Module I

Motherboard (System board or Main board)

It is a large Printed Circuit Board (PCB) to which every component of a computer is directly or indirectly connected. It is the spine of the computer. It is the home to processor, main memory, chipset, cache memory, expansion bus, parallel and serial ports, mouse and keyboard connectors, IDE (Integrated Drive Electronics), EIDE (Enhanced/Expanded IDE), SCSI(Small Computer System Interface), SATA (Serial Advanced Technolody Attachment), etc. Motherboards are available in wide range.

Some motherboards are **blackplane style**, which are large circuit boards containing slots for expansion cards and enables communication between them. Backplanes are often described as being either *passive or active*. Passive backplanes contain just slots for expansion cards but almost no computing circuitry. Active backplanes contain, in addition to the slots, logical circuitry that performs computing functions.

A motherboard is specified by its **form factor**. It defines the style, dimension, powersupply type, location of mounting holes, number of ports on the backpanel, etc. Different form factors are AT, Baby AT, LPX, NLX, ATX, MicroATX, FlexATX, BTX,etc.

*** AT Form Factor (also referred to as Full AT or full-size AT):**

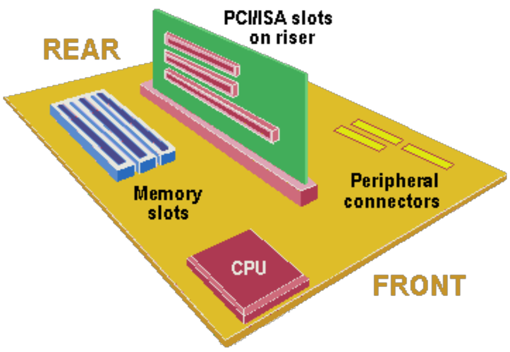
AT means Advanced Technology. The full-size AT board first came in August 1984 when IBM introduced the Personal Computer AT. The AT form factor was the first to introduce tower-style cases and systems to the PC world. The tower introduced the first front-side power switch in the PC world, rather than placed at the back panel of the case with the power supply unit. AT used the standard 5-pin DIN type connector for keyboard.

*** Baby AT Form Factor:**

The Baby-AT form factor replaced the AT form factor because of its smaller size. It was perfectly fitted into the AT case screw-holes and used the standard 5-pin DIN type connector for the keyboard. BabyAT was the most popular form factor from 1984 to 96 until the coming of ATX form factor. The Baby-AT motherboard has only one type visible connector directly attached to the board, which is the keyboard connector; full size 5-pin DIN connector or a 6-pin mini-DIN connector (also called PS/2 connector – Personal System/2) and might even have a PS/2 mouse connector (purple for keyboard and green for mouse). All other connectors are mounted on the case or on card edge brackets and are attached to the motherboard via cables.

*** LPX (Low Profile Extension):**

The LPX and mini-LPX form factor boards were semi-proprietary designs developed by Western Digital in 1980s for some motherboards. These boards had slots for inserting raiser cards. The expansion cards can be installed on these raiser cards parallel to the motherboard, which is why this design is called "Low Profile". This allows for a slim or low-profile case design and overall a smaller system than the Baby-AT. Slots are located on one or both sides of the riser card depending on the system and case design. Another distinguishing feature of the LPX design is the standard placement of connectors on the back of the board. An LPX board has a row of connectors for video, parallel, two serial ports and mini-DIN PS/2-style mouse and keyboard connectors. All these connectors are mounted across the rear of the motherboard and protrude through a slot in the case. Some boards have SCSI connectors also.



*** NLX (New Low-profile Extension):**

It is a fully standardised low-profile form factor which is an improved form of LPX and to replace the non-standard LPX. The main characteristic of an NLX system is that the motherboard itself plugs into the riser, unlike LPX where the riser plugs into the motherboard. All devices such as drive cables, the power supply, the front panel light, switch connectors, etc too are plugged into the riser. Therefore, the motherboard can be removed from the system without disturbing the riser or any of the expansion cards plugged into it. In addition, the motherboard in a typical NLX system literally has no internal cables or connectors attached to it.

*** ATX (Advanced Technology eXtended):**

The ATX form factor was the first of a dramatic evolution in motherboard form factors. ATX is designed by Intel and is a combination of the best features of the Baby-AT and LPX motherboard designs, with many new enhancements and features, but physically incompatible with both. A standard ATX motherboard has the size 12 inches x 9.6 inches. Its common features are;

Built-in double high external I/O connector panel - The back portion of the motherboard includes an I/O connector area. This enables external I/O connectors to be located directly on the board and minimizes the need for cables running from internal connectors to the back of the case as with Baby-AT designs.

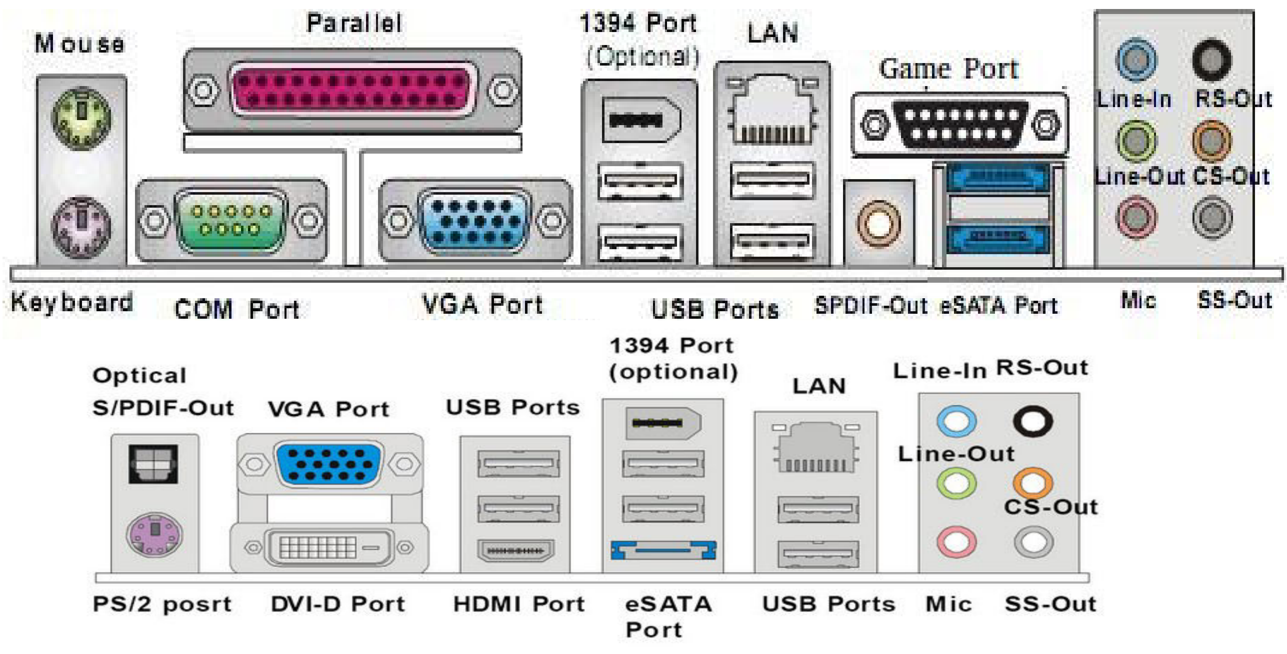
Single main keyed internal power supply connector - The ATX specification includes a keyed main power connector (20/24 pin) that is easy to plug in and install. This connector also features pins for supplying 3.3V to the motherboard, helping to minimize the use of built-in voltage regulators.

Relocated CPU and memory - The CPU and memory modules are located away from expansion cards so that they can't interfere with bus expansion cards and can easily be accessed for upgrade without removing any of the installed bus adapters. This arrangement puts the processor and memory in line with the fan output of the power supply, allowing the processor to run cooler. And because those components are not in line with the expansion cards, you can install full-length expansion cards.

Relocated internal I/O connectors - The internal I/O connectors for the floppy and hard disk drives are relocated to be near the drive bays.

Improved cooling - The CPU and main memory are designed and positioned to improve overall system cooling compared to Baby-AT and older designs.

Lower cost to manufacture - The ATX specification eliminates the need for the bunch of cables to external I/O port connectors found on Baby-AT motherboards.



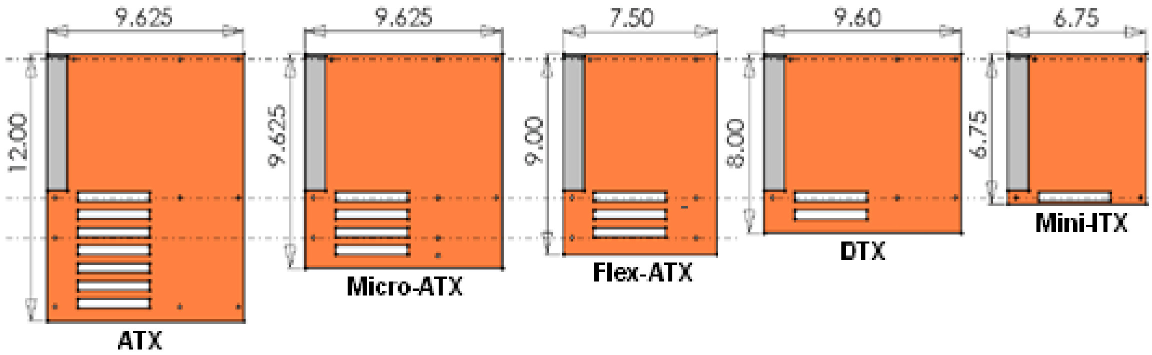
ATX Back panel Connectors

*** Micro ATX (also referred to as μATX):**

Intel introduced the microATX form factor as an evolution of the ATX form factor for smaller and lower-cost systems. They are backward compatible with ATX and can be used in ATX cases. Their maximum size is only 9.6 in × 9.6 in. The microATX and ATX form factors have same standard power connectors and I/O panel and microATX mounting holes are a subset of ATX. Since the size was smaller, the quantity of memory slots, motherboard headers, expansion slots, integrated components, etc are also smaller. This reduced the power consumption and heat production.

*** FlexATX:**

It is a modification over the microATX form factor intended to make PC designs for extremely inexpensive, smaller, consumer-oriented, appliance-type systems. Some of these designs might not even have expansion slots, allowing expansion only through USB or IEEE 1394/FireWire ports. FlexATX has a board size of 9 inches×7.5 inches and fully backward compatible to ATX and microATX with the same I/O and power supply connector specifications.



*** BTX (Balanced Technology Extended):**

It was designed by Intel. BTX offered increased component power, cooling requirements, improved circuit routing and more flexible case designs. However, they have become obsolete by the flexibility and acceptance of ATX and related form factors.

*** ITX (Information Technology eXtended):**

The ITX line of motherboard form factors was developed by VIA as a low-power, small form factor (SFF) board for specialty uses, such as home-theater systems and as embedded components. ITX itself is not an actual form factor but a family of form factors consisting of Mini-ITX, Nano-ITX, Pico-ITX and Mobile-ITX form factors. The Mini-ITX boards are compatible with ATX cases, but others are used in embedded systems, such as set-top boxes.

<u>Motherboard Components:</u>

Many of the following components can be found on a typical motherboard:

- ✔ Chipsets
- ✔ Expansion slots and buses
- ✔ Memory slots and external cache
- ✔ CPUs and their sockets
- ✔ Power connectors
- ✔ Onboard disk drive connectors
- ✔ Keyboard connectors
- ✔ Integrated peripheral ports and headers
- ✔ BIOS/firmware
- ✔ CMOS battery
- ✔ Jumpers and DIP switches
- ✔ Front-panel connectors

Bus Architecture:

In computer architecture, a bus is a communication path that transfers data between components inside a computer, or between computers. The heart of any motherboard is the various buses that carry signals between the components. The PC has a hierarchy of different buses. Most modern PCs have at least three buses. They are hierarchical because each slower bus is connected to the faster one above it. Each device in the system is connected to one of the buses, and some devices (primarily the chipset) act as bridges between the various buses. Some main buses in modern computer systems are the processor bus, Input/Output (I/O) buses and local buses. Buses can be parallel buses, which carry data words in parallel on multiple wires, or serial buses, which carry data in bit-serial form. The down- side of parallel communications is the limit of circuit length (how far the signal can travel) and throughput (the amount of data moved per unit of time). Careful synchronization of all lines must be needed for the data to reach the receiver. The only limitation of serial circuits is in the capability of the transceivers, which tends to grow over time at a refreshing rate due to technical advancements.

Expansion buses of various architectures, such as PCI and AGP, incorporate slots at certain points in the bus to allow insertion of external devices, or adapters, into the bus.

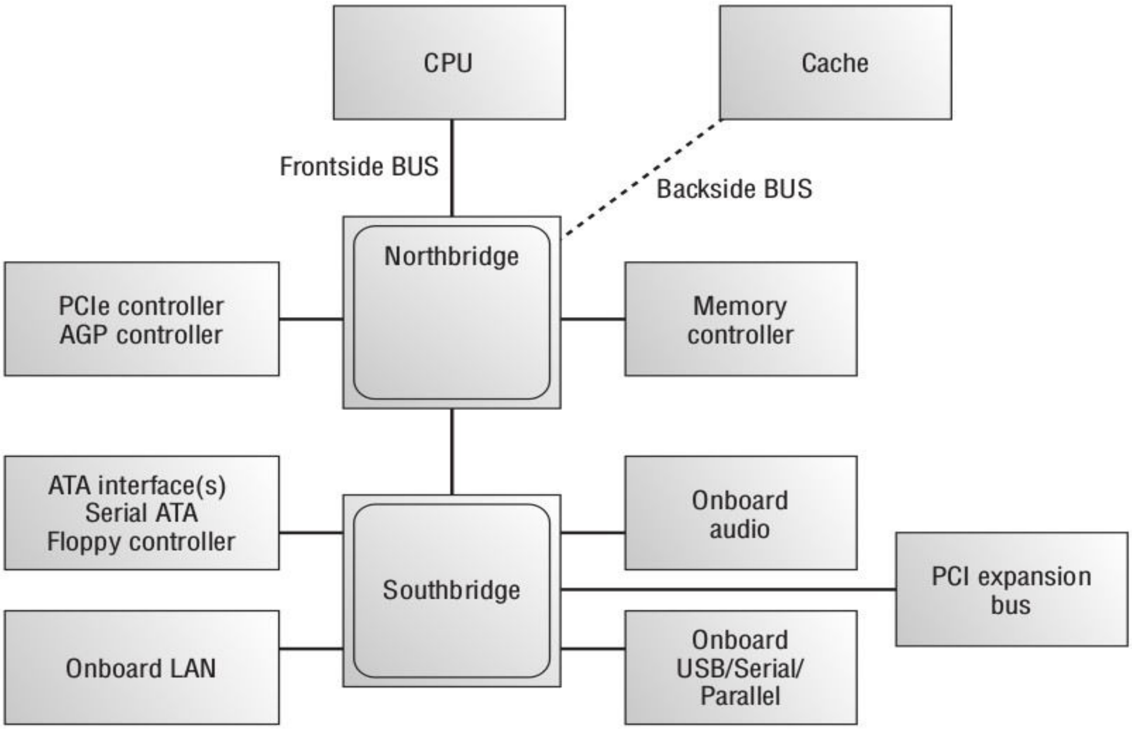
Chipsets

A chipset is a collection of chips or circuits that perform interface and peripheral functions for the processor. This collection of chips is usually the circuitry that provides interfaces for memory, expansion cards, and onboard peripherals and generally specifies how a motherboard will communicate with the installed peripherals. The chipset is the "glue" that connects the microprocessor to the rest of the motherboard and therefore to the rest of the computer. All of the various components of the computer communicate with the CPU through the chipset. Chipset selection and processor selection go hand in hand, because manufacturers optimize chipsets to work with specific processors. The chipset is an integrated part of the motherboard, so it cannot be removed or upgraded.

On a PC, it consists of two basic parts - the northbridge and the southbridge. The Northbridge part of the chipset controls the high-speed channels, while the Southbridge controls the lower speed devices.

The **Northbridge** is the controller that interconnects the processor to memory via the frontside bus (FSB). It also connects peripherals via high-speed channels such as AGP and PCI Express. The clock signal that drives the FSB is used to drive communications by certain other devices, such as AGP and PCIe slots, making them local-bus technologies. The backside bus (BSB), if present, is a set of signal pathways between the CPU and external cache memory (Level 2 or 3). The BSB uses the same clock signal that drives the FSB. If no backside bus exists, cache is placed on the frontside bus with the CPU and main memory. Much of the true performance of a PC relies on the specifications of the Northbridge component and its communications capability with the peripherals it controls. The Northbridge may include a display controller, eliminating the need for a separate display adapter. The North Bridge is sometimes referred to as the PAC (PCI/AGP Controller). In Intel's Hub Architecture, the Northbridge is called Memory Controller Hub (MCH). The Northbridge is directly connected to the Southbridge. It controls the Southbridge and helps to manage the communications between the Southbridge and the rest of the computer. Since the Northbridge handles high speed devices it heats up more, it is provided with heat sinks to cool down.

The **Southbridge** controller supports the slower peripheral I/O, including the Peripheral Component Interconnect (PCI), parallel and Serial ATA drives (IDE), USB, FireWire, serial and parallel ports, audio ports and legacy buses. These components do not need to keep up with the external clock of the CPU and do not represent a bottleneck in the overall performance of the system. Earlier chipsets supported the ISA bus in the Southbridge. In Intel's Hub Architecture, the Southbridge is called I/O Controller Hub (ICH). The Southbridge has no direct connection to the CPU in most architectures. Some Southbridge contains functionalities for RTC/NVRAM of CMOS.



Super I/O Chip

It's a separate chip attached to the ISA bus that is not really considered part of the chipset and often comes from some third parties. The Super I/O chip included some commonly used peripheral items combined into a single chip. Most South Bridge chips include Super I/O functions (such chips are known as Super-South Bridge chips), so that most motherboards no longer include a separate Super I/O chip. The Super I/O chip contains all the standard peripherals that are built into a motherboard. For example, most Super I/O chips contain the serial ports, parallel port, floppy controller, and keyboard/mouse interface. Optionally, they might contain the CMOS RAM/clock, IDE controllers, and game port interface as well.

Expansion Slots:

The most visible parts of any motherboard are the expansion slots. These are small plastic slots, usually from 1 to 6 inches long and approximately 1 ⁄ 2 inch wide. As their name suggests, these slots are used to install various devices in the computer to expand its capabilities. Some expansion devices that might be installed in these slots include video, network, sound, and disk interface cards.

PCI (Peripheral Component Interconnect) Expansion Slots:

Many computers in use today contain 32-bit Peripheral Component Interconnect (PCI) slots. They are easily recognizable because they are only around 3 inches long and classically white, although modern boards take liberties with the color. PCI slots became extremely popular with the advent of Pentium-class processors. The PCI bus often is called a *mezzanine bus* because it adds another layer to the traditional bus configuration. Information typically is transferred across the PCI bus at 33MHz or 66MHz with 32 bits at a time.

33.33MHz × 4 bytes (32 bits) = 133MBps (It is most common)

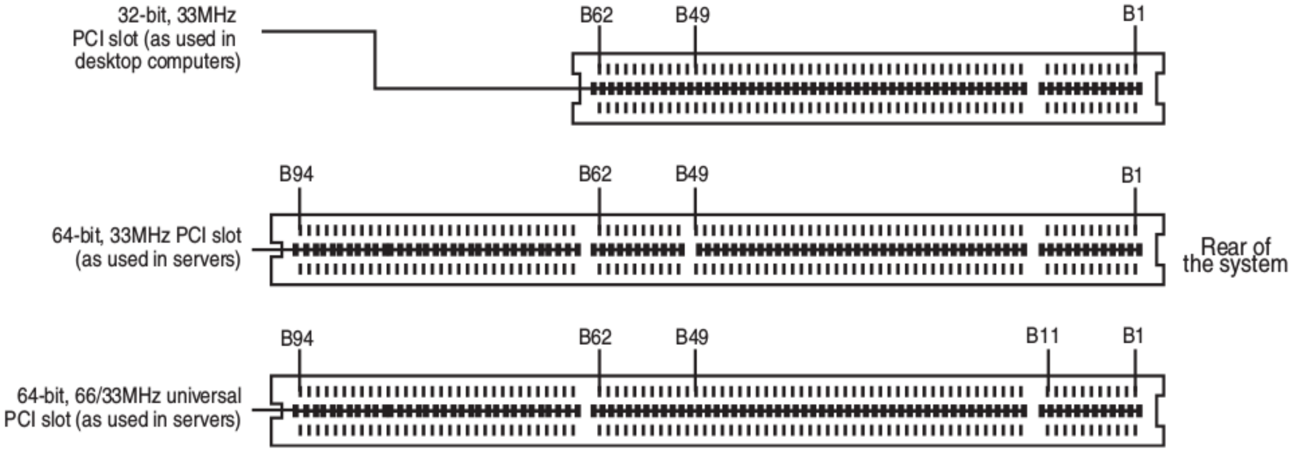
66.66MHz × 4 bytes (32 bits) = 266MBps

PCI of 66MHz is used in server systems. 64Bit PCI are also available which have data rates of 266MHz and 533MBps respectively for 33MHz and 66MHz varieties. These too are used in servers.

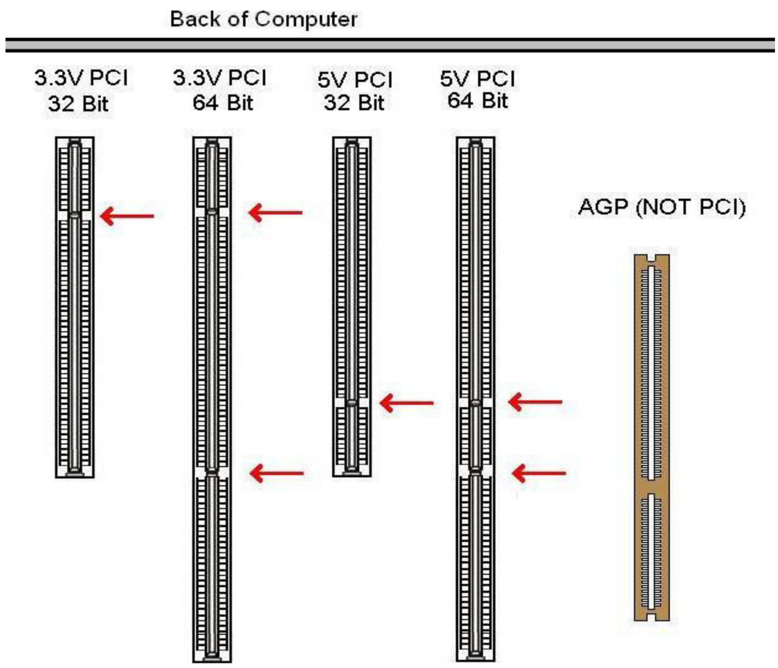
PCI slots and adapters are manufactured in 3.3 and 5V versions. Each PCI 32/64 specification identifies three board configurations based on power requirements; the 5V specification is for stationary computer systems, the 3.3V specification is for portable systems, and the universal specification is for motherboards and cards that work in either type of system. The notch in the card edge of the common 5V slots and adapters is oriented toward the front of the motherboard, and the notch in the 3.3V adapters toward the rear. The universal PCI board specifications effectively combine the 5V and 3.3V specifications and are keyed to fit in slots based on either of the two voltages. 64-bit versions of the 5V and universal PCI slots are found primarily on server motherboards.

PCI is a shared-bus topology, but mixing 33 and 66MHz adapters in a 66MHz system will slow all adapters to 33MHz. The PCI was the model for the Intel PnP (Plug and Play) specification. Therefore, PCI cards do not have jumpers and switches and are instead configured through software.

PCI Bus Type	Bus Width (Bits)	Bus Speed (MHz)	Data Cycles per Clock	Bandwidth (MBps)
PCI	32	33	1	133
PCI 66MHz	32	66	1	266
PCI 64-bit	64	33	1	266
PCI 66MHz/64-bit	64	66	1	533



A 32-bit 33MHz PCI slot (top) compared to a 64-bit 33MHz PCI slot (center) and a 64-bit universal PCI slot that runs at 66MHz (bottom).



PCI-X (Peripheral Component Interconnect eXtended) Expansion Slots:

A faster PCI version with 64 bit width. Visually it is *similar* to the PCI slots. But the frequency ranges from 66 MHz to 533MHz which gives the bandwidth of 533MBps to 4266MBps. Since PCI and PCI-X have some frequencies in common, PCI-X is backward compatible with PCI. It has the ability to disable faulty add-on cards.

PCI-X is targeted at server platforms with its speed and support for hot-plugging but became less useful after the invention of PCI Express (PCIe). PCI-X also suffers from the same shared-bus topology as PCI, resulting in all adapters falling back to the frequency of the slowest inserted adapter.

PCI Bus Type	Bus Width (Bits)	Bus Speed (MHz)	Data Cycles per Clock	Bandwidth (MBps)
PCI-X 64	64	66	1	533
PCI-X 133	64	133	1	1,066
PCI-X 266	64	133	2	2,132
PCI-X 533	64	133	4	4,266

AGP (Accelerated Graphics Port) Expansion Slots:

Intel created AGP as a new bus specifically designed for high-performance graphics and video support. AGP slots were designed to be a direct connection between the video circuitry and the PC's memory. AGP is based on PCI, but it contains several additions and enhancements and is physically, electrically, and logically independent of PCI. For example, the AGP connector is similar to PCI, although it has additional signals and is positioned differently in the system. Unlike PCI, which is a true bus with multiple connectors (slots), AGP is a point-to-point high-performance connection designed specifically for a video card in a system because only one AGP slot is allowed for a single video card.

AGP slots are easily recognizable because they are usually brown and are located right next to the PCI slots on the motherboard. AGP slots are slightly shorter than PCI slots and are pushed back from the rear of the motherboard in comparison with the position of the PCI slots *(see the above figure).*

AGP performance is based on the original specification, known as AGP 1x. It uses a 32-bit (4-byte) channel and a 66MHz clock, resulting in a data rate of 266MBps. AGP 2x, 4x, and 8x specifications multiply the 66MHz clock they receive to increase throughput. For instance, AGP 8x uses the 66MHz clock to produce an effective clock frequency of 533MHz, resulting in throughput of 2133MBps over the 4-byte channel. Note that this maximum throughput is only half the maximum of PCI-X.

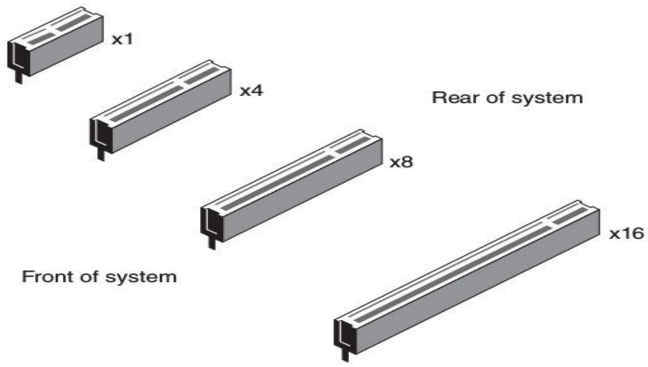
Bus Type	Bus Width (Bits)	Bus Speed (MHz)	DataCycles per Clock	Bandwidth (MBps)
AGP	32	66	1	266
AGP 2X	32	66	2	533
AGP 4X	32	66	4	1,066
AGP 8X	32	66	8	2,133

PCIe (PCI Express) Expansion Slots:

It was designed to be a replacement for AGP and PCI. PCIe has the advantage of being faster than AGP while maintaining the flexibility of PCI. PCIe has no compatibility with AGP or PCI. As a result, modern PCIe motherboards still tend to have regular PCI slots for backward compatibility, but AGP slots are not included. Here PCIe video cards can be used instead of AGP cards.

Unlike other expansion buses, which have parallel architectures, PCIe is a serial technology, striping data packets across multiple serial paths to achieve higher data rates. Also, PCIe uses a switching component with point-to-point connections to slots, giving each component full use of the corresponding bandwidth and producing more of a star topology versus a bus. Furthermore, PCIe uses the concept of lanes, which are the switched point-to-point signal paths between any two PCIe components. Each lane that the switch interconnects between any two intercommunicating devices consists of a separate pair of wires for both directions of traffic. The single lane or combined collection of lanes that the switch interconnects between devices is referred to as a link. There are seven different link widths supported by PCIe, designated as PCI Express x1 (pronounced "by 1"), x2, x4, x8, x12, x16, and x32. The x1, x4, and x16 are the most commonly used links. The length of the slot depends on the type of link, means the x1 is the smallest and x32 is the largest. Every PCIe slot has a 22-pin portion in common toward the rear of the motherboard. These 22 pins has mostly voltage and ground leads.

There are three major versions of PCIe: 1.x, 2.x, and 3.x. The version 4.0 is in progress.



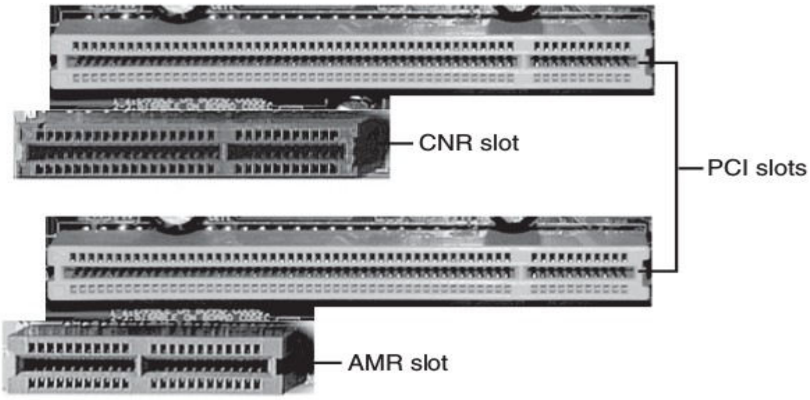
PCI Express x1, x4, x8, and x16 slots.

PCI Bus Type	Bus Width (Bits)	Bus Speed (MHz)	Data Cycles per Clock	Bandwidth (MBps)
PCI Express 1.x	1	2,500	0.8	250
PCI Express 1.x	16	2,500	0.8	4,000
PCI Express 1.x	32	2,500	0.8	8,000
PCI Express 2.x	1	5,000	0.8	500
PCI Express 2.x	16	5,000	0.8	8,000
PCI Express 2.x	32	5,000	0.8	16,000
PCI Express 3.x	1	8,000	~0.98	1,000
PCI Express 3.x	16	8,000	~0.98	16,000
PCI Express 3.x	32	8,000	~0.98	32,000

PCI Express 1.x and 2.x use 8b/10b encoding, which transfers 8 bits of data for every 10 bits sent.
PCI Express 3.x uses 128b/130b encoding, which transfers 128 bits of data for every 130 bits sent.

CNR (Communications and Networking Riser) Expansion Slots:

CNR slot can be found on some older Intel motherboards was a replacement for Intel's even earlier Audio/ Modem Riser (AMR) slot. The AMR was used to implement analog I/O (audio and modem functionality). The CNR was used for specialized networking, audio, and telephony equipment. A motherboard manufacturer can choose to provide analog modem, audio or networking functionality in any combination on a CNR card. One portion of this slot is the same length as one of the portions of the AMR slot, but the other portion of the CNR slot is longer than that of the AMR slot. A CNR riser card could be added to enhance the onboard sound capabilities. Additional advantages of CNR over AMR include networking support, Plug and Play compatibility, support for hardware acceleration, and the fact that there's no need to lose a competing PCI slot for networking unless the CNR slot is in use. Most motherboard manufacturers engineered boards which allow the CNR and last PCI slot to share the same space. The below given figure represents an AMR/CNR with its paired PCI slot. When the AMR/CNR slot is used, the PCI slot paired with it cannot be used.



<u>Memory Slots and Cache:</u>

Memory or Main Memory or Random Access Memory (RAM) slots are used to insert the memory modules. The memory modules hold memory chips which make up primary memory to store currently used data and instructions for the CPU. The single inline memory module (SIMM) is an older memory form factor that began the trend of placing memory chips on modules. Today's motherboards use Dual Inline Memory Module (DIMM) slots. DIMMs differ in the number of conductors, or pins, that each particular physical form factor uses. Some common examples include 168-, 184-, and 240-pin configurations. In addition, laptop memory comes in smaller form factors known as small outline DIMMs (SODIMMs) and MicroDIMMs.

Memory slots are easy to identify on a motherboard. Classic DIMM slots were usually black and, like all memory slots, were placed very close together. DIMM slots with color coding are more common these days, however. The color coding of the slots acts as a guide to the installer of the memory as channels (Single, Dual or Tripple channels). The number of memory slots varies from motherboard to motherboard, but the structure of the different slots is similar. Metal pins in the bottom make contact with the metallic pins on each memory module. Small metal or plastic tabs on each side of the slot keep the memory module securely in its slot.

(Virtual memory: see Operating System)

Cache Memory:

For a high speed processor, accessing the main memory all the times is a time consuming process eventhough the data needed are frequently used ones. Cache memory is a high-speed memory buffer that temporarily stores data the processor needs, allowing the processor to retrieve that data faster than if it came from main memory. A cache is a buffer with a brain. The cache controller anticipates the processor's memory needs and preloads the data/instruction into the cache. This enables the processor to continue working at either full speed or close to it without having to wait for the data to be retrieved from the slower main memory. This improves its performance.

Cache memory is usually made up of static RAM (SRAM) memory integrated into the processor die, although older systems with cache also used chips installed on the motherboard. The integrated cache can run at full processor speed. There are three levels of cache memory namely Level 1, Level 2, and Level 3 (L1, L2 and L3) in a PC. If the data that the processor wants is already in L1 cache, the CPU does not have to wait. If the data is not in L1 cache, the CPU must fetch it from the Level 2 or Level 3 cache or main memory directly.

<u>Internal Level 1 Cache:</u>

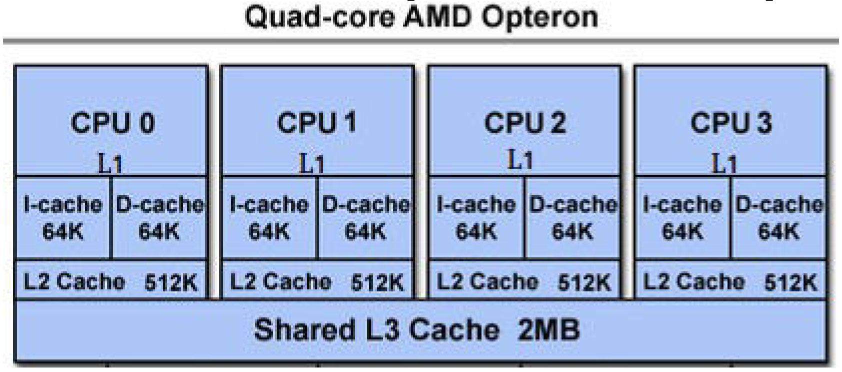
All modern processors starting with 486 have *integrated L1 cache* inside the core, working at full processor speed, size ranging from 8KB to 128 KB. This cache holds some of the current working set of instruction and data required by the processor. When the processor needs a instruction/data, it first checks whether the instruction/data is present in the L1 cache and fetches if it is there. It is said as a ***cache hit***. If the data is not there in L1 cache a ***cache miss*** is said to be occured and the processor has to wait until the data is fetched from other level caches or main memory. According to Intel, the L1 cache in most of its processors has approximately a 90% hit ratio. Multi-core processors include separate L1 caches for each processor core. Also, L1 cache is divided into *equal amounts for instructions (L1-I cache) and data (L1-D cache).*

L2 Cache:

To reduce the dramatic slowdown every time an L1 cache miss occurs, a secondary (L2) cache is employed. On an L1 cache miss the data is checked on this L2 cache. All modern processors have processor-integrated L2 cache that runs at almost the same speed as the processor core, but slower than L1 cache. L2 cache may be present in the processor die itself but outside the core. Multi-core processors may have separate L2 caches. L2 cache size may vary from 64kB to some MBs.

L3 Cache:

Some processors, primarily those designed for high-performance desktop operation or enterprise-level servers, contain a third level of cache known as L3 cache. Similar to L1-L2 association, an L2 cache miss leads to L3 cache check. Newer and faster multicore processors such as the Intel Core i7 and AMD Phenom II processors have L3 cache. There may be only one L3 cache for all the cores in a multi-core processor. L3 cache may be present on the motherboard, outside the processor. The size can be upto 12MB.



Central Processing Unit and Processor Socket:

The 'brain' of any computer is the central processing unit (CPU). It is usually the component that has either a fan or a heat sink (usually both) attached to it. These devices are used to draw away and disperse the heat a processor generates. The CPU is installed in either a socket or a slot, depending on the type of chip. The chip package can be PGA (Pin Grid Array – lot of pins at the bottom of the processor), LGA (Land Grid Array – lot of flat conducting areas at the bottom of the processor), BGA (Ball Grid Array – lot of conducting balls at the bottom of the processor), etc. CPU sockets are almost as varied as the processors they hold. Sockets are basically flat and have several columns and rows of holes or pins arranged in a square. For example, Socket A or Socket 462 has holes to receive the pins on the AMD Athlon processor which is of PGA type. Socket T or Socket LGA 775 has spring-loaded pins in the socket which come into contact with the lands (or pads) under the LGA type processors (Pentium 4, Pentium Core 2 Duo, etc).

Starting with the 486 processors, Intel designed the processor to be a user-installable and replaceable part. One key innovation was to use a **Zero Insertion Force (ZIF) socket** design for PGA processors, which meant that you could easily install or remove the processor with no tools. ZIF sockets use a lever to engage or release the grip on the chip, and with the lever released, the chip can be easily inserted or removed.

LGA processors do not have opportunity for a locking mechanism that holds the component with the pins in place. The LGA sockets have a lid that closes over the CPU and is locked in place by an L-shaped arm.

In the late 1990s , both Intel and AMD temporarily shifted to a **slot**-based approach for their processors, because the processors began incorporating built-in L2 cache, purchased as separate chips from third- party Static RAM (SRAM) memory chip manufacturers. Therefore, the processor then consisted not of one but of several chips, all mounted on a daughterboard that was then plugged into a slot in the motherboard. Slots were generally used in servers/workstations with low profile (backplane) mother boards which provided ease of processor/motherboard maintenance and replacement. This worked well, but there were additional expenses in the extra cache chips, the daughterboard itself, the slot, optional casings or packaging, and the support mechanisms and physical stands and latches for the processor and heatsink. All in all, slot-based processors were expensive to produce compared to the previous socketed versions. As the L2 cache was integrated directly into the processor die, thus the processor was back to being a single chip again, and regained the socket form.

BIOS and POST:

Other than the processor, the most important chip on the motherboard is the Basic Input/ Output System (BIOS) chip, also referred to as the ROM BIOS chip. The BIOS consists of low-level software that boots up the system, controls the system hardware and acts as an interface between the operating system (OS) and the hardware. It runs a power-on self test (POST) program and a bootstrap loader. The BIOS is stored in a fixed ROM (EEPROM) chip on the motherboard. It can be easily identified as it holds the name *BIOS* on it. Major BIOS manufacturers are AMI (American Megatrends Inc.), Phoenix/Award, etc.

BIOS has four main functions;

>> POST: A major function of the BIOS is to perform a process known as a power-on self-test (POST). It is a series of system checks to test the computer's processor, memory, chipset, video adapter, disk controllers, disk drives, keyboard, and other crucial components. POST routine verifies the integrity of the BIOS itself. It also verifies and confirms the size of primary memory. During POST, the BIOS also analyzes other forms of hardware, such as buses, boot devices and CPU fans. Once the POST has been done successfully, the BIOS continues with booting by finding the bootable device and executes its Master Boot Record (MBR). The MBR can call its associated Operating System's boot loader and continue booting up. If any error has occured during POST, it ends with some specific beep codes through speaker or some specific error codes displayed on the screen. Each BIOS publisher has its own series of codes.

>> Setup: Enables to configure the motherboard and chipset settings along with the date and time, passwords, disk drives, and other basic system settings. It controls the power-management settings and boot-drive sequence from the BIOS Setup, and on some systems, configure CPU timing and clock-multiplier settings.

>> Bootstrap loader: A routine that reads the first physical sector of various disk drives looking for a valid master boot record (MBR). The MBR program code then continues the boot process by reading the first physical sector of the bootable volume, which is the start of the volume boot record (VBR). The VBR then loads the OS.

>> Finally, BIOS loads actual drivers that act as a basic interface between the OS and hardware when the system is booted up and running.

CMOS (Complementary Metal Oxide Semiconductor) and CMOS Battery:

The PC has to store certain settings and parameters even when it is turned-off and its power cord is unplugged. These include the system date, time, harddrive/optical drive configuration, memory parameters, CPU settings such as overclocking, integrated ports parameters (enable/disable), boot sequence, power management, security passwords etc. The PC keeps these settings in a special memory chip called the complementary metal oxide semiconductor (CMOS) memory chip (CMOS RAM). The BIOS starts with its own default information and then reads information from the CMOS, such as which hard drive types are configured for this computer to use, which drive(s) it should search for boot sectors, and so on. Any overlapping information read from the CMOS overrides the default information from the BIOS. Also it includes a clock part to handle the Real Time Clock (RTC). To keep these parameters in the CMOS RAM, it uses a very small current (of range micro ampere) from a tiny nonrechargeable lithium battery. Hence this RAM is called Non-Volatile RAM (NVRAM). This battery is called the CMOS battery. In some models, the RTC/NVRAM functions are included in the Southbridge of the motherboard chipset. CMOS memory capacity is usually not upgradable and might be integrated into the BIOS chip or the Southbridge.

Identifying Purposes and Characteristics of Processors

The CPU or Processor is the most important part in a motherboard. Its purpose is to control and direct all activities in the computer system using both external and internal buses. A processor is basically a semiconductor (silicon) wafer containing arrays of millions of transisters. Since this wafer is very delicate, it is protected inside a hard material with the contacts protruding outwards. Intel and Advanced Micro Devices

(AMD) are the two largest PC-compatible CPU manufacturers.

Packaging:

Older chips were found in a rectangle with two rows of pins known as a dual inline package (DIP).

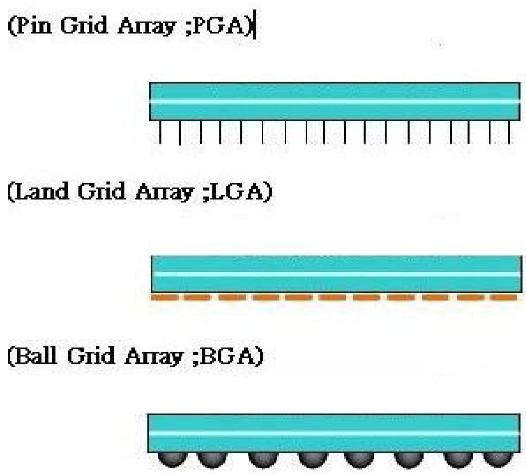
After this came the **PGA (Pin Grid Array)** packaging. The PGA chip packaging and its varients (like Plastic PGA, Ceramic PGA, etc) have been the most commonly used chip packages over the years. It has a grid-like array of pins on the bottom of the package. PGA chips are inserted into sockets, which are often of a zero insertion force (ZIF) design. A ZIF socket has a lever to allow for easy installation and removal of the chip.

Most original Pentium processors (like Pentium Pro) use a variation on the regular PGA called **staggered pin grid array (SPGA)**, in which the pins are staggered on the underside of the chip rather than in standard rows and columns. This was done to move the pins closer together and decrease the overall size of the chip when a large number of pins is required.

Early PGA variations mounted the processor die in a cavity under the substrate, whereas "**Flip Chip**" versions **(FC-PGA)** mount the processor die upside down to face away from the motherboard, so that less expensive solder bonding rather than expensive wire bonding can be used to connect the processor die to the chip package. Unfortunately, there were some problems with attaching the heatsink to an FC-PGA chip. The heatsink sat on the top of the die, which acted as a pedestal. If you pressed down on one side of the heatsink excessively during the installation process (such as when you attach the clip), the silicon die may be cracked and distroyed. This was especially a problem as heatsinks became larger and heavier and the force applied by the clip became greater. Intel and AMD then used a metal cap called a *heat spreader* over the top of the CPU to prevent damage when the heatsink is installed. This type of packaging is known as **FC-PGA2.**

Bumpless build-up layer (BBUL) packaging embeds the die completely in the package; in fact, the package layers are built up around and on top of the die, fully encapsulating it within the package. This embeds the chip die and allows for a full flat surface for attaching the heatsink.

Intel and AMD made slot based packaging called **single edge contact cartridge (SECC)** or **single edge processor package (SEPP)** and consisted of the CPU and optional separate L2 cache chips mounted on a circuit board that looked similar to an oversized memory module and that plugged into a *slot*. These forms allowed independent processor and cache testing. SECC had a plastic cartridge envelop whereas SEPP do not have that.



Ball Grid Array (BGA) packaging replaced the base pins of PGA with solder balls.

LGA (Land Grid Array) is a modified version of BGA packaging, with solder balls are replaced by gold pads (called *lands*), with greater stability and improved thermal transfer (better cooling). Here the pins are on the socket.

Characteristics of Modern Processors

Hyperthreading: Modern processors have a superscalar architecture with which they can execute multiple instructions operating on separate data in parallel, using internal instruction execution pipelines. Such type of execution is called simultaneous multithreading (SMT). Intel named such a technology as Hyper-Threading Technology (HTT). HTT-capable processors appear to the operating system to be two processors. As a result, the operating system can schedule two processes at the same time (as in the case of symmetric multiprocessing (SMP), where two or more processors use the same system resources). In fact, the operating system must support SMP in order to take advantage of HTT. If the current process stops because of a missing data, the execution resources of the processor can be reallocated for a different process that is ready to go, reducing processor downtime.

Multicore: A processor that exhibits a multicore architecture has multiple completely *separate processor dies (silicon wafer)* in the same package. The operating system and applications see multiple processors in the same way that they see multiple processors in separate sockets. As with HTT, the operating system must support SMP to benefit from the separate processors. In addition, SMP is not a benefit if the applications run on the SMP system are not written for parallel processing. Dual-core and quad-core processors are common specific examples of the multicore technology. Processors, such as certain models of AMD's Phenom series, can contain an odd number of multiple cores as well. The triple-core processor, which obviously contains three cores, is the most common implementation of multiple odd cores.

Throttling: CPU throttling allows automatically reducing the operating frequency of the CPU during times of less demand or during battery operation either to conserve power or to reduce the heat generated by the chip. Less heat output inturn allows the system cooling fans to be throttled down or turned off, reducing noise level and further decreasing power consumption. Throttling is also used to reduce heat in insufficiently cooled systems where the temperature reaches a certain threshold. CPU throttling is very common in processors for laptops and other mobile devices.

Speed: The speed of the processor is generally described in *clock frequency (MHz or GHz)*. Since the starting of the personal computer industry, motherboards have included quartz crystal oscillators . The phenomenon of a quartz crystal vibrating when exposed to a current is known as the *piezoelectric effect*. The crystal known as the *system clock* keeps the time for the flow of data on the motherboard. The frontside bus uses this clock as an effective clock rate known as the FSB speed. The FSB speed is computed differently for different types of RAM (DDR, DDR2, etc.). The CPU multiplies the FSB speed to produce its *own internal clock rate.* The CPU is capable of splitting the clock signal it receives from the external oscillator that drives the frontside bus into multiple regular signals for its own internal use.

32- and 64-bit processors: The set of data lines between the CPU and the primary memory of the system can be 32 or 64 bits wide, among other widths. The wider the bus, the more data that can be processed per unit of time, and hence, more work can be performed. Internal registers in the 32-bit CPU might be only 32 bits wide, but with a 64-bit system bus, two separate pipelines can receive information simultaneously. For true 64-bit CPUs, which have 64-bit internal registers and can run x64 versions of operating systems, the external system data bus will always be 64 bits wide or some larger multiple.

Virtualization support: Virtualization technology enables a CPU to act as if you have several independent computers, in order to enable several operating systems to run at the same time on the same machine. Many of today's CPUs support virtualization in hardware, which eases the burden on the system that software-based virtualization imposes. AMD's AMD-V (V for virtualization) technology and Intel's Virtualization Technology (VT) are examples.

Integrated GPU: Intel and AMD both have a line of low-power CPUs aimed at the netbook and embedded markets that have built-in Graphics Processing Units (GPU). A GPU is normally a large chip on the graphics adapter. Integrated GPUs reduces the burden of the CPU on handling the graphics part. This improves overall system performance. These type CPUs are quite a bit smaller than standard CPUs. The Intel Atom and AMD Fusion lines of CPUs have built-in GPUs.

Note:

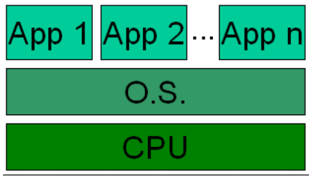
Virtualization with multitasking, multi-core, or Hyper-Threading.

When *multitasking*, there is a single operating system and several programs running at the same time. With virtualization, you can have several operating systems running in parallel, each one with several programs running. Each operating system runs on a "virtual machine," i.e., each operating system thinks it is running on a completely independent computer.

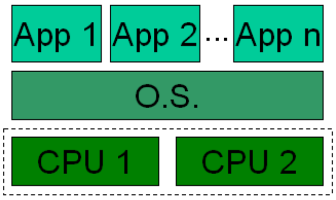
Multi-core technology allows a single processor to have more than one physical processor inside. For example, a computer with one dual-core processor acts as if it were a computer with two CPUs installed, working under a mode called symmetrical multiprocessing (SMP). Even though multi-core CPUs have more than one processor inside, they cannot be used independently. The operating system is run by the first CPU core, and the additional cores must be used by the same operating system.

Hyper-Threading technology simulates an additional processor per CPU core. For example, a dual-core CPU with Hyper-Threading technology is seen by the operating system as if it were a quad-core CPU. These additional processors cannot run separate operating systems, so for the operating system the Hyper-Threading technology has the same effect as the multi-core technology.

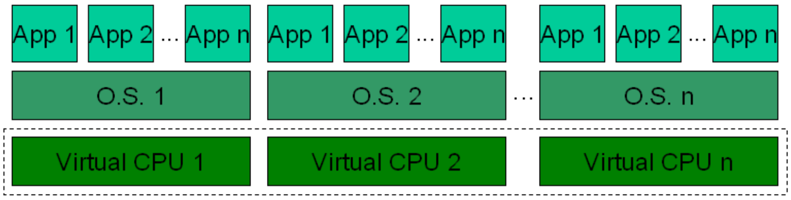
Multitasking



Multi-core or Hyper-Threading



Virtualization



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Identifying Purposes and Characteristics of Memory

Memory is the workspace for the processor. Memory is called Random Access Memory (RAM) as data can be randomly accessed from anywhere in the memory space. In this sense ROM is also a RAM. But usually the tarm 'main memory' or 'primary memory' refers to the volatile memory in the system. Physically, the main memory in a system is a collection of memory chips (as modules on a circuit board) that are usually plugged into the respective slots in the motherboard. These chips or modules vary in their electrical and physical designs, sizes, voltages and must be compatible with the system into which they are being installed to function properly.

There are a few technical terms and phrases with regard to memory and its function:

* Parity checking
* Error-correcting code (ECC)
* Single- and double-sided memory
* Single-, dual-, and triple-channel memory

Parity Checking and Memory Banks:

Parity checking is an *error-checking* scheme that offers *no error correction*. Parity checking works most often on a byte, or 8 bits, of data. A ninth bit is added at the transmitting end and removed at the receiving end so that it does not affect the actual data transmitted. The four most common parity schemes affecting this extra bit are known as *even*, *odd*, *mark* and *space*. *Even* and *odd* parity are used in systems that actually compute parity. *Mark* (a term for a 1 bit) and *space* (a term for a 0 bit) parity are used in systems that do not compute parity but expect to see a fixed bit value stored in the parity location. Systems that do not support or reserve the location required for the parity bit are said to implement *non-parity memory*. The most basic model for implementing memory in a computer system uses eight memory chips to form a set. Each memory chip holds millions or billions of bits of information, each in its own cell. For every byte in memory, one bit is stored in each of the eight chips. A ninth chip is added to the set to support the parity bit in systems that require it. One or more of these sets, implemented as individual chips or as chips mounted on a memory module, form *memory bank*.

The width of the system data bus, the external bus of the processor, tells how many memory chips or modules are required to satisfy a bank. For example, one 32-bit, 72-pin SIMM (single inline memory module) satisfies a bank for an old 32-bit CPU, such as a 386 or 486 processor. Two such modules are required to satisfy a bank for a 64-bit processor, a Pentium, for instance. However, only a single 64-bit, 168-pin DIMM is required to satisfy the same Pentium processor.

Even parity in a byte tells that the number of 1's in that byte should be even. If yes, a zero bit is added at the ninth place as the parity bit, if not (ie, the number of 1's is odd), a 1 is added at the ninth place to make the parity even. This is same for odd parity. In the receiver keeping even parity, if the data (8 bits plus parity bit) seems to be having odd number of 1's, an error is supposed to be occured. Thus parity can find out single bit error, but fails in multibit errors.

In the early days of personal computing, almost all memory was parity based and the cost of those modules were higher due to additional memory chips and additional circuitry. Now-a-days parity is rarely used.

Error Checking and Correction :

If memory supports error-correcting code (ECC), check bits are generated and stored with the data. An algorithm is performed on the data and its check bits whenever the memory is accessed. If the result of the algorithm is all zeros, then the data is considered as valid and processing continues. ECC can detect single- and double-bit errors and actually correct single-bit errors.

Single- and Double-Sided Memory :

Commonly speaking, the terms single-sided memory and double-sided memory refer to how some memory modules have chips on one side while others have chips on both sides. Double-sided memory is essentially treated by the system as two separate memory modules. Motherboards that support such memory have memory controllers that must switch between the two “sides” of the modules and, at any particular moment, can access only the side they have switched to. Double-sided memory allows more memory to be inserted into a computer using half the physical space of single-sided memory, which requires no switching by the memory controller.

Single-, Dual-, and Triple-Channel Memory:

Standard memory controllers manage access to memory in chunks of the same size as the system bus’s data width. This is considered communicating over a *single-channel*. *Dual-channel* memory is the memory controller’s coordination of two memory banks to work as a synchronized set during communication with the CPU, doubling the specified system bus width from the memory’s perspective. *Triple-channel* memory demands the coordination of three memory modules at a time. Usually memory modules of same type, speed and capacity are used in the slots of dual / tripple channels.

When operating in triple-channel mode, memory latency is reduced due to *interleaving*, meaning that each module is accessed sequentially for smaller bits of data rather than completely filling up one module before accessing the next one. Data is spread amongst the modules in an alternating pattern, potentially tripling available memory bandwidth for the same amount of data, as opposed to storing it all on one module. The architecture can only be used when all three, or a multiple of three, memory modules are identical in capacity and speed, and are placed in three-channel slots. When two memory modules are installed, the architecture will operate in dual-channel architecture mode.

Single channel memory slots may have tha same colour. In some motherboards supporting dual-channel memory architecture, the slots of the same channel will have the same colour. Similary slots of tripple-channel will also have the same colour.

Types of Memory:

Memory comes in many formats. Each one has a particular set of features and characteristics, making it best suited for a particular application. The following is the classification of different types of memory (RAM).

- DRAM
    - Asynchronous DRAM
        - FPM DRAM
        - EDO DRAM
        - BEDO DRAM

        - Synchronous DRAM
            - SDR SDRAM
            - DDR SDRAM
            - DDR2 SDRAM
            - DDR3 SDRAM
            - DRDRAM
- SRAM
- ROM

DRAM (Dynamic RAM):

Dynamic RAM (DRAM) is the type of memory chip used for most of the main memory in a modern PC. The main advantages of DRAM are that it is very dense, meaning you can pack a lot of bits into a small chip, and it is inexpensive, which makes purchasing large amounts of memory affordable. The memory cells in a DRAM chip are tiny capacitors (along with a transistor) that retain a charge to indicate a bit. If the capacitor is charged, the cell is read to contain a 1; no charge indicates a 0. The problem with DRAM is that it is dynamic- that is, its contents may be changed at any time. With every keystroke or every mouse swipe, the contents of RAM change. It must be constantly refreshed using a *refresh signal*; otherwise, the electrical charges in the individual memory capacitors drain and the data is lost. Refresh occurs when the memory controller takes a tiny break and accesses all the rows of data in the memory chips. The standard refresh time is 15ms (milliseconds), which means that every 15ms, all the rows in the memory are automatically read to refresh the data. Some memory cells drains faster causing Soft Errors in memory. If the draining happens for more cells it may lead to blue screen, global protection faults, corrupted files, system crash, etc. Many modern systems don’t allow changes to memory timings and are permanently set to automatic settings. DRAMs can be *synchronous* or *asynchronous*.

<u>Asynchronous DRAM (ADRAM):</u>

Asynchronous DRAM is an older type of DRAM used in the first personal computers. It is called "asynchronous" because memory access is not synchronized with the computer system clock. When a program issued an instruction to access data in asynchronous memory, the data would be accessible on the system bus some time later, but this time was variable (40- to 120-nanosecond) and not guaranteed. This makes the faster CPU to wait for the data to be available and reduces the performance. These wait states represents intervals that the CPU will do nothing other than waiting for the data.

Common asynchronous DRAM technologies included Fast Page Mode (FPM), Extended Data Out (EDO), and Burst EDO (BEDO) .

Fast Page Mode (FPM) DRAM is slightly faster than convensional DRAM. While standard DRAM requires that a row and column to be sent for each address, FPM works by sending the row address just once for many accesses to memory in locations near each other, improving access time. This memory doesn't need any compatibility or support. Even though it was faster than convensional DRAM, in modern PCs it is one of the slowest DRAMs. Most 386, 486, and Pentium systems from 1987 through 1995 used FPM memory, which came in either 30-pin or 72-pin SIMM form with 5V operational voltage.

Extended Data Out (EDO) DRAM is the most common type of *asynchronous* DRAM. It is a modification of FPM memory and sometimes called *hyper page mode DRAM*. It has a modified timing circuit, so one access to the memory can begin before the last one has finished and hence it is a little bit faster than FPM memory. EDO memory requires support from the system chipset. EDO RAM generally came in 72-pin SIMM form with 5V operational voltage.

Burst EDO (BEDO) DRAM was a modification of EDO memory. Burst mode cycling takes advantage of the consecutive nature of most memory accesses. After setting up the row and column addresses for a given access, using burst mode, we can then access the *next three* adjacent addresses with no additional latency or wait states. This improved speed of BEDO memory. Unfortunately, the technology was owned by the company Micron and not a free industry standard, so it was quickly replaced by industry-standard SDRAM.

<u>Synchronous DRAM (SDRAM)</u>

Synchronous DRAM (SDRAM) shares a common clock signal with the computer’s systembus clock, which provides the common signal that all local-bus components use for each step that they perform. This characteristic makes SDRAM to work with the speed of the FSB and hence the processor, eliminating the need to configure the CPU to wait for the memory to catch up.

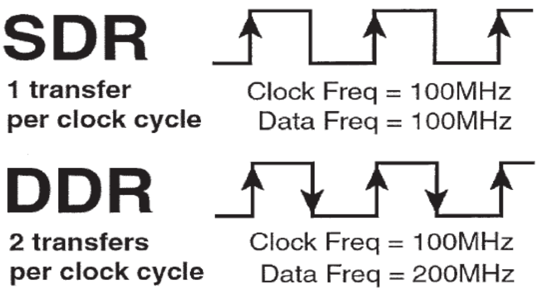
SDRAM normally came in 168-pin DIMMs, running at several speeds. Intel created specifications for SDRAM called PC66, PC100, and PC133 with speeds 66MHz, 100MHz and 133MHz and run at 3.3V.

SDRAM Module (168-Pin DIMM) Speeds and Transfer Rates

Module Type	Chip Type	Clock Speed	Cycles per Clock	Bus Speed	Bus Width	Transfer Rate
PC66	15ns 10ns	66MHz	1	66MTps	8 bytes	533MBps
PC100	8ns	100MHz	1	100MTps	8 bytes	800MBps
PC133	7.5ns 7ns	133MHz	1	133MTps	8 bytes	1,066MBps

MHz = Million cycles per second
MTps = Million transfers per second
MBps = Million bytes per second
ns = Nanoseconds (billionths of a second)

SDR SDRAM: Originally, the term SDRAM was used to denote a synchronous DRAM where the data transfer occurs once in a clock pulse, ie on the edge of the clock pulse. Hence, later this form of SDRAM was called *Single Data Rate SDRAM (SDR SDRAM).* For such a memory with 64bit data width, 64 bits (8 bytes) are transferred in a single clock tick. For example, for a PC100 (with speed 100 Mhz), the data transfer rate is 800MBps (100MHz x 8 bytes/tfr).



DDR SDRAM: Double data rate (DDR) SDRAM earns its name by doubling the transfer rate of ordinary SDRAM; it does so by transferring the bits on both the rising and falling edges of the clock signal. This obtains twice the transfer rate at the *same* FSB clock frequency. For example, the same 100MHz clock gives a DDR SDRAM system the impression of a 200MHz clock in comparison to an SDR SDRAM system. DDR SDRAM uses a DIMM module design with 184 pins. DDR DIMMs come in a variety of speed or throughput ratings and normally run on 2.5 volts. Most chipsets that support DDR also support dual-channel operation.

Table JEDEC Standard DDR Module (184-Pin DIMM) Speeds and Transfer Rates

Module Type	Chip Type	Base Clock Speed	Cycle Time	Cycles per Clock	Bus Speed	Bus Width	Module Transfer Rate	Dual-Channel Transfer Rate
PC1600	DDR200	100MHz	10.0ns	2	200MTps	8 bytes	1,600MBps	3,200MBps
PC2100	DDR266	133MHz	7.5ns	2	266MTps	8 bytes	2,133MBps	4,266MBps
PC2700	DDR333	166MHz	6.0ns	2	333MTps	8 bytes	2,667MBps	5,333MBps
PC3200	DDR400	200MHz	5.0ns	2	400MTps	8 bytes	3,200MBps	6,400MBps

DDR = Double data rate
MHz = Million cycles per second
MTps = Million transfers per second
MBps = Million bytes per second
ns = Nanoseconds (billionths of a second)

Consider a base clock speed of 100MHz. A DDR memory chip that works on this speed will have an effective rate of 200MHz (because of the data transfer at the two edges of the clock). This chip is called a *DDR200* chip. A memory module that is made up of such chips for 64bit (8Byte) data transfer will have transfer rate of 1600MBps (8B x 200MHz). Such modules are called *PC1600*. And the memory bus will have a transfer rate of *200 Million Transfers per second (MTps)*. In a sustem supporting *dual-channel* operation two PC1600 memory modules will give a data transfer rate of 3200MBps.

Most DDR and conventional SDRAM chips use the *thin small outline package (TSOP)* chip packaging in their modules due to the lower pin count.

DDR2 SDRAM: DDR2 is 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 to achieve four times of the FSB clock speeds with more immunity to noise and crosstalk between the signals. The additional signals increases the pin count to 240 pins. The original DDR specification officially has maximum 400MHz whereas DDR2 starts at 400MHz and goes up to an official maximum of 1,066MHz. It uses *lower voltage (1.8V)* than conventional DDR, so power consumption and heat generation are reduced. Because of the greater number of pins required on DDR2 chips, the chips typically use Fine-pitch Ball Grid Array (FBGA) packaging. FBGA chips connect to the substrate (circuit board) through tightly spaced solder balls on the base of the chip. DDR3 modules support single and dual channel operation.

Similar to DDR chip specification, DDR2 chips are specified by their effective clock frequency. For 100MHz FSB the internal clock for DDR2 chips are boosted so that the effective clock frequency will be double that of the original FSB. Thus for 100MHz FSB, the internal clock of DDR2 will be *200MHz*. Since the data transfer happens at both the clock edges, the transfer rate and the bus speed will be *400MTps*. Thus the chip is designated as DDR2-400. Since one transfer contains 8 Bytes, the memory module transfer rate will be 400MTps x 8 Bytes = 3200MBps. Thus the module is designated as PC2-3200. In both the chip and the module the figure '2' denotes that it is a DDR2 type.

DDR2 Module (240-Pin DIMM) Speeds and Transfer Rates

Module Type	Chip Type	Base Clock Speed	Cycle Time	Cycles per Clock	Bus Speed	Bus Width	Module Transfer Rate	Dual-Channel Transfer Rate
PC2-3200	DDR2-400	200MHz	5.00ns	2	400MTps	8 bytes	3,200MBps	6,400MBps
PC2-4200	DDR2-533	266MHz	3.75ns	2	533MTps	8 bytes	4,266MBps	8,533MBps
PC2-5300	DDR2-667	333MHz	3.00ns	2	667MTps	8 bytes	5,333MBps	10,667MBps
PC2-6400	DDR2-800	400MHz	2.50ns	2	800MTps	8 bytes	6,400MBps	12,800MBps
PC2-8500	DDR2-1066	533MHz	1.88ns	2	1,066MTps	8 bytes	8,533MBps	17,066MBps

DDR = Double data rate
MHz = Million cycles per second
MTps = Million transfers per second
MBps = Million bytes per second
ns = Nanoseconds (billionths of a second)

DDR3 SDRAM: DDR3 is a memory type that was designed to be twice as fast as the DDR2 memory that operates with the same system clock speed. DDR3 modules use advanced signaling techniques, including self-driver calibration and data synchronization, along with an optional onboard thermal sensor. DDR3 memory runs on only 1.5V, which is less than the DDR2 (1.8V) uses. The lower voltage combined with higher efficiency reduces overall power consumption compared to DDR2. The 240-pin DDR3 modules are similar in pin count, size, and shape to the DDR2 modules; however, the DDR3 modules are incompatible with the DDR2 circuits and are designed with different keying to make them physically noninterchangeable. DDR3 modules support single, dual and tripple channel operation. DDR3 chips are designated by the term DDR3 with their effective clock rate (or bus speed) such as DDR3-800. The DDR3 memory modules are designated by the term PC3 with their effective data transfer rate, such as PC3-6400. The earliest DDR3 chips were based on 100MHz clock (which gives an effective clock speed of 400MHz and bus speed of 800MTps) but most DDR3 chips starts from 133MHz (which gives an effective clock speed of 533MHz and bus speed of 1066MTps).

DDR3 Module (240-Pin DIMM) Speeds and Transfer Rates

Module Type	Chip Type	Base Clock Speed	Cycle Time	Cycles per Clock	Bus Speed	Bus Width	Module Transfer Rate	Dual-Channel Transfer Rate	Tri-Channel Transfer Rate
PC3-6400	DDR3-800	400MHz	2.50ns	2	800MTps	8 bytes	6,400MBps	12,800MBps	19,200MBps
PC3-8500	DDR3-1066	533MHz	1.88ns	2	1,066MTps	8 bytes	8,533MBps	17,066MBps	25,600MBps
PC3-10600	DDR3-1333	667MHz	1.50ns	2	1,333MTps	8 bytes	10,667MBps	21,333MBps	32,000MBps
PC3-12800	DDR3-1600	800MHz	1.25ns	2	1,600MTps	8 bytes	12,800MBps	25,600MBps	38,400MBps
PC3-14900	DDR3-1866	933MHz	1.07ns	2	1,866MTps	8 bytes	14,933MBps	29,866MBps	44,800MBps
PC3-17000	DDR3-2133	1066MHz	0.94ns	2	2,133MTps	8 bytes	17,066MBps	34,133MBps	51,200MBps

DDR = Double data rate
MHz = Million cycles per second
MTps = Million transfers per second
MBps = Million bytes per second
ns = Nanoseconds (billionths of a second)

PC Memory Types and Performance Levels

Memory Type	Years Popular	Desktop Module Type	Laptop Module Type	Voltage	Max. Clock Speed	Max. Throughput Single-Channel	Max. Throughput Dual-Channel	Max. Throughput Triple-Channel
Fast Page Mode (FPM) DRAM	1987–1995	30/72-pin SIMM	72/144-pin SODIMM	5V	22MHz	177MBps	N/A	N/A
Extended Data Out (EDO) DRAM	1995–1998	72-pin SIMM	72/144-pin SODIMM	5V	33MHz	266MBps	N/A	N/A
Single Data Rate (SDR) SDRAM	1998–2002	168-pin DIMM	144-pin SODIMM	3.3V	133MHz	1,066MBps	N/A	N/A
Double Data Rate (DDR) SDRAM	2002–2005	184-pin DIMM	200-pin SODIMM	2.5V	400MTps	3,200MBps	6,400MBps	N/A
DDR2 SDRAM	2005–2008	240-pin DDR2 DIMM	200-pin SODIMM	1.8V	1,066MTps	8,533MBps	17,066MBps	N/A
DDR3 SDRAM	2008+	240-pin DDR3 DIMM	204-pin SODIMM	1.5V	2,133MTps	17,066MBps	34,133MBps	51,200MBps

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

[DDR4 is now available. DDR4 operates at a voltage of 1.2 V with a frequency between 800 and 1600 MHz]

DRDRAM: Direct Rambus DRAM or simply RDRAM (Rambus DRAM), named for Rambus (the company that designed it) is a proprietary SDRAM technology and most often associated with server platforms mainly in certain Intel-based Pentium III and 4 systems from 2000 through 2002. Since it was a proprietary standard, it didn't became popular and AMD didnot use RDRAM at all. While other DRAMs used 64bit wide channel for data transfer, RDRAM was only 16bit wide. Thus it was more serial than parallel. It worked on an 800MHz clock and offered a 2Byte x 800MHz = 1600 MBps of theoretical memory bandwidth and offers improved memory access at a slightly higher cost when compared to SDRAM. In Pentium 4, the RDRAM was used as dual channel, increasing the throughput to 3200 MBps. All memory transfers are done between the memory controller and a single chip, not between modules. Each RDRAM chip operates as a standalone device sitting on the 16-bit data channel. Internally, each RDRAM chip has a core that operates on a 128-bit wide bus split into eight 16-bit banks running at 100MHz (10ns). This internally wide (16byte) yet externally narrow (2 byte) high-speed interface is the key to RDRAM. RDRAM used 2.5V and had 184 pins. Its disadvantages are increased latency, heat output, complexity in the manufacturing process and cost. Due to high heat output, RDRAM is provided with heatsinks.

SRAM: Static RAM is much faster than DRAM and much more capable of keeping pace with modern processors. Static RAM does not need periodic refreshing like DRAM, since there are no capacitors. For each bit SRAM uses a cluster of six transisters and hence it is less denser than DRAM. The cost of production is much larger too. Since SRAM is much faster than DRAM, it is used for cache memory.

Memory Packaging:

Originally, PCs had memory installed via individual chips. They are often referred to as *dual inline package (DIP)* chips because of their physical designs. The original IBM XT and AT systems had 36 sockets on the motherboard for these individual chips. Later, to avoid *chip creep* (chips coming out of the sockets gradually) and for easy use, the memory chips soldered on motherboard. But if a chip got damaged the entire motherboard had to be changed. Then came the *memory modules*; ie, memory chips soldered on removable cards. These modules are inserted into memory slots on the motherboard.

Early modules had one row of electrical contacts and were called *SIMMs (single inline memory modules)*, whereas later modules had two rows and were called *DIMMs (Dual Inline Memory Modules)* or *RIMMs (Rambus Inline Memory Modules)*. These small boards plug into special slots on a motherboard. The module is treated as though it were one large memory chip.

The memory module packaging refers to the type of chips used, number of pins on the module, keying, etc. Some older packages are DIP and SIMM. Newer packagings include the following:

- DIMM (Dual Inline Memory Module)
- RIMM (Rambus Inline Memory Module)
- SODIMM (Small Outline DIMM)
- MicroDIMM

Single In-line Memory Module (SIMM): In this module, the connections on both sides are the same. The pins are numbered from left to right and are connected to both sides of the module on the SIMMs. The chips can be seen The 30-Pin SIMM was the first generation of the SIMM memory family. They come in both 8 bit and 9 bit (parity) configurations, used 5Volts, with memory ranges of 256KB to 16MB. They supported Fast Page Mode memory access. The 72-Pin SIMM was the second generation of the SIMM family and are physically larger than 30-Pin SIMMs. Both versions can have chips on one or both sides. They come in both 32 bit and 36 bit (parity) configurations, with memory ranges from 1MB to 128MB. They used 5Volts. Both FPM and EDO DRAMS supported 72 pin configurations.

Dual Inline Memory Modules (DIMM): DIMMs are commonly 64-bit memory modules that are used as a package for the SDRAM family: SDR, DDR, DDR2, and DDR3. The term *dual* refers to the fact that, unlike their SIMM predecessors, the pins on both sides of the DIMM module have different functionalities. Also each type has keying placed at different positions to represent the type of memory and its voltage specification. All DIMMs are either 64 bits (non-ECC/non-parity) or 72 bits (data plus parity/ECC) wide.

DIMMs are available in four main types.

* SDR (single data rate) DIMMs have 168 pins, one notch on either side for locking, and two notches along the contact area. It has 5V and 3.3 V standards but mainly used 3.3V. The main feature was the inclusion of a serial EEPROM called the *"Serial Presence Detect (SPD)"* which contains information about the module type. Later generations of the 168 Pin DIMM became available as Registered DIMM's or Buffered DIMM's for

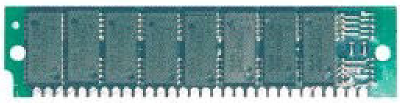
high-end workstations and servers and Un-buffered DIMM's for most personal computers. (The buffered DIMM has register-chips which act as an interface buffer between the chipset and the RAM, for modules with large number of memory chips). The position of the notches in the contact area indicate *the voltage* and the *type of the DIMM* (buffered ot not).

* DDR DIMMs have 184 pins, two notches on each side for locking, and only one offset notch along the contact area. DDR DIMMs use two notches on each side to enable compatibility with both low- and high-profile latched sockets. These DIMMs work on 2.5V.

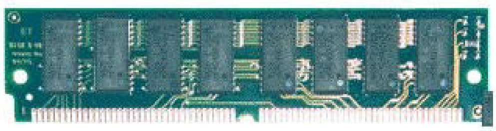
* DDR2 DIMMs have 240 pins, two notches on each side for locking, and one near the center of the contact area. There is no voltage keying because all DDR2 DIMMs run on 1.8V.

* DDR3 DIMMs have 240 pins, two notches on each side for locking and one near center of the contact area . There is no voltage keying because all DDR3 DIMMs run on 1.5V.

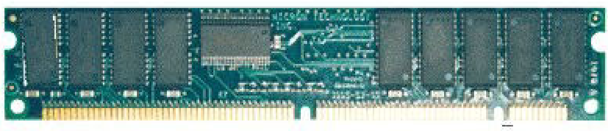
RIMM (Rambus Inline Memory Module): This is used for RDRAMs. The 184 pin RIMM module comes in both 16bit and 18bit ECC configurations for RDRAMs. The Rambus packaging is referred to as the Ball Grid Array (BGA) form factor. The Rambus modules only require 2.5 volts. Unlike most other computer memory, computers that support RIMM require a continuous signal through memory sockets. If a memory socket is left empty, the computer will not work properly. Therefore, users must utilize C-RIMM modules in any slots that do not have RIMM modules.



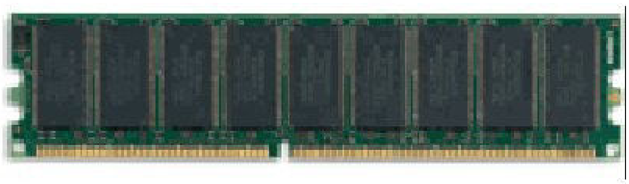
30 Pin SIMM



72 Pin SIMM



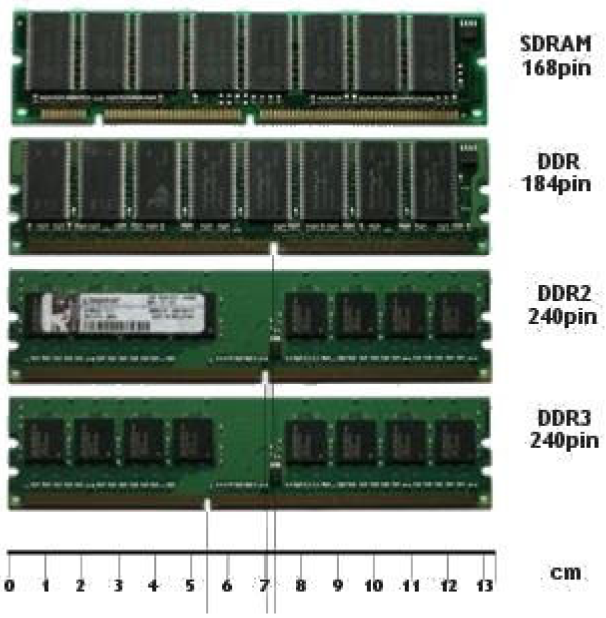
168 Pin SDRAM DIMM

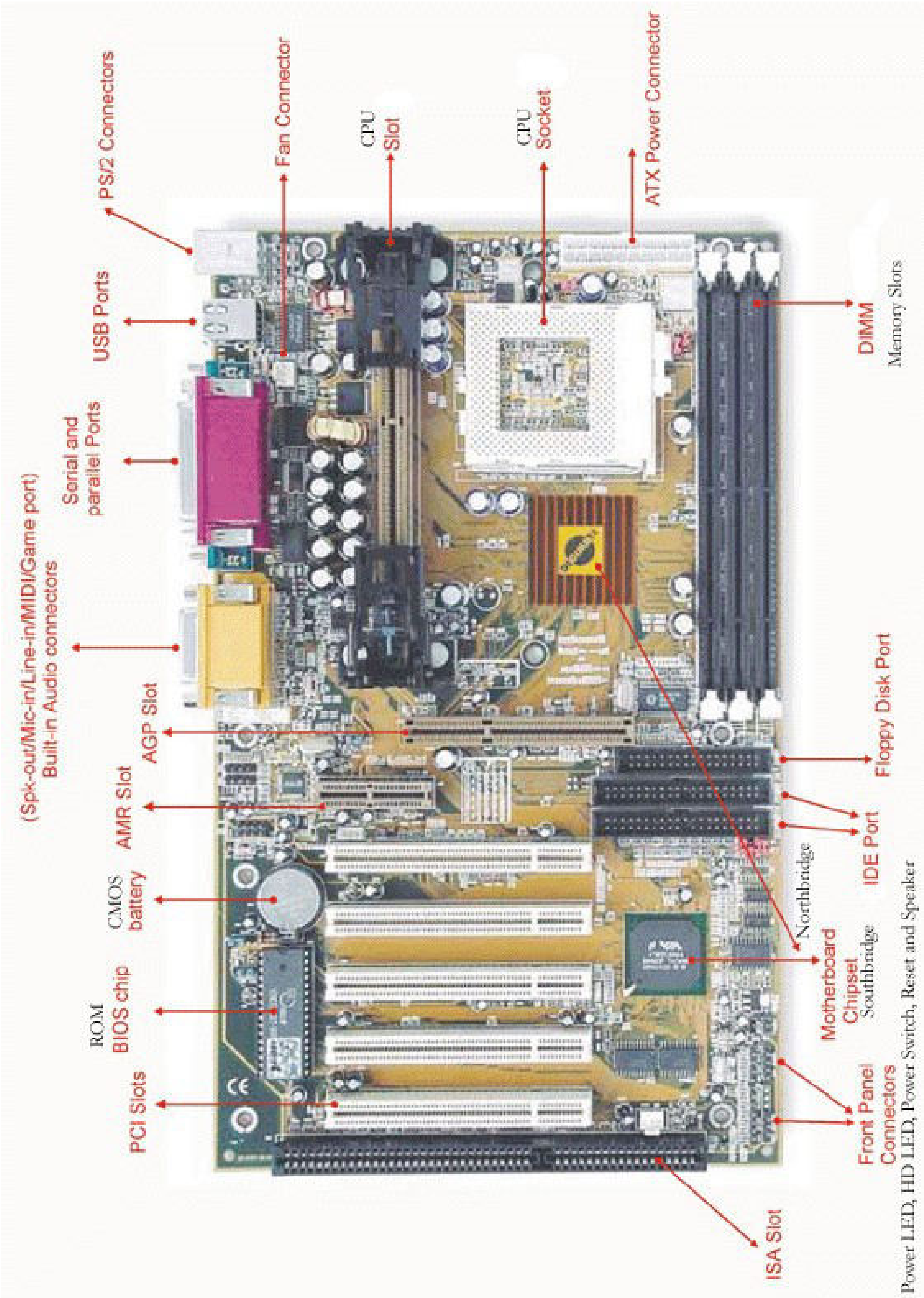


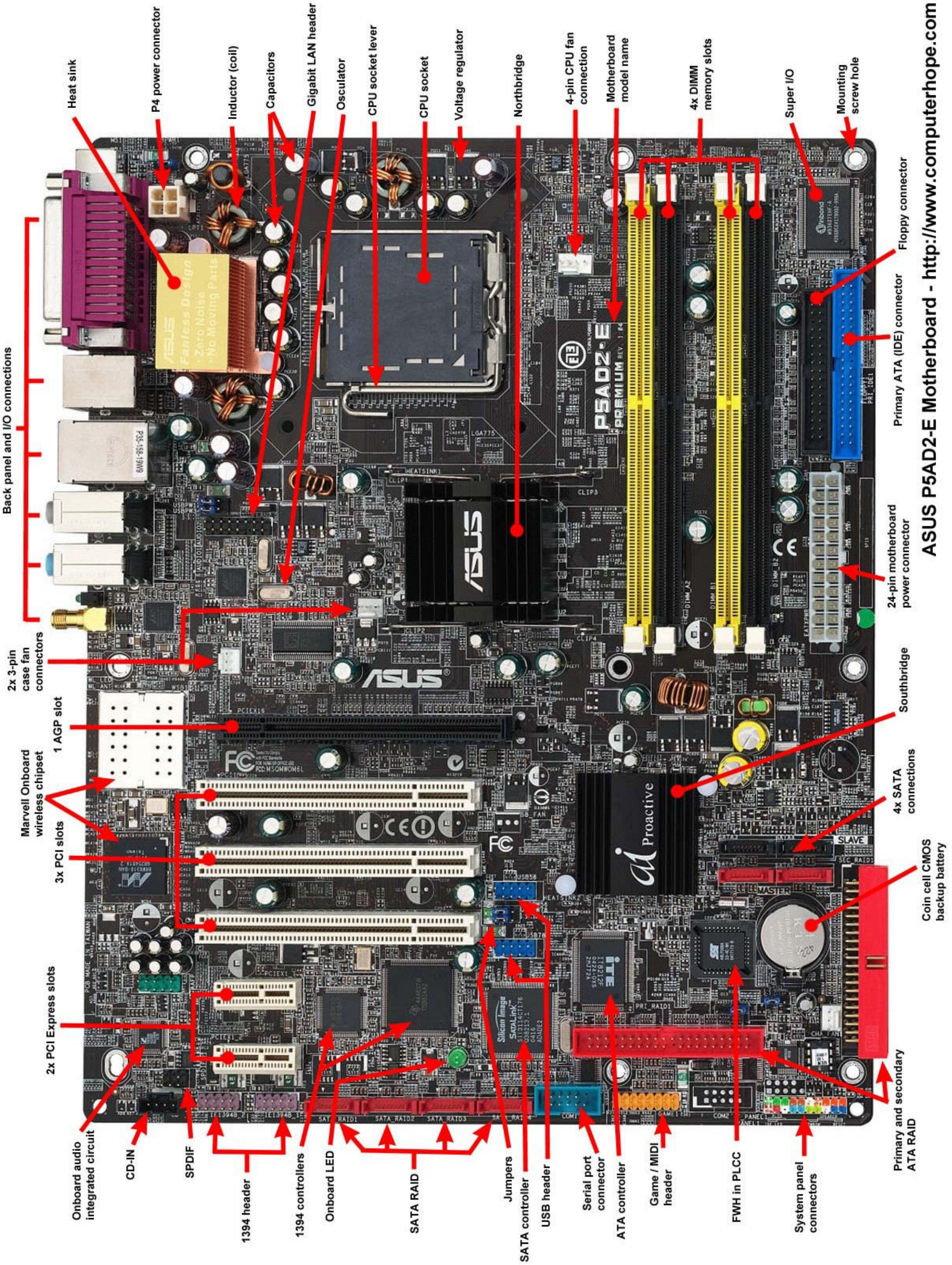
184 Pin DDR DIMM

RAMBUS DIMM

DIMM




PS/2 Connectors
Fan Connector
CPU Slot
CPU Socket
ATX Power Connector
USB Ports
Serial and parallel Ports
(Spk-out/Mic-in/Line-in/MIDI/Game port) Built-in Audio connectors
AGP Slot
AMR Slot
CMOS battery
ROM BIOS chip
PCI Slots
ISA Slot
DIMM Memory Slots
Floppy Disk Port
IDE Port
Northbridge
Motherboard Chipset Southbridge
Front Panel Connectors
Power LED, HD LED, Power Switch, Reset and Speaker


Heat sink
P4 power connector
Inductor (coil)
Capacitors
Gigabit LAN header
Osculator
CPU socket lever
CPU socket
Voltage regulator
Northbridge
4-pin CPU fan connection
Motherboard model name
4x DIMM memory slots
Super I/O
Mounting screw hole
Floppy connector
Primary ATA (IDE) connector
24-pin motherboard power connector
Southbridge
4x SATA connections
Coin cell CMOS backup battery
Primary and secondary ATA RAID
System panel connectors
FWH in PLCC
Game / MIDI header
ATA controller
Serial port connector
USB header
SATA controller
Jumpers
SATA RAID
Onboard LED
1394 controllers
1394 header
SPDIF
CD-IN
Onboard audio integrated circuit
2x PCI Express slots
3x PCI slots
Marvell Onboard wireless chipset
1 AGP slot
2x 3-pin case fan connectors
Back panel and I/O connections
ASUS P5AD2-E Motherboard - http://www.computerhope.com

Module II

Identifying Purposes and Characteristics of Power Supplies

A **power supply unit** (or **PSU**) converts mains AC to low-voltage regulated DC power for the internal components of a computer. It is a non-linear system (feedback controlled system) which operates on 120V-60Hz AC or 240V-50Hz AC and output DC voltages of various magnitudes such as +3.3V, +5V, +12V. Since this PSU operates by switching the internal voltage, it is called a Switched Mode Power Supply (SMPS).

Power Requirements of PC Components

The PSU normally supplies +3.3V, +5V, and +12V to the system. Although there are multiple wires carrying a specific voltage, they are normally tied to a single rail (or tap) in the PSU. Each rail is rated for a specified maximum current in Amperes. There are two negative volts such as -5V and -12V. -5V was used by ISA bus and not in use now. -12V is used by some circuits for serial port or local area network (LAN) circuits. Although older serial port circuits used +/–12V outputs, today most run only on +3.3V or +5V.

Other than these standard voltages, some components use some different voltages. For example, older DDR (double data rate) dual inline memory modules (DIMMs) and Rambus inline memory modules (RIMMs) require 2.5V, whereas DDR2 and DDR3 DIMMs require 1.8V and 1.5V, AGP 4x/8x cards require 1.5V, and current PCI Express cards use only 0.8V differential signaling - all of which are supplied by simple **onboard regulators** on motherboard which take the 5V or 12V from the power supply and convert that to the lower voltages. Processors also require a variety of voltages (1.3V or less) that are supplied by a **voltage regulator module (VRM)** that is either built into or plugged into the motherboard.

The below table lists the devices typically powered by the various voltage rails.

Rail	Devices Powered
+3.3V	Chipsets, some DIMMs, PCI/AGP/PCIe cards, miscellaneous chips
+5V	Disk drive logic, low-voltage motors, SIMMs, PCI/AGP/ISA cards, voltage regulators, miscellaneous chips
+12V	Motors, high-output voltage regulators, AGP/PCIe cards

SIMM = Single Inline Memory Module | *PCIe = PCI Express*
DIMM = Dual Inline Memory Module | *AGP = Accellerated Graphics Port*
PCI = Peripheral Component Interconnect | *ISA = Industry Standard Architecture*

Systems with modern form factors based on the ATX or BTX standards include a special active low signal, called **PS_ON.** It can turn the power supply (and thus the system) on or off via software/OS (during shut down or restart). It is sometimes known as the **soft-power feature**. It is generally **Green** coloured wire.

The Power Good Signal (PG, Power_OK or PWR_OK)

When the input AC to the power supply is turned ON, it checks internally whether all the output voltages are correct, before allowing the system to start. This test takes about 100ms to 500ms. If the tests are successful, the power supply sends a special signal to the motherboard called **Power_Good**. It is a +5V active high signal (may vary between +2.4V and +6.0V). This signal must be continuously present for the system to run. Therefore, when the AC voltage dips and the power supply can't maintain outputs within regulation tolerance, the Power_Good signal is withdrawn (goes low) and forces the system to reset (turn off). The system does not restart until the Power_Good signal returns. Improper Power_Good timing causes CMOS memory corruption in some systems. On pre-ATX systems, the Power_Good connection is made via connector P8-1 (P8 pin 1) from the power supply to the motherboard. ATX, BTX, and later systems use pin 8 of the 20/24-pin main power connector, which is usually a **gray** wire.

Voltage Signals and Colour Codes of an SMPS

Most modern desktop computers conform to the ATX standard, which supplies three positive rails: +3.3V, +5V and +12V. Wires coming out of an ATX PSU are color-coded as follows:

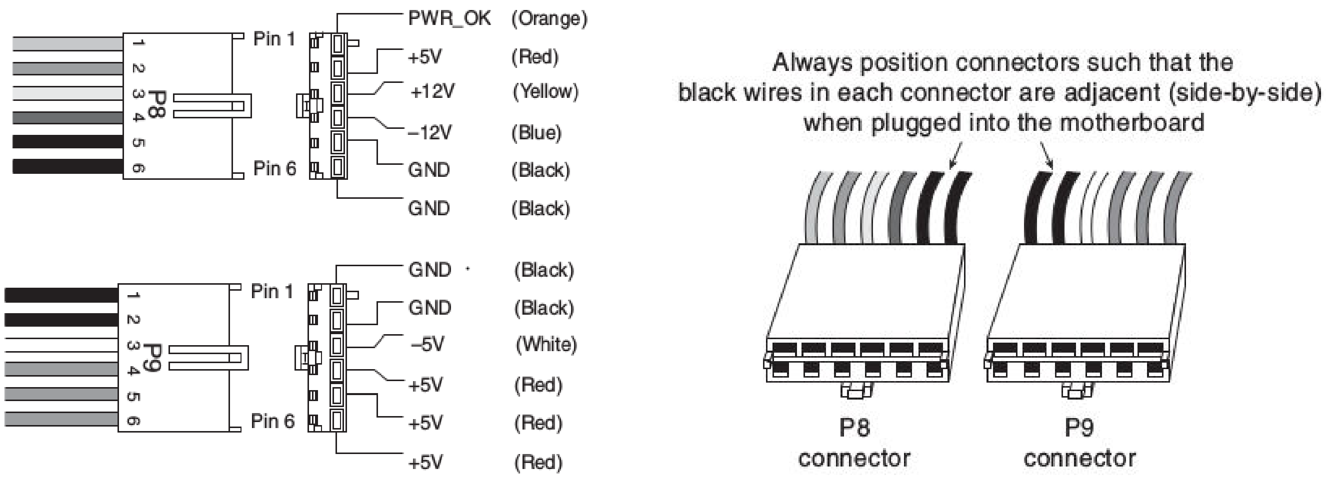
Yellow:	+12V (mostly for motors)
Red:	+5V (for logic)
Orange:	+3.3V
Black:	Ground
Purple:	5V SB (**S**tand**B**y voltage)
Green:	PS_ON (Active Low. It can be shorted to ground to start PSU)
Grey:	PWR_OK (power_good. status signal generated by PSU to indicate voltages are OK)
White:	-5V (used by ISA; absent on newer ATX PSUs)
Blue:	-12V (uses very small current of range mA, for LAN)

Power connectors of various components

Every PC power supply has connectors that attach to the motherboard, providing power to the motherboard, processor, memory, chipset, integrated components (such as video, LAN, universal serial bus [USB], and FireWire), and any cards plugged into bus slots. Two main sets of motherboard power connectors have been used over the years: AT/LPX type and the ATX type. Each of these has minor variations also.

AT / LPX Power Supply Connectors

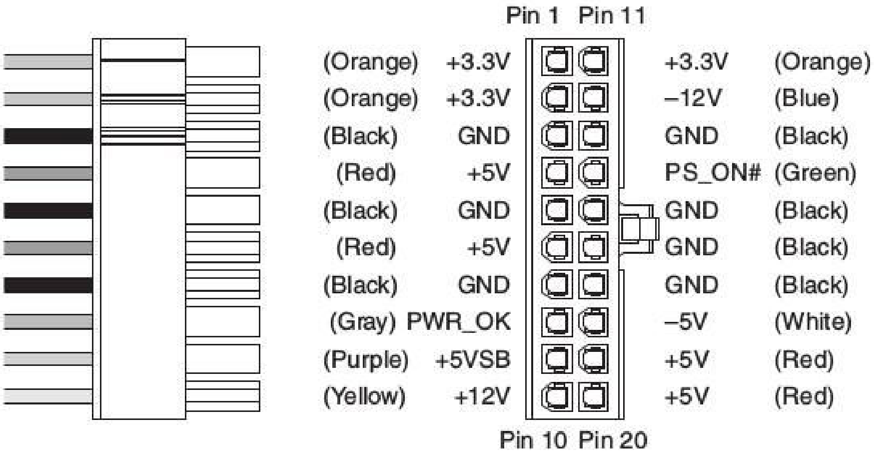
Industry-standard PC, XT, AT, Baby-AT, and LPX motherboards use the same type of main power supply connectors. AT/LPX power supplies feature two main power connectors (P8, P9) (sometimes called P1, P2), each with six pins that attach the power supply to the motherboard. The terminals used in these connectors are rated to handle up to 5 amps at up to 250V (even though the maximum used in a PC is +12V). All AT/LPX power supplies that use the P8 and P9 connectors have them installed end to end so that the two black wires (ground connections) on both power connectors are next to each other when properly plugged in.



ATX, ATX12V and EPS12V Motherboard Power Connectors

ATX power supply replaced the mother board connectors P8 and P9 with a single 20-pin connector. Other connectors remained the same. But later, additional power connectors were required for network interfaces, PCIe cards, server components, and the CPU itself. These additional connectors follow the ATX12V and EPS12V (*Entry-level Power Supply*) standards.

The *original ATX motherboard power connector is the 20-pin Molex Mini-Fit Jr. connector* housing with female terminals. The standard colour coding is given below; but they may vary. The connector has three varients; a standard version (each terminal support a current of 6A), an HCS (High Current System – supports 9A) version, and a Plus HCS (11A) version. By counting the number of terminals for each voltage level, the power handling capability of the connector can be calculated. Ie, for a standard terminal, the power rating is 251W.

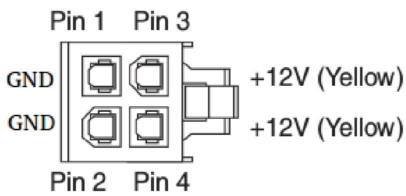


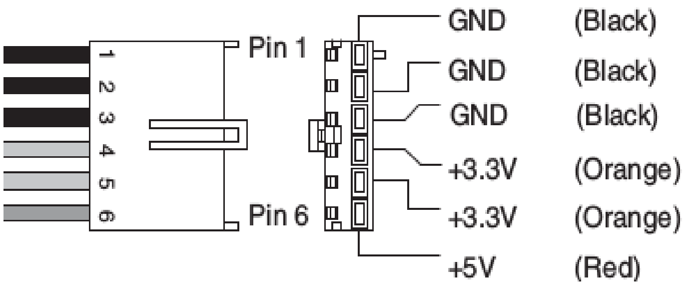
ATX 20-pin main power connector, side and terminal end view.

When the Pentium 4 processor was introduced, it needed more power than an ATX connector could supply. Thus **ATX12V 1.0** standard came, which added two supplemental connectors.

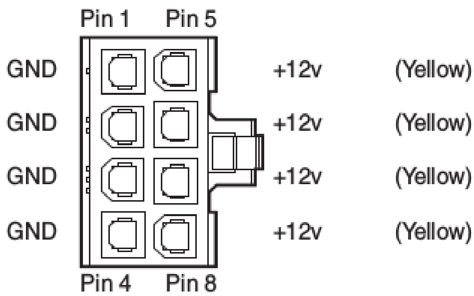
One was a single *6-pin P8/P9 AT type auxiliary connector* that supplied additional +3.3V (2 nos.) and +5V leads, and their grounds.

The other was a *4-pin square Molex Mini fit Jr. connector*, referred to as a P4 (for the processor that first required them) connector, that supplied two +12V leads and their grounds. EPS12V uses an *8-pin* version, called the processor power connector, that doubles the P4's function with four +12V leads and four grounds.





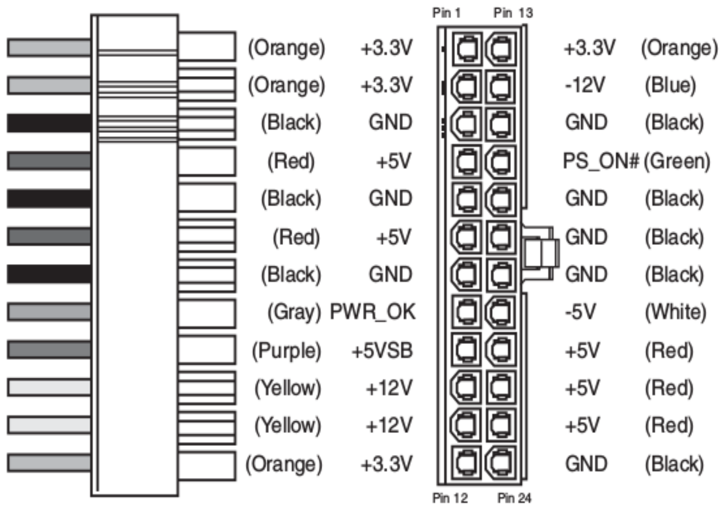
ATX 2.02/2.03 and ATX12V 1.x auxiliary power connector, side and terminal end view.



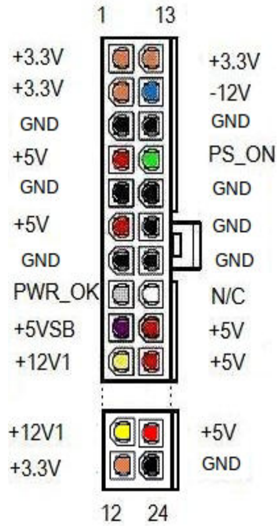
For servers and more advanced ATX motherboards that include *PCIe slots*, the 20-pin system connector proved inadequate. This led to the **ATX12V 2.0** standard and the even higher-end EPS12V standard for servers. These specifications introduced a 24-pin Molex connector that added additional positive voltage leads directly to the original ATX 20-pin connector. The 20-pin connector could fit into the new 24-pin standard. Many power supplies brought a 20-pin connector along with a separate 4-pin portion (12V, 5V, 3.3V, GND) for flexibility, called a 20+4 connector, for the new standard. The *6-pin auxiliary connector disappeared* with the ATX12V 2.0 specification and was never part of the EPS12V standard.

ATX12V 2.1 introduced a different 75W 6-pin connector, which was a molex mini-fit Jr. connector. This 6-pin connector was specifically designed to give additional dedicated power to PCIe adapters that required it.

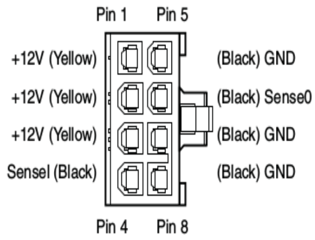
ATX12V 2.2 replaced the 75W 6-pin PCIe connector with a 150W 8-pin PCIe connector. This 8-pin connector *(below figure)* was different from that in the EPS12V standard *(above figure)*.



24-pin connector



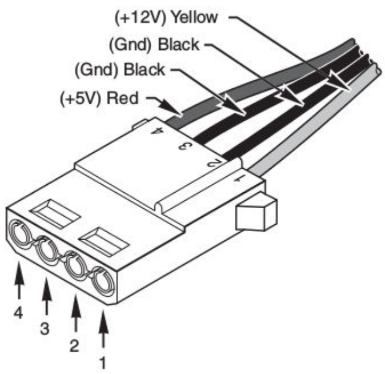
20+4 connector



Pin 13 might have a second orange or brown wire, used for +3.3V sense feedback. The power supply uses this wire to monitor 3.3V regulation. Pin 20 will be N/C (no connection) because –5V was removed from the ATX12V 1.3 and later specifications.

<u>Standard Peripheral Power Connectors (Disk drive power connectors)</u> - for AT/ATX

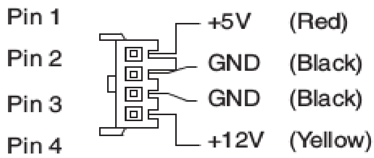
It has four terminals; a +12V (for motor), a +5V (for logic) and two grounds. It is the one connector type that has been on all PC power supplies from the original IBM PC to the latest systems built today. It is most commonly known as a disk drive connector, but it is also used in some systems to provide additional power to the motherboard, video card, cooling fans, or just about anything that can use +5V or +12V power.



A peripheral power connector.

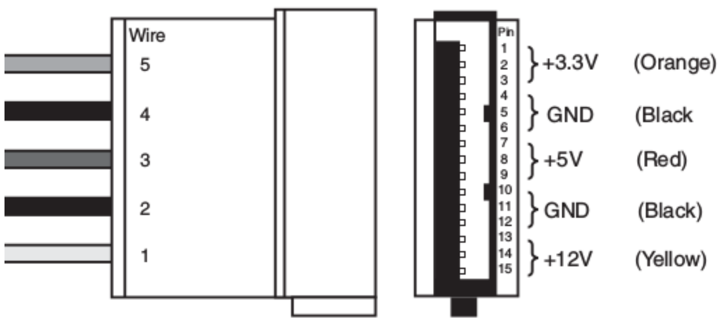
<u>Floppy Power Connectors</u> – for AT/ATX

These connectors are also called *Berg* connectors. It is a small connector with a +12V (for motor), a +5V (for logic) and two ground terminals. The peripheral and floppy power connectors are universal with regard to pin configuration and wire color.



<u>Serial ATA Power Connectors</u>

The SATA power connector is a special 15-pin connector fed by only five wires, meaning three pins are connected directly to each wire (+3.3V, GND, +5V, GND, +12V). If the power supply does not have SATA power connectors, a peripheral-to-SATA adapter can be used, but such adapters do not include the +3.3V power. This is not a problem as most drives use only +12V and +5V.



A SATA power connector.

Identifying Purposes and Characteristics of Storage Devices

Magnetic storage devices: Most permanent or semipermanent computer data is stored magnetically, meaning a stream of 0 and 1 is stored by magnetizing tiny pieces of metal embedded on the surface of a disk or tape in a pattern that represents the data. Later, this magnetic pattern can be read and converted back into the same original stream of bits. This is the principle of magnetic storage. All magnetic storage devices read and write data by using electromagnetism. Several types of magnetized storages are used in computer systems, including magnetic tape, floppy disks and hard disk drives.

Hard Disk Drive Systems

Hard disk drive (HDD) systems (*hard disks* or *hard drives* for short) are used for permanent storage and quick access. The hard disk drive system contains three critical components:

Controller: This component controls the drive. The controller chip controls how the drive operates and how the data is encoded onto the platters. It controls how the data sends signals to the various motors in the drive and receives signals from the sensors inside the drive. Most of today's hard disk technologies incorporate the controller and drive into one assembly. The most common and well-known of these are PATA and SATA.

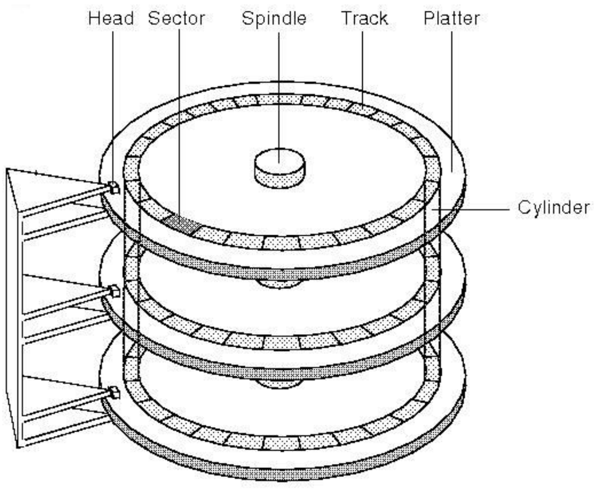
Hard disk: This is the physical storage medium. Hard disk drive systems store information on small discs (from under 1 inch to 5 inches in diameter), also called platters, stacked together and placed in an enclosure.

Host bus adapter (HBA): This is the translator, converting signals from the controller to signals the computer can understand. Most motherboards today incorporate the host adapter into the motherboard's circuitry, offering headers for drive-cable connection. Legacy host adapters and certain modern adapters house the hard drive controller circuitry.

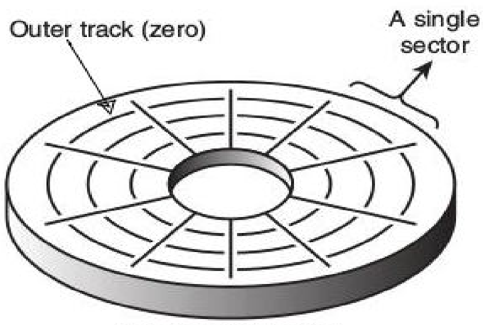
Track, sector, cluster and cylinder

Track: a single ring of data on one side of a platter. Each track holds several megabytes of data. Too large to manage and not efficient when the data is small, hence tracks are divided into several numbered (2000 or more) arc-shaped divisions called **sectors**. Tracks are numbered starting from 0 from outside.

Sectors: Arc-shaped pieces of a track and is the smallest addressible unit in a disk. Sectors are numbered starting with 1 from outside. Each stores 512 or 4,096 bytes of data; some additional bytes used in sector headers and trailers to manage the tracks and sectors. On low-level (and sometimes the high-level) formatting process fills the sector *data* fields with some specific values, such as 00h or some repeating test patterns.



Anatomy of a regular hard disk



Tracks and Sectors

Cylinder: The identically aligned tracks on each side of every platter together make up a **cylinder**. The outermost cylinder is numbered as cylinder 0. Each sector in the HDD is addressed as cylinder x, head y, sector z.

Cluster: (or allocation unit). a fixed number of continuous sectors (but not necessarily physically contiguous). File system stores and accesses files on disks as clusters. A cluster is the smallest unit of disk space that can be allocated to a file. Every file must be allocated an integer number of clusters. Larger cluster sizes result in more wasted space. If contiguous clusters are not available, the data is written elsewhere on the disk, and the file is considered to be **fragmented**. Cluster is the smallest allocation unit (equals to 1 or more sectors and the number of clusters depends on the file system).

<u>Anatomy of Hard Disk</u>

The basic components of a typical HDD are as follows.

- Disk platters
- Read/write heads
- Head actuator mechanism (actuator, axis and arm)
- Spindle motor (inside platter hub)
- Logic board (controller or Printed Circuit Board)
- Cables and connectors
- Configuration items (such as jumpers or switches)

Platters: The basic physical construction of an HDD consists of stacked spinning disks (2,3 or upto 12) called platters. The platters can't bend or flex - hence the name **hard disk**. Platters were originally made from an aluminum/magnesium alloy but some modern platters are made from a glass-ceramic composite material which do not bend and are thermally stable. Platters are coated with magnetic material, called **medium,** on one or both sides**.** The physical size of a drive is expressed as the size of the platters and are available in 5.25in, 3.5in, 2.5in, 1.8in, 1in and 0.85in. Currently, 3.5in are used in desktop systems and 2.5in and smaller drives are used in portable and notebook systems. Modern drives spin the platters at 3600 rpm, 4200 rpm, 5400 rpm, 7200 rpm, 10000 rpm, 12000 rpm or 15000 rpm. (rpm – rotations per minute).

Read/Write Heads: One read/write head for each platter surface, but all heads are connected or *ganged* on a single axis (called *actuator*). For head landing, older drives use **Contact Start Stop (CSS)** design. Here, when the system is powered off, the heads move near the centre of the platter and rests there. When powered on, the heads slide on the platter surface as they spin up, until a thin cushion of air builds up between the heads and platter surface, then it floats above the disk. Newer drives use **Load/Unload** design for head landing. Here, when powered off, the heads rest on a ramp just outside the platters. When powered on, the platters comes to full speed and then the heads comes over them from the ramp. These heads never touch the disks even when powered off.

Head Actuator Mechanisms: It moves the heads across the disk and positions them accurately above the desired location. It consists of actuator, axis and arms.

The older type called <u>Stepper motor actuators</u> use a stepper motor which steps to the desired cylinder. But they cannot stop in between two steps. It affects the operation as the tracks are narrow and when the platters expands and contracts on temperature change. Low access speed. Highly position sensitive. No automatic head parking. Low reliability.

The newer <u>Voice coil actuators</u> use electromagnetism just like in audio speakers, hence the name *voice coil*. An electromagnetic coil is attached at the back end of the actuator and placed near a strong stationary magnet. On energizing the coil, it becomes magnetized and moves accordingly in the permanent magnetic field. No steps so free movement. A <u>guidance mechanism</u> called **Servo** to tell the actuator about the head position and to place the head accurately. This is by sending an index and getting a feedback. This mechanism is also called a **closed loop feedback mechanism** or **servo controlled mechanism**. Not at all sensitive to temperature. Great accuracy. High performance. High reliability.

Spindle Motor: It spins the platters at a constant speed (3,600 rpm to 15,000 rpm based on HDDs). It has a control circuit with a feedback mechanism to rotate precisely and accurately. It is placed inside or below the HDA. Most motors use a <u>fluid dynamic bearing</u>, which uses a highly viscous lubricating fluid between the spindle and sleeve in the motor. Enables improved speed control, less noice and shock resistant.

Logic Board: It controls the spindle and the head actuator systems.

Cables and Connectors: Interface connectors carry the data and command signals between the system and the drive, such as ATA, SATA and SCSI. Power connector may be generally 4-pin peripheral power connector.

Configuration Items: To configure an HDD for installation in a system, like jumpers.

The **air filters** filter the air inside the HDA and prevents the dust particles from damaging the platters and heads, and there by the data. HDDs have two air filters - one is the **recirculating filter**, and the other is a **barometric** or **breather filter**. HDDs do not circulate air from inside to outside the HDA or vice versa. Hence they can work in extremely dirty environments. The **recirculating filter** filters this air. **Barometric or breather filter** equalizes the pressure between the inside and the outside of the drive and it can filter particles greater than a micron.

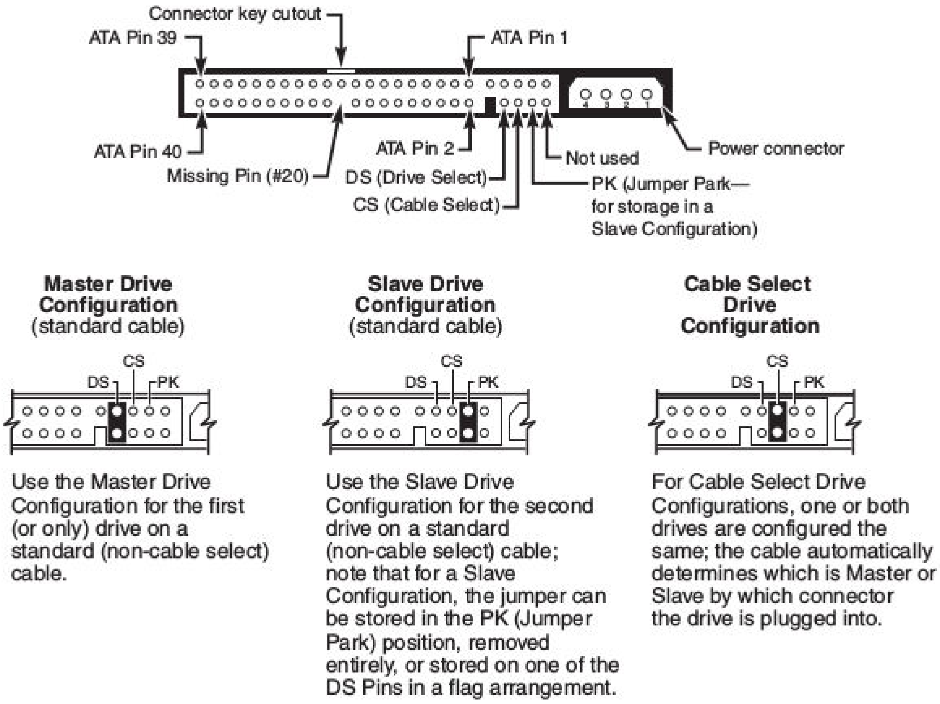
IDE/PATA Drives (Integrated Drive Electronics / Parallel Advanced Technology Attachment)

IDE is a technology which put the controller chip and its related electronics right on the drive, and use a relatively short ribbon cable to connect the drive and controller to an interface on the system. Hence the name IDE. This offers the benefits of decreasing signal loss, thus increasing reliability, and making the drive easier to install. The IDE interface can be an expansion board or it can be built into the motherboard (commonly found). The IDE was once more properly called advanced technology attachment (ATA). With the invent of Serial ATA (SATA) drives, the former was called Parallel ATA (PATA) since the data transfer was parallel.

The PATA is a 16-bit parallel interface, speed at 16/33/66/100/133 Mbps.

PATA I/O Connector: 40-pin header type. Generally the 20^{th} pin is absent for keying. Pin 1 will be near the power connector. There is a colored (usually red) stripe on one edge of the PATA ribbon cable that comes near the power connector. The 2.5-inch drives found in notebook/laptop-size computers typically use a smaller 50-pin header connector. The PATA I/O Cable may be with 40 or 80 conductors. In 80 conductor cable, the additional 40 lines (between signal lines) eliminate the noise and interference and are grounded. These are required when working in high speed modes, ie ATA/66, ATA/100 and ATA/133 modes. The official limit for PATA cables is 18 inches. Over that the signals degrades and data error occurs. Some 80-conductor cables stretch more than that. Generally the cable will have three connectors; two at the ends and one in between the two.

ATA drives can be configured as M*aster*, S*lave* or *Cable Select*. When two drives are connected on AT bus they must be identified separately, hence using the terms Master/Slave**.** The system detects this either by jumper settings (manual) or by cable select (automatic). If a cable select cable is used, the CS jumper should be set to On and all others should be set to Off. The cable connector then determines which drive will be master or slave.



ATA had different revisions over years, namely ATA-1 to ATA-8, each newer one is backward compatible.

Drives that support ATA-2 and higher are generically referred to as Enhanced IDE (EIDE) or Fast-ATA.

With ATA-3, a technology called ATA Packet Interface (ATAPI) was introduced to help deal with IDE devices other than hard disks. ATAPI enables the BIOS to recognize an IDE CD-ROM drive, for example, or a tape backup or Zip drive. ATA-3 also introduced the Self-Monitoring And Reporting Technology (SMART). SMART allows a hard drive to monitor itself and warn the user during and after boot-up of any failure. This, in most cases, helps the user to save the data before it is lost.

Starting with ATA-4, a new technology was introduced called *UltraDMA*, supporting transfer modes capable of rates of up to 33MBps. These are called UltraDMA/33 or Ultra-ATA/33 or ATA-33

ATA-5 supports UltraDMA/66 (Ultra-ATA/66 or ATA-66), with transfer modes having rates of up to 66MBps. To achieve this high rate, the drive must have a special 80-wire ribbon cable, and the motherboard or IDE controller card must support ATA-5. The additional 40 lines eliminate the noise and interference and are grounded.

ATA-6 supports UltraDMA/100 (Ultra-ATA/100 or ATA-100), with transfer modes capable of up to 100MBps.

ATA-7 supports UltraDMA/133 (Ultra-ATA/133 or ATA-133), with transfer modes of 133MBps and up to 150MBps for serial ATA.

ATA-8 made only minor revisions to ATA-7 and also supports UltraDMA/133 and 150MBps SATA and has the potential to support SATA 300.

SATA Drives (Serial ATA)

In Serial ATA, the data transfer occurs serially. 1 bit serial transfer with speed 150, 300 and 600 Mbytes/s (1.5, 3 and 6 Gbits/ps) and 8b/10b encoding. It use a thin cable with 7 wires and maximum 1m with identical ends. Thin wire helps in more airflow than PATA cable. Only one device can be connected per cable, hence no master/slave confusion. The cable has uses balanced pair of wires. If one wire carries +0.25V, the other carries -0.25V giving 0.5V differential voltage. This reduces electromagnetic radiation and makes the signals easy to read. All ground pins are longer so they will make contact before the signal/power pins to allow hot-plugging. SATA has 15-pin power connector.

SATA Data Connector Pinout

Signal Pin	Signal	Description
S1	Gnd	First mate
S2	A+	Host Transmit +
S3	A-	Host Transmit –
S4	Gnd	First mate
S5	B–	Host Receive –
S6	B+	Host Receive +
S7	Gnd	First mate

Small Computer System Interface (SCSI) Drives

The SCSI is a set of parallel interface standards for physically connecting and transferring data between computers and peripheral devices especially disk drives. SCSI is used to increase performance, deliver faster data transfer transmission and provide larger expansion for devices such as CD-ROM drives, scanners, DVD drives and CD writers. SCSI is also frequently used with RAID, servers, high-performance PCs and storage area networks.

SCSI devices can be either internal or external to the computer.

8-bit SCSI-1 and SCSI-2 *internal* devices use a 50-pin SCSI A ribbon cable with a colored stripe (usually blue or red). 16-bit SCSI uses a SCSI P cable, with 68 wires and a 68-pin D-subminiature connector. There is also an 80-pin internal SCA connector ideal for use in hot-swapping environments. In internal cabling the connectors are attached to the devices in the computer with one connector connecting to the adapter.

External SCSI connectors depend on the type of standard in use. SCSI-1 uses a 50-pin Centronics (printe-type) connector. SCSI-2 uses a 25-, 50-, or 68-pin connector. SCSI-3 uses a 68- or 80-pin connector. External cabling is done through *daisy-chaining*. Here each device has two ports on it (in & out).

To configure SCSI, a unique device number (often called a SCSI address, SCSI ID, or SCSI device ID) must be assigned to each device on the SCSI bus. These numbers are configured through jumpers, DIP switches, and up/down pushbuttons with the selected ID displayed through a hole on a wheel. When the SCSI controller needs to send data to the device, it activates the wire dedicated to signaling that address. The device then responds with a signal that contains the number of the device that sent the information and the data itself. A device called a *terminator* (technically a terminating resistor pack) must be installed at both ends of the bus to keep the signal-bouncing.

Termination can be either *active* or *passive*. A *passive terminator* works with resistors driven by the small amount of electricity that travels through the SCSI bus. *Active termination* uses voltage regulators inside the terminator. Active termination is much better, and are used whenever fast, wide, or Ultra SCSI devices are connected.

RAID (Redundant Array of Independent/Inexpensive Disks)

It is a way of combining the storage power of more than one hard disk for a special purpose, such as increased performance or fault tolerance. RAID was once more commonly done with SCSI drives, but it can be done with other drives. RAID can be implemented in software or in hardware, but hardware RAID is more efficient and offers higher performance at an increased cost.

There are seven levels of RAID (0-6) to give fault tolerance (reliability), storage capacity, performance, or a combination of the three.

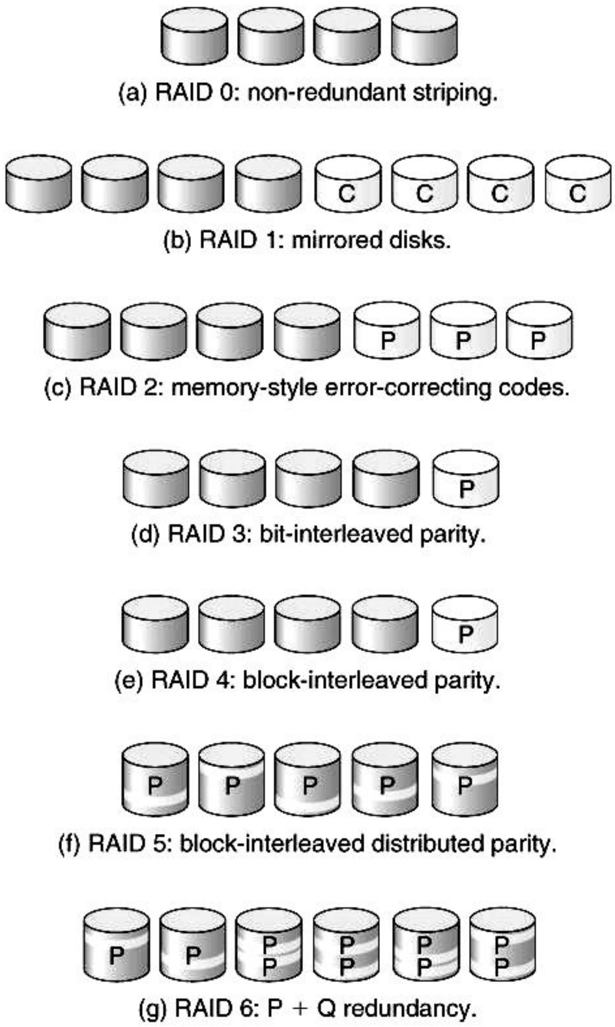
■ <u>RAID Level 0: Striping</u> – It is a technique that breaks up a file into blocks and spreads the data across all the disk drives in a RAID group. This offers high read/write performance but low reliability. Requires a minimum of two drives to implement.

■ RAID Level 1: Mirroring—Data written to one drive is duplicated on another, providing excellent fault tolerance (if one drive fails, the other is used and no is data lost) but no real increase in performance as compared to a single drive. Requires a minimum of two drives to implement (same capacity as one drive).

■ RAID Level 2: Bit-level ECC—Data is split one bit at a time across multiple drives, and error correction codes (ECCs) are written to other drives. This is intended for storage devices that do not incorporate ECC internally (All SCSI and ATA drives have internal ECC). It's a standard that theoretically provides high data rates with good fault tolerance, but seven (4 data + 3 ECC) or more drives are required for greater than 50% efficiency.

■ RAID Level 3: Striped with parity—Combines RAID Level 0 striping with an additional drive used for parity information. It stripes the bytes across the disks. The disks have to spin in sync to get to the data. Sequential read and write will have good performance. But random read and write will have worst performance. However, it also achieves a high level of data integrity or fault tolerance. Requires a minimum of three drives to implement (two or more for data and one for parity).

■ RAID Level 4: Blocked data with parity—Similar to RAID 3 except data is written in larger blocks to the independent drives, offering faster read performance with larger files. Requires a minimum of three drives to implement (two or more for data and one for parity).



(a) RAID 0: non-redundant striping.
(b) RAID 1: mirrored disks.
(c) RAID 2: memory-style error-correcting codes.
(d) RAID 3: bit-interleaved parity.
(e) RAID 4: block-interleaved parity.
(f) RAID 5: block-interleaved distributed parity.
(g) RAID 6: P + Q redundancy.

■ RAID Level 5: Blocked data with distributed parity—Similar to RAID 4 but offers improved performance by distributing the parity stripes over a series of hard drives. Requires a minimum of three drives to implement.

■ RAID Level 6: Blocked data with double distributed parity—Similar to RAID 5 except parity information is written twice using two parity schemes to provide even better fault tolerance in case of multiple drive failures. Requires a minimum of four drives to implement.

There are also nested RAID levels created by combining several forms of RAID. The most common are as follows:

■ RAID Level 01: Mirrored stripes—Drives are first combined in striped RAID 0 sets; then the RAID 0 sets are mirrored in a RAID 1 configuration. A minimum of four drives is required, and the total number of drives must be an even number. The total usable storage capacity is equal to half of the number of drives in the array times the size of the lowest capacity drive. RAID 01 arrays can tolerate a single drive failure and some (but not all) combinations of multiple drive failures.

■ RAID Level 10: Striped mirrors—Drives are first combined in mirrored RAID 1 sets; then the RAID 1 sets are striped in a RAID 0 configuration. Rest are similar to level 01 but more reliable.

Removable storage and media

Tape Backup Devices

An older form of removable storage is the tape backup. It is a sequential storage medium used for data collection, backup and archiving. It is made of flexible plastic with one side coated with a ferromagnetic material. Large organisations use it for backing up data. If tapes are stored for longer duration, they must be periodically recopied, otherwise the tightly coiled magnetic surfaces may contaminate each other. It can store terabytes of uncompressed data. Tape backup devices can be installed internally or externally and use either a digital or analog magnetic tape medium instead of disks for storage. They hold much more data than any other medium but are also much slower. They are primarily used for batch archival storage, not interactive storage.

Flash memory

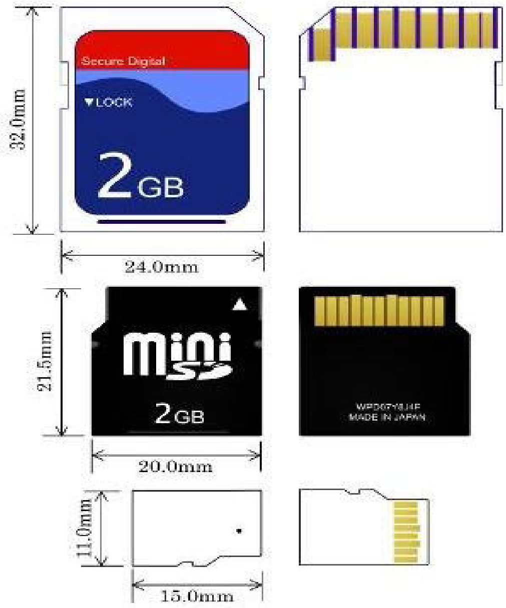
The name 'flash memory' comes from the concept of easily being able to use electricity to instantly alter the contents of the memory. The original flash memory is still used in devices that require a nonvolatile means of storing critical data and code often used in booting the device, such as routers and switches. The following represents different types of flash memory.

SD and Other Memory Cards: Older digital cameras used a solid state flash memory called a *MultiMedia Card (MMC)* fot storing the images. MMC lead to a new type of technology called the Secure Digital Card (SD Card). It is a card format developed by the SD Card Association (SDA) for use in portable devices. Both of these cards measure 32mm X 24mm, and slots that receive them are often marked for both. The SD card is slightly thicker than the MMC, and has a write-protect notch.

SD Card has three form factors based on its physical size; the *standard SD*, the *miniSD* (21.5mm X 20mm) and the *microSD* (15mm X 11mm). Smaller cards can be used in bigger interfaces using adapters.

The SD Card includes four card families which are; the original Standard-Capacity (SD or SDSC – upto 2GB), the High-Capacity (SDHC above 2GB upto 32GB), the eXtended-Capacity (SDXC – above 32GB upto 2TB), and the SDIO, which combines input/output functions with data storage.

	Mark	Minimum Serial Data	SD Bus Mode
UHS Speed Class	U3	30MB/s	UHS-II UHS-I
	U1	10MB/s	
Speed Class	CLASS 10	10MB/s	High Speed
	CLASS 6	6MB/s	Normal Speed
	CLASS 4	4MB/s	
	CLASS 2	2MB/s	



<u>USB Flash Drives (USB drive, USB stick, thumb drive, pen drive, flash-disk, or USB memory)</u>: It is a portable flash memory with an integrated USB interface and is used for data storage and data transfer. USB flash drives use the *USB mass storage device class standard* to connect to the Operating System and is treated as a removable drive to the host device.

Externally attached drives

Before USB, an external drive used SCSI, serial or parallel port or proprietary adapter and interface/cable combination.

USB devices that comply with the USB Mass Storage-device Class (USB MSC or UMS) specification are recognized as drives by the operating system upon connection. If the power requirement for the unit is high enough, there might also be a separate power connection for the device. Otherwise, the USB interface on the host provides all the power for the drive.

An external drive-attachment technology based on SATA is called eSATA for “external” SATA. It has higher performance than USB-attached drives. Even though SATA, the SATA data cable cannot be used for eSATA. Also, eSATA connectors cannot supply power, and require a power supply for the external device.

Note: More on HDD

<u>Average Seek Time:</u>

Average seek time, usually measured in milliseconds (ms), <u>is the average amount of time it takes to move the heads from one cylinder to another a random distance away</u>. One way to measure this specification is to run many random track-seek operations and then divide the timed results by the number of seeks performed.

<u>Latency:</u>

<u>The average time (in milliseconds) taken for a sector to be available after the heads have reached a track</u>. On average, this figure is <u>half the time it takes for the disk to rotate once</u>. Latency is a factor in disk read and write performance. Decreasing the latency increases the speed of access to data or files and is accomplished only by spinning the drive platters more quickly.

<u>Average Access Time:</u>

A measurement of a drive's average access time (in milliseconds) is <u>the sum of its average seek time and latency</u>. It provides the total amount of time required for the drive to access a randomly requested sector.

Disk Formatting

* preparing an HDD for data storage.

* three steps;

1. Physical, or Low-level formatting (LLF; done at the factory)
2. Partitioning
3. Logical, or High-level formatting (HLF)

1. Low-Level Formatting:

* tracks are divided into sectors, creating intersector and intertrack gaps and recording the sector header and trailer information.

* sector's data areas are filled with a dummy byte value or a pattern of test values.

* most HDDs use zoned bit recording (ZBR) than standard recording. Cylinders are grouped into zones (generally 16-32). The number of sectors in each zone increases from inside to outside of the disk bacause the circumference of tracks increase from inside to outside, and can store more data.

2. Partitioning

* partition enables to support separate file systems, each in its own partition. Every HDD must have at least one partition on it.

* each file system can then use its own method to allocate file space in logical units called clusters or allocation units.

* Examples of file systems: FAT (File Allocation Table - for Windows), NTFS (New Technology File System - for Windows), Ext (Extended file system – for Linux)

3. High-Level Formatting

* the OS writes the file system structures necessary for managing files and data on the disk. These data structures enable the OS to manage the space on the disk, keep track of files, and even manage defective areas so they do not cause problems.

* not really a physical formatting of the drive, but rather the creation of a table of contents for the disk.

Solid-State Drives

Solid-state drives (SSDs) have no moving parts but use the same solid-state memory technology found in the flash memory. All solid-state memory is limited to a finite number of write (including erase) operations. SSDs read contents more quickly, can consume less power and produce less heat, and are more reliable and less susceptible to damage from physical shock and heat production than their magnetic counterparts. However, the technology to build an SSD is still more expensive per byte, and SSDs are not yet available in capacities high enough to rival the upper limits of conventional hard disk drive technology.

SSDs are separated into two broad categories, *volatile DRAM-based* and *non-volatile flash-based*. Flash-based SSDs made with NAND memory use considerably less power than HDDs. Those made with DRAM can use every bit as much power as conventional drives, however. The advantage of those made using the standard RAM modules used in desktop motherboards is that the modules can often be upgraded using larger modules, making a larger SSD overall. The volatility of DRAM-based SSDs can be compensated for by adding a backup power source, such as a battery or capacitor. Flash-based SSDs, while faster during read operations than their HDD counterparts, can be made faster still by including a small amount of DRAM as a cache. DRAM-based SSDs are faster than both.

Optical Storage Drives

Optical Storage disks read and write data using light (laser). The common types in the order of development and storage size are; Compact Disk – CD, Digital Versatile Disk – DVD and Blue-ray Disk – BD (smallest to largest). Each one has its ROM, Recordable and Re-recordable versions. The drives for each new type of disk is backward compatible with older disks.

<u>CD</u>: The compact disk was developed from the then available digital audio disk. CD may be CD-ROM, CD-R (Recordable) or CD-RW (ReWritable). General size of a CD is 700MB with speed varies from 1X to 52X but for CD-RW the speed is very low. The first CD-ROM drives transferred data at the same speed as home audio CD players, 150KBps, referred to as 1X. Thus 2X means 300KBps and so on. CD-ROMs are read-only, meaning that information written on it in the factory can't be erased or changed. These were generally used for software and media distribution. A blank CD-R can be recorded ('burned') once and is called WORM (Write Once Read Many). A CD-RW can be burned again and again just like burning many CDs and is expensive than CD-R. The disk is made of an optically transparent polycarbonate wafer, 120mm in diameter and 1.2mm thick, with a 15mm hole in the center. It has only a single physical track, from inside and spiraling outward and when viewed from the reading side (the bottom), the disk rotates counterclockwise.

In CD-ROM along the track, there are raised bumps, called **pits**, and flat areas between the pits, called **lands**. The stamped (upper) surface is coated with a reflective layer of metal (usually aluminum) to make it reflective. Above it a thin protective layer of acrylic lacquer, and finally a label or printing is added. In blank CD-Rs the pits and lands are replaced by raised **pre-grooves**.

On **writing**, a powerful 780nm red laser beam burns the bit 0 (or 1) on the grooves making them darker and thus very less reflective. On **reading** – a mild 780nm laser is pointed to the specified rotating disk-track with the help of a servo motor mechanism. The lands/non-burned grooves will reflect the laser and is received by a photo sensitive receptor through a lense and beam splitter. The pits/burned-area will not reflect the laser. Based on the presence or absence of the laser, receptor recognises a 1 or 0.

<u>DVD</u>: It uses the same optical technology as CD but the tracks are very dense and use a 650nm red laser. Like a CD, it has varieties like ROM, Recordable and ReWritable. It has the same physical dimension as CD (120mm diameter, 1.2mm thick, with a 15mm hole in the center), but can store in *two layers* on one side and can make *both sides writable*. The pits and lands are similar to the CD. The standard DVD-ROM 1X transfer rate is 1.4MBps, already nine times that of the comparably labeled CD-ROM. A single layer DVD has a size of 4.7GB. A dual layer DVD (DVD DL) has 9.4GB capacity (but only 8.5GB is usable). A dual layer dual sided DVD can store 17.1GB of data. The variations of DVD burning technologies include DVD+R (DVD-R), DVD+RW (DVD-RW), DVD-R DL (DVD+R DL) and DVD-RAM (to be written to and erased just like a hard or floppy disk).

BD: It was designed for modern high-definition video sources. The BD drives uses violet laser (405nm) for reading and writing which is very much narrow than the CD-DVD red laser. A basic single side BD (BD SS) can store 25GB of data, a dual layer (BD DL) disk can store 50GB and a dual layer dual side BD (BD DL, DS) can store 100GB of data. The 1X transfer rate for Blu-ray is 4.5MBps. It takes 2X speeds to properly play commercial Blu-ray videos. BD discs are labeled BD-R (recordable) and BD-RE (re-recordable) and have their dual layer versions also.

Module III

External Peripherals

An expansion card (also known as an adapter card) is simply a circuit board which install into a computer to increase the capabilities of that computer. Expansion cards come in varying formats for different uses, but the card being installed must match the bus type of the motherboard. For example, a PCI network card can be installed into a PCI expansion slot only. The following are the four most common categories of expansion cards installed today:

* Video
* Multimedia
* I/O
* Communication

Video

A video adapter (*graphics adapter* or *video card*) is the expansion card that allows the computer to display information on some kind of monitor. A video card is also responsible for converting the data sent to it by the CPU into the pixels, addresses, and other items required for display. Sometimes, video cards can include dedicated chips to perform some of these functions, thus accelerating the speed of display. At a basic level, PCI video adapters operate sufficiently. However, because AGP and PCIe slots offer more resources to the adapter, most manufacturers and computer owners prefer not to use PCI slots for video adapters.

Multimedia

The commonly used multimedia cards are sound card, TV tuner card and video captures card.

Sound Card: It converts the computer signals to sound. Although sound cards started out as pluggable adapters, now this functionality has been integrated on motherboards today. A sound card typically has 3.5mm jacks for connecting microphones, headphones, and speakers as well as other sound equipment. Many sound cards used to have a DA15 game port, which can be used for either joysticks or MIDI (Musical Instrument Digital Interface) controllers. Sound cards today might come with an RCA (Radio Corporation of America) jack.

TV Tuner Cards and Video Capture Cards: The TV tuner card is a class of internal and external devices that allows to connect a broadcast signal, such as home cable television, to the computer and display the output on the computer monitor. TV tuner cards come in analog, digital, and hybrid varieties. Most TV tuner cards act as video capture cards as well. A video capture card can also be a standalone device and is often used to save a video stream to the computer for later manipulation or sharing. TV tuner cards and video capture cards often come with software to aid in the processing of multimedia input.

I/O

Common examples of I/O are the classic serial (RS-232 or *Recommended Standard-232*) and parallel (printer) ports and drive interface connections. A popular expansion card of the 1980s and early 1990s was known as the Super I/O card. This one adapter had the circuitry for two standard serial ports, one parallel port, two IDE (PATA) controllers, and one floppy controller. Some versions included other components, such as a game port. Some cards enables the motherboard to connect to SCSI devices.

Communications

Network adapters and modems are the two most popular types of communications adapter. Network adapters are generally used within the administrative domain of a home or enterprise and rely on other devices to relay their transmissions around the world. In contrast, modems allow direct domestic or international communication between two devices across the Public Switched Telephone Network (PSTN).

Network Interface Card (NIC or Network Interface Controller): It connects a computer to a network so that it can communicate with other computers on that network. It translates the data from the parallel data stream used inside the computer into the serial data stream that makes up the frames used on the network. It has a connector for the type of expansion bus on the motherboard (PCIe, PCI, and so on) as well as a connector for the type of network (such as fibre connectors, RJ-45 for UTP, antenna for wireless, or BNC for legacy coax). Some motherboards have integrated NICs.

Wireless NICs: Wireless NICs have the unique characteristic of requiring that their connecting device has to be configured before configuring the NIC.

Modem: Any computer that connects to the Internet using an analog dial-up connectio,eeds a modem, or modulator/demodulator. A modem is a device that converts digital signals from a computer into analog signals that can be transmitted over phone lines and back again. These expansion card devices have one connector for the expansion bus being used (PCIe, PCI, and so on) and another for connection to the telephone line.

Characteristics of Connectors (ports) and Cables

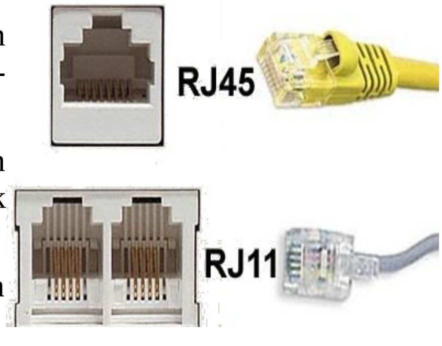
A port is a generic name for any connector on a computer or peripheral into which a cable can be plugged. A cable is simply a way of connecting a peripheral or other device to a computer using multiple copper or fiber-optic conductors inside a common wrapping or sheath. Typically, cables connect two ports: one on the computer and one on some other device.

Device Connector Types

D-subminiature Connectors: D-sub connectors, for a number of years the most common style of connector found on computers, are typically designated with DXn, where the letter X is replaced by the letters A through E, which refer to the size of the connector, and the letter n is replaced by the number of pins or sockets in the connector. D-sub connectors are usually shaped like a trapezoid and have at least two rows of pins with no other keying structure. The “D” shape ensures that only one orientation is possible. Some common D-sub connectors are;

Connector	Gender	Use
DE9	Male	Serial port
DB25	Female	Parallel port
DA15	Female	Game port or MIDI port
DE15	Female	Video port (has three rows of five pins instead of two rows)

RJ-Series:



Registered jack (RJ) connectors are most often used in telecommunications. The two most common examples of RJ ports are RJ-11 and RJ-45.

RJ-45 connectors are larger than RJ-11 and most commonly found on Ethernet networks that use twisted-pair cabling. The Ethernet Network Interface Card has RJ-45 jacks on it.

RJ-11 connectors are used most often on cables in telephones. The ports in older external and internal analog modems are RJ-11.

Other Types of Ports

There are many other types of ports that are used with computers today, including these:

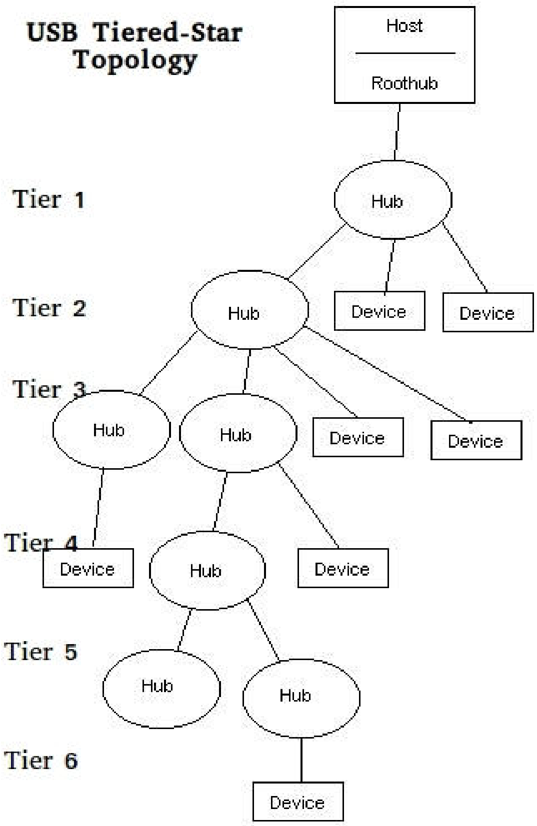
* Universal Serial Bus (USB)
* IEEE 1394 (FireWire)
* Infrared

* Audio jacks
* PS/2 (mini-DIN)
* Centronics

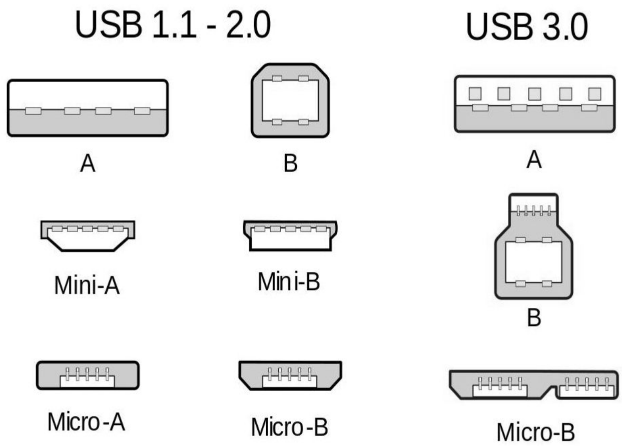
Universal Serial Bus (USB) port

They are seen in most computers now. They are used for connecting multiple (up to 127 to one port) peripherals to one computer through a single port (and the use of multiport peripheral hubs). PCs equipped with USB enable peripherals to be automatically recognized and configured as soon as they are physically attached, without the need to reboot or run a setup program (Plug and Play). All the devices connected to a single USB port share the bandwidth of that port. The USB is based on a so-called 'tiered star topology' in which there is a single host controller and up to 127 'slave' devices. The host controller is connected to a hub, integrated within the PC, which allows a number of attachment points (often loosely referred to as ports). A further hub may be plugged into each of these attachment points, and so on. However the maximum number of tiers permitted is six. The length of any cable is limited to 5 metres.

Release name	Release date	Maximum transfer rate
USB 1.0	January 1996	Low Speed (1.5 Mbit/s)
USB 1.1	August 1998	Full Speed (12 Mbit/s)
USB 2.0	April 2000	High Speed (480 Mbit/s)
USB 3.0	November 2008	SuperSpeed (5 Gbit/s)



USB Types:



USB Icons:

IEEE 1394 (FireWire) Port

It is an interface standard for a serial bus for high-speed communications and real-time data transfer, developed by Apple. Its popularity is due to its ease of use, isochronous (synchronized clock) mode, and very high (400Mbps to 3.2Gbps and higher) transmission rates. FireWire is essentially a peer-to-peer network (where any device may serve as the host or client), allowing multiple devices to be connected on one bus. It is often used as a way to get digital video into a PC so it can be edited with digital video editing tools. Security applications benefit from FireWire's higher power output, reducing the need for external power to devices such as security cameras.

Infrared Port

An infrared (IR) port is a small port on the computer that allows data to be sent and received using electromagnetic radiation in the infrared band (ie, wirelessly). The infrared port itself is a small, dark square of plastic (usually a very dark maroon) and can typically be found on the front of a PC or on the side of a laptop or portable. These ports are very slow, they are line-of-sight only and take place within a short distance (typically less than four meters). Not commonly used today.

Audio/Video Jacks

RCA jacks and connectors (or plugs) are used to transmit both audio and video information. On a video card, a yellow-coded RCA connector is used to transmit composite video signal to a television. The RCA cable is a simple coaxial cable. There are two connectors, usually male, one on each end of the cable. There are two contacts on each connector, the ground ring and the positive data pin in the middle.

PS/2 (Keyboard and Mouse)

A PS/2 port (also known as a 6-pin mini-DIN connector) is a mouse and keyboard interface port first found on the IBM PS/2 (hence the name).

Centronics Port

The Centronics connector was primarily used in parallel printer connections and SCSI interfaces. It has a unique shape. It consists of a central connection bar surrounding by an outer shielding ring.

<u>Common Peripheral Cables and Their Interfaces</u>

* Drive interfaces (PATA/SATA)

* SCSI

* Parallel

* Serial

* USB

* IEEE 1394 (FireWire)

* RJ-45

* Audio

* PS/2

Drive interfaces (PATA/SATA)

The connections on the motherboard through which the disk drives communicates with the motherboard are called drive interfaces. There are two main types: floppy disk drive interfaces and hard disk drive interfaces.

Floppy disk drive interfaces allow floppy disk drives (FDDs) and certain other devices, such as some internal tape drives, to be connected to the motherboard through a 34-pin connector, and similarly, hard disk drive interfaces do the same for hard disks and optical drives through 40-pin parallel ATA or 7-pin Serial ATA connectors. The interfaces consist of circuitry and a port, or *header*. Server motherboards often include SCSI headers and circuitry. The PATA headers on older motherboards will normally be black or some other neutral color if they follow the classic ATA 40-wire standard. From ATA-5 version, the motherboard connector is blue in colour with 40-pins and 80 wires indicating that it is a high speed version operating with Ultra-DMA technology. Out of these 80-wires, 40 are ground wires, each of which is placed inbetween two wires of the older 40-wired cable inorder to reduce the crosstalk and increase speed.

Parallel Interfaces

The parallel interface transfers data 8 bits at a time over eight separate transmit wires inside a parallel cable (1 bit per wire). Normal parallel interfaces use a DB25 female connector on the computer to transfer data to peripherals. Most parallel cables use a DB25 male connector on one end and either a DB25 male connector or, more commonly, a Centronics-36 connector on the other end. Parallel ports are faster than the original serial ports, which were also once used for printers in electrically noisy environments or at greater distances from the computer. The most common use of the parallel interface was printer communication. There are three major specifications of parallel port: standard, bidirectional, and enhanced parallel ports.

Standard Parallel Ports (SPP): The standard parallel port only transmits data out of the computer. It cannot receive data. The standard parallel port was found on the original IBM PC, XT, and AT. It can transmit data at only *150KBps* and was most commonly used to transmit data to printers. This technology also had a maximum transmission distance of 10 feet.

Bidirectional Parallel Ports (BPP): The bidirectional parallel port can transmit and receive data. These parallel ports can interface with devices such as external CD-ROM drives and external parallel port backup drives.

Enhanced Parallel Ports (IEEE 1284): This is a faster standard that allows the parallel port to act as an extension to the main bus with the ability to send memory addresses as well as data. An enhanced parallel port (EPP) has a bidirectional throughput from 600KBps to 1.5MBps. An enhanced capabilities port (ECP) is designed to transfer data at even higher speeds, around 2MBps. ECP uses direct memory access (DMA) and buffering to increase printing performance over EPP.

Serial Interfaces

In serial communications, bits of data are sent one after another on one wire, and they return on a different wire in the same cable. Three main types of serial interfaces are: standard serial (RS-232), Universal Serial Bus (USB), and FireWire (IEEE 1394).

Standard Serial: Serial ports are present from the original IBM PC and they have either a DE9 or DB25 male port. Standard serial ports have a maximum data transmission speed of 57Kbps and a maximum cable length of 50 feet. Serial cables come in two common wiring configurations: *standard serial cable* and *null modem serial cable*. A standard serial cable is used to hook various peripherals such as modems and printers to a computer. A null modem serial cable is used to hook two computers together without a modem. The transmit-centric pins on one end are wired to the receive-centric pins on the other side, so it's as if a modem connection exists between the two computers but without the need for a modem.

Universal Serial Bus (USB): USB cables are used to connect a wide variety of peripherals to computers, including keyboards, mice, digital cameras, printers, and scanners. There are different versions of USB namely USB 1.0 (1.5Mbps), USB 1.1 (12Mbps), USB 2.0 (480Mbps) and USB 3.0 (5Gbps). The connectors are broadly classified into Type A and Type B. A standard USB cable has some form of Type A connector on one end and some form of Type B connector on the other end. If the computers has not enough USB ports, a USB hub can be connected to an existing USB port so that many devices can be connected to the hub's USB ports. This leads to a tiered system, means maximum 5 hubs can be connected back to back with the sixth one being a device (maximum 6 tiers). The maximum cable length of different USB versions are;

Specification	Maximum Cable Length	Total Cable with 5 Hubs
USB 1.0 / 1.1	3m	18m
USB 2.0	5m	30m
USB 3.0	3m	18m

In addition to the cable length difference between USB 2.0 and 3.0, there are other differences between these specifications.

Shielding: USB 3.0 requires that each pair in the cable assembly be shielded to withstand the electromagnetic interference (EMI) inherent with transmissions at higher frequencies.

Connectors: Although all connectors are compatible with all receptacles, to attain SuperSpeed performance, SuperSpeed connectors with five additional pins must be used on cables and receptacles. These pins do not obstruct the four legacy pins required for backward compatibility. Instead, they sit farther back and are accessible only to compatible interfaces.

Bursting and streaming: USB 3.0 supports continuous bursting and streaming, but USB 2.0 does not.

Duplex: USB 2.0 is a half-duplex technology, meaning that all devices must share a common bandwidth, but USB 3.0 supports duplex communications.

Media access method: USB 2.0 peripheral devices must wait until polled by the host before transmitting data. USB 3.0 endpoints use an asynchronous transmission mechanism, similar to that of Ethernet, where data is transmitted at will.

Host control: The host (computer system) is the only device in the USB 2.0 specification that can control power management. The endpoints are the only devices that can participate in error detection and recovery as well as flow control. USB 3.0 endpoints can all control when they enter low-power mode to conserve power. Error handling and flow control are performed on each link in USB 3.0, not just at the endpoints.

Power : USB 2.0 provides a maximum of 100 milliamperes (mA) of current at low power and 500mA at high power. USB 3.0 provides 150mA and 900mA.

FireWire (IEEE 1394): The other major difference between the USB and FireWire is the amount of power accessible to FireWire devices. Whereas USB provides less than an ampere of current at 5VDC, FireWire specifications allow for the provision of 1.5A at up to 30VDC (and slightly more in some implementations). This production of 45W of power allows for larger devices to be powered by the FireWire interface, obviating the need for separate external power.

FireWire interface has two varients; FireWire 400 and FireWire 800.

FireWire 400 has a maximum data throughput of 400Mbps and works in half duplex. It carries data over a maximum cable length of 4.5 meters with a maximum of 63 devices connected to each interface on the computer.

FireWire 800 (specified under IEEE 1394b), has a maximum data throughput of 800Mbps and works in full duplex. When implemented over copper, FireWire 800 is limited to 4.5m cable runs, but can be extended to 100m using new beta connectors and fibre optic cabling.

IEEE 1394c standardized the running of FireWire over the same Category 5e infrastructure that supports Ethernet, including the use of RJ-45 connectors. IEEE 1394b also allows for 1.6Gbps (S1600) and 3.2Gbps (S3200) implementations.

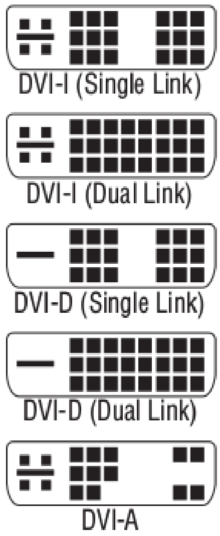
Video Display Cables and Connectors

VGA (Video Graphics Array): It is an analog standard introduced by IBM. It has a 15 pin D interface connector and cable. The original VGA modes allowed for a maximum graphics resolution of 640×480 in only 16 (4-bit) colors. Today the minimum resolution and color depth (number of colors) is 1024×768 and 32-bit color.

Digital Visual (or Video) Interface (DVI): It is a digital standard with more quality than analog standard. There are three main categories of DVI connectors:

DVI-A: An analog-only connector. The source must produce analog output, and the monitor must understand analog input.

DVI-D: A digital-only connector. The source must produce digital output, and the monitor must understand digital input.

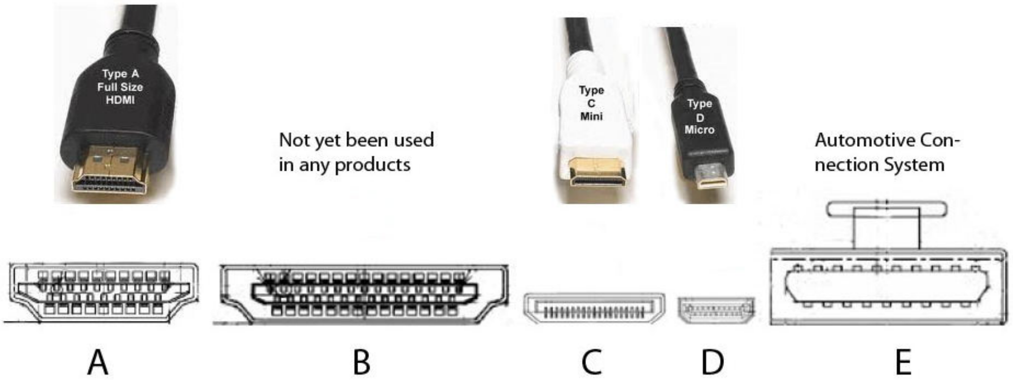


DVI-I: A combination analog/digital connector. The source and monitor must both support the same technology, but this cable works with either a digital or an analog signal.

The DVI-D and DVI-I connectors come in two varieties: single link and dual link. The dual-link options have more conductors taking into account the six center conductors than their single-link counterparts, which accommodate higher speed and signal quality.

DVI-A and DVI-I analog quality is superior to that of VGA, travel longer distances than VGA and are pin compatible to VGA using passive adapters. DVI-I cables and interfaces are designed to interconnect two analog or two digital devices; they cannot convert between analog and digital.

High-Definition Multimedia Interface (HDMI): It is a digital video technology that includes high-quality high-resolution video and audio. It is the first industry-supported uncompressed, all-digital audio/video interface. HDMI cabling also supports an optional Consumer Electronics Control (CEC) feature that allows transmission of signals from a remote control unit to control multiple devices without separate cabling to carry infrared signals. HDMI is compatible with DVI-D and DVI-I interfaces through proper adapters, but HDMI's audio and remote-control pass-through features are lost. Additionally, 3D video sources work only with HDMI.

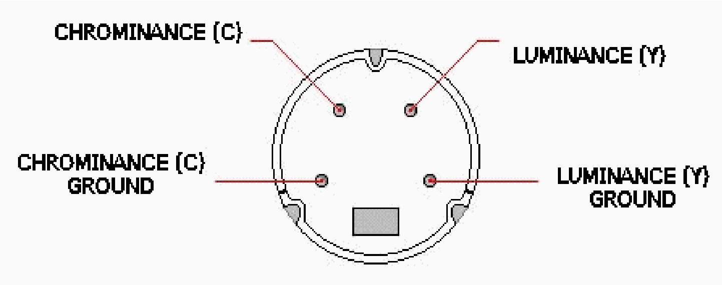


The HDMI connector (Type A) has 19 pins, Type B has 29 pins, a smaller 19-pin Type C connector (mini-HDMI) for portable devices. There is also Type D (micro-HDMI) and Type E connectors. The cable length depends heavily on the materials used to construct the cable. Passive cables tend to extend upto 15 meters, while adding electronics within the cable to create an active version results in lengths as long as 30 meters. Twisted-pair and fiber cabling options can extend cabling to 50 meters and 100 meters, respectively.

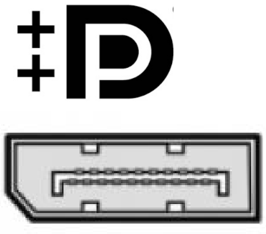
Component Video: It is an analog technology for broadcast video, which gives better-quality video by splitting the red, green, and blue components in the signal into different streams right at the source. Component video uses one uncompressed signal and two compressed signals, reducing the overall bandwidth needed. These signals are delivered over coax either as red, green, and blue color-coded RCA plugs or similarly coded BNC connectors. The uncompressed signal is called luma (Y), which is essentially the colorless version of the original signal that represents the "brightness" of the source feed as a grayscale image. The component-video source also creates two compressed color-difference signals known as Pb and Pr. These two chrominance (chroma, for short) signals are also known as B – Y and R – Y, respectively, because they are created by subtracting out the luma from the blue and red source signals. This technology is also called YPbPr. In fact, the often green-colored lead in the component-video cable carries the luma. There is no need for a separate green color-difference signal. After creating the blue and red part of the image, whatever details in the luma version of the image have weak representation in the blue and red versions are inferred to be green. A digital version of this technology, usually found on high-end devices, is represented as YCbCr.

S-video: S-video is a component video technology that, in its basic form, combines the two chroma signals into one, resulting in video quality not quite as high as that of YPbPr. This is because the R, G, and B signals are harder to approximate after the Pb and Pr signals have been combined. Standard S-video connectors are 7-

pin mini-DIN and 4-pin mini-DIN connectors. It has some other non-standard versions too. The most basic connector is the 4-pin mini-DIN that has one luma and one chroma (C) output lead and a ground for each. A 4-pin male connector is compatible with a 7-pin female connector.

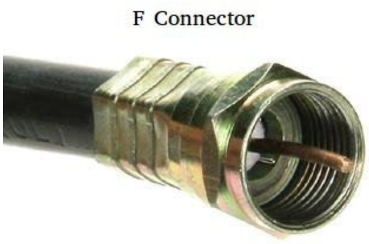


Composite Video: It combines all luma and chroma leads into one. It is the bottom type for analog signal. Unfortunately, once the four signals are combined into one, the display equipment has no way of faithfully splitting them back out, leading to less than optimal quality but great cost efficiency. While still fairly decent in video quality, composite video is more susceptible to undesirable video effects. This connector is generally a yellow RCA connector generally found in most TV and DVD players.



DisplayPort: DisplayPort is a digital display interface from the Video Electronics Standards Association (VESA) that uses less power than other digital interfaces and VGA. A simple adapter allows HDMI and DVI voltages to be lowered to those required by DisplayPort because it is functionally similar to HDMI and DVI. DisplayPort cables can extend 3 meters, and with an active cable power the cable can extend to 33 meters. A full-size DisplayPort interface has 20 pins.

A smaller compatible version called Thunderbolt has been created in collaboration between Intel and Apple. Thunderbolt combines PCI Express with the DisplayPort technology. The Thunderbolt cable is a powered active cable extending as far as 3m and was designed to be less expensive than an active version of the full-size DisplayPort cable of the same length. It has the same label as the Lightning-bolt port. It also has 20-pins.



Coaxial: Two main forms of coaxial cable are used to deliver video from a source to a monitor or television. One of them is terminated by RCA or BNC plugs and tends to serve a single frequency, while the other is terminated by F connectors, those seen in cable television settings, and tends to require tuning/demodulation equipment to choose the frequency to display. The terms that refer to whether a single frequency or multiple frequencies are carried over a cable are *baseband* and *broadband* respectively.

Input Devices

An input device is one that transfers information from outside the computer system to an internal storage location, such as system RAM, video RAM, flash memory, or disk storage. Without input devices, computers would be unable to change from their default boot-up state. Most common input devices are Mouse, Keyboard, Barcode reader, Multimedia devices, Biometric devices, Touchscreen, KVM switch, Scanner, Gamepads & joysticks and Digitizer.

Mouse

In its most basic form, the mouse is a hand-fitting device that uses some form of motion-detection mechanism to translate its own physical two-dimensional movement into onscreen cursor motion. Many variations of the mouse exist, including trackballs, tablets, touchpads, and pointing sticks.

It was Apple in 1984 that made the mouse an integral part of the personal computer image with the introduction of the Macintosh. The Apple mouse had a simple ball that protruded from the bottom of the device so that when the bottom was placed against a flat surface that offered a slight amount of friction, the mouse would glide over the surface but the ball would roll, actuating two rollers that mapped the linear movement to a Cartesian plane and transmitted the results to the software interface. Later technologies used optical receptors to catch LED light reflected from specially made surfaces purchased with the devices and used like a mouse pad. Later, lasers were used to allow a sharper image to be captured by the mouse and more sensitivity in motion detection. Today's mouse use battery powered wireless mechanism to connect to the computer. For the Macintosh, one button has always been sufficient, but for a Windows-based computer, at least two are recommended, hence the term right-click. Today, the mouse is commonly found to have a wheel on top to aid in scrolling and other specialty movement and it act as a button for some special applications.

On laptops, Touch pads (flat panels below the spacebar) and pointing sticks (eraser-like protrusions in the middle of the keyboard) are found. Also a trackball which has a protruding rorating-ball and buttons on the top of the device to use in a tight space.

Keyboard

Computer keyboard is a typewriter-style device which uses an arrangement of buttons or keys to act as a mechanical lever or electronic switch. It is the most common input device to feed input data into the PC. The US English keyboard places keys in the same orientation as the QWERTY typewriter keyboards. In addition to these, function keys, numeric keys, cursor movement keys and some special keys are used in modern keyboards and among these the basic 104-key type is the most popular one. In addition to the layout for a standard keyboard, other keyboard layouts exist. For example, without changing the order of the keys, an ergonomic keyboard is designed to feel more comfortable to users as they type. To accomplish that goal, manufacturers split the keyboard down the middle, angling keys on each side downward from the center. There are different types of keyboard technologies such as dome-switch, membrane type, scissor switch, mechanical switch, capacitive keyboards etc.

The main component of a keyboard is the key switch. These switches generate typical codes of signal when they are depressed and these signals are used for interfacing with the PC. Mechanical switches and membrane type switches are commonly used in keyboards. When a key is depressed or released, it makes or breakes an electrical contact. These two contacts make scan codes and these two scan codes helps to identify the key and whether it is stuck. The proces of finding the pressed key is called keyboard scanning.

Scanner

The scanner is an input device which captures images and sends digital information to the computer. Before USB, the scanner was connected to the system through SCSI bus. The working of a scanner is as follows: a light source illuminates the image to be scanned. Blank or white spaces reclect more light than coloured or inked letters or images. Either the image or the scan head is moved from one side to the other to capture the bounced-off light from the image. The reflected image is routed through a series of mirrors and colour filters to a lens. This lens focuses the light beam into a Charge Coupled Device (CCD) which converts the light spot into electrical signals. Commonly used scanners are of three types.

Flat Bed scanner: Here the image to be scanned is placed on the top of the scanning surface and it remains stationary. The scan head with the light source is moved slowly from one end of the image to the other and scans the image.

Sheet Fed scanner: Here the scan head remains stationary and the image is moved in front of the head. It occupies less space and it is less expensive.

Hand Held scanner: Here the scan head and the image will not move. The user moves the scanner above the image two-three times to get the full image. The quality of the scanned image will be low and it totally depends on the skill of the user.

Barcode Reader

A barcode reader (or barcode scanner) is a specialized input device commonly used in retail and other industrial sectors that manage inventory. Barcode readers can use LEDs or lasers as light sources and can scan one- or two-dimensional barcodes. Barcode readers can connect to the host system in a number of ways, but serial connections, such as RS-232 and USB, are fairly common. The code read from the barcodes may be the product's identification number, a website's URL, a phone number, a GEO location, an email address, or an SMS message.

Digitizer (Digitizing Tablet)

One way to faithfully reproduce incredibly good artwork in digital form for computer use is to place the analog artwork on top of a sensor and use a stylus to trace the artwork after choosing an onscreen “crayon” or “pen”. The end result can be a work of art almost as good as the original. The device used to trace an analog source, turning it into a digital representation, is a digitizer. Digitizing, in fact, is the act of turning any analog source—artwork, audio, video, slides and photographs—into a binary bit stream. As an input device, however, a digitizer or digitizing tablet takes pen strokes in the analog world and turns them into a digital rendering through the software controlling the digitizer.

Biometric Devices

Any device that measures one or more physical or behavioral features of an organism is considered a biometric device. When the same device forwards this biometric information to the computer, it becomes an input device. The list includes fingerprint scanners, retinal and iris scanners, voice recognition devices, etc. A computer can use this input to authenticate the user based on preestablished biometric information captured during user setup. Even the system-locks that authenticate the user before allowing entry to secure environments can be replaced with biometric devices. Many offerings allow multiple forms of authentication to be required in sequence. An example of a highly secure approach to authentication with multiple factors would be a biometric scan, followed by a challenge that requires a code from a token card, followed finally by the opportunity to enter a password.

Touchscreens

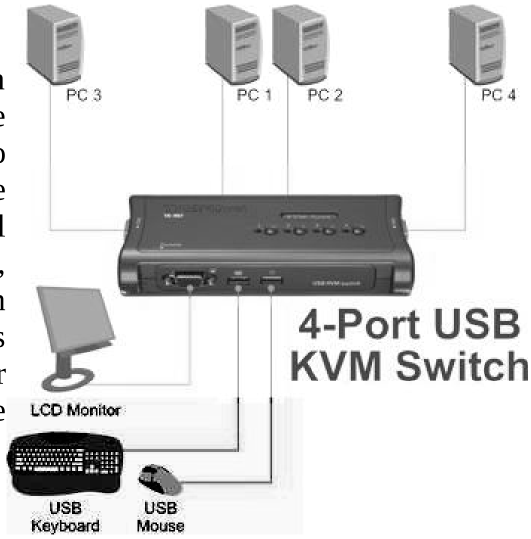
A touchscreen is an important source of input device and output device normally layered on the top of an electronic visual display of an information processing system. A user can give input or control the information processing system through simple or multi-touch gestures by touching the screen with a special stylus and/or one or more fingers. Touchscreen technology converts the touch the screen to electrical impulses that travel over serial connections to the computer system. These input signals allow for the replacement of the mouse, simultaneously in movement and in click. This technology can also be seen in PDAs and smartphones, point-of-sale venues, ATMs, vehicles etc. The two most popular with handheld devices are resistive and capacitive touch screens. Capacitive interfaces are generally smoother to the touch than resistive interfaces and can be controlled by the pad of the finger or a special stylus that mimics this soft part of the fingertip. Resistive interfaces usually have to be controlled by the fingernail or a plastic or metal stylus. Installing monitors with touch capability on standard computers entails not only attachment to the graphics adapter, but also attachment to a serial interface (like USB).

Gamepads and Joysticks

Two popular types of controllers are the generic *joystick*, a controller with one or more buttons and a stick of varying length and girth, and the often proprietary *gamepad*, usually comprising function and directional buttons specific to the gaming console in use. Standardized PC connections have included the DA15 game port (also known as the joystick port), the DB25/DE9 serial port, and the USB port.

KVM Switch

A KVM switch is not an input device, but it allows to switch between sets of input devices such as Keyboard, Video, and Mouse. The purpose of the switch is to allow to have multiple systems attached to the same keyboard, monitor, and mouse. You can use these three devices with only one system at a time. Some switches have a dial that you turn to select which system attaches to the components, while others feature buttons for each system connected. Common uses of KVM switches include using the same components alternately for a desktop computer and a laptop docking station or having a server room with multiple servers but no need to interface with them simultaneously.



<u>Multimedia Input Devices</u>

Web cams

These are video camera only devices which got popularity with the growth of the Internet, hence the name web cam. Web cams make great security devices as well. Users can keep an eye on their property from anywhere that Internet access is offered. Care must be taken, however, because the security that the web cam is intended to provide can backfire on the user if the web cam is not set up properly. A web cam connects directly to the computer through an I/O interface, such as USB or WiFi, and does not have any self-contained recording mechanism. Its sole purpose is to transfer its captured video directly to the host computer, usually for further transfer over the Internet. Some web cams have in-built wired or wireless NIC interfaces for connecting to web directly.

MIDI Devices

Microphones, audio playback, and audio synthesizing devices are common input components connected to a sound card or serial port so that audio from these devices can be collected and processed. MIDI (Musical Instrument Digital Interface) is an example for such device. These devices are also called controllers. These devices do not make sound that is recorded directly; they are merely designed to somewhat realistically fabricate the music the instruments they represent might produce. Computers can receive MIDI controllers directly, such as through a sound card with a built-in MIDI interface or through the use of an external MIDI interface that originally connected to the computer’s game port. Today, USB and FireWire ports are more commonly used. Ethernet-attached interfaces also exist and require very little processing power to convert the MIDI messages into Ethernet frames.

Digital Cameras and Camcorders

A digital camera is a device that takes still pictures and records them to digital media of some sort for later access. A camcorder is a video capture device that performs a similar function to that of the digital camera, but for moving video. Most of today’s multimedia recording devices perform the functions of both the digital camera and the digital camcorder. Originally the digital cameras used floppy disks to store the images and camcoders used tape drives and hard disks. Then came internal flash memory which lead to memory slots for SD type cards.

<u>Output Devices</u>

The major output devices are printers, speakers and display devices.

Understanding Display Types and Settings

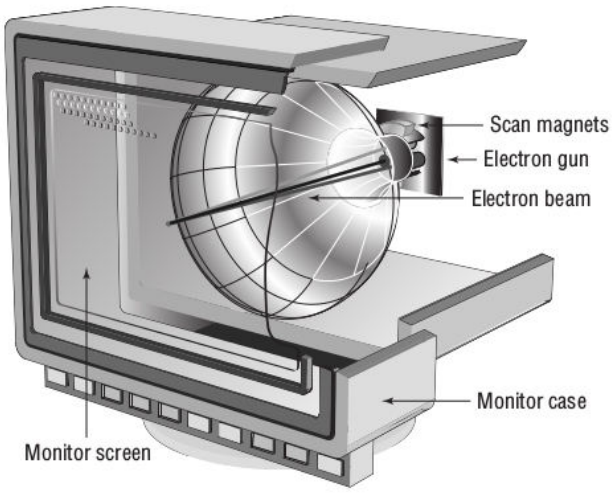
The primary method of getting information out of a computer is to use a computer video display unit (VDU). Display systems convert computer signals into text and pictures and display them on a TV-like screen. Most display systems work the same way. First, the computer sends a signal to a device called the video adapter (an expansion card or integrated video circuitry) on the motherboard, telling it to display a particular graphic or character. The adapter then renders the character for the display and sends the instructions to the display device, based on the connection technology between the two. The primary differences after that are in the type of video adapter you are using (digital or analog) and the type of display (CRT, LCD, projector, etc.).

Video Display Types

The different VDU types are;

1. CRT
2. Liquid crystal display
3. LED displays
4. Plasma
5. OLED
6. Projection systems

CRT (Cathode Ray Tube) Displays



In a CRT, a device called an electron gun shoots a beam of electrons toward the back side of the monitor screen . Color CRTs often use three guns, one each for red, green, and blue image components. The back of the screen is coated with special chemical dots called phosphors that glow when electrons strike them. The beam of electrons scans across the monitor from left to right, as you face it, and top to bottom in a raster pattern to create the image. A special metallic screen called a shadow mask (in most implementations) has holes spaced and angled in an extremely precise manner. For color CRTs that employ shadow masks, a trio of dot phosphors is often grouped in a triangle for each hardware picture element. The separate electron beams that control red, green, and blue strike only their own phosphors at the correct angle to cause them to glow. The glow of the phosphors decays very quickly, requiring the electron beam's regular return to each phosphor to sustain the glow. The more dot phosphors that are placed in a given area, the better the image quality at higher resolutions.

There are two ways to measure a CRT monitor's image quality: dot pitch and resolution. Dot pitch is a physical characteristic of the monitor hardware, but resolution is configurable through software.

Dot pitch (Pixel Pitch) is the measurement between the same coloured spot in two vertically adjacent dot trios. It tells how "sharp" the picture can be. The lower the measurement in millimeters or the higher the number of dots per inch, the closer together the phosphors are, and as a result, the sharper the image can be. An average dot pitch is 0.28mm to 0.32mm.

Resolution is defined by how many software picture elements (pixels) are used to draw the screen. An advantage of higher resolutions is that more information can be displayed in the same screen area. A disadvantage is that the same objects and text displayed at a higher resolution appear smaller and might be harder to see. The resolution is described in terms of the visible image's dimensions (number of pixels on rows and columns), eg: 1024X768 means 1024 pixels across and 768 pixels down were used to draw the pixel matrix.

Liquid Crystal Display (LCD)

LCD is a flat display technology used for displays in digital watches and calculators to laptops and other smaller computers. The LCD is made of two sheets of a flexible polarizing material placed at right angle to each other and a layer of liquid crystal solution between the two. Passing electricity through the liquid crystal will change its polarization in a way to pass light through the two polarized layers. Based on the amount of back light passes out of the second polarizer filter, the filter seems to be darker or brighter. Calculators use the outside light as backlight and LCD monitors use fluorescent backlight. Colour LCDs have three sub-pixels (RGB) for each pixel. Transistors are used to control the current flow through the liquid crystal.

The LCDs are available in either analog or digital interfaces. The analog interface is the VGA type and the computer first converts its internal digital video signals to analog before transmitting through the VGA cable. The digital type LCDs have digital interfaces (like DVI) and the computer can send its digital video signals as such. Hence the digital LCD is sharper than tha analog LCD.

An LCD is available as a passive-matrix, active matrix or dual-scan.

<u>Passive Matrix LCD</u>: It has a row of transistors running on the top of the screen (x-axes) as well as the left of the screen (y-axes). The amount of transistors are defined by the LCD manufacturer, for example, the manufacturer may define 800 transistors along the x-axes and 600 transistors along the y-axes. For colour monitor, there will be separate transistors for each subpixel (Red, Green and Blue colors). These transistors power the pixels that are in the grids. For each pixel to be ON or OFF, the corresponding x and y transistors are used. Unfortunately, if one of these transistors were to fail, a solid black line going vertical or horizontal will be seen on the screen. Once a pixel’s charge is gone, the pixel begins to return to normal, or decay, requiring a refresh to make it appear static. Angles of visibility and response times are lower. These have some disadvantages: Less contrast, low response time to ON and OFF the transistor and hence low refresh rate. These bring a 'ghost effect' for moving onjects.

<u>Active Matrix LCD</u>: Alternatively referred to as **Thin Film Transistor** (**TFT**) and **Active-matrix LCD** (**AMLCD**). Here three transistors are used for each <u>pixel</u> (for each of the three colours RGB) and turns ON/OFF by selecting the corresponding row and column. It does not require constant refreshing to maintain an image because transistors conduct current in only one direction and the pixel acts like a capacitor by holding its charge until it is refreshed with new information. It can make the screen brighter and more colorful than passive-matrix displays. Active-matrix displays also update the screen faster than passive-matrix, and are capable of being viewed at a greater viewing angles. Because of this improved technology, active matrix screens are often more expensive and consumes more power than their passive matrix counterparts. The vast majority of LCDs manufactured today are based on active-matrix technology.

<u>Dual Scan LCD</u>: It is a passive LCD technology in which a screen is divided into two sections which are simultaneously refreshed giving faster refresh rate than traditional passive matrix screens. It offers low power consumption but less sharpness and brightness compared to Active Matrix LCDs. Display quality is poor compared to TFT, with visible noise, much lower contrast and slow response. Such screens are unsuitable for viewing movies.

LED Displays

LED displays are simply LCD panels with light emitting diodes (LEDs) as back light sources instead of the fluorescent bulbs used by conventional LCD monitors. Because there are many individually controlled LEDs in an LED display, sometimes as many as there are transistors in the LCD panel, the image can be intelligently backlit to enhance the quality of the picture. Additionally, there is no need for laptops with LED displays to convert the DC power coming into the laptop to the AC needed to power traditional fluorescent backlights because LEDs operate on DC power like the rest of the laptop.

Plasma Displays

The word plasma refers to a cloud of ionized (charged) particles—atoms and molecules with electrons in an unstable state. This electrical imbalance is used to create light from the changes in energy levels as they achieve balance. Plasma display panels (PDPs) create just such a cloud from an inert gas, such as neon, by placing electrodes in front of and behind sealed chambers full of the gas and vaporized mercury. This technology of running a current through an inert gas to ionize it is shared with neon signs and fluorescent bulbs. Because of the pressurized nature of the gas in the chambers, PDPs are not optimal for high-altitude use, leading to CRTs and LCDs being more popular for high-altitude applications, such as aboard aircraft, where PDPs can be heard to buzz the way fluorescent bulbs sometimes do. Just like CRTs, these have phosphor pixels (with RGB subpixels) and they do not need backlight. In both displays, the the phosphor chemicals can be "used up" over time, reducing the overall image quality.

OLED Displays

In OLED displays, the OLEDs are the image-producing parts of the display. An organic light-emitting (electro-lumiescent) compound forms the heart of the OLED and is placed between an anode and a cathode, which produce a current that runs through the electroluminescent compound, causing it to emit light. An OLED is the combination of the compound and the electrodes on each side of it. The electrode in the back of the OLED cell is usually opaque, allowing a rich black display when the OLED cell is not lit. The front electrode should be transparent to allow the emission of light from the OLED. If thin-film electrodes and a flexible compound are used to produce the OLEDs, an OLED display can be made flexible. In darker surroundings, OLED displays produce better images than do LCD panels. Because OLEDs create the image in an OLED display and supply the light source, there is no need for a backlight. The power to drive an OLED display is, on average, less than that required for LCDs. However, as the image progresses toward all white, the power consumption can increase to two or three times that of an LCD panel.

OLED panels can be classified as active matrix (AMOLED) or passive matrix (PMOLED). AMOLED displays have better quality than PMOLED displays but, as a result, require more electrodes, a pair for each OLED.

Two important enhancements to AMOLED technology have resulted in the development of the Super AMOLED and Super AMOLED Plus displays, both owing their existence to Samsung. The Super AMOLED display removes the standard touch sensor panel (TSP) found in the LCD and AMOLED displays and replaces it with an on-cell TSP that is flat and applied directly to the front of the AMOLED panel. The thinner TSP leads to a more visible screen in all lighting conditions and more sensitivity when used with touch panels.

Projection Systems (Projectors)

Portable projectors can be thought of as condensed video display units with a lighting system that projects the VDU's image onto a screen or other flat surface for group viewing. To accommodate using portable units at variable distances from the projection surface, a focusing mechanism is included on the lens. Other adjustments, such as keystone, are provided through a menu system on many models as well as a way to rotate the image 180^0 for ceiling-mount applications.

Another popular implementation of projection systems has been the *rear-projection* television, in which a projector is built into a cabinet behind a screen onto which the image is projected in reverse so that an observer in front of the TV can view the image correctly. Early rear-projection TVs as well as ceiling-mounted home-theater units used CRT technology to drive three filtered light sources that worked together to create an RGB image. Later rear-projection systems, including most modern portable projectors, implement LCD gates. *Digital light processing (DLP)* is another popular technology that allows projectors to be extremely small. These DLP chips (also called optical semi-conductors) have millions of mirror pieces whose orientation can be changed through corresponding semiconductor back ends.

Projection systems are required to produce a lighted image and display it many feet away from the system. The challenge to this technology is that ambient light tends to interfere with the image's projection. One solution to this problem is to increase the brightness of the image being projected.

Adjusting Display Settings

Although most monitors are automatically detected by the operating system and configured to the best quality that they and the graphics adapter support, sometimes manually changing display settings, such as for a new monitor or when adding a new adapter, becomes necessary. Some of such settings are given below. Each of these terms relates to settings available through the operating system by way of display-option settings or through the monitor's control panel (degauss).

- Refresh rate
- Resolution
- Multiple displays
- Degauss

Refresh Rate

The refresh rate is the vertical scan frequency and specifies how many times in one second the scanning beam of electrons redraws the screen in CRTs. The phosphors stay bright for only a fraction of a second, so they must constantly be hit with electrons to appear to stay lit to the human eye. The refresh rate is measured in Hertz. The refresh rate on smaller CRT monitors (14 to 16 inches), can be 60Hz to 72Hz, but for larger CRT monitors, it may be 85Hz or higher. For LCD televisions, the refresh rates can be 60Hz, 120Hz, 240Hz or 480Hz and can't be controlled by the user. But for LCD monitors, it is possible to select the refresh rate from a list of allowable rates. In LCDs, the refresh rates do not deal with the pixel decay, but with the flow of display frames and thereby affects the perfect motion of the video being displayed. Any way, the refresh rate selected must be supported by both the display device and the display adapter.

Resolution

The resolution is represented as the number of horizontal dots (pixels) by the number of vertical dots that make up the rows and columns of the display. For example, 640x480 (VGA), 1920x1080 (HD 1080). As the resolution increases, the number of pixels and size of the image increases. With more pixels, the image can be viewed in greater detail. There are software and hardware resolutions. The video adapter can have an allowable maximum resolution, but it can support several resolutions less than that.

Multiple Displays

In some situations, say business presentations, two computers have to be used on the same computer simultaneously. Here the adapter must support both displays simultaneously.

Degauss

Degaussing is the reduction of the magnetic field of an object, but cannot neutralize it completely. Because CRTs use magnetic fields to guide the electron beams to their intended targets, and LCDs do not, degaussing a monitor is strictly a CRT-related practice.

Understanding Video Standards and Technologies

Video Standards

The early video standards differ in two major areas: the highest resolution supported and the maximum number of colors in their palette. The supported resolution and palette size are directly related to the amount of memory on the adapter, which is used to hold the rendered images to be displayed. Display adapters through the years can be divided into five primary groups:

- Monochrome
- CGA
- EGA
- VGA
- DVI, HDMI, and other modern digital video

The amount of memory used to implement the pre-VGA adapters was fixed, hence the resolution and number of colors supported by these cards was fixed as well. Newer standards, based on VGA analog technology and connectivity, were eventually developed using adapters with expandable memory or separately priced models with differing fixed memory. Adapters featuring variable amounts of memory resulted in selectable resolutions and color palettes (24-bit color palettes known as *Truecolor* and made up of 16.7 million colors).

Monochrome: The first video technology for PCs was monochrome (black and white) by IBM. This was fine for the main operating system of the day, DOS. The first adapter, developed by IBM, was known as the Monochrome Display Adapter (MDA). It could display text but not graphics and used a resolution of 720x350 pixels.The Hercules Graphics Card (HGC), introduced by Hercules Computer Technology, had the same resolution and could support text mode and graphics mode.

CGA (Color Graphics Adapter): The first color adapter. By IBM. CGA displays 16-color text in resolutions of 320x200 (40 columns) and 640x200 (80 columns), but it displays 320x200 graphics with only four colors per mode. Each of the six possible modes has 3 fixed colors and a selectable 4th; each of the 4 colors comes from the 16 used for text. CGA's 640x200 graphics resolution has only 2 colors—black and one other color from the same palette of 16.

EGA (Enhanced Graphics Adapter): By IBM. EGA could display 16 colors out of a palette of 64 with CGA resolutions as well as a high-resolution 640x350 mode. It was fully hardware compatible with CGA.

VGA (Video Graphics Array): By IBM with its PS/2 series computers. This analog video technology had a 256KB of video memory on board and could display 16 colors at 640x480, 640x350, and 320x200 pixels or 256 colors at 320x200 pixels. The colors are chosen from a palette of 262144 colors (256k) because VGA uses 6 bits to specify each color, instead of the 8 that is the standard today.

Advanced Video Resolutions and Concepts

Advancements after the VGA adapter occurred only in the memory and firmware of the adapter, not the connector or its fundamental analog functionality.

SVGA (Super VGA): By Video Electronics Standards Association (VESA). it could support 16 colors at a resolution of 800x600 (the VESA standard), but it soon expanded to support 1024x768 pixels with 256 colors.

XGA (Extended Graphics Array): By IBM, but it was available only as a Micro Channel Architecture (MCA) expansion board. XGA could support 256 colors at 1024x768 pixels or 65,536 colors at 800x600 pixels. It was also an interlaced technology when operating at the 1024x768 resolution, meaning that rather than scan every line one at a time on each pass to create the image, it scanned every other line on each pass.

More Recent Video Standards

Any standard other than the ones already mentioned are probably extensions of SVGA or XGA. Whenever a known technology is preceded by the letter W, it has the same vertical resolution but a wider horizontal resolution to accommodate 16:10 wide-screen formats (16:9 for LCD and plasma televisions). Preceding the technology with the letter Q indicates that the horizontal and vertical resolutions were each doubled. H means that the horizontal and vertical resolutions were each increased to four times.

Therefore, if XGA has a resolution of 1024x768, then QXGA will have a resolution of 2048x1536.

Nonadjustable Characteristics

The below characteristics are non-adjustable.

Native Resolution

One of the peculiarities of LCD, plasma, OLED, and other flat-panel displays is that they have a single fixed resolution, known as the native resolution. Unlike CRT monitors, which can display a crisp image at many resolutions within a supported range, flat-panel monitors have trouble displaying most resolutions other than their native resolution. The native resolution comes from the placement of the transistors in the hardware display matrix of the monitor. For a native resolution of 1680x1050, for example, there are 1,764,000 transistors (LCDs) or cells (PDPs and OLED displays) arranged in a grid of 1680 columns and 1050 rows. Trying to display a resolution other than 1680x1050 through the operating system tends to result in the monitor interpolating the resolution to fit the differing number of software pixels to the 1,764,000 transistors, often resulting in a distortion of the image on the screen.

Contrast Ratio

The contrast ratio is the measure of the ratio of the luminance of the brightest color to that of the darkest color the screen is capable of producing. A display with a low contrast ratio won't show a "true black" very well, and the other colors will look washed out when you have a light source nearby. Also, lower contrast ratios mean that you'll have a harder time viewing images from the side as compared with being directly in front of the display. Ratios for smaller LCD monitors and televisions typically start out around 500:1. Common ratios for larger units range from 20,000:1 to 100,000:1.

Graphic and CAD/CAM Design Workstations

Graphic design workstations and computer-aided design/computer-aided manufacturing (CAD/CAM) workstations are computers used for similar yet distinct reasons. Graphic design workstations are used by desktop publishers in the creation of high-quality copy consisting of professional text and graphical images. This output is used in advertising, marketing, and other forms of specialized documentation. CAD/CAM workstations are used in the design of engineering and architectural documentation, including blueprints in both two and three dimensions.

Workstations used in the design of graphical content place a heavy load on three primary areas of the system:

1. CPU enhancements
2. Video enhancements
3. Maximized RAM

CPU Enhancements: The above systems place quite a load on their CPUs. Systems with average CPUs can become overwhelmed by the amount of processing required by professional graphical software. For this reason, such systems must be designed with CPUs of above-average performance. Computers used by graphic-design artists must process a constant flow of colors and detailed shapes, the combination of which can put a strain on the CPU, RAM, and video components. CAD/CAM systems can carry the designer's vision from conception to design in a 100% digital setting including three-dimensional drawings. Software used for such projects requires a high number of CPU cycles during the rendering of the designs before display on the monitor or output to a printer or plotter.

Video Enhancements: These systems need graphics adapters with better graphics processing units (GPUs) and additional RAM on board. Such applications place an unacceptable load on the CPU and system RAM when specialized processors and adequate RAM are not present on the graphics adapter.

Maximized RAM: All these applications need enough RAM to hold the instructions. Maximizing the amount of RAM that can be accessed by the CPU and operating system will result in better overall performance by graphic design workstations.

Audio/Video Editing Workstations

Professionals that edit multimedia material require workstations that excel in three areas:

1. Video enhancements
2. Specialized audio
3. Specialized drives

In digital *video editing*, *non-linear* editing is a method that allows to access any frame in a digital video clip regardless of sequence in the clip. NLE differs from linear editing by storing the video to be edited on a local drive instead of editing being performed in real time as the source video is fed into the computer. NLE requires workstations with much higher RAM capacity and disk space than does linear editing.

Video Enhancements: Audio/video editing workstations benefit most from a graphics adapter with multiple video interfaces that can be used simultaneously. When editing multimedia content, or even generalized documents, it is imperative that the editor have multiple views of the same or similar files. The editor of such material often needs to view different parts of the same file. For example, in video editing, many packages optimize their desktop arrangement when multiple monitors are detected, allowing less horizontal scrolling through timelines.These workstations also need high resolution displays capable of hadling huge amount of video data with high refresh rates.

To improve video-editing performance, graphics adapter may support CUDA and OpenCL. CUDA is Nvidia's Compute Unified Device Architecture, a parallel computing architecture for breaking down larger processing tasks into smaller tasks and processing them simultaneously on a GPU. Open Computing Language (OpenCL) is a similar, yet cross-platform, open standard. The rendering of 2D and 3D graphics occurs much more quickly and fluidly with one of these technologies. CUDA is optimized for Nvidia GPUs, while OpenCL is less specific, more universal, and perhaps, as a result, less ideal when used with the same Nvidia GPUs that CUDA supports.

Specialized Audio: Most common type audio controllers and add-on sound cards are basic two-channel types and cannot be used for higher level applications. Editors of audio information who are expected to perform quality work often require six to eight channels of audio. Although analog controllers work well, digital controllers are mostly preferred for such workstations.

Specialized Drives: Graphics editing workstations and other systems running drive-intensive NLE software prefer to use different drives to store the OS, media files that are under editing, and for the results/outputs of those editing. This helps to reduce multitasking by a single drive and improves the performance of the workstation. These drives must be large and fast such as SATA 6Gbps HDD with 7200rpm or above, in order to avoid the delay due to buffering. External drives prefer eSATA interface rather than USB 2.0. It is possible to use RAID such as Level 0 in order to improve performance.

Virtualization Workstations

Virtualization workstations must exceed the specifications of standard servers and workstations in two primary areas; (1) CPU enhancements, (2) Maximized RAM

Depending on the specific guest systems and processes that the workstation will host, it may be necessary to increase the hard drive capacity of the workstation as well. Because this is only a possibility, increased drive capacity is not considered a primary enhancement for virtualization workstations. Eventhough virtual machines (VMs) running on a host system appear to come along with their own resources, some important components that are shared by the host and all guest operating systems:

1. CPU cycles
2. System memory
3. Drive storage space
4. Systemwide network bandwidth

CPU Enhancements: Because the physical host's processor is shared by all operating systems running, virtual or not, the virtual machines have to use the cycles of the existing CPU without disturbing the host OS and processes. The operating system is capable of treating each core in a multicore processor separately and creating virtual CPUs for the VMs from them. Therefore, the more CPUs you can install in a workstation, each with as many cores as possible, the more dedicated CPU cycles that can be assigned to each virtual machine.

Maximized RAM: Evenif it is working on a Virtual Machine, an OS requires the same amount of RAM for working as required on a conventional machine. This RAM is accessed from the host system when the guest is booted. In such situation the host must also have atleast the minimum required RAM, otherwise the system will not work properly. Thus the host system physically must have enough RAM for the host environment itself and all the virtual machines that work simultaneously. The maximum installed RAM depends on three primary constraints:

* The CPU’s address-bus width

* The operating system’s maximum supported RAM

* The motherboard’s maximum supported RAM

The smallest of these constraints dictates the maximum RAM that can be use d in the workstation. Thus these limitations are to be taken into consideration when choosing the workstations.

Gaming PCs

In older days the PC games were expected to be played on conventional PCs. Today’s PC-based gaming software cannot be expected to run on the average system of the da, but in specialized gaming Pcs (computers optimized for running modern video games). A gaming PC must have enhancements in the below four areas:

1. CPU enhancements
2. Video enhancements
3. Specialized audio
4. Enhanced cooling

CPU Enhancements: Unlike with A/V editing, gaming requires millions of decisions to be made by the CPU every second. It’s not enough that the graphics subsystem can keep up with the action; the CPU must be able to create that action. Some people overclock their CPU to get a higher performance; but their CPU will almost certainly not live as long as if they had used the default maximum speed determined by the manufacturer and detected by the BIOS. Internal damage can be occured to CPU, memory or any other components. Enhancing the cooling system can prevent this damaga to a particular extend.

Video Enhancements: The CPU has limitations in handling high end graphics with higher refresh rates and heavy rendering of 2-D and 3-D models. This need heavy CPU power and a lot of RAM. To solve the RAM-size issue, a separate RAM of the order of GBs are placed on the video adapter itself.

Specialized Audio: In addition to several channel sound effects with high-definition digital audio, today's games work with interactive sound from the user, and hence need more powerful sound adapter than convensional systems. Technologies such as S/PDIF (Sony/Philips Digital Interface Format) and HDMI produce high-quality digital audio.

Enhanced Cooling: High performance processors and highly overclocked processors need an enhanced cooling mechanism for their proper working. Today’s high-end graphics adapters come equipped with their own cooling mechanisms designed to keep such adapters properly cooled under even extreme circumstances. But these expelled air circulates inside the CPU chassis and increases the inner temperature, leading to undesired effects.

Home Theater PCs (HTPC)

An HTPC might have multiple capabilities, such as storing large amounts of video media and streaming it to an output device, streaming it directly from the Internet, or acting as an A/V tuner and receiver, mating input sources with output devices. HTPCs are personal computers with operating systems that allow easy access to local storage, allowing the user to add whatever media they want whenever they feel the need. the following list comprises the specializations inherent in true HTPCs:

1. Video enhancements
2. Specialized audio
3. Special chassis
4. TV tuner requirement

Video Enhancements: Because of effective handling of high-definition video standards, most of the HTPC systems use HDMI as the major video interface. Graphics adapters present in HTPCs should have one or more HDMI interfaces. Ideally, the adapter will have both input and output HDMI interfaces, giving the PC the capability to combine and mix signals as well as interconnect sources and output devices. The monitor should also support such HD videos.

Specialized Audio: HDMI is capable of eight-channel 7.1 surround sound, which is ideal for the home theater. The fact that the HTPC should be equipped with HDMI interfaces means that surround-sound audio is almost an afterthought. Also, there will be atleast 7.1 analog surround sound (characterized by a sound card with a full complement of six 3.5mm stereo minijacks).

Special Chassis and TV Tuner: HTPCs have their own specialized computer case form factor. These machines should be able to blend well with other home theater appliances, such as digital video recorders (DVRs) from a cable company or satellite provider, or look totally fine taking their place. Some major HTPC specifications are given below.

- HTPC chassis, typically with dimensions such as 17x17x7 inch and 150W HTPC power supply
- Motherboard, typically mini-ITX with integrated HDMI video
- HDD or SSD, usually 2 1/2 inch portable form factor, larger capacity if storage of multimedia content is likely
- RAM—DIMMs for mini-ITX motherboard; SODIMMs for many pre-built models
- Blu-ray drive, player minimum
- PCIe or USB TV tuner card, optionally with capture feature

TV tuner cards are available as system add-ons and not commonly as integrated motherboard components. HTPCs that will be used only for streaming video from Internet sources and playing music do not require a TV tuner card. Otherwise, such a card might allow one or more sources, including one source split into two inputs, to be watched or recorded.

Standard Thick Clients

A thick client (also called a fat client) is one that will perform the bulk of the processing in client/server applications. With thick clients, there is no need for continuous server communications as it is mainly communicating archival storage information to the server. A standard thick client is a standard configuration that allows the definition of custom configurations. In other words, a thick client is a standard client computer system, and as such, it must meet only the basic standards that any system running a particular operating system and particular applications must meet. Each operating system requires a minimum set of hardware features to support its installation. Each additional desktop application installed requires its own set of features concurrent with or on top of those required for the operating system. For example, the operating system requires a certain amount of RAM for its installation and a certain amount of hard drive space. A typical application might be able to run with the same amount of RAM but will most certainly require enough additional hard-drive space to store its related files.

Thin Clients

A thin client is designed to be especially small so that the bulk of the data processing occurs on the server. A thin client is any machine that does not have all or most local storage and varying levels of RAM and processing power without necessarily giving up all ability to process instructions and data. In the extreme, a thin client resembles a dumb terminal, only displaying graphical user interface output to the monitor and relaying input from the mouse and keyboard back to the server. Thin clients with low processing and storage capabilities is that there must be one or more servers with increased corresponding capacities. Unfortunately, this leads to a single or centralized point of failure in the infrastructure that can impact productivity to an unacceptable level.

Home Server PCs

Home server PCs differ from enterprise servers to the point that they qualify as custom configurations. because the home server PC is the center of the home network, fault tolerance considerations should be entertained, which is decidedly not the case for standard home systems. fault tolerance differs from redundancy in that fault tolerance seeks to retain accessibility during the failure while redundancy simply ensures recoverability after the failure. Redundancy, in the form of a data backup, does not ensure the continued accessibility of the data, but RAID, for example, seeks to do so. Home server PCs can be built from the same components that go into today's higher performance systems. They have some additional capabilities too, such as;

1. Media streaming capabilities
2. File sharing services
3. Print sharing services
4. Gigabit NIC
5. RAID array

Media streaming capabilities: A popular use for a home server is to stream music photos and videos to other devices, including those that are not Pcs. Built-in applications or third-party applications may be used for this.

File and Print Sharing Services: Home servers are expected to allow the static transfer of files to or from the server's hard drive or array. Streaming and file sharing are similar concepts, but streaming occurs in one direction from the server and does not affect the client's file system. File sharing can go in both directions, and it adds to the client's file system during downloads. The server acts as a repository for uploaded files that can then be downloaded from any other machine in the home network. Here all the uses have the same access to the shared files. Similarly, each printer attached to the home server should be accessible to anyone on the home network.

Gigabit NIC: The home server should be attached to a wired switched port in an Ethernet switch or in the wireless access point. The NIC and the switch port should be capable of gigabit speeds. But the client machines should not have such high speed NICs as they may saturate the server interfaces.

RAID Array: Because the data that comprises the streaming content, shared data store, and client backup sets can become quite expansive, a large capacity of storage is desirable. Even a recoverable server outage results in a home network that is temporarily unusable by any client, so fault tolerance should be included. RAID provides the answer to all of these needs.

Module IV

Laptops and other Portable Devices

A portable computer is any computer that contains all the functionality of a desktop computer system but is portable. There are different types of portable computers such as laptops, netbooks, tablets etc. First portable computers were large like a suitcase and were less portable. Laptops were the next type of portable computer. They contain a built-in keyboard, pointing device, and LCD screen. They are also called notebook computers because they resemble large notebooks. Most portable computers in use today are laptop computers.

Understanding Laptop Architecture

Laptops are similar to desktop computers in architecture and functions of the parts. However, the parts that make up a laptop are completely different from those in desktop computers. The obvious major difference is size; laptops are space challenged. Another primary concern is heat. Restricted space means less airflow, meaning parts can heat up and overheat faster. To overcome space limitations, laptop parts are physically much smaller and lighter, and they must fit into the compact space of a laptop's case. Also, laptop parts are designed to consume less power and to shut themselves off or comes to power-saving mode when not being used. Finally, most laptop components are proprietary—the motherboard is especially proprietary, and the LCD screen from one laptop will not necessarily fit on another. For smaller usage there is a smaller variant of laptop called the netbook is there, which are ideal for Internet access and emailing but insufficient for mainstream usage.

Laptops vs. Desktops

The major differences between laptops and desktops are;

Portability: This is probably the most obvious difference. Laptops are designed to be portable. They run on batteries, so you aren't tied to one spot at home or at the office. Networking options are available that allow to connect to a network wirelessly and do work from just about anywhere, including malls, airports, coffee shops, and so on.

Cost: Laptops tend to cost more than desktop computers with similar features. The primary reason is that portability requires small components and unique proprietary designs so that those components fit into the small size necessary. Miniature versions of components cost more money than standard-sized (desktop) versions.

Performance: Compromises must often be made between performance and portability, and considering that portability is the major feature of a laptop, performance is what usually suffers. While it is possible to have a laptop with comparable performance to a desktop, the amount of money one would have to spend for a "desktop replacement" laptop is considerable.

Expandability: Because desktop computers were designed to be modular, their capabilities can be upgraded quite easily. It is almost impossible to upgrade the processor or motherboard on most laptops. Other than memory and hard drives, most laptop upgrades consist of adding an external device through one of the laptop's ports, such as a USB port.

Quality of construction: Considering how much abuse laptops get, it is much more important that the materials used to construct the laptop case and other components be extremely durable. Durability is important in a desktop too, but it won't be tested as much as in a laptop.

Laptop Case

A typical laptop case is made up of three main parts:

- ❏ The display—usually an LCD or LED display .
- ❏ The case frame, which is the metal reinforcing structure inside the laptop that provides rigidity and strength and that most components mount to.
- ❏ The case, or the plastic cover that surrounds the components and provides protection from the elements.

Laptop cases are made in a a clamshell design (ie, two halves, hinged together at the back). Usually, the display is the top half and everything else is in the bottom half. If a crack occurs at some part of the case, the entire components should be shifted to a new case which is a very tedious thing and very much costly.

MOTHERBOARDS AND PROCESSORS

As with desktop computers, the motherboard of a laptop is the backbone structure to which all internal components connect. However, with a laptop, almost all components must be integrated onto the motherboard, including onboard circuitry for the serial, parallel, USB, IEEE 1394, video, expansion, and network ports of the laptop. With desktop systems, the option remains to not integrate such components.

Laptop Motherboards

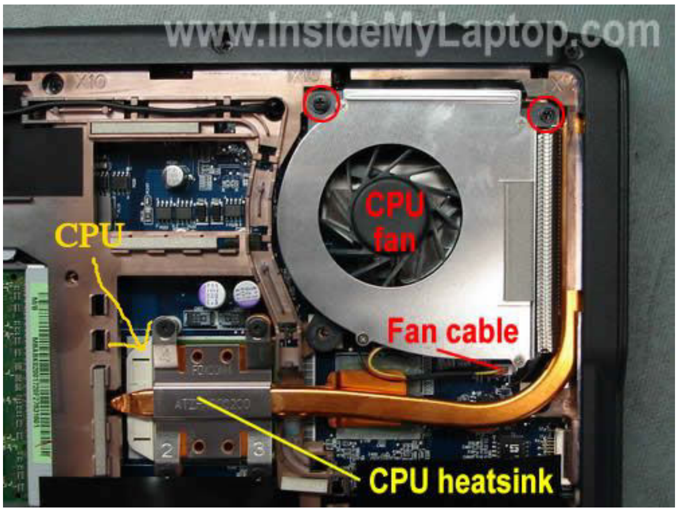
The primary differences between a laptop motherboard and a desktop motherboard are the lack of standards and the much smaller form factor. Most motherboards are designed along with the laptop case so that all the components will fit inside. Therefore, the motherboard is nearly always proprietary. To save space, components of the video circuitry (and possibly other circuits as well) are placed on a thin circuit board that connects directly to the motherboard. This circuit board is often known as a *riser card* or a *daughterboard*. But if one part goes bad, the entire board has to be replaced and is more expensive than just replacing one expansion card.

Various Laptop Motherboards

Laptop Processors

Just like everything else, compared to desktop hardware devices, laptop hardware devices are smaller and not quite as powerful. The laptop processor has less speed and consumes less power than corresponding desktop variants. Laptops have less space, and thus, heat is a major concern. To help combat this heat problem, laptop processors are engineered with the following features:

Streamlined connection to the motherboard: Since pins and sockets are big and bulky, laptops does not use such processors, but Laptop processors are generally either soldered directly to the motherboard or attached using the Micro-FCBGA (Flip Chip Ball Grid Array) standard, which uses balls instead of pins. In most cases, this means that the processor cannot be removed, meaning processor upgrades are not possible.



Lower voltages and clock speeds: Two ways to combat heat are to slow the processor down (run it at a lower speed) or give it less voltage. Again, performance will suffer compared to a desktop processor, but lowering heat is the goal here.

(Eg: Desktop Intel i5 processors are Quad Core, but the mobile Laptop versions are Dual-Core.

The Desktop i5 might be at 3.2ghz. The laptop will be much lower, such as 1.8ghz, with the ability to boost to 2.8ghz if it is not already very hot. If it is already hot (using all of its power), it will not Turbo to a higher clock speed.)

Active sleep and slowdown modes: Most laptops will run the processor in a lower power state when on battery power, in an effort to extend the life of the battery. This is known as processor throttling. The motherboard works closely with the operating system to determine if the processor really needs to run at full speed. If it doesn't, it's slowed down to save energy and to reduce heat. When more processing power is needed, the CPU is throttled back up. Some portable computers will simply use stripped-down versions of desktop processors. One of the best features of many laptop processors is that they include built-in wireless networking.

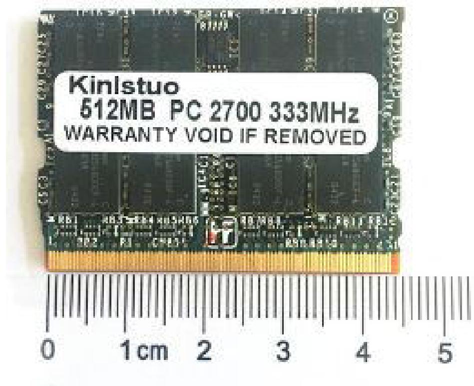
Memory

Notebooks don't use standard desktop computer memory chips, because they're too big. Thay use smaller versions of memory such as SODIMM and MicroDIMM.

Laptops commonly use SODIMM (Small Outline DIMM) which are much smaller than DIMM memory. SODIMMs are available in a variety of configurations, including 32-bit (72-pin) and 64-bit (144-pin SDRAM, 200-pin DDR, 200-pin DDR2, and 204-pin DDR3) options. The SODIMM must be compatible with the motherboard being used.

Another memory that the laptops use are the MicroDIMMs which are extremely smaller than DIMMs. Another major difference is that the MicroDIMM does not have any notches on the bottom. Popular MicroDIMM form factors include 64-bit modules with 172 or 214 pins for DDR2.

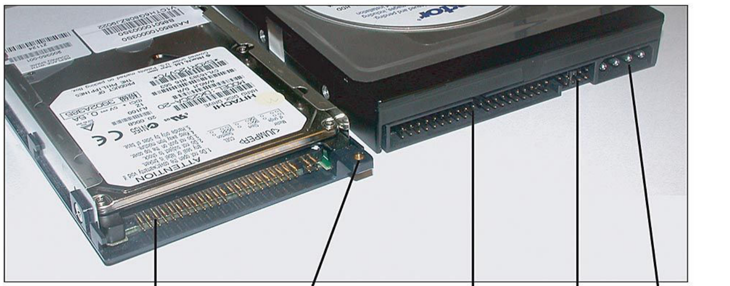
SODIMM



MicroDIMM

Storage

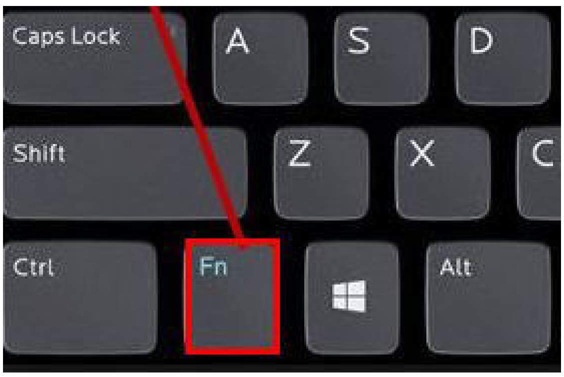
Laptops don't have the room for the full-sized 3.5 inch hard drives that desktop computers use. Instead, they use a hard drive with a 2.5 inch form factor that is less than 0.5 inch thick. These drives share the same controller technologies as desktop computers; however, they use smaller connectors. Optical drives on laptops are smaller than their desktop counterparts, but the functions are the same and cost is high. The drive mechanism and circuits have all been miniaturized to save space.



Input Devices

Because of the small size of laptops, getting data into them presents unique challenges to designers. The primary challenge is to design the peripherals so they fit within the design constraints of the laptop (low power and small form factor) while remaining usable.

Keyboards: Laptop keyboards are built into the lower portion of the clamshell. Sometimes, they can be removed easily to access peripherals below them like memory and hard drives. The keys must be smaller and packed together more tightly. People who learned to type on a typewriter or regular computer often have a difficult time adjusting to a laptop keyboard. Because of the much smaller space available for keys, some laptop keys are consolidated into special multifunction keys. These keys are accessed through the standard keys by using a special function (Fn) key, placed near the Windows key. The function key combinations can control many laptop functions, but the most common are video, audio, and networking settings. Video adjustments come in two varieties: changing the video output and dimming or brightening the screen. Dimming and brightening the screen is pretty straightforward. Every laptop has a video connector on the back to plug in an external monitor or a projector. The video toggle key can be used to get this external port to work. Usually there are three states: laptop only, external output only, and both displays. The audio setting can often be adjusted using the function keys too. There are key combinations to switch on/off the wireless connections such as bluetooth, wifi etc.



Function Key (Fn)

Mice and Pointing Devices: There are many methods of controlling the pointer on the screen. Some common methods are given below.

- Trackball
- Touchpad

- ❑ Point stick
- ❑ Touchscreen

Most laptops today include a mouse/keyboard port, a USB port, or both. Either of these ports can be used to add an input device like a mouse or a standard-sized keyboard.

Trackball: Many early laptops used trackballs as pointing devices. A trackball is essentially the same as a mouse turned upside down. The onscreen pointer moves in the same direction and at the same speed you move the trackball with your thumb or fingers. Trackballs are cheap to produce. But they do not last as long because they attract dust and dirt from surroundings and from the user's hand, and stops functioning abruptly.

Touchpad: It came to overcome the problems of trackballs, and are most common nowadays. A Touchpad is a device that has a pad of touch-sensitive material. The user draws with his finger on the Touchpad, and the onscreen pointer follows the finger motions. Included with the Touchpad are two buttons for left- or right-clicking even though the touchpad facilitates both.

Point Stick: With the introduction of the ThinkPad series of laptops, IBM introduced a new feature known as the Touchpoint, generically known as a point stick. The point stick is a pointing device that uses a small rubber-tipped stick. When you push the point stick in a particular direction, the onscreen pointer goes in the same direction. The harder you push, the faster the onscreen pointer moves. The point allows fingertip control of the onscreen pointer, without the reliability problems associated with trackballs. Point sticks have their own problems, however. Often, the stick does not return to center properly, causing the pointer to drift when not in use. The rubber cover for the stick becoming a bit gummy with extended use.

Touchscreen: These are screen with touch sensitivity. Instead of a keyboard and mouse, these computer screens have a film over them that is sensitive to touch. With the advent of the tablet PC (a laptop designed to be held like a pad of paper), the Touchscreen is becoming more popular as an input device for a laptop. Cleaning a Touchscreen is usually just as easy as cleaning a regular monitor with a glass cleaner. However, if the screen has a capacitive coating, glass cleaner may damage it. Instead, use a cloth dampened with water to clean the dirt, dust, and fingerprints from the screen.

Expansion Buses and Ports

PCMCIA (PC Card) Expansion Bus: PCMCIA stands for Personal Computer Memory Card International Association. The PCMCIA was organized to provide a standard way of expanding portable computers. A PCMCIA bus was introduced for this, which is commonly called as PC Card. PC Card uses a small expansion card (about the size of a credit card). The interface is a thin, 68-pin connector that has remained relatively unchanged from the original specification. Now they are used in some desktops too. In addition to the card, the PC Card architecture includes two other components:

Socket Services software is a BIOS-level interface to the PCMCIA bus slot. When loaded, it hides the details of the PC Card hardware from the computer. This software can detect when a card has been inserted and what type of card it is.

Card Services software is the interface between the application and Socket Services. It tells the applications which interrupts and I/O ports the card is using. Applications that need to access the PC Card don't access the hardware directly; instead, they tell Card Services that they need access to a particular feature, and Card Services gets the appropriate feature from the PC Card.

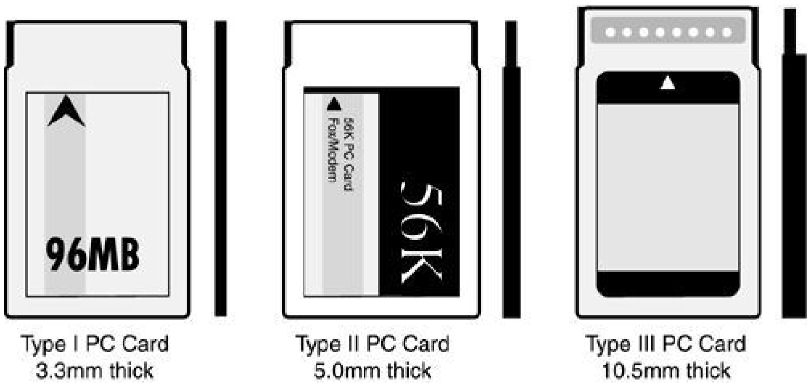
The first release of the PCMCIA standard (PCMCIA 1.0) defined a 16-bit ISA-like bus to be used for memory expansion only, using 5 Volts. PCMCIA 2.x introduced a backward compatible 3.3V memory. Later PC Card increased its bus width to 32 bits with PCI like-access method and 133 MBps speed. A newer CardBay standard designed to integrate USB functionality into the PC Card format.

Three major types of PC Cards (and slots) have been specified. Each has different uses and physical characteristics, although each one measures 54mm in width and 85.6mm in length. They are called Type I, Type II, and Type III:

Type I cards are 3.3mm thick and are most commonly used for memory cards.

Type II cards are 5mm thick and are mostly used for modems and LAN adapters but for sound cards, SCSI controllers, and other devices as well. This is the most common PC Card type found today.

Type III slot is 10.5mm thick. Its most common application is PC Card hard disks. These slots are all but extinct.



<u>ExpressCard</u>: ExpressCard was launched by PCMCIA as a way to support USB 2.0 and PCI Express (hence the term ExpressCard) connectivity for portable computers. It has a speed of 2.5 Gbps. Version 2 of the ExpressCard specification is designed to support USB 3.0 and PCIe 2.0. This helps to use Gigabit Ethernet and eSATA in portable computers through ExpressCard. These cards are smaller than older CardBuses and allows hot swapping too.

A USB 3.0 ExpressCard

Mini PCI and Mini PCIe: The Mini PCI is a smaller version of the standard PCI and is designed for laptops. Mini PCI is functionally identical to the PCI, meaning it's a 32-bit, 33MHz bus with a 3.3V-powered connection. It also supports bus mastering and DMA. Common Mini PCI devices include sound cards, modems, networking cards, and SCSI, ATA, and SATA controllers. Adapters are available that allow to use a Mini PCI adapter in a standard PCI slot. Mini PCIe cards support USB 2.0 and PCIe x1 functionality and have the 1.5V and 3.3V power options.

The traditional Mini PCI slot (shown first), the full height Mini PCIe slot
(shown second) and the half height Mini PCIe slot(shown last)

USB Ports: Like desktops, laptops use USB ports for expansion. However, because of the lack of internal expansion in laptops, most peripherals for laptops are found as either PC Cards or USB expansion devices.

Mouse/Keyboard Port: Some laptops come with a combination keyboard/mouse port that allows to connect either an external keyboard or an external mouse. On laptops that don't have USB ports, this port is most often used for a standard PS/2 mouse.

Communications Ports: Since laptops are portable, there has to be communication ports to connect this with other devices or network. Laptops come equipped with some version of an 802.11 wireless card. Others may have connections for an analog dial-up modem or an infrared, cellular, Bluetooth, or Ethernet device. Each of these can also be added to laptops through USB or PC Card connection.

Docking Stations

Some laptops are designed to be desktop replacement laptops. That is, they will replace a standard desktop computer for day-to-day use and are thus more full-featured than other laptops.

These laptops often have a proprietary docking port. A docking port is used to connect the laptop to a special laptop-only peripheral known as a docking station. A docking station is basically an extension of the motherboard of a laptop. Because a docking station is designed to stay behind when the laptop is removed, it can contain things like a full-sized drive bay, expansion bus slots, keyboard/mouse ports, video ports etc which are seen on a standard desktop computer. Also, the docking station can function as a port replicator. Peripherals such as monitors, keyboards, printers, and so on that don't travel with the laptop can remain connected to the dock and don't have to all be physically unplugged each time the laptop is taken away.

(a) Laptop on a docking station

(b) Docking port behind a laptop. A docking station is seen on the top of the picture.

<u>Power Systems</u>

Because portable computers have unique characteristics as a result of their portability, they have unique power systems as well. Portable computers can use either of two power sources: batteries or adapted power from an AC or DC source. Regardless the source of their power, laptops utilize DC power to energize their internal components. Therefore, any AC power source needs to be rectified (converted) to DC. If the monitor needs AC for backlighting, an inverter is used for this conversion.

<u>Batteries</u>: Nickel cadmium (NiCd), lithium-ion (Li-ion), nickel-metal hydride (NiMH) and lithium-polymer (Li-poly) have been the most popular chemistries for laptop batteries. Battery chemistries can be compared by energy density and power density. Energy density measures how much energy a battery can hold. Power density measures how quickly the stored energy can be accessed, focusing on access in bursts, not prolonged runtime. Another common metric for battery comparison is rate of self-discharge, or how fast an unused battery reduces its stored charge.

<u>Power Adapters</u>: Most notebook computers can also use AC power with a special adapter (called an AC adapter) that converts AC-power input to DC output. The adapter can be integrated into the notebook, but more often it's a separate "brick" with two cords, one that plugs into the back of the laptop and another that plugs into a wall outlet. Another power accessory that is often used is a DC adapter, which allows a user to plug the laptop into the power source inside a car or on an airplane.

Laptop Displays

The display system is the primary component in the top half of the clamshell case. The wireless antenna often resides here alongside the screen. The commonly used display technology is the LCD (Liquid Crystal Display) technology. There are LED, Plasma and OLED displays too.

Video Card: Most laptop manufacturers choose to integrate the LCD circuitry on the motherboard to save space. There are also interfaces to connect the laptop to external analog displays (like VGA, S-video) and digital displays (like HDMI, DVI, etc).

Backlight: To generate brightness LCD displays use a backlight. This backlight is a small fluorescent lamp (cold cathode fluorescent lamp- CCFL) placed behind, above, or to the side of an LCD display. The light from the lamp is diffused across the screen, producing brightness.

Inverter: The fluorescent backlight for the screen needs fairly high-AC voltage, high-frequency energy. To get this from the DC battery of the laptop, an inverter circuit board is placed behind the screen. If there are having problems with flickering screens or dimness, it's more likely that the inverter is the problem and not the backlight itself.

Screen: The screen on a laptop produces the image. The overall quality of the picture depends a lot on the quality of the screen and the technology of the laptop. Current options include LCD, LED, OLED, and plasma.

WiFi Antenna: Most laptops have WiFi capability through built-in wireless adapters. The wireless antenna is generally run up from the adapter in the motherboard through the hinges to the upper half of the clamshell case. This is to get the antenna higher up and improve signal reception.

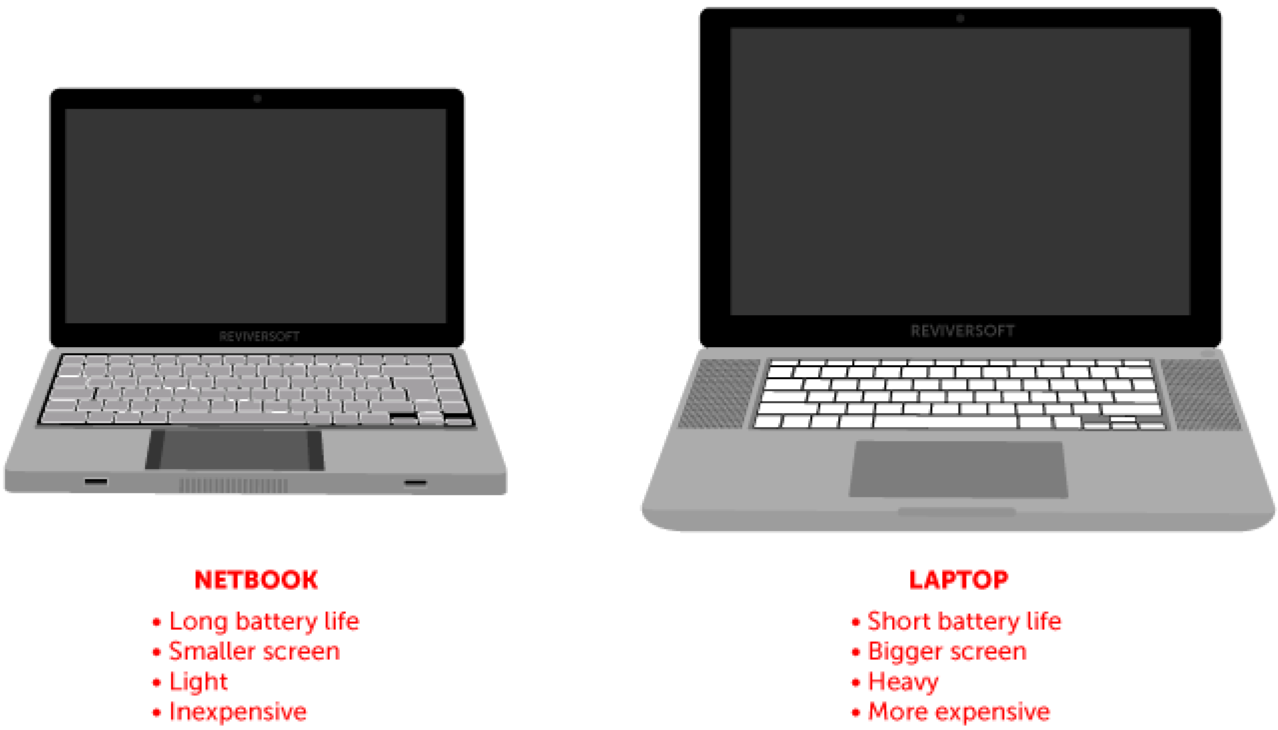
Cable Locks

Cable lock is used to physically secure the laptop. A cable lock anchors the laptop to a physical structure, making it nearly impossible for someone to walk off with it. Some locks are number locks and some have keys. Here's how it works. First, find a secure structure, such as the permanent metal supports of at workstation. Then, wrap the lock cord around the structure, putting the lock through the loop at the other end. Finally, secure the lock into the cable lock hole on the back or side of the laptop. If you forget your combination or lose your key, you have to cut through the cord, which will require a large cable cutter or a hack saw.

Netbooks

Netbook is a generic name given to a category of small, lightweight, and inexpensive laptop computers that were introduced in 2007. To reduce weight and cost, netbooks omitted certain features (e.g., the optical drive), they have smaller screens (5 to 12 inches) and keyboards, and offer reduced computing power when compared to a full-sized laptop. Some netbooks do not even have a conventional hard drive. Such netbooks use solid-state storage devices instead, as these require less power, are faster, lighter, and generally more shock-resistant, but with much less storage capacity (such as 32, 64, or 128 GB). Most netbooks, such as those from Asus, BenQ, Dell, Toshiba, Acer use the Intel Atom notebook processor. Some netbooks use AMD Fusion processors.

Netbooks are primarily mobile Web browsing tools. They do not have some of the functionalities offered by a desktop or laptop, like advanced or heavy design programming or gaming. However, because they offer connectivity to the Internet and the most pertinent productivity tools, such as word processing, calculations and the like, they are actually excellent budget computing options, educational tools and mobile workstations.



Ultrabooks

Ultrabook is an Intel specification and trademark for a line of high-end subnotebook computers featuring reduced bulk (thickness) without compromising battery life. Its thickness is less than 1 inch because Intel envisioned Ultrabooks that boasted all the features found in regular laptops, but in a thin and light body. Intel also wanted Ultrabooks to be a showcase for its latest technology, so they had to include features such as Intel Rapid Start, which means Ultrabooks could wake up and load up Windows in five seconds or less. This involved putting the Ultrabook into a low-powered hibernation state, and Intel intended for these devices to be able to stay in that state for up to 30 days before needing to be recharged. This meant that Ultrabooks usually come with solid state drives (SSDs). Ultrabooks also use Intel's Smart Response feature that stores frequently used files and apps on fast SSD storage, so that the Ultrabook performs faster than a regular laptop. The longer battery life is achieved by using components that have been specially chosen for their power saving features.

Thickness comparison: Laptop and Ultrabook

Tablet PC

A tablet PC is a portable PC that is a hybrid between a personal digital assistant (PDA) and notebook PC. Equipped with a touch screen interface, a tablet PC usually has a software application used to run a virtual keyboard. However, many tablet PCs support external keyboards.

Tablet PCs have built-in Web browsing capabilities, multiple connectivity options, capacitive touch screens and multimedia - including high definition (HD) support. Tablet PCs are also equipped with accelerometers, which allow users to view display screens in portrait or landscape mode.

Most tablet PC displays range between seven and 10 inches. Some models run on x86 central processing units (CPU), but many rely on Advanced RISC Machine (ARM) processors, which consume less power and facilitate extended battery life. Tablet PCs have different data connectivity options including 3G, 4G and Wi-Fi.

Tablet and Laptop

Disassembling and Reassembling Laptops

In laptops, space is precious and every screw matters.

Great care is needed when repairing laptops, especially electrostatic discharge (ESD).

Also there must be no compromise of using the right tools. A small flashlight might also come in handy.

Have an organization and documentation plan in place. Know where you are going to put the parts. Have a container set aside for different screws. For documentation, many technicians find it handy to draw a map of the computer they're getting into, generally the positions of screws, adapter cards, etc.

Replacing Laptop Components: The list of components that may be replaceable could include input devices such as the keyboard and Touchpad; storage devices, including hard drives and optical drives; core components such as memory, the processor, and the motherboard; expansion options, including wireless cards and mini-PCIe cards.

Replacing a Laptop Hard Drive

1. Turn off the computer.
2. Disconnect the computer and any peripherals from their power sources, and remove any installed batteries.
3. Locate the hard drive door and remove the screw holding it in place.
4. Lift the hard drive door until it clicks.
5. Slide the hard drive out to remove it.
6. Remove the two screws holding the hard drive to the hard drive door.
7. Attach a new hard drive to the hard drive door.
8. Slide the new hard drive back into the hard drive bay.
9. Snap the hard drive door back into place, and insert and tighten the screw to hold the door in place.

Replacing Laptop Memory

1. Turn off the computer.

2. Disconnect the computer and any peripherals from their power sources, and remove any installed batteries.
3. Remove the screws holding the memory door in place.
4. Use your fingers to gently separate the plastic tabs holding the memory module in place. The module should pop up so you can grab it.
5. Align the notch in the new memory module to the one in the connector.
6. Insert the new memory module into the socket at a 45-degree angle. Once full contact is made, press the module down. It should click into place.
7. Replace the memory door and fasten the screws.

Similarly we can replace the expansion cards, wireless network cards, video cards, LCD components, other internal components, keyboard, processor, cooling assembly, BIOS battery and other components.

Mobile Devices - Features and Capabilities

Modern mobile devices fall into two categories, smartphones and tablets, and both types of device have similar features and capabilities. The primary distinction between the types is that a *smartphone* is a cell phone enhanced to do things formerly reserved for fully grown PCs; a *tablet* embodies those enhanced computing features and capabilities on an expanded format and screen. Tablets generally do *not* have cellular phone capability.

Features:

* Touch Interface

Don't have keyboard or mouse

Different gestures with fingers accomplish different tasks (tap, swipe, etc)

* Screen Technology

Older technologies used *resistive* touchscreens that responded to the pressure applied to the screen.

Current *capacitive* touchscreens use electrical current in your body to determine movement of your fingers across the screen. They measure the difference between the electrical charge in your body and the static charge on the screen. So gloved fingers won’t work.

Most tablets use some type of LCD panel. The less expensive ones use twisted nematic (TN); the better ones use an In-Plane Switching (IPS) panel for richer colors and better viewing angles. Even better smartphones, use *organic light-emitting diode (OLED)* screens.

* Orientation

Orientation of the screen rotates right along with the display with the use of accelerometer.

Some devices feature a *gyroscope* that can detect the position of the tablet or phone in 3-D space.

* Mobile Operating Systems

Apple’s closed-source mobile operating system, iOS, runs on the iPhone, iPad, and iPod

Touch.

Android is an open-source platform, based on yet another open platform, Linux, and is owned by Google.

Windows Phone is a closed-source operating system, but Microsoft licenses it to device manufacturers for use on their devices.

* Apps

An *app* enables you to accomplish a specific task on a mobile device, such as check e-mail, surf the Web, play games, and so on.

* Multimedia

Most mobile devices today come with one or two cameras for taking digital photos and movies and for video conferencing.

* All the smartphones and nearly every tablet, for example, include some sort map tool that also includes *positioning software*. This software taps into the *Global Positioning System (GPS)* network of satellites maintained by the U.S. government to pinpoint your current location on a map.

* Access Internet

Enhancing Hardware

A mobile device is a computer, just like your desktop PC or laptop, with the same basic components doing the same basic things. The construction centers around a primary circuit board, a *motherboard*, onto which every other component is attached. Each mobile device has a CPU and GPU, though not necessarily based on the same architecture as a portable PC.

Mobile devices use a *solid state drive (SSD)* for storage, because SSDs use much less electricity than platter-based drives. Plus they're cooler in general.

Every mobile device enables you to attach some kind of peripheral or external storage device.

The mobile devices can expand their physical capabilities wirelessly by using the Bluetooth or WiFi standard.

Configuration

Mobile devices require some setup and configuration to function seamlessly in your online life. That means you need to set up network connectivity, add Bluetooth devices, configure e-mail account(s), and enable the devices to synchronize with a PC.

*** Network Connectivity**

Mobile devices connect to the outside world through the cellular networks or through various 802.11 Wi-Fi standards.

* **Bluetooth**

Turn on Bluetooth on the smartphone or tablet, then power on the Bluetooth device. Return to the mobile device to select to pair with the Bluetooth device, and then enter the appropriate personal identification number (PIN) code. For a keyboard, for example, the smartphone or tablet will display a set of characters for you to type on the keyboard. Once you type in the PIN code, the devices connect.

* **E-Mail**

Android-based tablets assume you'll have a Gmail account as your primary account, so that option is offered as a distinctive icon on the home screen.

* **Synchronization**

Smartphones and tablets can *synchronize*, or *sync*, with local machines or over the Internet with cloud-based servers to keep files and data up-to-date, such as contacts and calendars. Most tablets and many smartphones use a proprietary dongle for syncing through a USB port on the computer. Some devices can sync through Wi-Fi connections.

Security

* **Preventing Damage**

For physical damage, the first step you must take is to get a protective cover or sleeve for the mobile device. Don't get them anywhere near liquids.

Your options for software-based issues depend on your mobile platform. Android devices support a large number of antivirus applications, while iOS devices have no antivirus software.

*** Dealing with Loss**

Losing a mobile device creates a series of issues that you need to address. First, protect your data from access by putting a good *passcode lock* on the device. Mobile devices also have a preset number of failed login attempt restrictions that, when exceeded, lock up the mobile device.

* **Recovering from Theft**

First, make sure you have your data backed up. You should have everything synced to a local machine and, if possible, backed up to one of the remote backup applications.

Second, you can remotely wipe your mobile device.