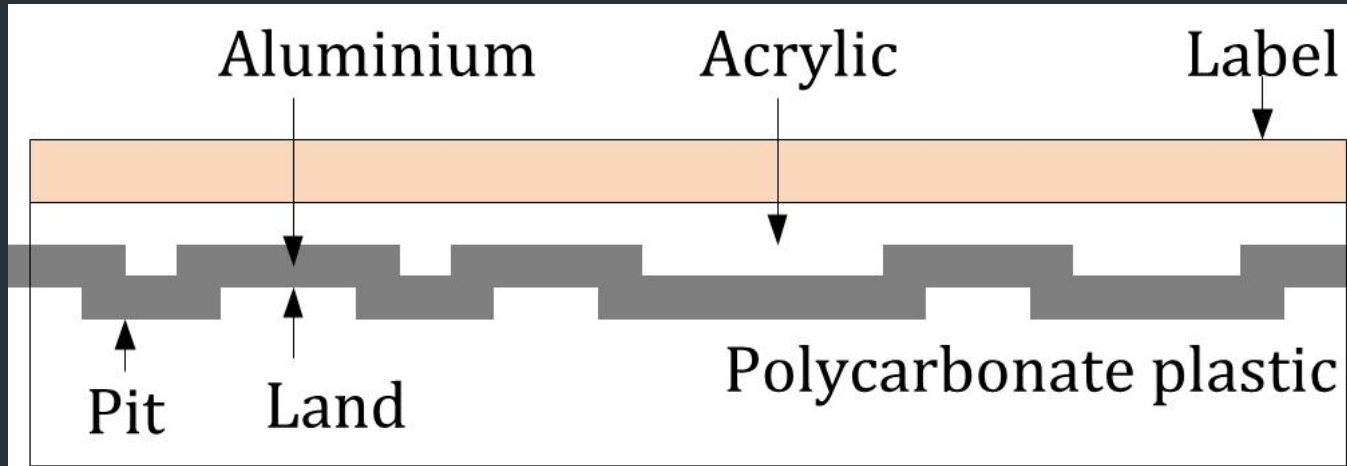
# Optical Disks

- Laser beam and photodetector are used
- Encodes binary data (bits) in the form of pits and lands.
- Pits:- 0 or OFF, No/Lack of reflection
- Lands:- 1 or ON, reflection when read.

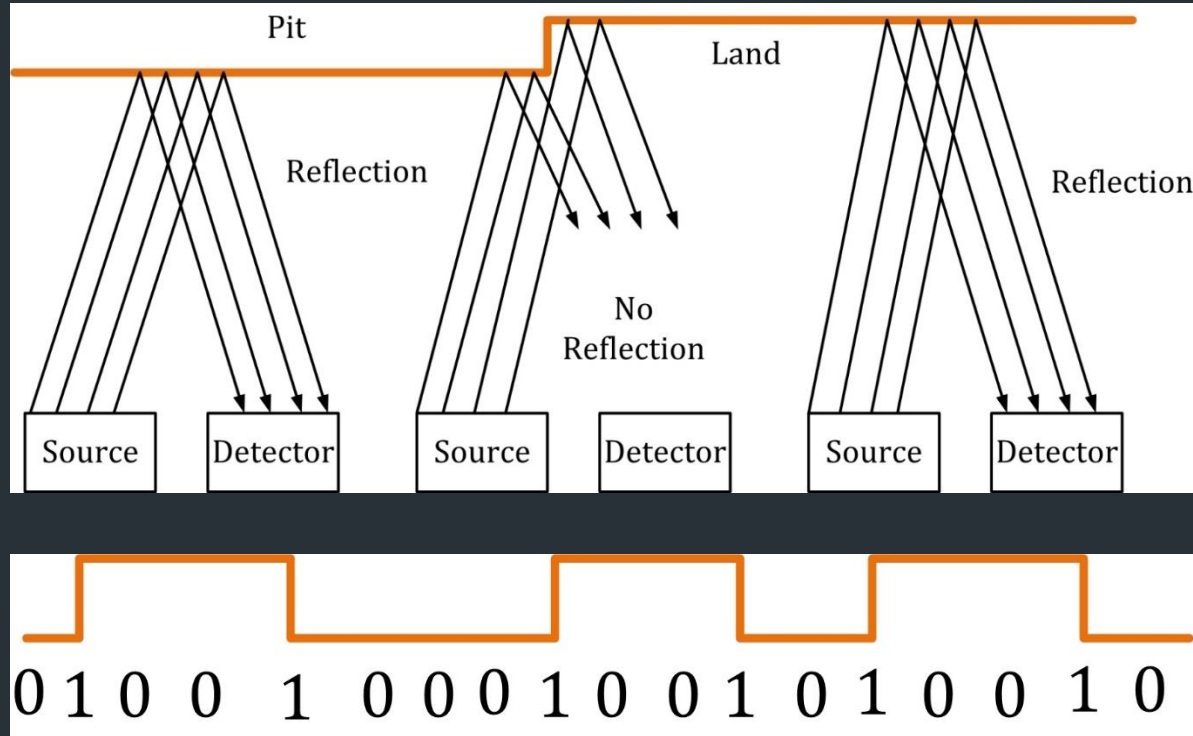




# Cross Section



# Transition from Pit to Land



# Magnetic Tapes

- Magnetic tape primarily used for magnetic recording.
- A thin narrow plastic film is coated with magnetizable element.
- The concept originated in Germany in 1928.
- Examples: Tape Recorder, video tape recorder, and on computer a tape drive.





# Thank you

## References

- Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Naraig Manjikian - Computer organization and embedded systems (2011, McGraw-Hill)