

**Department of Computer Science and Engineering**

Subject Name: **COMPUTER HARDWARE AND NETWORK TROUBLESHOOTING**

Subject Code: **CS T72**

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**UNIT – III**

**Primary Memory:** Basics- RAM types and performance – Fast page mode DRAM – EDO RAM –

SDRAM – DDRx RAM – RDRAM - Memory modules: SIMM, DIMM, DDR DIMM – Memory banks –

Parity and ECC – logical memory layout.

**Secondary Storage:** Magnetic Storage: Data Encoding Schemes - Hard disk drive – SATA. Flash memory devices: CompactFlash, MMC, SecureDigital, SSD, RAMdisk, USB Flash disks. Optical Storage - CD, DVD, BD – Disk formats - Optical Drive Performance specifications - Troubleshooting

memory problems.

**1. Write few memory types?**

**2 Marks**

RAM: Read Access Memory

ROM: Read Only Memory

PROM: Programmable Read Only Memory

EPROM: Erasable Programmable Read Only Memory

EEPROM: Electrically Erasable Programmable Read Only Memory

Flash Memory

**2. What are two categories of Memory?**

**Volatile memory:** The data stored in the memory will be erased once the supply voltage removed. **Non volatile memory:** The data stored in the memory will Not be erased if the supply

voltage removed.

**3. What are the two types of semiconductor memory? (NOV 2014)**

• Static RAM (SRAM)

• Dynamic RAM (DRAM)

**4. Define RAM?**

**Random access memory** (usually known by its [acronym, **RA**](http://en.wikipedia.org/wiki/Acronym)**M**) is a type of [data store u](http://en.wikipedia.org/wiki/Data_storage)sed in [computers t](http://en.wikipedia.org/wiki/Computer)hat allows the stored [data to](http://en.wikipedia.org/wiki/Data) be accessed in any order —at [random, n](http://en.wikipedia.org/wiki/Random_access)ot just [i](http://en.wikipedia.org/wiki/Sequential_access)n

[sequence.](http://en.wikipedia.org/wiki/Sequential_access)

**5. What is Memory Module?**

**Memory module** is a broad term used to refer to a series of [dynamic random access memory](http://en.wikipedia.org/wiki/Dynamic_random_access_memory) [integrated circuits m](http://en.wikipedia.org/wiki/Integrated_circuit)odules mounted on a [printed circuit board a](http://en.wikipedia.org/wiki/Printed_circuit_board)nd designed for use in [persona](http://en.wikipedia.org/wiki/Personal_computer)l

[computers,](http://en.wikipedia.org/wiki/Personal_computer) [workstations a](http://en.wikipedia.org/wiki/Workstation)nd [servers.](http://en.wikipedia.org/wiki/Server_%28computing%29)

**6. What are the types of RAM module? (NOV 2013)**

DIP 18-pin (DRAM chip, usually pre-FPRAM)[ [Dual in-line package m](http://en.wikipedia.org/wiki/Dual_in-line_package)emory]

SIPP (usual[ly FPRAM)](http://en.wikipedia.org/w/index.php?title=FPRAM&action=edit)[Single in-line pin package memory]

SIMM 30-pin (usually FPRAM)[ single in-line memory module]

SIMM 72-pin (so-called "PS/2 SIMM", usually [EDO RAM)](http://en.wikipedia.org/wiki/EDO_RAM)

DIMM 168-pin, 184-pin, etc., ([SDRAM)](http://en.wikipedia.org/wiki/SDRAM)[ dual in-line memory module]

**7. How to troubleshoot memory problems?**

Back up your system.

Check your hardware and system configuration.

Reinstall the computer memory modules.

**8. What is Floppy?**

A floppy disk, like a cassette tape, is made from a thin piece of plastic coated with a magnetic

material on both sides. However, it is shaped like a disk rather than a long thin ribbon. The tracks are arranged in **concentric rings** so that the software can jump from "file 1" to "file 19" without having to fast forward through files 2-18. The diskette spins like a record and the heads move to the correct track, providing what is known as **direct access storage**.

**9. What is mean by disk and diskette? (APR 2012)**

A diskette is a random access, removable data storage medium that can be used with personal

computers. The term usually refers to the magnetic medium housed in a rigid plastic cartridge measuring 3.5 inches square and about 2millimeters thick. Also called a "3.5-inch diskette,"

These were sometimes called "floppy disks" or "floppies" because their housings are flexible.

5.25-inch

**10. What is Floppy Disk Drive?**

The floppy disk drive (**FDD**) was invented at IBM by Alan Shugart in 1967. The first floppy

drives used an 8-inch [disk (](http://electronics.howstuffworks.com/hard-disk.htm)later called a "**diskette**" as it got smaller), which evolved into the 5.25- inch disk that was used on the first IBM Personal Computer in August 1981. The 5.25-inch disk held 360 kilobytes compared to the 1.44 megabyte capacity of today's 3.5-inch diskette. The 5.25- inch disks were dubbed "**floppy**" because the diskette packaging was a very **flexible plastic envelope**, unlike the rigid case used to hold today's 3.5-inch diskettes.

**11. Write the parts of a Floppy?**

A floppy disk is a lot like a [cassette tape:](http://electronics.howstuffworks.com/cassette.htm)

Both use a thin plastic base material coated with iron oxide. This oxide is a **ferromagnetic**

material, meaning that if you expose it to a magnetic field it is permanently magnetized by the field.

Both can record information instantly.

Both can be erased and reused many times.

Both are very inexpensive and easy to use.

**12. Differentiate hard sector and soft sector disk. (APR 2011)**

**13. Classify the floppy diskette according to the sector organisation. (NOV 2014)**

Depending on the sector organisation, the floppy diskette is classified into two types:

**1.** Hard sectored floppy diskette – the no. of sectors on each track is physically fixed while manufacturing

**2.** Soft Sectored floppy diskette - tracks are divided into sectors while formatting the disk

**14. What are the two formats for recording on a magnetic disk? (APR 2011)**

The *constant linear velocity* (CLV) format optimizes utilisation of the usable recording area by having an uniform recording density throughout the disk.

*Zoned constant angular velocity* (ZCAV) reduces the inefficiencies of the CAV format by dividing the disk into typically five zones.

**15.Differentiate single and dual head assembly drive. (NOV 2010)**

In a single head assembly drive, there is one head for each surface. All these are mounted on

one spindle and always move together. At a given time all the heads are positioned on same cylinder.

In a dual head assembly drive, there are two heads for each surface. One set of heads covers the

first half of the cylinder and the second set of heads covers the second half of cylinder.

**16. What is the hard disk and how does it work? (NOV 2012)**

A **hard disk** (commonly known as a *hard disk drive* or *hard drive* and formerly known as a

*fixed disk*) is a digitally encoded [non-volatile storage d](http://en.wikipedia.org/wiki/Non-volatile_storage)evice which stores data on rapidly rotating

[platters w](http://en.wikipedia.org/wiki/Hard_disk_platters)ith [magnetic s](http://en.wikipedia.org/wiki/Magnetic)urfaces.

**17.Write any two common aspects between HDD and FDD. (NOV 2012)**

Both are having Magnetic Disks

Both disks having tracks and sectors

HDD and FDD to spindle disks using spindle motor

Heads are used to read and write datas on the disk

**18. Write about serial ATA. (NOV 2013)**

Serial ATA (Serial Advanced Technology Attachment or SATA) is a new standard for connecting hard drives into computer systems. As its name implies, SATA is based on serial signaling

technology, unlike current IDE ([Integrated Drive Electronics)](http://searchstorage.techtarget.com/definition/IDE) hard drives that use parallel signaling.

**19. What is PATA?**

Parallel ATA (PATA) is an [IDE s](http://pcsupport.about.com/od/termshm/g/idecable.htm)tandard for connecting storage devices like [hard drives a](http://pcsupport.about.com/od/componentprofiles/p/p_hdd.htm)nd [optica](http://pcsupport.about.com/od/componentprofiles/p/p_odd.htm)l [drives t](http://pcsupport.about.com/od/componentprofiles/p/p_odd.htm)o the [motherboard.](http://pcsupport.about.com/od/componentprofiles/p/p_mobo.htm) PATA generally refers to the types of cables and connections that follow

this standard.

**20. Define SCSI?**

Small Computer System Interface (SCSI is a set of standards for physically connecting and transferring data between computers and [peripheral devices. T](http://en.wikipedia.org/wiki/Peripheral_device)he SCSI standards define [commands,](http://en.wikipedia.org/wiki/SCSI_command)

protocols, and electrical and optical [interfaces. S](http://en.wikipedia.org/wiki/Interface_%28computer_science%29)CSI is most commonly used for hard disks and tape drives, but it can connect a wide range of other devices, including scanners and [CD](http://en.wikipedia.org/wiki/CD-ROM) [drives.](http://en.wikipedia.org/wiki/Optical_drive)

**21. Define CD?**

The **Compact Disc** (also known as a **CD**) is an [optical disc u](http://en.wikipedia.org/wiki/Optical_disc)sed to store [digital data.](http://en.wikipedia.org/wiki/Data_%28computing%29) It was originally

developed to store and play back sound recordings only, but the format was later adapted for storage of data ([CD-ROM)](http://en.wikipedia.org/wiki/CD-ROM), write-once audio and data storage ([CD-R)](http://en.wikipedia.org/wiki/CD-R), rewritable media ([CD-RW)](http://en.wikipedia.org/wiki/CD-RW), Video Compact Discs ([VCD](http://en.wikipedia.org/wiki/VCD)), Super Video Compact Discs ([SVCD](http://en.wikipedia.org/wiki/SVCD)), PhotoCD, PictureCD, CD-i, and Enhanced CD. Standard CDs are available in two sizes. By far, the most common is 120 millimetres (4.7 in) in diameter, with a 74- or 80-minute audio capacity and a 650 or 700 MB data capacity.

**22.** What is DVD? **(APR 2012)**

**DVD** (commonly "**Digital Versatile Disc**", previously "**Digital Video Disc**") is an [optical disc](http://en.wikipedia.org/wiki/Optical_disc) [storage m](http://en.wikipedia.org/wiki/Computer_storage)edia format that can be used for [data storage,](http://en.wikipedia.org/wiki/Data_storage) including movies with high video and sound quality. DVDs resemble [compact discs a](http://en.wikipedia.org/wiki/Compact_disc)s their physical dimensions are the same (120 mm (4.72 inches) or occasionally 80 mm (3.15 inches) in diameter), but they are encoded in a different format and at a much higher density.

**23.Write the DVD disc capacity.**

**Single layer capacity Dual/Double layer capacity**

**Physical size** [**GB**](http://en.wikipedia.org/wiki/Byte) [**GiB GB**](http://en.wikipedia.org/wiki/Gibibyte) **GiB**

12 [cm, s](http://en.wikipedia.org/wiki/Cm)ingle sided 4.7 4.38 8.5 7.92

12 cm, double sided 9.4 8.75 17.1 15.93

[8 cm, s](http://en.wikipedia.org/wiki/MiniDVD)ingle sided 1.4 1.30 2.6 2.42

[8 cm, d](http://en.wikipedia.org/wiki/MiniDVD)ouble sided 2.8 2.61 5.2 4.84

**24.Difference between CD and DVD?**

CD is short for compact disc. DVD initially stood for digital video disc, then digital versatile disc, but

today the term DVD is often used without referring to a specific set of words. Both CDs and DVDs are optical media, meaning media that use light technology (more specifically, laser light) for data retrieval. A disc drive focuses a laser light beam into the CD or DVD to ―read‖ the bits (data) in the disc. The drive can also ―write‖ bits by focusing the laser beam into recordable CDs or DVDs. The laser reads and writes data starting from the center of the disc and proceeding in a spiral direction toward the outer edge. A pre-groove is stamped in all blank recordable and rewritable CDs and DVDs to guide the laser as it writes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CD-** CD-ROM Audio/Video | **DVD-** DVD-ROM Video/Audio | **Type**  Read only | **Data Layer**  Molded | **Metal Layer** Aluminum (also silicon, |
| and PC use | and PC use |  |  | gold, or silver  in double |
| CD-R | DVD-R | Recordable | Organic dye | layered DVDs)  Gold, silver, or |
|  | DVD+R | (Write once  only) |  | silver alloy |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| CD-RW | DVD-RW | Rewritable | Phase- | Aluminum |
|  | DVD+RW  DVD-RAM | (Write, erase,  and re-write) | changing metal  alloy film |  |

**25.What is the function of the memory? (NOV 2012)**

The computer memory is a [temporary](http://simple.wikipedia.org/wiki/Temporary) [storage](http://simple.wikipedia.org/wiki/Storage) [area.](http://simple.wikipedia.org/wiki/Area) It holds the [data a](http://simple.wikipedia.org/wiki/Information)nd instructions that the

Central Processing Unit ([CPU)](http://simple.wikipedia.org/wiki/CPU) needs. Before a [program c](http://simple.wikipedia.org/wiki/Computer_program)an be run, the program is [loaded f](http://simple.wikipedia.org/wiki/Load)rom some [storage medium i](http://simple.wikipedia.org/wiki/Storage_medium)nto the memory. This allows the CPU direct access to the program. Memory is a need for any [computer.](http://simple.wikipedia.org/wiki/Computer)

**11 MARKS**

**1. What is Memory? Explain the types of memory.**

**2. How memory works with the processor? Discuss. (NOV 2012)**

**Basics of Memory**

*Memory* is the workspace for the processor. It is a temporary storage area where the programs and

data being operated on by the processor must reside.

Main memory is called RAM which can randomly access any location.

Primary memory workspace the processor uses to run programs called dynamic RAM (DRAM)

DRAM chip store data dynamically. Information in DRAM can be written repeatedly at any time. It requires the data to be refreshed every few milliseconds.

SRAM static RAM does not require the periodic refreshing.

Thus RAM stores data as long as the memory has electrical power.

1. **Memory cell** : A device or electrical circuit that can store a bit (0 or 1). A group of cells or bits in a memory that represents instructions or data.

2. **Memory word** :

3. **Byte** : A byte is a group of 8 bits. A number which identifies the location of a word in the memory. Each word location has a specific unique binary address.

4. **Address** :

**Read (Fetch)** : Take the data out from the memory.

5**.Write operation** : Store the data in to the memory. A way to specify how many bits can be stored in a memory.

6. **Capacity (Density)** : A memory capacity will be written in form of 4096 X 20 4096 is number of words & 20 is number of bits per word.

Where : That means this memory has a total of 81920 bit. In computer knowledge kilo equals to 1024, so 1 kw means 1024 word, we can write 4096 X 20 as 4K X 20.

7. **Memory Enable (ME)** : Used to disable or enable the operation of the Memory.

|  |  |  |
| --- | --- | --- |
|  | **Memory cells** | **Addresses** |
| Word 1 | 0 1 1 0 | 0 0 0 0 0 |
| Word 2 | 1 0 0 1 | 0 0 0 0 1 |
| Word 3 | 1 1 1 1 | 0 0 0 1 0 |
| Word 4 | 0 0 0 0 | 1 0 0 1 1 |
| .. |  |  |
| Word 32 | 0 1 1 1 | 1 1 1 1 1 |

Fig(1). memory R/W Operation

The above is representation of a memory system and how bits are stored in it. Each word has its own address in which we refer to it for write or read operations. For example Word 1 consists of data 0110 and stored in location 00000, word 2 consists of data 1001 and stored in location 00001 and so on. The above figure is example for 32 X 4 Memory system..

**Memory Categories**

Basically memories divided in to two categories,

**Volatile memory:** The data stored in the memory will be *erased* once the supply voltage removed.

**Non volatile memory:** The data stored in the memory will *Not be erased* if the supply voltage removed.

**Memory Types**

1. **RAM: R**ead **A**ccess **M**emory. R/W Operation can be performed at any selected address at any

sequence. It is used in place that has a fix operation such as start-up of the PC, game players..etc. Most

RAM is volatile.

2. **ROM: R**ead **O**nly **M**emory. They are programmed at the factory at the time of manufacture. Once data has been written onto a ROM chip, it cannot be erased and can only be read. ROM is a Nonvolatile memory.

3. **PROM: P**rogrammable **R**ead **O**nly **M**emory. It is a one time use, once the data stored in the PROM

you cannot wipe it and use it to store something else. PROMs are Nonvolatile.

4. **EPROM: E**rasable **P**rogrammable **R**ead **O**nly **M**emory. EPROM is a special type of memory that

retains its contents until it is exposed to ultraviolet light through its glass window on the top.

5. **EEPROM: E**lectrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory. It is a special type of PROM

that can be erased by exposing it to an electrical charge.

6. **Flash Memory**: It is type of EEPROM memory except that EEPROM Read and Write operations are

performed in bytes. However, Flash memory Read and Write operations are performed in blocks, this feature makes it faster for data update.

**Random Access Memory**

**Random access memory** (usually known by its [acronym, **RA**](http://en.wikipedia.org/wiki/Acronym)**M**) is a type of [data store u](http://en.wikipedia.org/wiki/Data_storage)sed in [computers t](http://en.wikipedia.org/wiki/Computer)hat allows the stored [data to](http://en.wikipedia.org/wiki/Data) be accessed in any order — that is, at [random, n](http://en.wikipedia.org/wiki/Random_access)ot just [i](http://en.wikipedia.org/wiki/Sequential_access)n

[sequence. I](http://en.wikipedia.org/wiki/Sequential_access)n contrast, other types of memory devices (such as [magnetic tapes, d](http://en.wikipedia.org/wiki/Magnetic_tape)isks, and drums) can access data on the storage medium only in a predetermined order due to constraints in their mechanical

design.

**Common Manufacturers:**

[Corsair Memory](http://en.wikipedia.org/wiki/Corsair_Memory)

[Kingston Technology](http://en.wikipedia.org/wiki/Kingston_Technology)

[Micron Technology](http://en.wikipedia.org/wiki/Micron_Technology)

[Samsung](http://en.wikipedia.org/wiki/Samsung)

[Others](http://en.wikipedia.org/wiki/Random_access_memory#RAM_manufacturers)

It costs practically the same time to access any piece of data stored in a RAM chip. In contrast,

[disks a](http://en.wikipedia.org/wiki/Hard_disk_drive)nd the like need a short time to retrieve a piece of data if it happens to be close to the current position of the read head, and a long time if the data is far away and the head needs to be repositioned considerably.

Generally, RAM in a computer is considered *main memory* or [primary storage:](http://en.wikipedia.org/wiki/Primary_storage) the working area

used for loading, displaying and manipulating applications and data. This type of RAM is usually in the form of [integrated circuits (](http://en.wikipedia.org/wiki/Integrated_circuit)ICs). These are commonly called *memory sticks* or *RAM sticks* because they are manufactured as small [circuit boards w](http://en.wikipedia.org/wiki/Circuit_board)ith plastic packaging and are about the size of a few sticks of chewing gum. Most [personal computers h](http://en.wikipedia.org/wiki/Personal_computer)ave slots for adding and replacing memory sticks.

Most RAM can be both written to and read from, so "RAM" is often used interchangeably with "[read- write memory."](http://en.wikipedia.org/wiki/Read-write_memory) In this sense, RAM is the "opposite" of [ROM,](http://en.wikipedia.org/wiki/Read-only_memory) but in a more true sense, of [sequential access m](http://en.wikipedia.org/wiki/Sequential_access)emory.

**Overview**

[Computers u](http://en.wikipedia.org/wiki/Computer)se RAM to hold the program code and data during computation. A defining characteristic of RAM is that all memory locations can be accessed at almost t he same speed. Most

other technologies have inherent delays for reading a particular [bit o](http://en.wikipedia.org/wiki/Bit)r [byte.](http://en.wikipedia.org/wiki/Byte)

Many types of RAM are *volatile*, which means that unlike some other forms of computer

storage such as [disk storage a](http://en.wikipedia.org/wiki/Disk_storage)nd [tape storage,](http://en.wikipedia.org/wiki/Tape_storage) they lose all data when the computer is powered down. Modern RAM generally stores a bit of data as either a [charge i](http://en.wikipedia.org/wiki/Electric_charge)n a [capacitor,](http://en.wikipedia.org/wiki/Capacitor) as in [dynamic RAM, o](http://en.wikipedia.org/wiki/Dynamic_random_access_memory)r the state of a [flip-flop, a](http://en.wikipedia.org/wiki/Flip-flop_%28electronics%29)s in [static RAM.](http://en.wikipedia.org/wiki/Static_random_access_memory)

Software can "partition" a portion of a computer's RAM, allowing it to act as a much faster [hard drive](http://en.wikipedia.org/wiki/Hard_drive)

that is called a [RAM disk. U](http://en.wikipedia.org/wiki/RAM_disk)nless the memory used is non-volatile, a RAM disk loses the stored data when the computer is shut down. However, volatile memory can retain its data when the computer is shut down if it has a separate power source, usually a [battery. S](http://en.wikipedia.org/wiki/Battery_%28electricity%29)ome types of RAM can detect or correct random faults called *memory errors* in the stored data, using [RAM parity.](http://en.wikipedia.org/wiki/RAM_parity)

**Shadow RAM**

**Shadow RAM** is RAM whose contents are copied from [read-only memory (](http://en.wikipedia.org/wiki/Read-only_memory)ROM) to allow

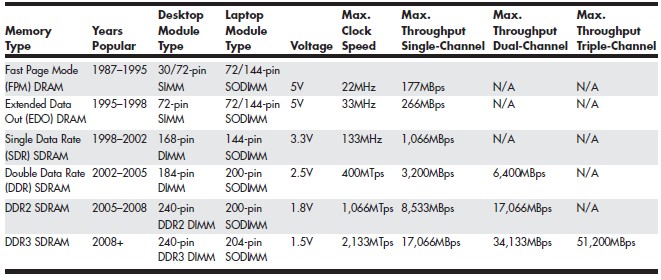
shorter access times, as ROM is in general slower than RAM. The original ROM is disabled and the new location on the RAM is write-protected. This process is called **shadowing**.

**DRAM packaging**

For economical reasons, the large (main) memories found in personal computers, workstations,

and non-handheld game-consoles (such as playstation and Xbox) normally consist of [dynamic RAM](http://en.wikipedia.org/wiki/Dynamic_RAM) ([DRAM)](http://en.wikipedia.org/wiki/DRAM). Other parts of the computer, such as [cache memories a](http://en.wikipedia.org/wiki/Cache_memory)nd data buffers in hard disks, normally use [static RAM (](http://en.wikipedia.org/wiki/Static_RAM)[SRAM).](http://en.wikipedia.org/wiki/SRAM)

**Table PC Memory Types and Performance Levels**



*MHz = Million cycles per second MTps = Million transfers per second MBps = Million bytes per second DIMM = Dual inline memory module SODIMM = Small outline DIMM SIMM = Single inline memory module*

*RIMM = Rambus inline memory module.*

**FAST PAGE MODE DRAM**

Standard DRAM is accessed through a technique called *paging*. Normal memory access requires that a row and column address be selected, which takes time. Paging enables faster access to all the data within a given row of memory by keeping the row address the same and changing only the column. Memory that uses this technique is called *Page Mode* or *Fast Page Mode* memory.

Paged memory is a simple scheme for improving memory performance that divides memory into pages ranging from 512 bytes to a few kilobytes long. The paging circuitry then enables memory locations in a page to be accessed with fewer wait states. If the desired memory location is outside the current page, one or more wait states are added while the system selects the new page.

One important change was the implementation of burst mode access. After setting up the row and column addresses for a given access, using burst mode, you can then access the next three adjacent addresses with no additional latency or wait states. A burst access usually is limited to four total accesses. A burst mode access of standard DRAM is expressed as x-y-y-y; x is the time for the first access and y represents the number of cycles required for each consecutive access.

Standard 60ns-rated DRAM normally runs 5-3-3-3 burst mode timing. This means the first access takes a total of five cycles (on a 66MHz system bus, this is about 75ns total, or 5 × 15ns cycles), and the consecutive cycles take three cycles each (3 × 15ns = 45ns).

DRAM memory that supports paging and this bursting technique is called Fast Page Mode

(FPM) memory. Most 386, 486, and Pentium systems from 1987 through 1995 used FPM memory, which came in either 30-pin or 72-pin SIMM form.

Another technique for speeding up FPM memory is called interleaving. In this design, two separate banks of memory are used together, alternating access from one to the other as even and odd bytes. While one is being accessed, the other is being precharged, when the row and column addresses are

being selected. Then, by the time the first bank in the pair is finished returning data, the second bank in the pair is finished with the latency part of the cycle and is now ready to return data. While the second bank is returning data, the first bank is being precharged, selecting the row and column address of the next access. This overlapping of accesses in two banks reduces the effect of the latency or precharge cycles and allows for faster overall data retrieval.

**EXTENDED DATA OUT RAM**

Extended data out (EDO) RAM is also called as hyper page mode. EDO was invented and patented by Micun Technology.

EDO memory consists of specially manufactured chips that allow a timing overlap between successive accesses. the data output drivers on the chip are not turned off when the memory controller removes the column address to begin the next cycle. This enables the next cycle to overlap the previous one, saving approximately 10ns per cycle.

The effect of EDO is that cycle times are improved by enabling the memory controller to begin a new column address instruction while it is reading data at the current address. This is similar to older systems but EDO didn’t need to install two identical banks of memory in the system at a time.

EDO RAM allows for burst mode cycling of 5-2-2-2, compared to the 5-3-3-3 of standard fast page mode memory. To do four memory transfers, then, EDO would require 11 total system cycles, compared to 14 total cycles for FPM. This is a 22% improvement in overall cycling time.

EDO uses the same basic DRAM chip design as FPM, and thus no additional cost over FPM. Thus EDO cost less and offers higher performance. EDO RAM generally came in 72-pin SIMM form. To use EDO memory, motherboard chipset had to support it.

EDO memory chips cost the same to manufacture as standard chips, combined with Intel’s support

of EDO. EDO RAM was used in systems with CPU bus speeds of up to 66MHz, upto 1998. After,

1998, with the advent of 100MHz and faster system bus speeds declined EDO by faster SDRAM.

Later EDO was extended by BEDO as burst EDO(BEDO). BEDO added burst capabilities for even speedier data transfers than standard EDO. But BEDO was overridden by SDRAM quickly.

**SDRAM**

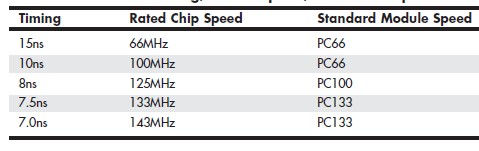
SDRAM is short for synchronous DRAM, runs in synchronization with the memory bus. SDRAM delivers information in very high-speed bursts using a high-speed clocked interface. SDRAM removes most of the latency involved in asynchronous DRAM because the signals are already in synchronization with the motherboard clock.

SDRAM performance is improved over that of FPM or EDO RAM. In SDRAM the initial latency is the same, but burst mode cycle times are much faster than with FPM or EDO. This is 20% faster than EDO.

SDRAM is sold in DIMM form and is normally rated by clock speed (MHz) rather than cycling time

(ns).

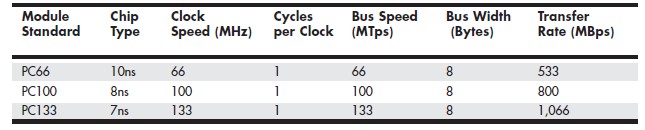
**Table SDRAM Timing, Actual Speed, and Rated Speed**



The Joint Electron Device Engineering Council (JEDEC) created a specification called PC133. It achieved this 33MHz speed increase by taking the PC100 specification and tightening up the timing and capacitance parameters.

These faster chips were still used on PC133 modules, but they allowed for improvements in column address strobe latency (abbreviated as CAS or CL), which improves overall memory cycling time. Table shows the standard single data rate SDRAM module speeds and resulting throughputs.

**Table JEDEC Standard SDRAM Module (168-pin DIMM) Speeds and Transfer Rates**

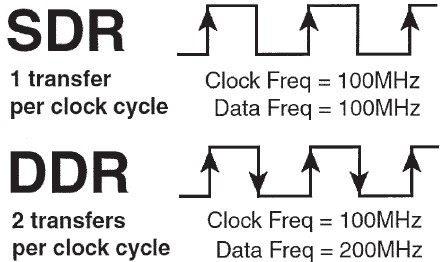


*MTps = Megatransfers per second MBps = Megabytes per second*

*ns = Nanoseconds (billionths of a second) DIMM = Dual inline memory module*

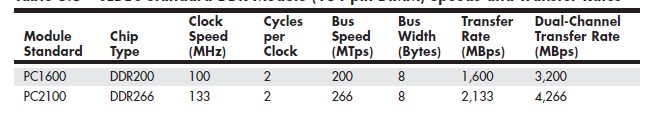
**DDR SDRAM**

Double data rate (DDR) SDRAM memory is a JEDEC standard that is an evolutionary upgrade in which data is transferred twice as quickly as standard SDRAM. Instead of doubling the actual clock rate, DDR memory achieves the doubling in performance by transferr ing twice per transfer cycle: once at the leading (falling) edge and once at the trailing (rising) edge of the cycleas shown in figure.



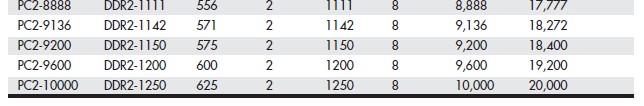
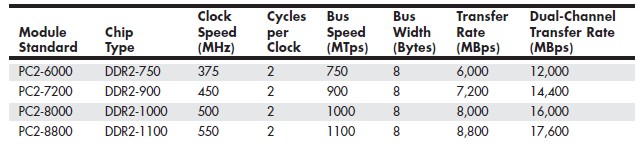
**Figure** SDR (single data rate) versus DDR (double data rate) cycling.

This effectively doubles the transfer rate, even though the same overall clock and timing signals are used. From 2002 through 2005, DDR was the most popular . DDR SDRAM uses a DIMM module design with 184 pins.

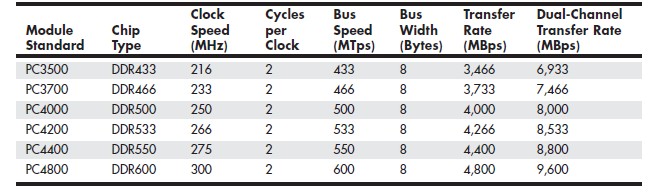


**Table JEDEC Standard DDR Module (184-pin DIMM) Speeds and Transfer Rates** *MTps = Megatransfers per second MBps = Megabytes per second DIMM = Dual inline memory module DDR = Double data rate*

The major memory chip and module manufacturers normally produce parts that conform to the official JEDEC standard speed ratings. To support overclocking, several memory module manufacturers purchase unmarked and untested chips from the memory chip manufacturers, then independently test and sort them by how fast they run. These are then packaged into modules with unofficial designations and performance figures that exceed the standard ratings. Table 6.7 shows the popular unofficial speed ratings



**Table Overclocked (non-JEDEC) DDR Module (184-pin DIMM) Speeds and Transfer Rates**



*MTps = Megatransfers per second MBps = Megabytes per second*

*DIMM = Dual inline memory module DR = Double data rate*

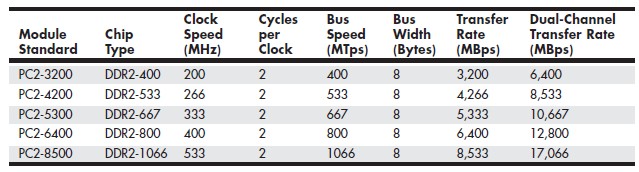
The bandwidths listed in these tables are per module. Most chipsets that support DDR also support dual-channel operation—a technique in which two matching DIMMs are installed to function as a single bank, with double the bandwidth of a single module.

Dual-channel operation optimizes PC design by ensuring that the CPU bus and memory bus both run at exactly the same speeds so that data can move synchronously between the buses without delays.

**DDR2 SDRAM**

DDR2 is simply a faster version of DDR memory: It achieves higher throughput by using differential pairs of signal wires to allow faster signaling without noise and interference problems. The modified signaling method enables higher clock speeds to be achieved with more immunity to noise and crosstalk between the signals. DDR2 DIMMs have 240 pins, which is more than the 184 pins of DDR. DDR2 starts at 400MHz and goes up to an official maximum of 1,066MHz. Table shows the various official JEDEC-approved DDR2 module types and bandwidth specifications.

**Table JEDEC Standard DDR2 Module (240-pin DIMM) Speeds and Transfer Rates**



*MTps = Megatransfers per second MBps = Megabytes per second*

*DIMM = Dual inline memory module DDR = Double data rate*

Many of the module manufacturers produce even faster modules designed for overclocked systems. Table shows the popular unofficial speed ratings on the market.

**Table Overclocked (non-JEDEC) DDR2 Module (240-pin DIMM) Speeds and Transfer Rates**

*MTps = Megatransfers per second MBps = Megabytes per second*

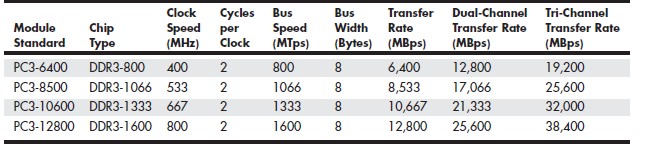
*DIMM = Dual inline memory module DDR = Double data rate*

It uses lower Voltage, power consumption and heat generation are reduced. DDR2 uses finepitch ball grid array (FBGA) packaging rather than the thin small outline package (TSOP) chip package.

**DDR3**

DDR3 is the latest JEDEC memory standard. It enables higher levels of performance along with

lower power consumption and higher reliability than DDR2.



During 2009, with full support from both Intel and AMD, DDR3 finally began to achieve price

parity with DDR2.

DDR3 modules use advanced signal designs, including self-driver calibration and data

synchronization, along with an optional onboard thermal sensor. DDR3 memory runs on only 1.5V, which is nearly 20% less than the 1.8V used by DDR2 memory. The lower voltage combined with higher efficiency reduces overall power consumption by up to 30% compared to DDR2.

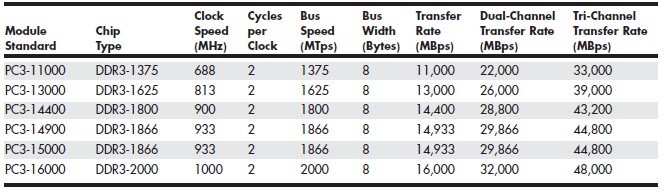
DDR3 is most suited to systems where the processor and/or memory bus runs at 1,333MHz or higher, which is faster than the 1,066MHz maximum supported by DDR2.

**Table JEDEC Standard DDR3 Module (240-pin DIMM) Speeds and Transfer Rates**

*MTps = Megatransfers per second MBps = Megabytes per second*

*DIMM = Dual inline memory module DDR = Double data rate*

**Table 6.11 Overclocked (non-JEDEC) DDR3 Module (240-pin DIMM) Speeds and Transfer Rates**



*MTps = Megatransfers per second MBps = Megabytes per second*

*DIMM = Dual inline memory module DDR = Double data rate*

**RDRAM**

Rambus DRAM (RDRAM) was a proprietary (non-JEDEC) memory technology found mainly in certain Intel systems. Intel had signed a contract with Rambus ensuring it would both adopt and

support RDRAM memory. Using or producing RDRAM would require licensing from RAMBUS and

Intel.

RDRAM is a chip-to-chip memory bus, with specialized devices that communicate at very high rates of speed. SDRAM are known as wide-channel systems.

The dual inline memory module (DIMM) is a 64-bit wide device, meaning data can be transferred to it 64 bits at a time.

RDRAM modules, on the other hand, are narrow-channel devices. They transfer data only 16 bits at a time but at faster speeds.

Each individual chip is serially connected to the next on a package called a Rambus inline memory module (RIMM),

The 16-bit single-channel RIMMs originally ran at 800MHz with the throughput is 800×2, or

1.6GB per second for a single channel

The RDRAM design features less latency between transfers because they all run synchronously in a looped system and in only one direction.

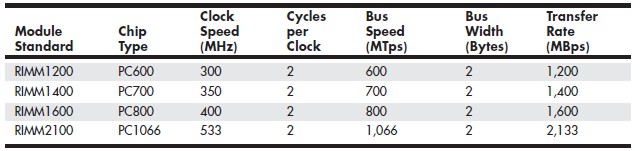
Another important feature of RDRAM is that it is designed for low power consumption. RIMMs are available in four primary speed grades and usually run in a dual-channel environment, so

they have to be installed in pairs, with each one of the pairs in a different set of sockets.

RDRAM quickly disappeared from the PC marketplace. It is generally not cost effective to

upgrade them by adding more memory.

**Table 6.12 RDRAM Module Types and Bandwidth**



*MTps = Megatransfers per second MBps = Megabytes per second*

*RIMM = Rambus inline memory module*

**3. Explain briefly about Memory modules. Explain briefly: SIMM,DIMM,DDR Common DRAM modules**

Common DRAM packages as illustrated to the right, from top to bottom:

1. DIP 18-pin (DRAM chip, usually pre-FPRAM)

2. SIPP (usual[ly FPRAM)](http://en.wikipedia.org/w/index.php?title=FPRAM&action=edit)

3. SIMM 30-pin (usually FPRAM)

4. SIMM 72-pin (so-called "PS/2 SIMM", usually [EDO RAM)](http://en.wikipedia.org/wiki/EDO_RAM)

5. DIMM 168-pin ([SDRAM)](http://en.wikipedia.org/wiki/SDRAM)

6. DIMM 184-pin ([DDR SDRAM)](http://en.wikipedia.org/wiki/DDR_SDRAM)

7. DIMM 240-pin ([DDR2 SDRAM)](http://en.wikipedia.org/wiki/DDR2_SDRAM) - (DRAM not pictured to the r

**Memory Modules:**

There are many types of **computer memory** modules available. In this day and age, computers

(laptops, PCs, etc.) generally do not use a single type of memory; rather, a combination of memory chips and modules are normally found in today's computers, depending on requirements and applications. The following is an overview of the types of computer memory:

**SIMM (Single In-Line Memory Module)** Dating back to the days of 286, 386, and 486 PCs, SIMMs

are generally plug-in memory modules that are inserted into the CPU motherboard (or an extender memory board). A SIMM can be comprised of BEDO (Burst Extended Data Out Dynamic Random Access Memory), DRAM (Dynamic Random Access Memory) or EDO (Extended Data Out Dynamic Random Access Memory), with the memory chips (one or more) soldered on a PCB (printed circu it board). As mentioned above, it is the SIMM that is plugged into the CPU motherboard or memory extend card to expand the memory capability of the computer. Generally, when one is adding memory to a computer, it is in the form of a SIMM. Early SIMMs handled 8 data bits at a time in a 30-pin configuration; later, when CPUs were processing 32-bits, newer generation SIMMs were constructed in a 72-pin configuration.



**72-pin SIMM**

**DIMM (Dual In-Line Memory Module)** DIMMs have two rows of DRAM, BEDO, or EDO memory chips. DIMMS allow for double the memory on the same size printed circuit board. A typical DIMM would be constructed in a 168-pin configuration and handle 64 data bits at a time.

**168-pin DIMM**



**240-pin DIMM**



**SODIMM (Small Outline Dual In-Line Memory Module)** SODIMMs are generally found in

notebook computers and are smaller than standard DIMMs. In general, there are 2 types of SODIMMs

– the first handling 32 data bits at a time with a 72-pin configuration, and the second handling 64 data

bits with a 144-pin configuration. RIMM (Rambus In-Line Memory Module) Rambus Inc. in coordination with Intel developed a new memory technology called Direct RDRAM, with the in-line modules known as RIMMs. RIMMs have a 184-pin configuration and deliver a peak transfer rate of 1.6

Gigabytes per second (in 16 data bit segments). SORIMM (Small Outline Rambus In-Line Memory

Module) SORIMMs have a similar outline as a SODIMM, but use the Rambus memory technology. Different Types of Memory Chips:

**144-pin SODIMM**



[**Double data rate**](http://en.wikipedia.org/wiki/Double_data_rate) [**synchronous dynamic random-access memory (**](http://en.wikipedia.org/wiki/Synchronous_dynamic_random-access_memory)**DDR SDRAM)**

DDR is a class of memory [integrated circuits u](http://en.wikipedia.org/wiki/Integrated_circuit)sed in [computers.](http://en.wikipedia.org/wiki/Computer) DDR SDRAM (sometimes referred to

as **DDR1 SDRAM**) has been superseded by [DDR2 SDRAM a](http://en.wikipedia.org/wiki/DDR2_SDRAM)nd [DDR3 SDRAM,](http://en.wikipedia.org/wiki/DDR3_SDRAM) neither of which are either [forward o](http://en.wikipedia.org/wiki/Forward_compatibility)r [backward compatible w](http://en.wikipedia.org/wiki/Backward_compatibility)ith DDR SDRAM, meaning that DDR2 or DDR3 [memor](http://en.wikipedia.org/wiki/Memory_module)y [modules w](http://en.wikipedia.org/wiki/Memory_module)ill not work in DDR equipped [motherboards,](http://en.wikipedia.org/wiki/Motherboard) and vice versa.

Compared to single data rate ([SDR)](http://en.wikipedia.org/wiki/SDRAM#SDR_SDRAM) SDRAM, the DDR SDRAM interface makes higher transfer rates

possible by more strict control of the timing of the electrical data and clock signals. Implementations often have to use schemes such as [phase-locked loops a](http://en.wikipedia.org/wiki/Phase-locked_loop)nd self-calibration to reach the required timing accuracy.[[1][](http://en.wikipedia.org/wiki/DDR_SDRAM#cite_note-0)2] The interface uses [double pumping (](http://en.wikipedia.org/wiki/Double_data_rate)transferring data on both the rising and falling edges of the [clock signal)](http://en.wikipedia.org/wiki/Clock_signal) to lower the clock frequency. One advantage of keeping the clock frequency down is that it reduces the [signal integrity r](http://en.wikipedia.org/wiki/Signal_integrity)equirements on the circuit board connecting the memory to the controller. The name "double data rate" refers to the fact that a DDR SDRAM with a certain clock frequency achieves nearly twice the [bandwidth o](http://en.wikipedia.org/wiki/Bandwidth_%28computing%29)f a single data rate (SDR) [SDRAM r](http://en.wikipedia.org/wiki/SDRAM)unning at the same clock frequency, due to this double pumping.



**184-pin DIMM DDR**

With data being transferred 64 [bits a](http://en.wikipedia.org/wiki/Bit)t a time, DDR SDRAM gives a transfer rate of (memory bus clock rate) × 2 (for dual rate) × 64 (number of bits transferred) / 8 (number of bits/byte). Thus, with a bus

frequency of 100 MHz, DDR SDRAM gives a maximum transfer rate of 1600 [MB/s.](http://en.wikipedia.org/wiki/MB/s)

"Beginning in 1996 and concluding in June 2000, [JEDEC d](http://en.wikipedia.org/wiki/JEDEC)eveloped the DDR (Double Data Rate) SDRAM specification (JESD79)."JEDEC has set standards for data rates of DDR SDRAM, divided into two parts. The first specification is for memory chips, and the second is for memory modules. **DRAM (Dynamic Random Access Memory)** The most common type of computer memory. DRAMs hold data for a relatively brief period of time and need to be refreshed at regular intervals. DRAMs are measured by access time (in nanoseconds, or ns) and storage capacity (in megabytes, or MB). EDO (Extended Data Out) Memory Higher-performing memory than DRAM, with a gain in performance of roughly 10-15% over DRAM. BEDO (Burst Extended Data Out) Memory Higher-performing memory than EDO, with a gain in performance of roughly 13% over EDO. SDRAM (Static Dynamic Random Access Memory) A memory chip that retains memory and does not need refreshing. Another advantage of SDRAM is that it synchronizes with the CPU timing. Although faster than DRAM, it is also more expensive; available in speeds from 66 to 266 MHz. DDR SDRAM (Double Data Rate Synchronous Dynamic Random Access Memory) A memory integrated circuit that permits transactions on the rising as well as the falling edges of the clock cycle, with a bus clock speed of 100 MHz with a data transfer rate of 200 MHz.

**OTHER MEMORY TYPES VRAM (Video Random Access Memory)** VRAM is a video version of

fast page mode memory and is found primarily in video accelerator cards.

**Flash Memory** A memory chip that is non-volatile, re-writable that functions like a combination

random access memory and a hard disk drive. In the case of power being lost, data is retained in memory. Advantages of flash memory include low voltage, durability and high speed; for this reason, flash memory is used in printers, pagers, digital cameras, audio recorders and cell phones.

**Shadow RAM (Random Access Memory)** During the booting up of a computer, a minimal set of

instructions to start the computer and video are stored in ROM (read only memory), known as BIOS (basic input output system). Since ROM normally executes slowly, Shadow RAM allows for the transfer of selected segments of the BIOS code from ROM to RAM memory (which is faster).

**4.Explain about Memory Banks**

Memory chips (DIPs, SIMMs, SIPPs, and DIMMs) are organized in banks on motherboards and

memory cards.

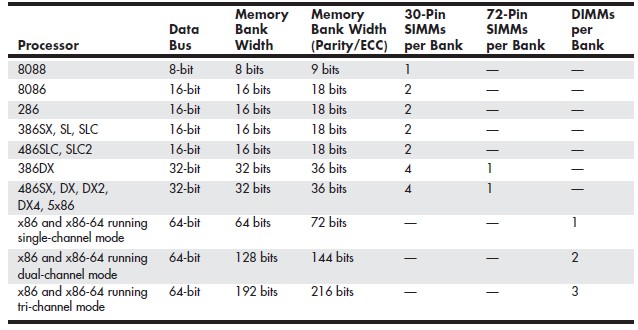
The bank layout when adding memory to the system.

Memory diagnostics report error locations by byte and bit addresses, use these numbers to locate which bank in your system contains the problem.

The banks usually correspond to the data bus capacity of the system’s microprocessor. Table

shows the widths of individual banks based on the type of PC.

**Table Memory Bank Widths on Various Systems**



Each DIMM represents an individual bank, and these can be added or removed one at a time.―Dual-

channel‖ and ―tri-channel‖ designs treat two or three matched modules as a single bank of memory.

**5. Explain about Parity and ECC in detail.**

Memory modules have traditionally been available in different basic flavors:

Non-parity

Parity

ECC

**Non-parity** is "regular" memory it contains exactly one bit of memory for every bit of data to be stored. 8 bits are used to store each byte of data. Parity memory adds an extra single bit for every eight bits of data, used only for error detection and correction. 9 bits of data are used to store each byte. The

table below shows a summary of the different common module sizes and their bit widths:

|  |  |  |
| --- | --- | --- |
| **Module Type** | **Bit Width of Non-** | **Bit Width of** |
| **Parity SIMM** | **Parity SIMM** |
| **30-Pin SIMM** | 8 bits | 9 bits |
| **72-Pin SIMM** | 32 bits | 36 bits |
| **168-Pin DIMM** | 64 bits | 72 bits |

**Parity memory** can be used for [parity checking, a](http://www.pcguide.com/ref/ram/errChecking-c.html) basic form of error detection, on PCs that support it. It can also be used for an advanced form of error detection and correction called [ECC o](http://www.pcguide.com/ref/ram/errECC-c.html)n Pentium class or later systems that support ECC. Non-parity memory provides no error detection capabilities at all unless these are provided through external circuitry

**ECC memory** As the name implies, this is memory specifically designed to allow the use of ECC on modern systems that have a chipset that supports it, much the way that parity memory can on some systems. Due to the fact that both types of memory support ECC, there has been a great deal of confusion about the difference between ECC and parity memory, especially since they often are quoted with the same specifications.

The biggest difference between the two types of memory is that ECC memory works in ECC mode and so does parity memory, but ECC memory does not work in plain parity checking mode. The reason is that while an ECC module contains one extra bit per byte the way parity ones do, the extra bits cannot be individually accessed, which is required for parity operation.

|  |  |  |
| --- | --- | --- |
| **Module Type** | **Parity Operation** | **ECC Operation** |
| **True Parity** | Yes | Yes |
| **ECC** | No | Yes |

**6.Explain about Logical Memory Layout.**

The design decisions made in the earliest PCs, memory is broken into the following four basic pieces:

**Conventional Memory:** The first 640 KB of system memory is the (in)famous conventional memory that every PC user has over time grown to know and hate. This is the area that is available for use by standard DOS programs, along with many drivers, memory-resident programs, and most anything else that has to run under standard DOS. It is found at addresses

00000h to 9FFFFh.

**Upper Memory Area (UMA):** This is the upper 384 KB of the first megabyte of system

memory (immediately above conventional memory). It is reserved for use by system devices and for special uses such as ROM shadowing and drivers. It uses addresses A0000h to FFFFFh.

**High Memory Area (HMA):** This is the first 64 KB (less 16 bytes) of the second megabyte of system memory. Technically this is the first 64 KB of extended memory, but it can be accessed when the processor is in real mode, which makes it different from the rest of extended memory. It is usually used for DOS, to allow more conventional memory to be preserved. It occupies addresses 100000h to 10FFEFh.

**Extended Memory:** This is all the memory above the high memory area until the end of system

memory. It is used for programs and data when using an operating system running in protected mode, such as any version of Windows. Extended memory is found from address 10 FFF0h to the last address of system memory. (Technically, the high memory area is part of extended memory, it all depends on how you are looking at things).

**DOS Memory Organization**

|  |
| --- |
| Extended Memory upto  4 GB of total memory |
| High Memory area – 64K |
| Upper Memory area  (Reserved Memory 384K) |
| Conventional Memory  640K |

**7. Explain about data-encoding schemes.**

Magnetic storage is an analog medium. The data in PC is digital information.

When the drive sends digital information to a magnetic recording head, the head creates magnetic domains on the storage medium with specific polarities corresponding to the positive and negative voltages the drive applies to the head.

The flux reversals form the boundaries between the areas of positive and negative polarity that the drive controller uses to encode the digital data onto the analog medium.

During a read operation, each flux reversal the drive detects generates a positive or negative

pulse that the device uses to reconstruct the original binary data.

The drive passes the raw digital input data through a device called an encoder/decoder (endec), which converts the raw binary information to a waveform designed to optimally p lace the flux transitions on the media.

During a read operation, the endec reverses the process and decodes the pulse train back into the

original binary data.

The three basic types are:

Frequency Modulation

Modified Frequency Modulation

Run Length Limited

**Frequency Modulation Encoding**

One of the earliest techniques for encoding data for magnetic storage is called Frequency

Modulation

Encoding and also called as Single-Density encoding.

It was used in floppy disk drives, which stored about 80KB of data on a single disk.

It was used until 1970’s.

**16 Computer Hardware and Troubleshooting**

**Modified FM Encoding**

It reduces the number of flux reversals used in the original FM encoding scheme to pack more data onto the disk.

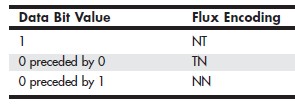
It records clock transitions only when a stored 0 bit is preceded by another 0 bit; in all other

cases, a clock transition is not required.

It minimizes the use of clock transitions, it can double the clock frequency used by FM encoding, which enables it to store twice as many data bits in the same number of flux transitions.

It is also called double-density recording.

**Table MFM Data-to-Flux Transition Encoding**



*T = Flux transition*

*N = No flux transition*

**Run Length Limited Encoding**

Encoding scheme for hard disks, called Run Length Limited, packs up to twice the information on a given disk than MFM.

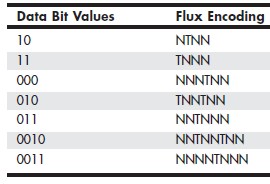
The drive combines groups of bits into a unit to generate specific patterns of flux reversals.

Because the clock and data signals are combined in these patterns, the clock rate can be further increased while maintaining the same basic distance between the flux transitions on the storage medium.

During the late 1980s, the PC hard disk industry began using RLL.

The term Run Length Limited is derived from the two primary specifications of these codes, which are the minimum number (the run length) and maximum number (the run limit) of transition cells allowed between two actual flux transitions.

**Table. RLL 2,7 Data-to-Flux Transition Encoding**



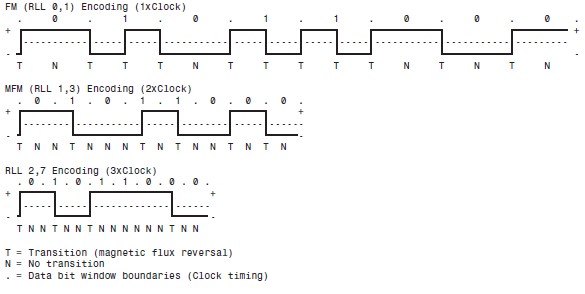
*T = Flux transition*

*N = No flux transition*

**Encoding Scheme Comparisons**

Figure shows an example of the waveform written to store the ASCII character X on a hard disk drive by using three encoding schemes.

**17 Computer Hardware and Troubleshooting**



**Figure** ASCII character X write waveforms using FM, MFM, and RLL 2,7 encoding.

The top line shows the individual data bits (01011000b, for example) in their bit cells separated in time by the clock signal, which is shown as a period (.).

Below that line is the actual write waveform, showing the positive and negative voltages as well

as head voltage transitions that result in the recording of flux transitions.

The bottom line shows the transition cells, with T representing a transition cell that contains a flux transition and N representing a transition cell that is empty.

The FM example, Each bit cell has two transition cells: one for the clock info rmation and one for the data.

All the clock transition cells contain flux transitions, and the data transition cells contain a flux transition only if the data is a 1 bit.

No transition is present when the data is a 0 bit.

Starting from the left, the first data bit is 0, which decodes as a flux transition pattern of TN.

The next bit is a 1, which decodes as TT. The next bit is 0, which decodes as TN, and so on.

In MFM, the clock transition cells carry a flux transition only when a 0 bit is stored after another 0 bit.

Starting from the left, the first bit is a 0, and the preceding bit is unknown , so the flux transition

pattern is TN for that bit.

The next bit is a 1, pattern is NT. The next bit is 0, which was preceded by 1, so the pattern stored is NN.

The RLL 2,7 pattern encodes groups of bits rather than individual bits.

Starting from the left, the first group is the first three bits 010, translated to pattern TNNTNN.

The next two bits, 11, are translated to TNNN; and the final group, 000 bits, to NNNTNN to complete the byte.

**Partial-Response, Maximum-Likelihood Decoders**

Read channel circuits using Partial-Response, Maximum-Likelihood (PRML) technology enable disk drive manufacturers to increase the amount of data stored on a disk platter by up to

40%.

The controller analyzes the analog data stream it receives from the heads by using digital signal sampling, processing, and detection algorithms (this is the partial response element) and predicts the sequence of bits the data stream is most likely to represent.

**8. Briefly explain about Hard Disk Drive. (APR 2011)**

**9. Discuss in detail about auxiliary storage device. (NOV 2012)**

**10.Explain components available in hard disk. (NOV 2013)**

**11.Describe the function of HDD. (APR 2012)**

A **hard disk** (commonly known as a *hard disk drive* or *hard drive* and formerly known as a

*fixed disk*) is a digitally encoded [non-volatile storage d](http://en.wikipedia.org/wiki/Non-volatile_storage)evice which stores data on rapidly rotating

[platters w](http://en.wikipedia.org/wiki/Hard_disk_platters)ith [magnetic s](http://en.wikipedia.org/wiki/Magnetic)urfaces. Strictly speaking, "drive" refers to an entire unit containing multiple platters, a read/write head assembly, driver electronics, and motor while "hard disk" (sometimes "platter") refers to the storage medium itself.

Hard disks were originally developed for use with [computers.](http://en.wikipedia.org/wiki/Computer) In the 21st century, applications

for hard disks have expanded beyond computers to include [digital video recorders,](http://en.wikipedia.org/wiki/Digital_video_recorder) [digital audi](http://en.wikipedia.org/wiki/Digital_audio_player)o [players,](http://en.wikipedia.org/wiki/Digital_audio_player) [personal digital assistants,](http://en.wikipedia.org/wiki/Personal_digital_assistant) and [digital cameras.](http://en.wikipedia.org/wiki/Digital_camera) In 2005 the first [mobile phones t](http://en.wikipedia.org/wiki/Mobile_phone)o include hard disks were introduced by [Samsung Group a](http://en.wikipedia.org/wiki/Samsung_Group)nd [Nokia. T](http://en.wikipedia.org/wiki/Nokia)he need for large-scale, reliable storage, independent of a particular device, led to the introduction of configurations such as [RAID, h](http://en.wikipedia.org/wiki/Redundant_array_of_independent_disks)ardware such as [network attached storage](http://en.wikipedia.org/wiki/Network_attached_storage) (NAS) devices, and systems such as [storage area networks (](http://en.wikipedia.org/wiki/Storage_area_network)SANs) for efficient access to large volumes of data.

**Technology**

Hard disks record data by magnetizing a magnetic material in a pattern that represents the data. They

read the data back by detecting the magnetization of the material. A typical hard disk design consists of a spindle which holds one or more flat circular disks called platters, onto which the data is recorded. The platters are made from a non-magnetic material, usually glass or aluminum, and are coated with a thin layer of magnetic material. Older disks used [iron(III) oxide a](http://en.wikipedia.org/wiki/Iron%28III%29_oxide)s the magnetic material, but current disks use a [cobalt-](http://en.wikipedia.org/wiki/Cobalt)based alloy.

The platters are spun at very high speeds. Information is written to a platter as it rotates past

mechanisms called read-and-write heads that fly very close over the magnetic surface. The read-and- write head is used to detect and modify the magnetization of the material immediately under it. There is one head for each magnetic platter surface on the spindle, mounted on a common arm. An actuator arm (or access arm) moves the heads on an arc (roughly radially) across the platters as they spin, allowing each head to access almost the entire surface of the platter as it spins.

The magnetic surface of each platter is divided into many small sub-[micrometre](http://en.wikipedia.org/wiki/Micrometre)-sized magnetic

regions, each of which is used to encode a single binary unit of information. In today's hard dis ks each of these magnetic regions is composed of a few hundred magnetic grains. Each magnetic region forms a [magnetic dipole w](http://en.wikipedia.org/wiki/Magnetic_dipole)hich generates a highly localised [magnetic field n](http://en.wikipedia.org/wiki/Magnetic_field)earby. The write head magnetizes a magnetic region by generating a strong local magnetic field nearby. Early hard disks used the same inductor that was used to read the data as an electromagnet to create this field. Later, metal in Gap (MIG) heads were used, and today [thin film h](http://en.wikipedia.org/wiki/Thin_film)eads are common. With these later technologies, the read and write head are separate mechanisms, but are on the same actuator arm.



*The inside of a hard disk drive with the disk itself removed. To the left is the read-write arm. In the middle the electromagnets of the platter's motor can be seen.*

Hard disks have a mostly sealed enclosure that protects the disk internals from [dust,](http://en.wikipedia.org/wiki/Dust) [condensation, a](http://en.wikipedia.org/wiki/Condensation)nd other sources of contamination. The hard disk's read-write heads fly on an [air bearing w](http://en.wikipedia.org/wiki/Air_bearing)hich is a

cushion of air only [nanometers a](http://en.wikipedia.org/wiki/Nanometer)bove the disk surface. The disk surface and the disk's internal environment must therefore be kept immaculate to prevent damage from fingerprints, hair, dust, smoke

particles and such, given the sub-microscopic gap between the heads and disk.

Using rigid platters and sealing the unit allows much tighter tolerances than in a [floppy disk.](http://en.wikipedia.org/wiki/Floppy_disk)

Consequently, hard disks can store much more data than floppy disk and access and transmit it faster. In 2006, a typica[l workstation h](http://en.wikipedia.org/wiki/Workstation)ard disk might store between 80 GB and 750 GB of data (as of local US market by December 2006), rotate at 7,200 to 10,800 [revolutions per minute (](http://en.wikipedia.org/wiki/Revolutions_per_minute)RPM), and have a

sequential media transfer rate of over 100 MB/s. The fastest workstation and server hard disks spin at

15,000 RPM, and can achieve sequential media transfer speeds up to and beyond 300 MB/s. [Laptop](http://en.wikipedia.org/wiki/Laptop)

hard disks, which are physically smaller than their desktop counterparts, tend to be slower and have less capacity. Most spin at only 4,200 RPM or 5,400 RPM whereas the newest top models sp in at 7.200

RPM.

**Capacity**

The capacity of hard disks has grown dramatically over time. The first commercial disk, the

IBM [RAMAC i](http://en.wikipedia.org/wiki/RAMAC)ntroduced in 1956, stored 5 million characters (about 5 megabytes) on fifty 24-inch

diameter disks. (*See* [early IBM disk storage.](http://en.wikipedia.org/wiki/Early_IBM_disk_storage)) With early [personal computers i](http://en.wikipedia.org/wiki/Personal_computer)n the 1980s, a disk with a

20 [megabyte c](http://en.wikipedia.org/wiki/Megabyte)apacity was considered large. In the latter half of the 1990s, hard disks with capacities of

1 [gigabyte a](http://en.wikipedia.org/wiki/Gigabyte)nd greater became available. [As of 2006,](http://en.wikipedia.org/wiki/As_of_2006) the lowest-capacity [desktop computer h](http://en.wikipedia.org/wiki/Desktop_computer)ard disk still in production has a capacity of 20 gigabytes, while the largest -capacity internal disks are a 3/4 [terabyte (](http://en.wikipedia.org/wiki/Terabyte)768 gigabytes), with external [disk enclosures a](http://en.wikipedia.org/wiki/Disk_enclosure)t or exceeding one terabyte by using multiple internal disks. These new internal disks increased their storage capacities with [perpendicular recording.](http://en.wikipedia.org/wiki/Perpendicular_recording)

The exponential increases in disk space and data access times for hard disks has enabled the commercial viability of consumer products that require large storage capacities, such as the Apple [iPod](http://en.wikipedia.org/wiki/IPod) [digital music player, t](http://en.wikipedia.org/wiki/Digital_music_player)he [TiVo](http://en.wikipedia.org/wiki/TiVo) [personal video recorder,](http://en.wikipedia.org/wiki/Personal_video_recorder) and web-based email programs.

This is also gradually but significantly altering how programmers think; in many programming

tasks there is a time-space tradeoff, so as space becomes cheaper and cheaper relative to CPU cycles the appropriate choice about time versus space changes. For instance in database work it is now common practice to store precomputed views, [transitive closures, a](http://en.wikipedia.org/wiki/Transitive_closure)nd the like on disk in order to speed up queries; 20 years ago such profligate use of disk space would have been impractical.

A vice president of [Seagate p](http://en.wikipedia.org/wiki/Seagate)rojects a future growth in disk density of 40% per year. [Acces](http://en.wikipedia.org/wiki/Access_time)s [times h](http://en.wikipedia.org/wiki/Access_time)ave not kept up with throughput increases, which themselves have not kept up with growth in storage capacity. The main way to increase either is to increase the number of read-write heads in a hard disk. Since flying heads are the most expensive component of hard disks, increasing their number per hard disk wouldn't help the situation. Currently, the most promising way to reduce access times and increase throughput are to replace rotating disks with [nonvolatile random access memory (](http://en.wikipedia.org/wiki/Nonvolatile_random_access_memory)NVRAM) or, possibly, [holographic memory t](http://en.wikipedia.org/wiki/Holographic_memory)echnology.

**Capacity measurements**

Hard disk [manufacturers t](http://en.wikipedia.org/wiki/Manufacturers)ypically specify disk capacity using the [SI definition o](http://en.wikipedia.org/wiki/SI_prefix)f the prefixes

"[mega"](http://en.wikipedia.org/wiki/Mega) and "[giga."](http://en.wikipedia.org/wiki/Giga) This is largely for historical reasons. Disks with multi-million byte capacity have

been used since 1956, long before there were standard [binary prefixes. T](http://en.wikipedia.org/wiki/Binary_prefix)he [Internationa](http://en.wikipedia.org/wiki/International_Electrotechnical_Commission)l [Electrotechnical Commission (](http://en.wikipedia.org/wiki/International_Electrotechnical_Commission)IEC) only standardized binary prefixes in 1999. Many practitioners early on in the computer and semiconductor industries used the prefix [kilo t](http://en.wikipedia.org/wiki/Kilo)o describe 210 (1024) bits, bytes or words because 1024 is close to 1000. Similar usage has been applied to the prefixes [*mega, giga,*](http://en.wikipedia.org/wiki/Mega)[*tera*,](http://en.wikipedia.org/wiki/Tera) and even [*peta*. O](http://en.wikipedia.org/wiki/Peta_%28prefix%29)ften this non-SI conforming usage is noted by a qualifier such as "1 kB = 1,024 bytes" but the qualifier is sometimes omitted, particularly in marketing literature.

Operating systems, such as [Microsoft Windows, f](http://en.wikipedia.org/wiki/Microsoft_Windows)requently report capacity using the binary interpretation of the prefixes, which results in a discrepancy between the disk manufacturer's stated capacity and what the system reports. The difference becomes much more noticeable in the multi- gigabyte range. For example, Microsoft's Windows 2000 reports disk capacity both in decimal t o 12 or more significant digits and with binary prefixes to 3 significant digits. Thus a disk specified by a disk manufacturer as a 30 GB disk might have its capacity reported by Windows 2000 both as "30,065,098,568 bytes" and "28.0 GB." The disk manufacturer used the [SI d](http://en.wikipedia.org/wiki/SI)efinition of "giga," 109. However utilities provided by Windows define a gigabyte as 230, or 1,073,741,824, bytes, so the reported capacity of the disk will be closer to 28.0 GB. For this reason, many utilities that report capacity have begun to use the aforementioned IEC standard binary prefixes (e.g. [KiB,](http://en.wikipedia.org/wiki/Kibibyte) [MiB,](http://en.wikipedia.org/wiki/Mebibyte) [GiB)](http://en.wikipedia.org/wiki/Gibibyte) since their definitions are unambiguous.

Some people mistakenly attribute the discrepancy in reported and specified capacities to reserved space used for file system and partition accounting information. However, for large (several

GiB) filesystems, this data rarely occupies more than a few MiB, and therefore cannot possibly account

for the apparent "loss" of tens of GBs.

The capacity of a hard disk can be calculated by multiplying the number of cylinders by the

number of heads by the number of sectors by the number of bytes/sector (most commonly 512).

**History**

**IBM 62PC "Piccolo" HDD, circa 1979 - an early 8" disk**

For many years, hard disks were large, cumbersome devices, more suited to use in the protected environment of a data center or large office than in a harsh industrial environment (due to their

delicacy), or small office or home (due to their size and power consumption). Before the early 1980s, most hard disks had 8-inch (20 cm) or 14-inch (35 cm) platters, required an equipment rack or a large

amount of floor space (especially the large removable-media disks, which were often referred to as

"[washing machines"](http://en.wikipedia.org/wiki/Washing_machine)), and in many cases needed high-current or even three-phase power hookups due

to the large motors they used. Because of this, hard disks were not commonly used with microcomputers until after 1980, when [Seagate Technology i](http://en.wikipedia.org/wiki/Seagate_Technology)ntroduced the ST-506, the first 5.25-inch hard disk, with a capacity of 5 megabytes. In fact, in its factory configuration, the original [IBM PC](http://en.wikipedia.org/wiki/IBM_PC) (IBM 5150) was not equipped with a hard disk.

Most microcomputer hard disks in the early 1980s were not sold under their manufacturer's names, but by [OEMs a](http://en.wikipedia.org/wiki/Original_equipment_manufacturer)s part of larger peripherals (such as the [Corvus Disk System a](http://en.wikipedia.org/w/index.php?title=Corvus_Disk_System&action=edit)nd the [Appl](http://en.wikipedia.org/wiki/Apple_ProFile)e [ProFile](http://en.wikipedia.org/wiki/Apple_ProFile)). The IBM PC/XT had an internal hard disk, however, and this started a trend toward buying "bare" disks (often by [mail order)](http://en.wikipedia.org/wiki/Mail_order) and installing them directly into a system. Hard disk makers started marketing to end users as well as OEMs, and by the mid-1990s, hard disks had become available on retail store shelves.

While internal disks became the system of choice on PCs, external hard disks remained popular for much longer on the [Apple Macintosh a](http://en.wikipedia.org/wiki/Apple_Macintosh)nd other platforms. Every Mac made between 1986 and 1998 has a [SCSI p](http://en.wikipedia.org/wiki/SCSI)ort on the back, making external expansion easy. External SCSI disks were also popular with older microcomputers such as the [Apple II s](http://en.wikipedia.org/wiki/Apple_II)eries, and were also used extensively in [servers, a](http://en.wikipedia.org/wiki/Server_%28computing%29) usage which is still popular today. The appearance in the late 1990s of high-speed external interfaces such as [USB a](http://en.wikipedia.org/wiki/Universal_Serial_Bus)nd [FireWire](http://en.wikipedia.org/wiki/FireWire) has made external disk systems popular among PC users once again, especially for users who move large amounts of data between two or more locat ions, and most hard disk makers now make their disks available in external cases.

**Hard disk characteristics**

*5.25" MFM 110 MB hard disk (2.5" IDE 6495 MB hard disk, US & UK pennies for comparison)*

Capacity, usually quoted in [gigabytes. (](http://en.wikipedia.org/wiki/Gigabyte)older hard disks used to quote their smaller capacities in [megabytes)](http://en.wikipedia.org/wiki/Megabytes)

Physical size, usually quoted in [inches:](http://en.wikipedia.org/wiki/Inch)

o Almost all hard disks today are of either the 3.5" or 2.5" varieties, used in desktops and laptops, respectively. 2.5" disks are usually slower and have less capacity but use less power and are more tolerant of movement. An increasingly common size is the 1.8"

disks used in [portable MP3 players a](http://en.wikipedia.org/w/index.php?title=Portable_MP3_player&action=edit)nd [subnotebooks,](http://en.wikipedia.org/wiki/Subnotebook) which have very low power consumption and are highly shock-resistant. Additionally, there is the 1" form factor designed to fit the dimensions of [CF T](http://en.wikipedia.org/wiki/Compact_Flash)ype II, which is also usually used as storage for portable devices including [digital cameras. 1"](http://en.wikipedia.org/wiki/Digital_camera) was a de facto form factor led by [IBM's](http://en.wikipedia.org/wiki/IBM) [Microdrive, b](http://en.wikipedia.org/wiki/Microdrive)ut is now generically called 1" due to other manufacturers producing similar products. There is also a 0.85" form factor produced by [Toshiba f](http://en.wikipedia.org/wiki/Toshiba)or use in mobile phones and similar applications. The size designations are more nomenclature than descriptive: for example, a 3.5" drive is named for the size of the floppy disk whose drive bay size it was originally designed to occupy; the drive itself is actually 4" wide. Server-class hard disks also come in both 3.5" and 2.5" form factors.

Reliability, usually given in terms of [mean time between failure (](http://en.wikipedia.org/wiki/Mean_time_between_failure)MTBF):

o [SATA 1](http://en.wikipedia.org/wiki/SATA).0 disks support speeds up to 10,000 RPM and MTBF levels up to 1 million hours under an eight-hour, low-duty cycle.

o [Fibre Channel (](http://en.wikipedia.org/wiki/Fibre_Channel)FC) disks support up to 15,000 RPM and an MTBF of 1.4 million hours under a 24-hour duty cycle.

Number of I/O operations per second:

o Modern disks can perform around 50 [random access o](http://en.wikipedia.org/wiki/Random_access)r 100 [Sequential access o](http://en.wikipedia.org/wiki/Sequential_access)perations per second.

[Power consumption](http://en.wikipedia.org/wiki/Power_consumption) (especially important in battery-powered laptops).

audible noise in [dBA (](http://en.wikipedia.org/wiki/DBA)although many still report it in bels, not decibels).

G-shock rating (surprisingly high in modern disks).

Transfer Rate:

o Inner Zone: from 44.2 MB/s to 74.5 MB/s.

o Outer Zone: from 74.0 MB/s to 111.4 MB/s.

[Random access time:](http://en.wikipedia.org/w/index.php?title=Random_access_time&action=edit) from 5 ms to 15 ms.

**Integrity**

The hard disk's spindle system relies on air pressure inside the enclosure to support the heads at

their proper *flying height* while the disk is in motion. A hard disk requires a certain range of air pressures in order to operate properly. The connection to the external environment and pressure occurs through a small hole in the enclosure (about 1/2 mm in diameter), usually with a carbon filter on the inside (the *breather filter,* see below). If the air pressure is too low, there will not be enough lift for the flying head, the head will not be at the proper height, and there is a risk of head crashes and data loss. Specially manufactured sealed and pressurized disks are needed for reliable high-altitude operation, above about 10,000 feet (3,000 m). This does not apply to pressurized enclosures, like an [airplane](http://en.wikipedia.org/wiki/Aircraft) [pressurized cabin. M](http://en.wikipedia.org/wiki/Pressurized_cabin)odern disks include temperature sensors and adjust their operation to the operating environment.

Very high humidity for extended periods can cause accelerated wear of the heads and platters by

corrosion. If the disk uses "Contact Start/Stop" (CSS) technology to park its heads on the platters when not operating, increased humidity can also lead to increased [stiction (](http://en.wikipedia.org/wiki/Stiction)the tendency for the heads to stick to the platter surface). This can cause physical damage to the platter and spindle motor and can also lead to [head crash. B](http://en.wikipedia.org/wiki/Head_crash)reather holes can be seen on all disks — they usually have a warning sticker next to them, informing the user not to cover the holes. The air inside the operating disk is constantly moving too, being swept in motion by friction with the spinning platters. This air passes through an internal recirculation (or "recirc") filter to remove any leftover contaminants from manufacture, any particles or chemicals that may have somehow entered the enclosure, and any particles or outgassing generated internally in normal operation.

Due to the extremely close spacing between the heads and the disk surface, any contamination

of the read-write heads or platters can lead to a [head crash —](http://en.wikipedia.org/wiki/Head_crash) a failure of the disk in which the head scrapes across the platter surface, often grinding away the thin magnetic film. For [gian](http://en.wikipedia.org/wiki/Giant_magnetoresistive_effect)t [magnetoresistive (](http://en.wikipedia.org/wiki/Giant_magnetoresistive_effect)GMR) heads in particular, a minor head crash from contamination (that does not remove the magnetic surface of the disk) will still result in the head temporarily overheating, due to friction with the disk surface, and can render the data unreadable for a short period until the head temperature stabilizes (so called "thermal asperity," a problem which can partially be dealt with by proper electronic filtering of the read signal). Head crashes can be caused by electronic failure, a sudden power failure, physical shock, wear and tear, corrosion, or poorly manufactured platters and heads. In most desktop and server disks, when powering down, the heads are moved to a *landing zone,* an area of the platter usually near its inner diameter (ID), where no data is stored. This area is called the CSS (Contact Start/Stop) zone. However, especially in old models, sudden power interruptions or a power supply failure can sometimes result in the device shutting down with the heads in the data zone, which increases the risk of data loss. In fact, it used to be procedure to "park" the hard disk before shutting down your computer. Newer disks are designed such that either a spring (at first) or (more recently) rotational inertia in the platters is used to safely park the heads in the case of unexpected power loss.

The hard disk's electronics control the movement of the actuator and the rotation of the disk, and perform reads and writes on demand from the [disk controller. M](http://en.wikipedia.org/wiki/Disk_controller)odern disk firmware is capable of scheduling reads and writes efficiently on the platter surfaces and remapping sectors of the media which have failed. Also, most major hard disk and motherboard vendors now support [self-monitoring, analysis, and reporting technology (](http://en.wikipedia.org/wiki/Self-Monitoring%2C_Analysis%2C_and_Reporting_Technology)S.M.A.R.T.), by which impending failures can be predicted, allowing the user to be alerted to prevent data loss.

**Landing zones**

Around 1995 IBM pioneered a technology where the landing zone is made by a precision laser

process (*Laser Zone Texture* = LZT) producing an array of smooth nanometer-scale "bumps" in the ID landing zone, thus vastly improving stiction and wear performance. This technology is still widely in use today (2006). A few years after LZT, initially for mobile applications (i.e. laptop etc.), and later also for the other HDD types, IBM introduced "head unloading" technology, where the heads are lifted off the platters onto plastic "ramps" near the outer disk edge, thus eliminating the risk of stiction

altogether and greatly improving non-operating shock performance. All HDD manufacturers use these two technologies to this day. Both have a list of advantages and drawbacks in terms of loss of storage space, relative difficulty of mechanical tolerance control, cost of implementation, et c.

[IBM c](http://en.wikipedia.org/wiki/IBM)reated a technology for their [Thinkpad l](http://en.wikipedia.org/wiki/Thinkpad)ine of laptop computers called the Active

Protection System. When a sudden, sharp movement is detected by the built-in motion sensor in the Thinkpad, internal hard disk heads automatically unload themselves into the parking zone to reduce the risk of any potential data loss or scratches made. Apple later also utilized this technology in the ir Powerbook, iBook, MacBook Pro, and MacBook line, known as the [Sudden Motion Sensor.](http://en.wikipedia.org/wiki/Sudden_Motion_Sensor)

Spring tension from the head mounting constantly pushes the heads towards the p latter. While the disk is spinning, the heads are supported by an air bearing and experience no physical contact or wear. In CSS drives the sliders carrying the head sensors (often also just called *heads*) are designed to reliably survive a number of landings and takeoffs from the media surface, though wear and tear on these microscopic components eventually takes its toll. Most manufacturers design the sliders to survive 50,000 contact cycles before the chance of damage on startup rises above 50%. However, the decay rate is not linear—when a disk is younger and has fewer start-stop cycles, it has a better chance of surviving the next startup than an older, higher-mileage disk (as the head literally drags along the disk's surface until the air bearing is established). For example, the Maxtor DiamondMax series of desktop hard disks are rated to 50,000 start-stop cycles. This means that no failures attributed to the head-platter interface were seen before at least 50,000 start-stop cycles during testing.

**Access and interfaces**

Hard disks are generally accessed over one of a number of bus types, including [ATA (](http://en.wikipedia.org/wiki/Advanced_Technology_Attachment)IDE, EIDE), [Serial ATA (](http://en.wikipedia.org/wiki/Serial_ATA)SATA), [SCSI](http://en.wikipedia.org/wiki/SCSI)[, SAS,](http://en.wikipedia.org/wiki/Serial_Attached_SCSI) [IEEE 1394,](http://en.wikipedia.org/wiki/IEEE_1394) [USB,](http://en.wikipedia.org/wiki/Universal_Serial_Bus) and [Fibre Channel.](http://en.wikipedia.org/wiki/Fibre_Channel)

Back in the days of the [ST-506 i](http://en.wikipedia.org/wiki/ST-506)nterface, the data [encoding s](http://en.wikipedia.org/wiki/Encoding)cheme was also important. The first ST-506 disks used [Modified Frequency Modulation (](http://en.wikipedia.org/wiki/Modified_Frequency_Modulation)MFM) encoding (which is still used on the

common "1.44 MB" (1440 [KiB)](http://en.wikipedia.org/wiki/Kibibyte) 3.5-inch floppy), and transferred data at a rate of 5 [megabits p](http://en.wikipedia.org/wiki/Megabit)er second. Later on, controllers using *2,7* [*RLL* (](http://en.wikipedia.org/wiki/RLL)or just "RLL") encoding increased the transfer rate by half,

to 7.5 megabits per second; it also increased disk capacity by half.

Many ST-506 interface disks were only certified by the manufacturer to run at the lower MFM

data rate, while other models (usually more expensive versions of the same basic disk) were certified to run at the higher RLL data rate. In some cases, the disk was overengineered just enough to allow the MFM-certified model to run at the faster data rate; however, this was often unreliable and was not recommended. (An RLL-certified disk could run on a MFM controller, but with 1/3 less data capacity and speed.)

[Enhanced Small Disk Interface (](http://en.wikipedia.org/wiki/Enhanced_Small_Disk_Interface)ESDI) also supported multiple data rates (ESDI disks always used 2,7

RLL, but at 10, 15 or 20 megabits per second), but this was usually negotiated automatically by the disk and controller; most of the time, however, 15 or 20 megabit ESDI disks weren't downward compatible (i.e. a 15 or 20 megabit disk wouldn't run on a 10 megabit controller). ESDI disks typically also had jumpers to set the number of sectors per track and (in some cases) sector size.

SCSI originally had just one speed, 5 MHz (for a maximum data rate of 5 megabytes per second), but later this was increased dramatically. The SCSI bus speed had no bearing on the disk's internal speed because of buffering between the SCSI bus and the disk's internal data bus; however, many early disks had very small buffers, and thus had to be reformatted to a different interleave (just like ST-506 disks) when used on slow computers, such as early [IBM PC compatibles a](http://en.wikipedia.org/wiki/IBM_PC_compatible)nd early [Appl](http://en.wikipedia.org/wiki/Apple_Macintosh)e [Macintoshes.](http://en.wikipedia.org/wiki/Apple_Macintosh)

ATA disks have typically had no problems with interleave or data rate, due to their controller design, but many early models were incompatible with each other and couldn't run in a master/slave setup (two disks on the same cable). This was mostly remedied by the mid-1990s, when ATA's specification was standardised and the details began to be cleaned up, but still causes problems occasionally (especially with CD-ROM and DVD-ROM disks, and when mixing [Ultra DMA a](http://en.wikipedia.org/wiki/Ultra_DMA)nd non- UDMA devices).

Serial ATA does away with master/slave setups entirely, placing each disk on its own channel

(with its own set of I/O ports) instead.

FireWire/IEEE 1394 and USB(1.0/2.0) hard disks are external units containing generally ATA or SCSI

disks with ports on the back allowing very simple and effective expansion and mobility. Most

FireWire/IEEE 1394 models are able to [daisy-chain i](http://en.wikipedia.org/wiki/Daisy_chain#Computer_Engineering)n order to continue adding peripherals without requiring additional ports on the computer itself.

**Disk families used in personal computers**

Notable disk families include:

[MFM (](http://en.wikipedia.org/wiki/Modified_Frequency_Modulation)Modified Frequency Modulation) disks required that the controller electronics be compatible with the disk electronics.

[RLL](http://en.wikipedia.org/wiki/Run_Length_Limited) (Run Length Limited) disks were named after the modulation technique that made them an improvement on MFM. They required large cables between the controller in the PC and the

hard disk, the disk did not have a controller, only a modulator/demodulator.

[ESDI (](http://en.wikipedia.org/wiki/Enhanced_Small_Disk_Interface)Enhanced Small Disk Interface) was an interface developed by Maxtor to allow faster

communication between the PC and the disk than MFM or RLL.

[Integrated Drive Electronics (](http://en.wikipedia.org/wiki/Integrated_Drive_Electronics)IDE) was later renamed to ATA, and then PATA. The name

comes from the way early families had the hard disk controller external to the disk. Moving the hard disk controller from the interface card to the disk helped to standardize interfaces, including reducing the cost and complexity. In 2005/2006 parlance, the 40 pin IDE/ATA is called "PATA" or parallel ATA, which means that there are 16 bits of data transferred in parallel at a time on the data cable. The data cable was originally 40 conductor, but UDMA modes from the later disks requires using an 80 conductor cable (note that the 80 conductor cable still uses a 40 position connector.) The interface changed from 40 pins to 39 pin. The missing pin acts as a key to prevent incorrect insertion of the connector, a common cause of disk and controller damage.

[SCSI (](http://en.wikipedia.org/wiki/SCSI)Small Computer System Interface) was an early competitor with ESDI, originally named

SASI for Shugart Associates. SCSI disks were standard on servers, workstations, and [Appl](http://en.wikipedia.org/wiki/Apple_Macintosh)e [Macintosh c](http://en.wikipedia.org/wiki/Apple_Macintosh)omputers through the mid-90s, by which time most models had been transitioned to IDE (and later, SATA) family disks. Only in 2005 did the capacity of SCSI disks fall behind IDE disk technology, though the highest-performance disks are still available in SCSI and Fibre Channel only. The length limitations of the data cable allows for external SCSI devices. Originally SCSI data cables used single ended data transmission, but server class SCSI could use differential transmission, and then [Fibre Channel (](http://en.wikipedia.org/wiki/Fibre_Channel)FC) interface, and then more specifically the [Fibre Channel Arbitrated Loop (](http://en.wikipedia.org/wiki/Arbitrated_loop)FC-AL), connected SCSI hard disks using fibre optics. FC- AL is the cornerstone of [storage area networks,](http://en.wikipedia.org/wiki/Storage_area_network) although other protocols like [iSCSI a](http://en.wikipedia.org/wiki/ISCSI)nd [AT](http://en.wikipedia.org/wiki/ATA_over_Ethernet)A [over Ethernet h](http://en.wikipedia.org/wiki/ATA_over_Ethernet)ave been developed as well.

[SATA (](http://en.wikipedia.org/wiki/Serial_ATA)Serial ATA). The SATA data cable has one data pair for differential transmission of data to the device, and one pair for differential receiving from the device, just like [EIA-422.](http://en.wikipedia.org/wiki/EIA-422) That requires that data be transmitted serially. The same [differential signaling s](http://en.wikipedia.org/wiki/Differential_signaling)ystem is used in [RS485,](http://en.wikipedia.org/wiki/RS485) [LocalTalk,](http://en.wikipedia.org/wiki/LocalTalk) [USB,](http://en.wikipedia.org/wiki/USB) [Firewire, a](http://en.wikipedia.org/wiki/Firewire)nd differential [SCSI.](http://en.wikipedia.org/wiki/SCSI)

[SAS (](http://en.wikipedia.org/wiki/Serial_Attached_SCSI)Serial Attached SCSI). The SAS is a new generation serial communication protocol for devices designed to allow for much higher speed data transfers and is compatible with SATA. SAS uses serial communication instead of the parallel method found in traditional SCSI devices but still uses SCSI commands for interacting with SAS

EIDE was an unofficial update (by Western Digital) to the original IDE standard, with the key improvement being the use of [DMA to](http://en.wikipedia.org/wiki/Direct_memory_access) transfer data between the disk and the computer, an improvement later adopted by the official ATA standards. DMA is used to transfer data without the CPU or program being responsible to transfer every word. That leaves the CPU/program/operating system to do other tasks while the data transfer occurs.

[**Acronym M**](http://en.wikipedia.org/wiki/Acronym)**eaning Description**

Shugart Associates

[SASI](http://en.wikipedia.org/wiki/SASI)

System Interface Predecessor to SCSI

Small Computer

[SCSI](http://en.wikipedia.org/wiki/SCSI)

System Interface [Bus](http://en.wikipedia.org/wiki/Computer_bus) oriented that handles [concurrent o](http://en.wikipedia.org/wiki/Concurrent)perations.

[ST-412 S](http://en.wikipedia.org/wiki/ST-412)eagate interface

[ST-506 S](http://en.wikipedia.org/wiki/ST-506)eagate interface (improvement over ST-412)

[ESDI E](http://en.wikipedia.org/wiki/Enhanced_Small_Disk_Interface)nhanced Small Disk Faster and more integrated than ST-412/506, but still backwards

Interface

compatible

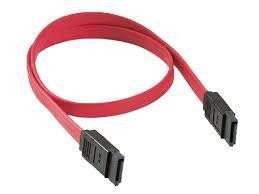
[Successor to](http://en.wikipedia.org/wiki/Successor) ST-412/506/ESDI by integrating the disk controller

[ATA A](http://en.wikipedia.org/wiki/Advanced_Technology_Attachment)dvanced Technology completely onto the device. Incapable of concurrent operations.

Attachment

**12. What is SATA? Explain.**

Serial ATA (SATA or Serial AT Attachment) is a [computer bus i](http://en.wikipedia.org/wiki/Computer_bus)nterface for connecting [hos](http://en.wikipedia.org/wiki/Host_adapter)t [bus adapters to](http://en.wikipedia.org/wiki/Host_adapter) [mass storage devices s](http://en.wikipedia.org/wiki/Mass_storage_device)uch as [hard disk drives a](http://en.wikipedia.org/wiki/Hard_disk_drive)nd [optical drives. S](http://en.wikipedia.org/wiki/Optical_drive)erial ATA was designed to replace the older [parallel ATA (](http://en.wikipedia.org/wiki/Parallel_ATA)PATA) standard (often called by the old name [IDE)](http://en.wikipedia.org/wiki/Parallel_ATA#IDE_and_ATA-1), offering several advantages over the older interface: reduced cable size and cost (7 conductors instead of 40), native [hot swapping, f](http://en.wikipedia.org/wiki/Hot_swapping)aster [data transfer t](http://en.wikipedia.org/wiki/Data_transfer)hrough higher signaling rates, and more efficient transfer through an (optional) I/O queuing protocol.



SATA host-adapters and devices communicate via a high-speed [serial c](http://en.wikipedia.org/wiki/Serial_communications)able over two pairs of conductors. In contrast, parallel ATA (the [redesignation f](http://en.wikipedia.org/wiki/Retronym)or the legacy ATA specifications) used a 16- bit wide data bus with many additional support and control signals, all operating at much lower frequency. To ensure backward compatibility with legacy ATA software and applications, SATA uses the same basic ATA and ATAPI command-set as legacy ATA devices.

SATA has replaced parallel ATA in consumer desktop and laptop [computers,](http://en.wikipedia.org/wiki/Computer) and has largely replaced

PATA in new embedded applications. SATA's market share in the desktop PC market was 99% in

2008.PATA remains widely used in industrial and embedded applications that use [CompactFlash](http://en.wikipedia.org/wiki/CompactFlash) storage, though even there, the new [CFast s](http://en.wikipedia.org/wiki/CFast)torage standard is based on SATA.

**13. Explain Flash Memory Devices.**

Flash memory is a special type of solid-state memory chip that requires no power to maintain its contents.

Flash memory cards can easily be moved from digital cameras to laptop or desktop computers.

Flash memory is a type of nonvolatile memory that can be electrically programmed and erased.

It is programmed or erased by special equipment outside of the motherboard.

The system cannot rewrite Flash memory; it must always erase it first.

When erased, flash memory cells are in a low-voltage state that carries a logical 1 value.

Programming flash places a charge in the transistor’s floating gate, which changes the 1 to a 0.

Changing o back to 1 is by erasing it.

The two major types of flash memory technology are called NOR and NAND.

NOR flash works more like dynamic RAM (DRAM), providing high-speed random-access capabilities with the ability to read or write data in single byte quantities.

NAND flash works more like a storage device, reading and writing data in pages or blocks

instead of individual bytes.

Several types of flash memory devices have been popular, including the following:

CompactFlash (CF)

SmartMedia (SM)

MultiMediaCard (MMC)

SecureDigital (SD)

Memory Stick

ATA Flash

xD-Picture Card

Solid-state drive (SSD)

USB flash devices

**CompactFlash**

CompactFlash was developed by SanDisk Corporation in 1994 and uses the ATA (AT

Attachment) architecture to emulate a disk drive.

The original size was Type I (3.3mm thick); a newer Type II size (5mm thick) accommodates higher capacity devices.

Both CompactFlash cards are 1.433-inch wide by 1.685-inch long, and adapters allow them to

be inserted into laptop computer PC Card slots.

**MultiMediaCard**

The MultiMediaCard (MMC) was co-developed by SanDisk and Infineon Technologies AG in

1997 for use with smart phones, MP3 players, digital cameras, and camcorders.

The MMC uses a simple 7-pin serial interface to devices and contains low-voltage flash memory.

The MultiMediaCard Association was founded in 1998.

In November 2002, MMCA announced the development of the Reduced Size MultiMediaCard (RS-MMC), which reduces the size of the standard MMC by about 40% and can be adapted for use with standard MMC devices.

**SecureDigital**

A SecureDigital (SD) storage device is about the same size as an MMC, but it’s a more

sophisticated product.

It was codeveloped by Toshiba, Matsushita Electric (Panasonic), and SanDisk in 1999,with two special features.

The first is encrypted storage of data for additional security, meeting current and future Secure

Digital Music Initiative (SDMI) standards for portable devices.

The second is a mechanical write-protection switch.

Reduced-size versions of SD include MiniSD and MicroSD.

Both are popular choices for smart phones and can be adapted to a standard SD slot.

MicroSD is compatible with the TransFlash standard for mobile phones.

SDHC (High Capacity) supports cards from 4GB to 32GB in capacity.

The SDXC (eXtended Capacity) format was released in 2009.

SDXC supports capacities of up to 2TB.

**SSD (Solid-State Drive)**

A solid-state drive (SSD) is any drive using solid-state electronics.

People believe that SSDs are a recent advancement in computer technology, but in actuality they have been around in one form or another since the 1950s, even before PCs existed.

**Virtual SSD (RAMdisk)**

These drives are available in both physical and virtual form.

A virtual SSD is traditionally called a RAMdisk because it uses a portion of system RAM to act as a disk drive.

The benefits are incredible read/write performance, whereas the drawbacks are the fact that all

data is lost when the system powers down or reboots, and that the RAM used for the RAMdisk is unavailable for the operating system (OS) and applications.

These DOS- or Windows-based RAMdisk programs are useful for creating high-speed SSDs using existing RAM.

**USB Flash Drives**

As an alternative to floppy removable-media drives, USB-based flash memory devices are

preferred way to move data between systems.

They can be plugged into any USB port or hub.

Typical read/write performance of USB 1.1–compatible drives is about 1MBps.

Hi-Speed USB 2.0 flash drives are much faster, providing read speeds ranging from 5MBps to

15MBps and write speeds ranging from 5MBps to 13MBps.

Some USB flash drives have a mechanical write-protect switch.

They also support password-protected data encryption as an option.

**14.Explain briefly about Compact Disk (CD)**

**15.What are the criteria to be considered when selecting a CD / DVD drive? Explain them. (NOV**

**2014)**

**16.Explain the structure and operating principles of CD-ROM in detail. (NOV 2010)**

**17. Explain in detail about CD and DVD technologies. (APR 2012)**

**18. What are the types of Disk Drives? Explain it. (NOV 2012)**

CD-ROM (an abbreviation "[Compact Disc](http://en.wikipedia.org/wiki/Compact_Disc) [read-only memory"](http://en.wikipedia.org/wiki/Read-only_memory)) is a Compact Disc that contains data accessible by a computer. While the Compact Disc format was originally designed for music storage and playback, the format was later adapted to hold any form of binary data. CD-ROMs are popularly used to distribute computer [software,](http://en.wikipedia.org/wiki/Software) including games and [multimedia a](http://en.wikipedia.org/wiki/Multimedia)pplications, though any data can be stored (up to the capacity limit of a disc). Some CDs hold both computer data and audio with the latter capable of being played on a CD player, whilst data (such as software or digital video) is only usable on a computer. These are called [Enhanced CDs.](http://en.wikipedia.org/wiki/Enhanced_CD)

[**Optical disc authoring**](http://en.wikipedia.org/wiki/Optical_disc_authoring)

[Optical disc](http://en.wikipedia.org/wiki/Optical_disc)

[Optical disc image](http://en.wikipedia.org/wiki/Optical_disc_image)

[Recorder hardware](http://en.wikipedia.org/wiki/Optical_disc_recorder)

[Authoring software](http://en.wikipedia.org/wiki/Optical_disc_authoring_software)

[Recording technologies](http://en.wikipedia.org/wiki/Optical_disc_recording_technologies)

o [Recording modes](http://en.wikipedia.org/wiki/Optical_disc_recording_modes)

o [Packet writing](http://en.wikipedia.org/wiki/Packet_writing)

**Optical media types**

[Laserdisc](http://en.wikipedia.org/wiki/Laserdisc)

[Compact Disc/](http://en.wikipedia.org/wiki/Compact_Disc)**CD-ROM**: [CD-R,](http://en.wikipedia.org/wiki/CD-R) [CD-RW](http://en.wikipedia.org/wiki/CD-RW)

DVD: [DVD-R,](http://en.wikipedia.org/wiki/DVD-R) [DVD-R DL](http://en.wikipedia.org/wiki/DVD-R_DL)[, DVD+R,](http://en.wikipedia.org/wiki/DVD%2BR) [DVD+R DL,](http://en.wikipedia.org/wiki/DVD%2BR_DL) [DVD-RW,](http://en.wikipedia.org/wiki/DVD-RW) [DVD+RW,](http://en.wikipedia.org/wiki/DVD%2BRW) [DVD+RW DL,](http://en.wikipedia.org/wiki/DVD%2BRW_DL) [DVD-RAM](http://en.wikipedia.org/wiki/DVD-RAM)

[Blu-ray Disc:](http://en.wikipedia.org/wiki/Blu-ray_Disc) [BD-R, BD-RE](http://en.wikipedia.org/wiki/Blu-ray_Disc_recordable)

[HD DVD:](http://en.wikipedia.org/wiki/HD_DVD) [HD DVD-R](http://en.wikipedia.org/wiki/HD_DVD-R)

**Standards**

[Rainbow Books](http://en.wikipedia.org/wiki/Rainbow_Books)

File systems

o [ISO 9660](http://en.wikipedia.org/wiki/ISO_9660)

[Joliet](http://en.wikipedia.org/wiki/Joliet_%28file_system%29)

[Rock Ridge](http://en.wikipedia.org/wiki/Rock_Ridge)

[Amiga extensions to Rock Ridge](http://en.wikipedia.org/wiki/Rock_Ridge#Amiga_Extensions_on_Rock_Ridge)

[El Torito](http://en.wikipedia.org/wiki/El_Torito_%28CD-ROM_standard%29)

[Apple ISO9660 Extensions](http://en.wikipedia.org/wiki/Apple_ISO9660_Extensions)

o [Universal Disk Format](http://en.wikipedia.org/wiki/Universal_Disk_Format)

[Mount Rainier](http://en.wikipedia.org/wiki/Mount_Rainier_%28packet_writing%29)

Although many people use lowercase letters in this acronym, proper presentation is in all capital letters with a hyphen between CD and ROM.

**Media**

CD-ROM discs are identical in appearance to audio CDs, and data is stored and retrieved in a very similar manner (only differing from audio CDs in the standards used to store the data). Discs are made from a 1.2 mm thick disc of [polycarbonate](http://en.wikipedia.org/wiki/Polycarbonate) [plastic, w](http://en.wikipedia.org/wiki/Plastic)ith a thin layer of [aluminium t](http://en.wikipedia.org/wiki/Aluminium)o make a reflective surface. The most common size of CD-ROM disc is 120 mm in diameter, though the smaller [Mini CD s](http://en.wikipedia.org/wiki/Mini_CD)tandard with an 80 mm diameter, as well as numerous non-standard sizes and shapes (e.g. business card-sized media) are also available.

Data is stored on the disc as a series of microscopic indentations ("pits", with the gaps between them referred to as "lands"). A laser is shone onto the reflective surface of the disc to read the pattern of pits and lands. Because the depth of the pits is approximately one-quarter to one-sixth of the wavelength of the laser light used to read the disc, the reflected beam's [phase i](http://en.wikipedia.org/wiki/Phase_%28waves%29)s shifted in relation to the incoming beam, causing destructive [interference a](http://en.wikipedia.org/wiki/Interference)nd reducing the reflected beam's intensity. This pattern of changing intensity of the reflected beam is converted into binary data.

**Standards**

There are several formats used for data stored on compact discs, known collectively as the [Rainbow Books.](http://en.wikipedia.org/wiki/Rainbow_Books) These include the original [Red Book s](http://en.wikipedia.org/wiki/Red_Book_%28audio_CD_standard%29)tandards for CD audio, [White Book a](http://en.wikipedia.org/wiki/White_Book_%28Video_CD_standards%29)nd [Yello](http://en.wikipedia.org/wiki/Yellow_Book_%28CD-ROM_standards%29)w [Book CD-ROM. T](http://en.wikipedia.org/wiki/Yellow_Book_%28CD-ROM_standards%29)he [ECMA-](http://en.wikipedia.org/wiki/ECMA)130 standard, which gives a thorough description of the physics and physical layer of the CD-ROM, inclusive of [CIRC a](http://en.wikipedia.org/wiki/CIRC)nd [Eight-to-Fourteen Modulation, c](http://en.wikipedia.org/wiki/Eight-to-Fourteen_Modulation)an be downloaded from.

[ISO 9660 d](http://en.wikipedia.org/wiki/ISO_9660)efines the standard file system of a CD-ROM, although it is due to be replaced by [ISO 13490.](http://en.wikipedia.org/wiki/ISO_13490) [UDF f](http://en.wikipedia.org/wiki/Universal_Disk_Format)ormat is used on user-writable [CD-R a](http://en.wikipedia.org/wiki/CD-R)nd [CD-RW d](http://en.wikipedia.org/wiki/CD-RW)iscs that are intended to be extended or overwritten. The bootable CD specification, to make a CD emulate a hard disk or floppy, is called [El Torito. A](http://en.wikipedia.org/wiki/El_Torito_%28CD-ROM_standard%29)pparently named this because its design originated in an El Torito restaurant in Irvine, California.

**CD-ROM format**

A CD-ROM *sector* contains 2352 bytes, divided into 98 24-byte frames. The CD-ROM is, in essence, a data disk, which cannot rely on error concealment, and therefore requires a higher reliability of the retrieved data. In order to achieve improved error correction and detection, a CD-ROM has a third layer of [Reed-Solomon error correction. A](http://en.wikipedia.org/wiki/Reed-Solomon_error_correction) Mode-1 CD-ROM, which has the full three layers of error correction data, contains a net 2048 bytes of the available 2352 per sector. In a Mode-2 CD-ROM, which is mostly used for video files, there are 2336 user-available bytes per sector. The net byte rate of a Mode-1 CD-ROM is 44.1k×2048/(6×98) = 153.6 kB/s. The playing time is 74 minutes, or 4440 seconds, so that the net capacity of a Mode-1 CD-ROM is 682 MB.

A 1x speed CD drive reads 75 consecutive sectors per second.

**CD sector contents**

A standard 74 min CD contains 333,000 [sectors.](http://en.wikipedia.org/wiki/Sector)

Each sector is 2352 bytes, and contains 2048 bytes of PC (MODE1) Data, 2336 bytes of

PSX/VCD (MODE2) Data, or 2352 bytes of AUDIO.

The difference between sector size and data content are the [Headers i](http://en.wikipedia.org/wiki/Header)nfo and the Error Correction Codes, that are big for Data (high precision required), small for VCD (standard for video) and none for audio.

If extracting the disc in RAW format (standard for creating images) always extract 2352 bytes per sector, not 2048/2336/2352 bytes depending on data type (basically, extracting the whole sector). This fact has two main consequences:

o Recording data CDs at very high speed (40x) can be done without losing information.

However, if done the same with [PlayStation o](http://en.wikipedia.org/wiki/PlayStation)r Audio CD it will result in an unreadable PlayStation disc or an audio CD with lots of clicks because there are no error correction codes and the errors are more likely to occur at high speed recording.

o On a 74 minute CD can fit very large RAW images, up to 333,000 × 2352 =

783,216,000 bytes (747 MiB). This should be the upper limit for a RAW image created from a 74 min CD. If the stored standard data ([backup f](http://en.wikipedia.org/wiki/Backup)iles), it can burn only 333,000 ×

2048 = 681,984,000 bytes (650 MiB).

Please note that an image size is *always* a multiple of 2352 bytes (the size of a block) when extracting in RAW mode.

**Manufacture**

Pre-pressed CD-ROMs are mass-produced by a process of stamping, where a glass master disc is created and used to make "stampers", which in turn are used to manufacture multiple copies of the final disc with the pits already present. Recordable ([CD-R)](http://en.wikipedia.org/wiki/CD-R) and rewritable ([CD-RW)](http://en.wikipedia.org/wiki/CD-RW) discs are manufactured by a similar method, but the data is recorded on them by a laser changing the properties of a dye or [phase change m](http://en.wikipedia.org/wiki/Phase_change)aterial in a process that is often referred to as "[burning".](http://en.wikipedia.org/wiki/Optical_disc_authoring)

**Capacity**

A standard 120 mm CD-ROM holds 650 or 700 [MiB o](http://en.wikipedia.org/wiki/Mebibyte)f data. To put this storage capacity into context, the average [novel c](http://en.wikipedia.org/wiki/Novel)ontains 60,000 words. Assume that average word length is 10 letters and that each letter occupies one [byte. A](http://en.wikipedia.org/wiki/Byte) novel therefore might occupy 600,000 bytes (600 kB, without layout information). One CD can therefore contain over 1,000 novels. If each novel occupies at least one centimetre of bookshelf space, then one CD can contain the equivalent of over te[n metres o](http://en.wikipedia.org/wiki/Metre)f bookshelf. However, textual data can be compressed by more than a factor of ten, using [compressio](http://en.wikipedia.org/wiki/Data_compression)n [algorithms, s](http://en.wikipedia.org/wiki/Data_compression)o a CD-ROM can accommodate at least 100 metres of bookshelf space.

In comparison a single layer [DVD c](http://en.wikipedia.org/wiki/DVD)ontains 4.4 GiB of data, nearly 7 times the amount of a CD-ROM.

Capacities of Compact Disc types

**Type Sectors**

**Data max size Audio max size Time**

**(**[**MB)**](http://en.wikipedia.org/wiki/Byte) **(**[**MiB)**](http://en.wikipedia.org/wiki/Mebibyte) **(MB) (MiB) (**[**min)**](http://en.wikipedia.org/wiki/Minute)

**8 cm** 94,500 193.536 ≈ 184.6 222.264 ≈ 212.0 21

283,500 580.608 ≈ 553.7 666.792 ≈ 635.9 63

**650 MB** 333,000 681.984 ≈ 650.3 783.216 ≈ 746.9 74

**700 MB** 360,000 737.280 ≈ 703.1 846.720 ≈ 807.4 80

**800 MB** 405,000 829.440 ≈ 791.0 952.560 ≈ 908.4 90

**900 MB** 445,500 912.384 ≈ 870.1 1,047.816 ≈ 999.3 99

*Note: Megabyte (MB) and minute (min) values are exact.*

CD capacities are always given in binary units, although decimal [SI prefixes a](http://en.wikipedia.org/wiki/SI_prefix)re usually used: A "700 MB" CD has a nominal capacity of about 700 [MiB. A](http://en.wikipedia.org/wiki/Mebibyte) [DVD c](http://en.wikipedia.org/wiki/DVD)apacities on the other hand are given in decimal units: A "4.7 GB" DVD has a nominal capacity of about 4.38 [GiB.](http://en.wikipedia.org/wiki/GiB)

**Durability**

Stability Study Care, Handling and Storage of Removeable Media.

**CD-ROM drives**



*CD-RW drive*

CD-ROM discs are read using CD-ROM drives, which are now almost universal on personal computers. A CD-ROM drive may be connected to the computer via an IDE ([ATA)](http://en.wikipedia.org/wiki/Advanced_Technology_Attachment), [SCSI,](http://en.wikipedia.org/wiki/SCSI) [S-ATA,](http://en.wikipedia.org/wiki/S-ATA) [Firewire, o](http://en.wikipedia.org/wiki/Firewire)r [USB i](http://en.wikipedia.org/wiki/USB)nterface or a proprietary interface, such as the [Panasonic CD interface. V](http://en.wikipedia.org/wiki/Panasonic_CD_interface)irtually all modern CD-ROM drives can also play [audio CDs a](http://en.wikipedia.org/wiki/Red_Book_%28audio_CD_standard%29)s well as [Video CDs a](http://en.wikipedia.org/wiki/Video_CD)nd other data standards when used in conjunction with the right software.

**Transfer rates**

The rate at which CD-ROM drives can transfer data from the disc is gauged by a speed factor relative to music CDs: 1x or 1-speed which gives a data transfer rate of 150 [kilobytes per second i](http://en.wikipedia.org/wiki/Kilobytes_per_second)n the most common data format. By increasing the speed at which the disc is spun, data can be transferred at greater rates. For example, a CD-ROM drive that can read at 8x speed spins the disc at up to 4000 rpm (compared to the 500 rpm maximum for 1x speed), giving a transfer rate of 1.2 [megabytes per second.](http://en.wikipedia.org/wiki/Megabytes_per_second) Above 12x speed, vibration and heat can become a problem. CD-ROM drives above this speed tackle the problem in several ways. [Constant angular velocity (](http://en.wikipedia.org/wiki/Constant_angular_velocity)CAV) drives spin the disc at a constant rate, leading to faster data transfer when reading from the outer parts of the disc, but slower towards the centre. 20x was thought to be the maximum speed due to mechanical constraints until [Samsung](http://en.wikipedia.org/wiki/Samsung) Electronics introduced the SCR-3230, a 32x CD-ROM drive which uses a ball [bearing s](http://en.wikipedia.org/wiki/Bearing_%28mechanical%29)ystem to balance the spinning disc in the drive to reduce vibration and noise. [As of 2004, t](http://en.wikipedia.org/wiki/As_of_2004)he fastest transfer rate commonly available is about 52x or 10,350 rpm and 7.62 megabytes per second, though this is only when reading information from the outer parts of a disc. Future speed increases based simply upon spinning the disc faster are particularly limited by the strength of polycarbonate plastic used in CD manufacturing, though improvements can still be obtained by the use of multiple laser pickups as demonstrated by the [Kenwood](http://en.wikipedia.org/wiki/Kenwood_Electronics) [TrueX 72x](http://en.wikipedia.org/w/index.php?title=TrueX&action=edit) which uses seven laser beams and a rotation speed of approximately 10x.

CD-Recordable drives are often sold with three different speed ratings, one speed for write-once operations, one for re-write operations, and one for read-only operations. The speeds are typically listed in that order; ie a 12x/10x/32x CD drive can, CPU and media permitting, write to CD-R disks at 12x speed (1.76 megabytes/s), write to CD-RW discs at 10x speed (1.46 megabytes/s), and read from CD discs at 32x speed (4.69 megabytes/s).

The 1x speed rating for CDs (150 kilobytes/s) is not to be confused with the 1x speed rating for

DVDs (1.32 megabytes/s).

**Common transfer speeds:**

Data Transfer Speeds

**Transfer Speed** [**Megabytes**](http://en.wikipedia.org/wiki/Megabytes)[**/s Megabits/s**](http://en.wikipedia.org/wiki/Megabits)[**Mebibits/s**](http://en.wikipedia.org/wiki/Mebibit)

**8x** 1.2 9.6 9.1553

**10x** 1.5 12.0 11.4441

|  |  |  |  |
| --- | --- | --- | --- |
| **12x** | 1.8 14.4 13.7329 | | |
| **20x** | 3.0 | 24.0 | 22.8882 |
| **32x** | 4.8 | 38.4 | 36.6211 |
| **36x** | 5.4 | 43.2 | 41.1987 |
| **40x** | 6.0 | 48.0 | 45.7764 |
| **48x** | 7.2 | 57.6 | 54.9316 |
| **50x** | 7.5 | 60.0 | 57.2205 |
| **52x** | 7.8 | 62.4 | 59.5093 |

**Loading mechanisms**

Current CD-ROM drives use either a tray-loading mechanism, where the disc is loaded onto a motorised or manually-operated tray, or a slot-loading mechanism, where the disc is slid into a slot and drawn in by motorised rollers. Slot-loading drives have the disadvantage that they cannot usually accept the smaller 80 mm mini CDs or any non-standard sizes; however, the Nintendo Wii seems to have defeated this problem, for it will be able to load standard size DVDs and smaller size GameCube discs in the same slot-loading drive. A small number of CD-ROM drive models, mostly compact portable units, have a top-loading mechanism where the drive lid is opened upwards and the disc is placed directly onto the spindle (similar to most portable CD players).

Some early CD-ROM drives used a mechanism where CDs had to be inserted into special [cartridges or](http://en.wikipedia.org/wiki/Cartridge_%28electronics%29) caddies, somewhat similar in appearance to a 3.5" [floppy diskette.](http://en.wikipedia.org/wiki/Floppy_drive#The_3.C2.BD-inch_micro_floppy_diskette) Although the idea behind this – a tougher plastic shell to protect the disc from damage – was sound, it did not gain wide acceptance among disc manufacturers due to the increased cost of production and the concern that the discs would not be compatible with drives that did not use caddies. One exception is the PSP (Play Station Portable), which uses an 80 mm DVD inside a unopenable caddie. This was partly as a copy protection system as well as damage prevention. Unspecialised drives that used the caddy format required "bare" discs to be placed into an openable cartridge before use, negating most of the protection offered by having discs in a permanent, integrated protective cartridge, as well as making the drives less convenient to use.

**19. Explain briefly about Digital Versatile Disc (DVD)**

DVD (commonly "Digital Versatile Disc", previously "Digital Video Disc") is an [optical disc](http://en.wikipedia.org/wiki/Optical_disc) [storage m](http://en.wikipedia.org/wiki/Computer_storage)edia format that can be used for [data storage,](http://en.wikipedia.org/wiki/Data_storage) including movies with high video and sound quality. DVDs resemble [compact discs a](http://en.wikipedia.org/wiki/Compact_disc)s their physical dimensions are the same (120 mm (4.72 inches) or occasionally 80 mm (3.15 inches) in diameter), but they are encoded in a different format and at a much higher density.

[**Optical disc authoring**](http://en.wikipedia.org/wiki/Optical_disc_authoring)

[Optical disc](http://en.wikipedia.org/wiki/Optical_disc)

[Optical disc image](http://en.wikipedia.org/wiki/Optical_disc_image)

[Recorder hardware](http://en.wikipedia.org/wiki/Optical_disc_recorder)

[Authoring software](http://en.wikipedia.org/wiki/Optical_disc_authoring_software)

[Recording technologies](http://en.wikipedia.org/wiki/Optical_disc_recording_technologies)

o [Recording modes](http://en.wikipedia.org/wiki/Optical_disc_recording_modes)

o [Packet writing](http://en.wikipedia.org/wiki/Packet_writing)

**Optical media types**

[Laserdisc](http://en.wikipedia.org/wiki/Laserdisc)

[Compact Disc/](http://en.wikipedia.org/wiki/Compact_Disc)[CD-ROM:](http://en.wikipedia.org/wiki/CD-ROM) [CD-R,](http://en.wikipedia.org/wiki/CD-R) [CD-RW](http://en.wikipedia.org/wiki/CD-RW)

**DVD**: [DVD-R](http://en.wikipedia.org/wiki/DVD-R)[, DVD-R DL,](http://en.wikipedia.org/wiki/DVD-R_DL) [DVD+R](http://en.wikipedia.org/wiki/DVD%2BR)[, DVD+R DL,](http://en.wikipedia.org/wiki/DVD%2BR_DL) [DVD-RW,](http://en.wikipedia.org/wiki/DVD-RW) [DVD+RW,](http://en.wikipedia.org/wiki/DVD%2BRW) [DVD+RW DL,](http://en.wikipedia.org/wiki/DVD%2BRW_DL) [DVD-RAM](http://en.wikipedia.org/wiki/DVD-RAM)

[Blu-ray Disc:](http://en.wikipedia.org/wiki/Blu-ray_Disc) [BD-R, BD-RE](http://en.wikipedia.org/wiki/Blu-ray_Disc_recordable)

[HD DVD:](http://en.wikipedia.org/wiki/HD_DVD) [HD DVD-R](http://en.wikipedia.org/wiki/HD_DVD-R)

**Standards**

[Rainbow Books](http://en.wikipedia.org/wiki/Rainbow_Books)

File systems

o [ISO 9660](http://en.wikipedia.org/wiki/ISO_9660)

[Joliet](http://en.wikipedia.org/wiki/Joliet_%28file_system%29)

[Rock Ridge](http://en.wikipedia.org/wiki/Rock_Ridge)

[Amiga extensions to Rock Ridge](http://en.wikipedia.org/wiki/Rock_Ridge#Amiga_Extensions_on_Rock_Ridge)

[El Torito](http://en.wikipedia.org/wiki/El_Torito_%28CD-ROM_standard%29)

[Apple ISO9660 Extensions](http://en.wikipedia.org/wiki/Apple_ISO9660_Extensions)

o [Universal Disk Format](http://en.wikipedia.org/wiki/Universal_Disk_Format)

[**Mount Rainier**](http://en.wikipedia.org/wiki/Mount_Rainier_%28packet_writing%29)

In the early 1990s two high-density optical storage standards were being developed; one was the MultiMedia Compact Disc, backed by [Philips a](http://en.wikipedia.org/wiki/Philips)nd [Sony, a](http://en.wikipedia.org/wiki/Sony)nd the other was the Super Density disc, supported by [Toshiba,](http://en.wikipedia.org/wiki/Toshiba) [Time-Warner,](http://en.wikipedia.org/wiki/Time-Warner) [Matsushita Electric,](http://en.wikipedia.org/wiki/Matsushita_Electric) [Hitachi,](http://en.wikipedia.org/wiki/Hitachi%2C_Ltd.) [Mitsubishi Electric,](http://en.wikipedia.org/wiki/Mitsubishi_Electric) [Pioneer,](http://en.wikipedia.org/wiki/Pioneer_Corporation) [Thomson, a](http://en.wikipedia.org/wiki/Thomson_SA)nd [JVC.](http://en.wikipedia.org/wiki/JVC) [IBM's](http://en.wikipedia.org/wiki/IBM) president, [Lou Gerstner,](http://en.wikipedia.org/wiki/Lou_Gerstner) acting as a matchmaker, led an effort to unite the two camps behind a single standard, anticipating a repeat of the costly [format war b](http://en.wikipedia.org/wiki/Videotape_format_war)etween [VHS a](http://en.wikipedia.org/wiki/VHS)nd [Betamax i](http://en.wikipedia.org/wiki/Betamax)n the 1980s.

Philips and Sony abandoned their MultiMedia Compact Disc and fully agreed upon Toshiba's SuperDensity Disc with only one modification, namely [EFMPlus.](http://en.wikipedia.org/wiki/Eight-to-Fourteen_Modulation) EFMPlus was chosen as it has a great resilience against disc damage such as scratches and fingerprints. EFMPlus, created by [Kee](http://en.wikipedia.org/wiki/Kees_A._Schouhamer_Immink)s [Immink, w](http://en.wikipedia.org/wiki/Kees_A._Schouhamer_Immink)ho also designed [EFM, i](http://en.wikipedia.org/wiki/Eight-to-Fourteen_Modulation)s 6% less efficient than the Toshiba's code, which resulted in a capacity of 4.7 GB as opposed to the original 5 GB. The result was the DVD specification Version 1.5, announced in 1995 and finalized in September 1996. In May 1997, the DVD Consortium was replaced by the DVD Forum, which is open to all other companies.

"DVD" was originally an [initialism f](http://en.wikipedia.org/wiki/Acronym_and_initialism)or "Digital Video Disc." Some members of the DVD Forum believe that it should stand for "Digital Versatile Disc" to reflect its widespread use for non- video applications. Toshiba, which maintains the official DVD Forum site, adheres to the latter interpretation, and indeed this appeared within the copyright warnings on some of the earliest examples. However, the DVD Forum never reached a consensus on the matter, and so today the official name of the format is simply "DVD"; the letters do not officially stand for anything.

**DVD disc capacity**

**Single layer capacity Dual/Double layer capacity**

**Physical size** [**GB**](http://en.wikipedia.org/wiki/Byte) [**GiB GB**](http://en.wikipedia.org/wiki/Gibibyte) **GiB**

12 [cm, s](http://en.wikipedia.org/wiki/Cm)ingle sided 4.7 4.38 8.5 7.92

12 cm, double sided 9.4 8.75 17.1 15.93

[8 cm, s](http://en.wikipedia.org/wiki/MiniDVD)ingle sided 1.4 1.30 2.6 2.42

[8 cm, d](http://en.wikipedia.org/wiki/MiniDVD)ouble sided 2.8 2.61 5.2 4.84

**Note:** GB here means [gigabyte, e](http://en.wikipedia.org/wiki/Gigabyte)qual to 109 (or 1,000,000,000) bytes. Many computers will display [gibibyte (](http://en.wikipedia.org/wiki/Gibibyte)GiB), equal to 230 (or 1,073,741,824) bytes.

**Example:** A disc with 8.5 GB capacity is equivalent to: (8.5 x 1,000,000,000) / 1,073,741,824 ≈

7.92 GiB.

**Capacity Nomenclature**

The four basic types of DVD are referred to by their capacity in gigabytes, rounded to the nearest integer.

**DVD type Name**

Single sided, single layer DVD-5

Single sided, dual layer DVD-9

Double sided, single layer DVD-10

Double sided, dual layer DVD-18

Another format in use (while remaining quite uncommon) is a double sided DVD with one side comprising a single layer of data while the opposite side comprises two layers of data. This format holds approximately 13.2 GB of data and is therefore known as DVD-14. However this format is limited in availability due to its infrequent use.

**DVD recordable and rewriteable**



*DVD-R read/write side*

HP initially developed recordable DVD media from the need to store data for back-up and transport. DVD recordable are now also used for consumer audio and video recording. Three formats were developed: -[R/](http://en.wikipedia.org/wiki/DVD-R)[RW (](http://en.wikipedia.org/wiki/DVD-RW)dash), +[R/](http://en.wikipedia.org/wiki/DVD%2BR)[RW (](http://en.wikipedia.org/wiki/DVD%2BRW)plus), [-RAM](http://en.wikipedia.org/wiki/DVD-RAM) (random access memory).

Note: in other countries, such as the [United Kingdom a](http://en.wikipedia.org/wiki/United_Kingdom)nd [Australia, "](http://en.wikipedia.org/wiki/Australia)DVD-R/RW" is pronounced "minus", not "dash" (the full sentence being pronounced as: DVD minus R, with the 'R' rhyming with car, not the 'ruh' format).

**Dual layer recording**

Dual Layer recording allows [DVD-R a](http://en.wikipedia.org/wiki/DVD-R)nd [DVD+R d](http://en.wikipedia.org/wiki/DVD%2BR)iscs to store significantly more data, up to

8.5 [Gigabytes p](http://en.wikipedia.org/wiki/Gigabyte)er disc, compared with 4.7 Gigabytes for single-layer discs. DVD-R DL (dual layer — see [figure)](http://www.burnworld.com/cdr/hardware/images/duallayer-disc.jpg) was developed for the DVD Forum by Pioneer Corporation, DVD+R DL (double layer — see [figure)](http://www.cd-info.com/tech/media/dl_fig.html) was developed for the DVD+RW Alliance by [Philips a](http://en.wikipedia.org/wiki/Philips)nd Mitsubishi Kagaku Media (MKM).

A Dual Layer disc differs from its usual DVD counterpart by employing a second physical layer within the disc itself. The drive with Dual Layer capability accesses t he second layer by shining the laser through the first semi-transparent layer. The layer change mechanism in some DVD players can show a noticeable pause, as long as two seconds by some accounts. More than a few viewers have worried that their dual layer discs were damaged or defective.

DVD recordable discs supporting this technology are backward compatible with some existing DVD players and DVD-ROM drives. Many current DVD recorders support dual-layer technology, and the price point is comparable to that of single-layer drives, though the blank media remains significantly more expensive.

**DVD-Video**

**DVD-Video** is a standard for storing video content on DVD media. As of 2003, DVD-Video has become the dominant form of consumer video formats in the United States, Europe, and Australia and now in the whole world.

Though many resolutions and formats are supported, most consumer DVD-Video disks utilize either 4:3 or 16:9 [aspect ratio](http://en.wikipedia.org/wiki/Aspect_ratio) [MPEG-2 v](http://en.wikipedia.org/wiki/MPEG-2)ideo, stored at a resolution of 720x480 ([NTSC)](http://en.wikipedia.org/wiki/NTSC) or 720x576 ([PAL)](http://en.wikipedia.org/wiki/PAL). Audio is commonly stored using the [Dolby Digital (](http://en.wikipedia.org/wiki/Dolby_Digital)AC-3) and/or [Digital Theater System](http://en.wikipedia.org/wiki/Digital_Theater_System) (DTS) formats, ranging from [monaural t](http://en.wikipedia.org/wiki/Monaural)o 5.1 channel "[Surround Sound"](http://en.wikipedia.org/wiki/Surround_Sound) presentations. DVD-Video also supports features like selectable subtitles, multiple camera angles and multiple audio tracks.

**DVD-Audio**

**DVD-Audio** is a format for delivering high-fidelity audio content on a DVD. It offers many channel configuration options (from [mono to](http://en.wikipedia.org/wiki/Monaural) 5.1 [surround sound)](http://en.wikipedia.org/wiki/Surround_sound) at various sampling frequencies and sample rates. Compared with the CD format, the much higher capacity DVD format enables the inclusion of either considerably more music (with respect to total running time and quantity of songs) or far higher audio quality (reflected by higher linear [sampling rates a](http://en.wikipedia.org/wiki/Sampling_rate)nd higher vertical [bit-](http://en.wikipedia.org/wiki/Bit)rates, and/or additional channels for [spatial sound r](http://en.wikipedia.org/w/index.php?title=Spatial_sound&action=edit)eproduction).

Despite DVD-Audio's superior technical specifications, there is debate as to whether or not the resulting audio enhancements are distinguishable to typical human ears. DVD-Audio currently forms a niche market, probably due to its dependency upon new and relatively expensive equipment.

**Security**

DVD-Audio discs employ a robust [copy prevention m](http://en.wikipedia.org/wiki/Copy_prevention)echanism, called [Content Protection fo](http://en.wikipedia.org/wiki/Content_Protection_for_Prerecorded_Media)r

[Prerecorded Media (](http://en.wikipedia.org/wiki/Content_Protection_for_Prerecorded_Media)CPPM) developed by the 4C group (IBM, Intel, Matsushita, and Toshiba).

CPPM can be circumvented on a PC by capturing decoded audio streams in PCM format, but the underlying protection mechanism, encryption algorithms, and keys have not yet been [cracked.](http://en.wikipedia.org/wiki/Software_cracking) **Players and recorders**

Modern [DVD recorders o](http://en.wikipedia.org/wiki/DVD_recorder)ften support additional formats, including DVD+/-R/RW, CD-R/RW,

[MP3,](http://en.wikipedia.org/wiki/MP3) [WMA,](http://en.wikipedia.org/wiki/Windows_Media_Audio) [SVCD,](http://en.wikipedia.org/wiki/SVCD) [JPEG,](http://en.wikipedia.org/wiki/JPEG) [PNG,](http://en.wikipedia.org/wiki/PNG) [SVG,](http://en.wikipedia.org/wiki/Scalable_Vector_Graphics) [KAR a](http://en.wikipedia.org/wiki/KAR)nd [MPEG-4 (](http://en.wikipedia.org/wiki/MPEG-4)[Div](http://en.wikipedia.org/wiki/DivX)[X/Xvid](http://en.wikipedia.org/wiki/Xvid)). Some also include [USB](http://en.wikipedia.org/wiki/USB)

ports or [flash memory r](http://en.wikipedia.org/wiki/Flash_memory)eaders. Player prices range from as low as $20 to as high as $3,800.

DVD drives for computers usually come with one of two kinds of Regional Playback Control (RPC), either RPC-1 or RPC-2. This is used to enforce the publisher's restrictions on what regions of the world the DVD can be played. See [Regional lockout.](http://en.wikipedia.org/wiki/Regional_lockout)

Windows XP lacks the ability to burn rewritable DVDs; additional software is required. However, [Windows Vista n](http://en.wikipedia.org/wiki/Windows_Vista)atively supports DVD RW discs. Newer Mac computers can burn DVD+RW, DVD- RW, and DVD-RAM natively from the OS X operating system.

**Competitors and successors**

There are several possible successors to DVD being developed by different consortiums: Sony/Panasonic's [Blu-ray Disc (](http://en.wikipedia.org/wiki/Blu-ray_Disc)BD), Toshiba's [HD DVD a](http://en.wikipedia.org/wiki/HD_DVD)nd [Maxell's](http://en.wikipedia.org/wiki/Maxell) [Holographic Versatile Disc](http://en.wikipedia.org/wiki/Holographic_Versatile_Disc) (HVD).

The first generation of holographic media with 300 GB of storage capacity and a 160 Mbit/s transfer rate was scheduled for release in late 2006 by Maxell and its partner, InPhase.

On [November 18,](http://en.wikipedia.org/wiki/November_18) [2003,](http://en.wikipedia.org/wiki/2003) the Chinese news agency [Xinhua r](http://en.wikipedia.org/wiki/Xinhua_News_Agency)eported the final standard of the Chinese government-sponsored [Enhanced Versatile Disc (](http://en.wikipedia.org/wiki/Enhanced_Versatile_Disc)EVD), and several patents for it. Shortly thereafter the development of the format was halted by a licensing dispute between Chinese companies and [On2 Technologies, b](http://en.wikipedia.org/wiki/On2_Technologies)ut on [December 6,](http://en.wikipedia.org/wiki/December_6) [2006,](http://en.wikipedia.org/wiki/2006) 20 Chinese electronic firms unveiled 54 prototype EVD players and announced their intention for the format to completely replace DVDs in China by

2008.

On [November 19, 2003,](http://en.wikipedia.org/wiki/November_19) the DVD Forum decided by a vote of eight to six that [HD DVD w](http://en.wikipedia.org/wiki/HD_DVD)ill be its official [HDTV s](http://en.wikipedia.org/wiki/High-definition_television)uccessor to DVD. This had no effect on the competing Blu-ray Disc Association's (BDA) determination that its format would succeed DVD, especially since most of the voters belonged to both groups.

On [April 15,](http://en.wikipedia.org/wiki/April_15) [2004, i](http://en.wikipedia.org/wiki/2004)n a co-op project with TOPPAN Printing Co., the electronics giant Sony

Corp. successfully developed the [paper disc, a](http://en.wikipedia.org/wiki/Paper_disc) storage medium that is made out of 51% paper and

offers up to 25 GB of storage, about five times more than the standard 4.7 GB DVD. The disc can be easily cut with scissors and recycled, offering foolproof data security and an environment -friendly storage media.

As reported in a mid 2005 issue of [*Popular Mechanics*, i](http://en.wikipedia.org/wiki/Popular_Mechanics)t is not yet clear which technology will win the [format war o](http://en.wikipedia.org/wiki/Format_war)ver DVD. HD DVD discs have a lower capacity than Blu-ray discs (15 GB vs. 25

GB for single layer, 30 GB vs. 50 GB for dual layer).

In April, 2000, Sonic Solutions and Ravisent announced hDVD, an [HDTV e](http://en.wikipedia.org/wiki/HDTV)xtension to DVD that presaged the HD formats that debuted 6 years later. This situation—multiple new [formats fighting a](http://en.wikipedia.org/wiki/Format_war)s the successor to a format approaching purported obsolescence—previously appeared as the "[war of th](http://en.wikipedia.org/wiki/Gramophone_record#Progress.2C_and_the_war_of_the_speeds)e [speeds"](http://en.wikipedia.org/wiki/Gramophone_record#Progress.2C_and_the_war_of_the_speeds) in the record industry of the 1950s. It is also, of course, similar to the VHS/Betamax war in consumer video recorders in the late 1980s.

**Blu-ray Disk**

The leading optical storage companies formed the Blu-ray Disc Founders (BDF) and announced the initial specifications for BD, a high-capacity optical disc format.

Blu-ray is a fully rewritable format that enables recording up to 25GB of data or up to 11.5

hours of standard-definition video on a single-sided, single-layer 12cm diameter disc (which is the same as existing CDs and DVDs) using a 405nm blue-violet laser.

Dual-layer BD-R DL recorders are also available and can record up to 50GB or 23 hours of

standard definition video. The latest BD specifications, BDXL (recordable) and BD-RE XL (rewritable), can store up to 100GB or 128GB at 2x or 4x speeds.

Blu-ray uses the industry-standard MPEG-2 compression technology.

The BD specification includes the following formats:

BD-ROM—Read-only for prerecorded content

BD-R—Recordable

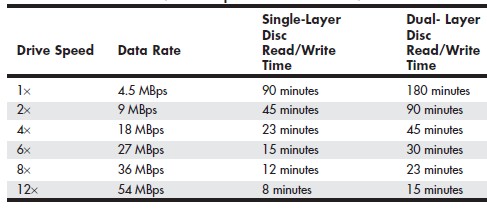
BD-RE—Rewritable

BD-RE XL—Rewritable

The data transfer speed of a BD depends on the speed rating of the drive and media.

The time to read or write an entire single- or dual-layer disc at various BD drive/media speeds is shown in Table.

**Table BD Drive/Media Speeds and Disc Read/Write Times**



Blu-ray uses a much shorter 405nm (blue-violet) laser with a 0.85 numerical aperture lens.

Numerical aperture is a measurement of the light-gathering capability of a lens, as well as the focal length and relative magnification.

The numerical aperture of a lens is derived by taking the sine of the maximum angle of light

entering the lens.

The higher the aperture, the shorter the focal length and the greater the magnification.

**20. Discuss about Optical Disc Format. Optical Disc File Systems**

Manufacturers of early data CDs did not deal with how data should be stored in files and how

these should be formatted for use by PCs with different OSs.

In 1985–1986, several companies got together and published the High Sierra file format specification, the first industry-standard CD-ROM file system that made CD-ROMs universally usable in PCs.

Several file systems are used on optical discs:

High Sierra

ISO 9660 (based on High Sierra)

Joliet

UDF (Universal Disk Format)

Mac HFS (Hierarchical File Format)

Rock Ridge

Mount Rainier

**High Sierra**

To make optical discs readable on all systems without having to develop custom file systems

and drivers.

Adoption of this standard also enabled disc publishers to provide cross-platform support for their software and easily manufacture discs for DOS, UNIX, and other OS formats.

The High Sierra format was submitted to the International Organization for Standardization

(ISO).

It was enhancements and republished as the ISO 9660.

**ISO 9660**

The ISO 9660 standard enabled full cross-compatibility among different computer and

operating systems.

It has three levels of interchange that dictate the features that can be used to ensure compatibility with different systems.

ISO 9660 Level 1 is the lowest common denominator of all CD file systems and is capable of

being read by almost every computer platform, including UNIX and Macintosh.

It is very limited with respect to filenames and directories.

Level 1 interchange restrictions include the following:

Only uppercase characters A–Z, numbers 0–9, and the underscore (\_) are allowed in filenames.

Only 8.3 characters maximum for the name.extension (based on DOS limits).

Directory names are eight characters maximum (no extension allowed).

Directories are limited to eight levels deep.

Files must be contiguous.

Level 2 interchange rules have the same limitations as Level 1, except that the filename and extension can be up to 30 characters long (both added together, not including the . separator).

Finally, Level 3 interchange rules are the same as Level 2 except that files don’t have to be

contiguous.

**Joliet**

It is an extension of the ISO 9660 standard developed by Microsoft.

In general, Joliet features the following specifications:

File or directory names can be up to 64 Unicode characters (128 bytes) in length.

Directory names can have extensions.

Directories can be deeper than eight levels.

Multisession recording is inherently supported.

**Universal Disk Format**

UDF is a file system created by the Optical Storage Technology Association (OSTA) as an

industry standard format for use on optical media, but it can also be used by other types of removable-media drives.

If it is unable to read a disc written with UDF on another system, return it to the original system

and close the media.

This option is usually displayed as part of the Eject Settings dialog box.

Closing the disc converts the filenames to Joliet format and causes them to be truncated to 64 characters.

**Macintosh HFS**

HFS is the file system used by the Macintosh OS.

HFS can also be used on optical discs; but they will not be readable on a PC.

A hybrid disc can be produced with both Joliet and HFS or ISO 9660 and HFS file systems, and the disc would then be readable on both PCs and Macs.

**Rock Ridge**

The Rock Ridge Interchange Protocol (RRIP) was developed by an industry consortium called

the Rock Ridge Group.

It was officially released in 1994 by the IEEE CD-ROM File System Format Working Group and specifies an extension to the ISO 9660 standard for CD-ROM that enables the recording of additional information to support UNIX/POSIX file system features.

**Mount Rainier**

Mount Rainier was designed to enable native OS support for data storage on rewritable optical

discs.

Mount Rainier’s main features include these:

Integral defect management

Direct addressing at the 2KB sector level to minimize wasted space

Background formatting so that new media can be used in seconds after first insertion

Standardized command set.

Standardized physical layout

**21. Discuss in detail about Optical drive performance specifications**

Performance figures published by manufacturers are the data transfer rate, the access time, the internal cache or buffers (if any), and the interface the drive uses.

**CD Data Transfer Rate**

The data transfer rate for a CD drive tells you how quickly the drive can read from the disc and

transfer to the host computer.

The one most commonly quoted with optical drives is the ―x‖ speed, which is defined as a

multiple of the particular standard base rate.

**CD Drive Speed**

The speed at which the drive reads the data had to be constant.

To maintain this constant flow, CD data is recorded using a technique called constant linear velocity (CLV).

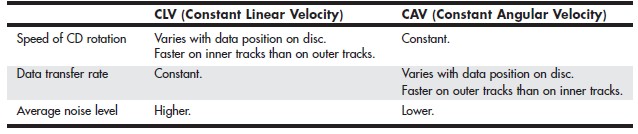
For greater performance, drive manufacturers began increasing the speeds of their drives by

making them spin more quickly.

A drive (such as most rewritables) that combines CLV and CAV technologies is referred to as

Partial-CAV or P-CAV.

**Table CLV Versus CAV Technology Quick Reference**



Vibration problems can cause high-speed drives to drop to lower speeds to enable reliable reading.

If a vibration is detected, it slows down the disc, thereby reducing the transfer rate performance.

Many of the faster optical drives come with auto-balancing or vibration control mechanisms to overcome these problems.

Most recent optical drives use Z-CLV (zoned CLV) or P-CAV (partial CAV) designs, which

help increase average performance while keeping rotational speeds under control.

**DVD Drive Speed**

DVDs rotate counter-clockwise and are recorded at a constant data rate called CLV.

To maintain a CLV, the disk must spin more quickly when the inner track area is being read and more slowly when the outer track area is being read.

DVD drives actually spin at a rate that is just under three times faster than a CD drive of the

same speed.

To increase the performance, faster DVD drives spin the disc at a fixed rotational speed rather than linear speed. This is termed CAV.

Having a faster drive can reduce or eliminate the pause during layer changes when playing a

DVD video disc, but having a faster drive has no effect on video quality.

**Access Time**

The access time is the delay between the drive receiving the command to read and its actual first reading of a bit of data.

**Buffer/Cache**

The buffers are actual memory chips installed on the drive’s circuit board that enable it to stage

or store data in larger segments before sending it to the PC.

It ranges from 2MB up to 8MB.

Faster rewritable drives come with more buffer memory to handle the higher transfer rates.

**Direct Memory Access and Ultra-DMA**

Busmastering PATA controllers use Direct Memory Access (DMA) or Ultra-DMA transfers to

improve performance and reduce CPU utilization.

Virtually all modern PATA drives support Ultra-DMA utilization.

Most motherboards refuse to enable Ultra-DMA modes faster than 33MBps if an 80-conductor cable is not detected.

These cabling issues affect only parallel ATA drives.

If the drives are Serial ATA (SATA) models, these cabling issues are not applicable.

**Interface**

Four types of interfaces are normally used for attaching an optical drive to your system:

**SATA (Serial ATA)**— Many recent systems featuring support for as little as one PATA (Parallel ATA) drive, but support for eight or more SATA drives, most optical drive vendors are now producing SATA versions of their drives.

**PATA (Parallel AT Attachment)**—The PATA interface is the same interface most older

computers use to connect to their hard disk drives. It is also called as ATA (AT Attachment) or

IDE (Integrated Drive Electronics).

**USB port**—Universal serial bus (USB) is normally used for external drives, and provides benefits such as hot-swappability, which is the capability to be plugged in or unplugged without removing the power or rebooting the system.

**FireWire (IEEE 1394)**— A few external optical drives are available with a FireWire (also

called IEEE 1394 or i.LINK) interface instead of, or in addition to USB 2.0

**Loading Mechanism**

Three distinctly different mechanisms exist for loading a disc into an optical dr ive: the tray, caddy, and

slot.

Most current drives use a **tray-loading mechanism**. This is similar to stereo system. Each disc has to be handled every time it is inserted or removed. The main advantage of the tray mechanism over the others is cost.

**Caddy systems** have been used on several types of optical drives. The caddy system requires that you place the disc into a special caddy, which is a sealed container with a metal shutter. The caddy has a hinged lid you open to insert the disc, but after that the lid remains shut. The drawbacks to the caddy system include the expense and the inconvenience of having to put the discs into the caddies.

Some drives use a **slot-loading mechanism**, identical to that used in most automotive players.

This is convenient because the disc can be slip into the slot, where the mechanism grabs it and draws it inside. The drawback is that if a jam occurs, it is more difficult to repair. It can’t handle the smaller 80mm discs, card-shaped discs, or other modified disc physical formats or shapes.

**Other Drive Features**

Although drive specifications are of the utmost importance, you should consider other factors

and features when evaluating optical drives.

Dust or dirt, when it collects on the lens portion of the mechanism, can cause read errors or severe performance loss.

Either the lens is scaled or has double dust doors to prolong the life of your drive.

Some drives are sealed, which means no air flows through the chamber in which the laser and lens reside.

Best for industrial or commercial environments than office or home environment.

**22. Explain how can you test and troubleshoot the memory. (NOV 2014)**

**23.What are the problems occurred in memory and how to troubleshoot it.**

**24.Troubleshooting memory using BIOS Beep Codes**

The BIOS on the motherboard will always perform a power-on-self-test ―POST‖ during power up,

usually this test is perform to ensure proper system function and if a failure occurs – the ―POST‖ will

identify the failure and emits a beeping sound to prompt the service technician to take corrective action

ASAP.

The exact meaning of the beeping codes varies from different BIOS developers, there are 3 basic BIOS

developer today, the most popular BIOS is made by ―American Mega-trend‖ - AMI, Award and

Phoenix BIOS. The beep codes for this AMI & Award BIOS developer are provided in this memory troubleshooter guide, we do not provide beep code reference for Phoenix BIOS and custom BIOS written by other companies other than the two mention.

Beep codes are not entirely consistent sometimes to detect the exact failures, but generally it is still the

most dependent methods to diagnose a fault without opening up the PC system or using any diagnostic software

The normal procedure is to power up the PC system, watch for error message on the monitor screen and listen to the PC beep tone. A single beep during boot-up process is normal and does not indicate a

failure if the system continues to boot-up.

1 Long Beep tone - Memory Problem

1 Long Beep and 2 Short Beeps - DRAM Parity failure

1 Long Beep and 3 Short Beeps - Video error

Continuous Beep tone - Memory or Video memory failures

**25. What is SCSI? Discuss the eight bus phases of SCSI. (APR 2011)**

Serial ATA (SATA or Serial AT Attachment) is a [computer bus i](http://en.wikipedia.org/wiki/Computer_bus)nterface for connecting [host b](http://en.wikipedia.org/wiki/Host_adapter)us

[adapters to](http://en.wikipedia.org/wiki/Host_adapter) [mass storage devices s](http://en.wikipedia.org/wiki/Mass_storage_device)uch as [hard disk drives a](http://en.wikipedia.org/wiki/Hard_disk_drive)nd [optical drives. S](http://en.wikipedia.org/wiki/Optical_drive)erial ATA was designed to replace the older [parallel ATA (](http://en.wikipedia.org/wiki/Parallel_ATA)PATA) standard (often called by the old name [IDE)](http://en.wikipedia.org/wiki/Parallel_ATA#IDE_and_ATA-1), offering several advantages over the older interface: reduced cable size and cost (7 conductors instead of 40), native [hot swapping, f](http://en.wikipedia.org/wiki/Hot_swapping)aster [data transfer t](http://en.wikipedia.org/wiki/Data_transfer)hrough higher signaling rates, and more efficient transfer through an (optional) I/O queuing protocol.

SATA host-adapters and devices communicate via a high-speed [serial c](http://en.wikipedia.org/wiki/Serial_communications)able over two pairs of

conductors. In contrast, parallel ATA (the [redesignation f](http://en.wikipedia.org/wiki/Retronym)or the legacy ATA specifications) used a 16- bit wide data bus with many additional support and control signals, all operating at much lower frequency. To ensure backward compatibility with legacy ATA software and applications, SATA uses the same basic ATA and ATAPI command-set as legacy ATA devices.

SATA has replaced parallel ATA in consumer desktop and laptop [computers,](http://en.wikipedia.org/wiki/Computer) and has largely replaced

PATA in new embedded applications. SATA's market share in the desktop PC market was 99% in

2008.PATA remains widely used in industrial and embedded applications that use [CompactFlash](http://en.wikipedia.org/wiki/CompactFlash) storage, though even there, the new [CFast s](http://en.wikipedia.org/wiki/CFast)torage standard is based on SATA.

**Small Computer System Interface, SCSI**, pronounced as *"****Scuzzy****"*, is the second most commonly used interface for disk drives that was first completed in [1982. U](http://www.computerhope.com/history/198090.htm)nlike competing standards, SCSI is

capable of supporting eight devices, or sixteen devices with Wide SCSI. However, with the SCSI host adapter located on ID number 07 and boots from the ID 00. This leaves the availability of six device connections.

**SCSI-1** is the original SCSI standard developed back in [1986 a](http://www.computerhope.com/history/198090.htm)s [ANSI X3](http://www.computerhope.com/jargon/a/ansi.htm).131-1986. SCSI-1 is capable

of transferring up to eight [bits](http://www.computerhope.com/jargon/b/bit.htm) a second.

**SCSI-2** was approved in [1990, a](http://www.computerhope.com/history/1990.htm)dded new features such as Fast and Wide SCSI, and support for

additional devices.

**SCSI-3** was approved in 1996 as [ANSI X3](http://www.computerhope.com/jargon/a/ansi.htm).270-1996.

SCSI is a standard for parallel interfaces that transfers information at a rate of eight bits per second and faster, which is faster than the average parallel interface. SCSI-2 and above supports up to seven peripheral devices, such as a hard drive, CD-ROM, and scanner, that can attach to a single SCSI port on a system's bus. SCSI ports were designed for Apple Macintosh and Unix computers, but also can be used with PCs. Although SCSI has been popular in the past many users are switching over to [SATA](http://www.computerhope.com/jargon/s/sata.htm) drives.

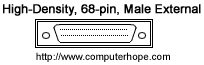
**SCSI connectors**

The below illustrations are examples of some of the most commonly found and used SCSI connectors

on computers and devices and illustrations of each of these connections.



**26. Discuss both FM and RLL recording methods of a magnetic disk drive. (NOV 2010)**



**27. Explain the following : a) Double Density Format, b) RLL Recording standards. (NOV 2012)**

**Physical Organization of Disk Drives**

Disk think of them are actually better described as *disk packs*. Each disk pack contains several disks, called *platters*, stack on top of each other. Each platter has two *surfaces*, the top and the bottom. Data is stored on these surfaces, each of which has a separate *head* for reading and writing the data.

Each of these surfaces is divided into concentric circles called *tracks*. Each track is further divided into *sectors* by *sector boundaries*. These sector boundaries are pie-like divisions along the radious of the platter. The sector is the fundamental unit of disk storage. Disks are sector addressable; each time the disk is accessed, a whole sector is read or written. Typically each sector holds 512 bytes, but this can vary.

One consequence of this sector based organization is that the full storage density of the media is only realized at the center of the disk where the sectors are physically smallest. Many modern drives cast the illusion of sectors to the operating system, while implementing *zones* at the physical level. Like the sector, each zone has the same storage capacity. But unlike the sector, more zones are placed on the outer tracks than the inner tracks.

All of the heads on most disk drives move from track-to-track together. For this reason it is often useful to consider those tracks in corresponding locations on all surfaces. We call this collection of tracks a *cylinder*.

There are three types of delay experienced in access data stored on disk (in order of significance):

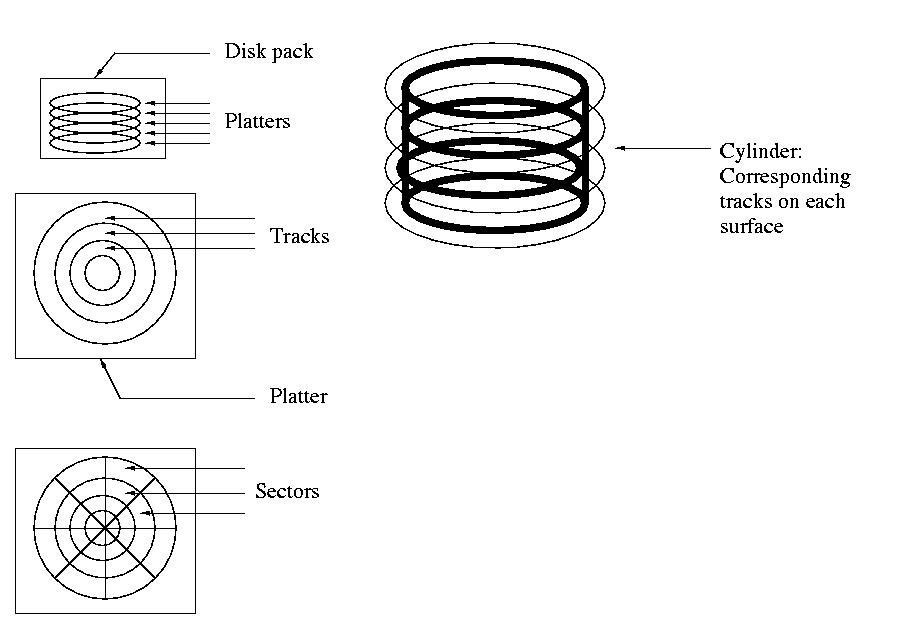
*seek latency*: the amount of time it takes to move the heads to the correct cylinder

*rotational latency*: the amount of time it takes for the disk to rotate so that the correct

secotor(s) can be read

*transfer latency*: the amount of time it takes for the sector(s) to completely pass under

the heads so that they can be read.



**Information on Disks: From Magnetism to 0's and 1's**

The heads used to read data from a disk drive are essentially coils of wire. As they pass through a magnetic fields, they sense the change in the field as a current flow through the wire. This means that the heads cannot sense a "1" or a "0" encoded as a north pole or south pole. Instead, they can only sense the *transition* from one pole to another. It is this transition that creates the current flow in the head. Regions encoded with multiple 1's or multiple 0's would not generate any current and would not be sensed by the heads.

**Frequency Modulation (FM)**

For this reason, the earliest disks were encoded using *Frequency Modulation*. This technique was used on what are now called *single-density* disks. Each bit of data was encoded in a cell that contained two bits of information -- two potential transitions.

The first part of the cell, called the *clock transition* always contained a transition. If the prior cell contained a north-pole, it would contain a south-pole and vice-versa. The second part of the cell contained the data transition. The cell would contain a transition if the bit was a one or no transition if the bit was a zero.

It is important to note that we are discussing transitions, changes in polarity, not the polarity of the media itself. It is also important to note that the limiting factor in the storage of informations is the maximum rate of transitions, not the density of the data bits on the disk. This will become important in our discussion f the next technique.

|  |  |  |
| --- | --- | --- |
| **Data bit** | **Clock Transition** | **Data Transition** |
|  |  |  |
| 0 | T | N |
|  |  |  |
| 1 | T | T |
|  |  | |

T = Transition

N = No Transition

**Modified Frequency Modulation (MFM)**

*Modified Frequency Modulation (MFM)* recording is a technique, based on FM recording, that reduces the number of transitions and as a consequence increases the rate and density (holding all other factors constant, increasing density increases rate). Magnetic media encoded using MFM are often known as *double denity (DD)*. This is because they can store twice as much information as media encoded with FM, holding all other factors constant.

Like FM, MFM encoding uses both clock and data transitions. But MFM encoding recognizes that in many cases the transition is not necessary, because it is preceded by another transition, anyway. MFM reduces the number of transtions required in the code by requiring a clock transition only if one did not previously occur naturally. Specifically, a clock transition only occurs for a data bit of zero preceded by a data bit of 0.

|  |  |  |
| --- | --- | --- |
| **Data bit** | **Clock Transition** | **Data Transition** |
|  |  | |
| 0 preceded by 0 | T | N |
|  |  | |
| 0 preceded by 1 | N | N |
|  |  | |
| 1 | N | T |
|  |  | |

**42 Computer Hardware and Troubleshooting**

T = Transition

N = No Transition

**Run Length Limited (RLL)**

*Run length limited (RLL)* encoding schemes include a collection of encodings that can be categorized by two parameters: *run length* and *run limit*. The run length is the minimum number of cells (potential transitions) that can occur between transitions and the run limit is the maximum number of cells (potential transisitions) that can occur between transitions.

It is actually possible to consider FM encoding to be RLL (0,1) and MFM encoding to be RLL (1, 3). An FM encoding of 111 (NTNTNT) shows the minimum run length of 0 and the encoding of 101 (NTNNNT) shows the maximum run limit of 3.

But the more interesting cases are the other encodings that are possible when we consider encodings with these parameters. One RLL (2,7) encoding, first used by IBM, is shown below. It allows for 1.5x the density and throughput of MFM. Notice that groups of bits, not single bits, are encoded.

The minimum run length of 3 can be observed as follows:

1. No flux encoding pattern, by itself, contains less than two N's next to each other.

2. Some encoding patterns, when placed next to each other can generate exactly 7 N's next

to each other (consider 0011 0010).

3. The greatest number of trailing N's is 3 (0011) and the greatest number of leading N's is

4 (0011). Back-to-back, this creates a maximum run length of 7.

|  |  |
| --- | --- |
| **Data Bit Values** | **Flux Encoding** |
| 10 | NTNN |
| 11 | TNNN |
| 000 | NNNTNN |
| 010 | TNNTNN |
| 011 | NNTNNN |
| 0010 | NNNTNNTNN |
| 0011 | NNNNTNNN |

T = Transition

N = No Transition

RLL (3,9), which allows for an even greater data density, has also been used, but some implementations proved to be somewhat unreliable, because of the increased transition density. RLL (1,7), which allows for a compression density of 1.27 x MFM is also popular, because of the increased robustness of a lower transition density.

**43 Computer Hardware and Troubleshooting**

**Pondicherry University Questions**

**PART A**

**1.** What is the function of the memory? **(NOV 2012)**

**2.** What is the hard disk and how does it work? **(NOV 2012)**

**3.** What are the types of RAM module? **(NOV 2013)**

**4.** Write about serial ATA. **(NOV 2013)**

**5.** What are the two types of semiconductor memory? **(NOV 2014)**

**6.** Classify the floppy diskette according to the sector organisation. **(NOV 2014)**

**7.** Differentiate hard sector and soft sector disk. **(APR 2011)**

**8.** What are the two formats for recording on a magnetic disk? **(APR 2011)**

**9.** What is mean by disk and diskette? **(APR 2012)**

**10.** Differentiate single and dual head assembly drive. **(NOV 2010)**

**11.** What is DVD? **(APR 2012)**

**12.** Write any two common aspects between HDD and FDD. **(NOV 2012)**

**PART B**

1. What is Memory? Explain the types of memory. (Ref.Pg.No.5,Qn.No.1)

2. How memory works with the processor? Discuss. **(NOV 2012)** (Ref.Pg.No.5,Qn.No.2)

3. Explain briefly about Memory modules. Explain briefly: SIMM,DIMM,DDR (Ref.Pg.No.12,Qn.No.3)

4. Explain about Memory Banks (Ref.Pg.No.14,Qn.No.4)

5. Explain about Parity and ECC in detail. (Ref.Pg.No.15,Qn.No.5)

6. Explain about Logical Memory Layout. (Ref.Pg.No.15,Qn.No.6)

7. Explain about data-encoding schemes. (Ref.Pg.No.16,Qn.No.7)

8. Briefly explain about Hard Disk Drive. **(APR 2011)** (Ref.Pg.No.19,Qn.No.8)

9. Discuss in detail about auxiliary storage device. **(NOV 2012)** (Ref.Pg.No.19,Qn.No.9)

10. Explain components available in hard disk. **(NOV 2013)** (Ref.Pg.No.19,Qn.No.10)

11. Describe the function of HDD. (APR 2012) (Ref.Pg.No.19,Qn.No.11)

12. What is SATA? Explain. (Ref.Pg.No.25,Qn.No.12)

13. Explain Flash Memory Devices. (Ref.Pg.No.25,Qn.No.13)

14. Explain briefly about Compact Disk (CD) (Ref.Pg.No.27,Qn.No.14)

15. What are the criteria to be considered when selecting a CD / DVD drive? Explain them. **(NOV**

**2014)** (Ref.Pg.No.27,Qn.No.15)

16. Explain the structure and operating principles of CD-ROM in detail. **(NOV 2010)**

(Ref.Pg.No.27,Qn.No.16)

17. Explain in detail about CD and DVD technologies. **(APR 2012)** (Ref.Pg.No.27,Qn.No.17)

18. What are the types of Disk Drives? Explain it. **(NOV 2012)** (Ref.Pg.No.27,Qn.No.18)

19. Explain briefly about Digital Versatile Disc (DVD) (Ref.Pg.No.31,Qn.No.19)

20. Discuss about Optical Disc Format. (Ref.Pg.No.36,Qn.No.20)

**44 Computer Hardware and Troubleshooting**

21. Discuss in detail about Optical drive performance specifications (Ref.Pg.No.37,Qn.No.21)

22. Explain how can you test and troubleshoot the memory. **(NOV 2014)** (Ref.Pg.No.39,Qn.No.22)

23. What are the problems occurred in memory and how to troubleshoot it. (Ref.Pg.No.39,Qn.No.23)

24. Troubleshooting memory using BIOS Beep Codes (Ref.Pg.No.39,Qn.No.24)

25. What is SCSI? Discuss the eight bus phases of SCSI. **(APR 2011)** (Ref.Pg.No.40,Qn.No.25)

26. Discuss both FM and RLL recording methods of a magnetic disk drive. **(NOV 2010)**

(Ref.Pg.No.41,Qn.No.26)

27. Explain the following : a) Double Density Format, b) RLL Recording standards. **(NOV 2012)**

(Ref.Pg.No.41,Qn.No.26)