COMPUTER PERIPHERALS AND INTERFACES

PERIPHERAL

A **peripheral** is a device that is connected to a host computer, but not part of it. It expands the host's capabilities but does not form part of the core computer architecture. It is often, but not always, partially or completely dependent on the host.

There are three different types of peripherals:

- Input, used to interact with, or send data to the computer (mouse, keyboards, etc.)
- Output, which provides output to the user from the computer (monitors, printers, etc.)
- Storage, which stores data processed by the computer (hard drives, flash drives, etc.)

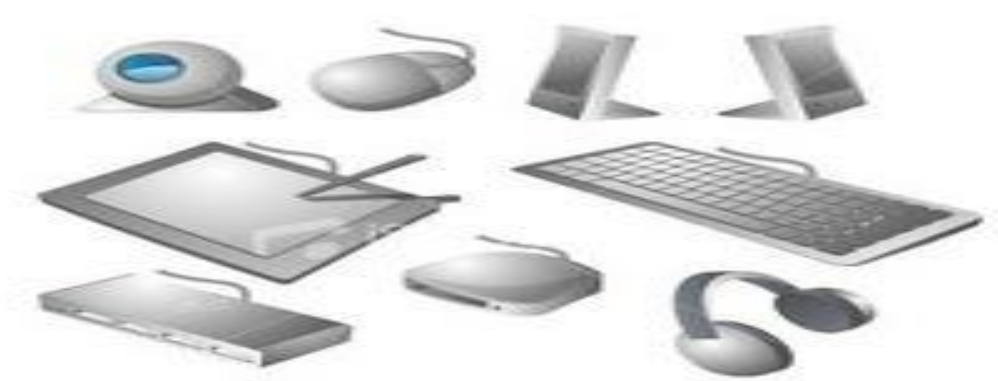


FIGURE: PERIPHERALS

A peripheral is generally defined as any auxiliary device such as, for example, a computer mouse or keyboard, that connects to and works with the computer in some way. Other examples of peripherals are expansion cards, graphics cards, computers, image scanners, tape drives, microphones, loudspeakers, webcams, and digital cameras.

INTERFACES

In computer science, an interface is the point of interaction with software, or computer hardware, or with peripheral devices such as a computer monitor or a keyboard. Some computer interfaces such as a touch screen can send and receive data, while others such as a mouse or microphone, can only send data.

There are two types of interfaces:

1. Hardware Interfaces.
2. Software Interfaces.

HARDWARE INTERFACES: Hardware interfaces exist in computing systems between many of the components such as the various buses, storage devices, other I/O devices, etc.

SOFTWARE INTERFACES: A software interface may refer to a range of different types of interface at different "levels": an operating system may interface with pieces of hardware. Applications or programs running on the operating system may need to interact via streams, and in object oriented programs, objects within an application may need to interact via methods.

CHAPTER 1

SYSTEM RESOURCES

SYLLABUS

Interrupt, DMA Channel, I/O port Addresses and resolving and resolving the conflict of resources. I/O buses- ISA, EISA, Local bus, VESA Local bus, PCI bus, PCI Express, Accelerated graphics port bus.

1.1 SYSTEM RESOURCE

A resource, or system resource, is any physical or virtual component of limited availability within a computer system. Every device connected to a computer system is a resource. Every internal system component is a resource.

1.2 INTERRUPT

In systems programming, an interrupt is a signal to the processor emitted by hardware or software indicating an event that needs immediate attention. An interrupt alerts the processor to a high-priority condition requiring the interruption of the current code the processor is executing, the current thread. The processor responds by suspending its current activities, saving its state, and executing a small program called an interrupt handler (or interrupt service routine, ISR) to deal with the event. This interruption is temporary, and after the interrupt handler finishes, the processor resumes execution of the previous thread. There are two types of interrupts:

A **hardware interrupt** is an electronic alerting signal sent to the processor from an external device, either a part of the computer itself such as a disk controller or an external peripheral. For example, pressing a key on the keyboard or moving the mouse triggers hardware interrupts that cause the processor to read the keystroke or mouse position. Unlike the software type (below), hardware interrupts are asynchronous and can occur in the middle of instruction execution, requiring additional care in programming. The act of initiating a hardware interrupt is referred to as an interrupt request (IRQ).

A **software interrupt** is caused either by an exceptional condition in the processor itself, or a special instruction in the instruction set which causes an interrupt when it is executed. The former is often called a trap or exception and is used for errors or events occurring during program execution that are exceptional enough that they cannot be handled within the program itself. For example, if the processor's arithmetic logic unit is commanded to divide a number by zero, this impossible demand will cause a divide-by-zero exception, perhaps causing the computer to abandon the calculation or display an error message. Software interrupt instructions function similarly to subroutine calls and are used for a variety of purposes, such as to request services from low level system software such as device drivers. For example, computers often use software interrupt instructions to communicate with the disk controller to request data be read or written to the disk.

Each interrupt has its own interrupt handler. The number of hardware interrupts is limited by the number of interrupt request (IRQ) lines to the processor, but there may be hundreds of different software interrupts.

Interrupts are a commonly used technique for computer multitasking, especially in real-time computing. Such a system is said to be interrupt-driven.

Interrupts can be categorized into these different types:

Maskable interrupt (IRQ): a hardware interrupt that may be ignored by setting a bit in an interrupt mask register's (IMR) bit-mask.

Non-maskable interrupt (NMI): a hardware interrupt that lacks an associated bit-mask, so that it can never be ignored. NMIs are used for the highest priority tasks such as timers, especially watchdog timers.

1.3 DIRECT MEMORY ACCESS (DMA)

Direct memory access (DMA) is a feature of modern computers that allows certain hardware subsystems within the computer to access system memory independently of the central processing unit (CPU).

Without DMA, when the CPU is using programmed input/output, it is typically fully occupied for the entire duration of the read or write operation, and is thus unavailable to perform other work. With DMA, the CPU initiates the transfer, does other operations while the transfer is in progress, and receives an interrupt from the DMA controller when the operation is done. This feature is useful any time the CPU cannot keep up with the rate of data transfer, or where the CPU needs to perform useful work while waiting for a relatively slow I/O data transfer. Many hardware systems use DMA, including disk drive controllers, graphics cards, network cards and sound cards. DMA is also used for intra-chip data transfer in multi-core processors. Computers that have DMA channels can transfer data to and from devices with much less CPU overhead than computers without a DMA channel. Similarly, a processing element inside a multi-core processor can transfer data to and from its local memory without occupying its processor time, allowing computation and data transfer to proceed in parallel.

DMA can also be used for "memory to memory" copying or moving of data within memory. DMA can offload expensive memory operations, such as large copies or scatter-gather operations, from the CPU to a dedicated DMA engine. An implementation example is the I/O Acceleration Technology.

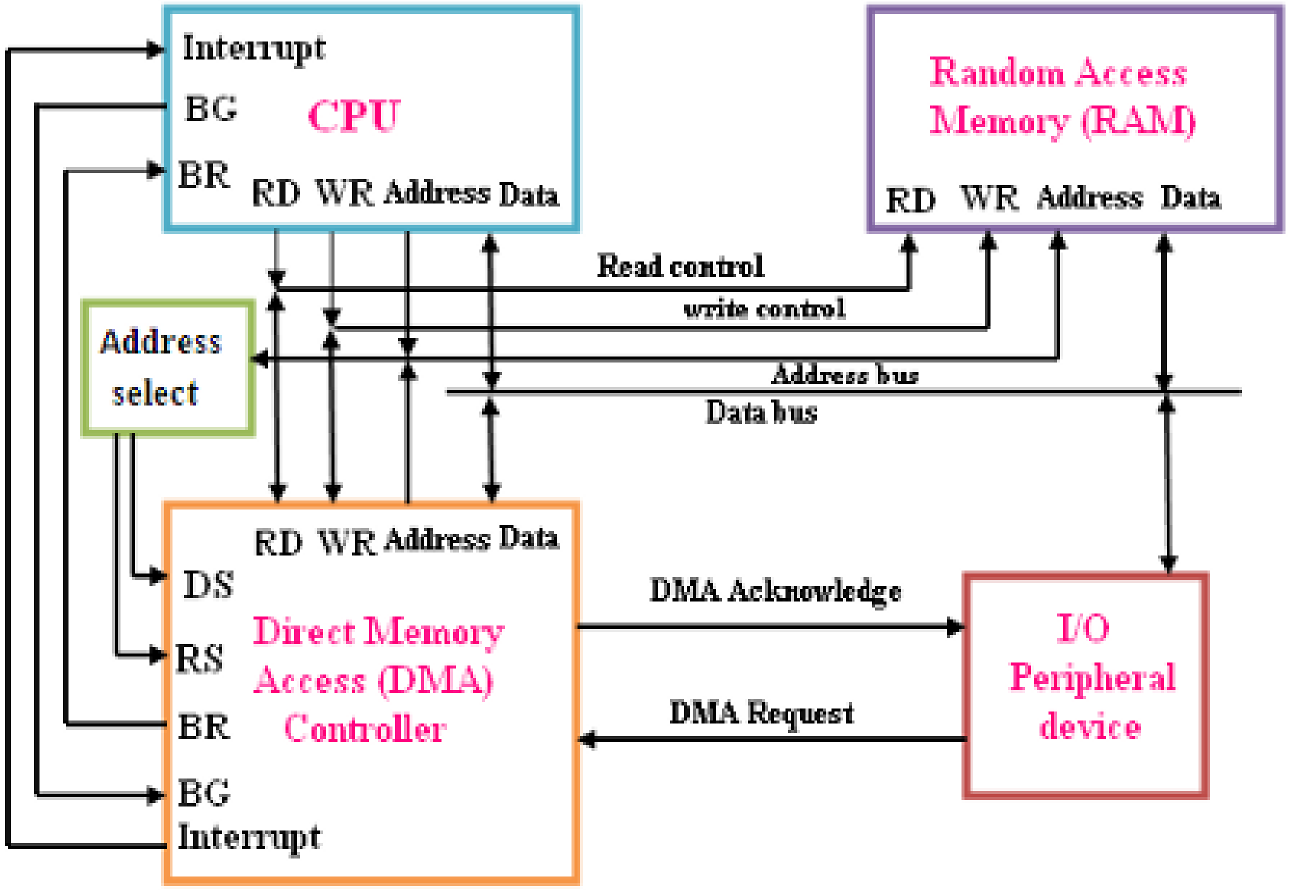


FIGURE: DMA TRANSFER

A direct memory access (DMA) channel provides high speed data transfer between a peripheral device, such as a disk drive controller, and memory without intervention by the CPU. Computers that have DMA channels can transfer data to and from devices much more quickly than computers without a DMA channel can. This is useful for making quick backups and for real-time applications.

Some expansion boards, such as CD-ROM cards, are capable of accessing the computer's DMA channel. When you install the board, you must specify which DMA channel is to be used.

1.4 BUSES

A computer bus is used to transfer data from one location or device on the motherboard to the central processing unit where all calculations take place.

A **system bus** is a single computer bus that connects the major components of a computer system. The technique was developed to reduce costs and improve modularity. It combines the functions of a **data bus** to carry information, an address bus to determine where it should be sent, and a control bus to determine its operation.

Two different parts of a Bus:

- Address bus-transfers information about where the data should go.
- Data bus-transfers the actual data.

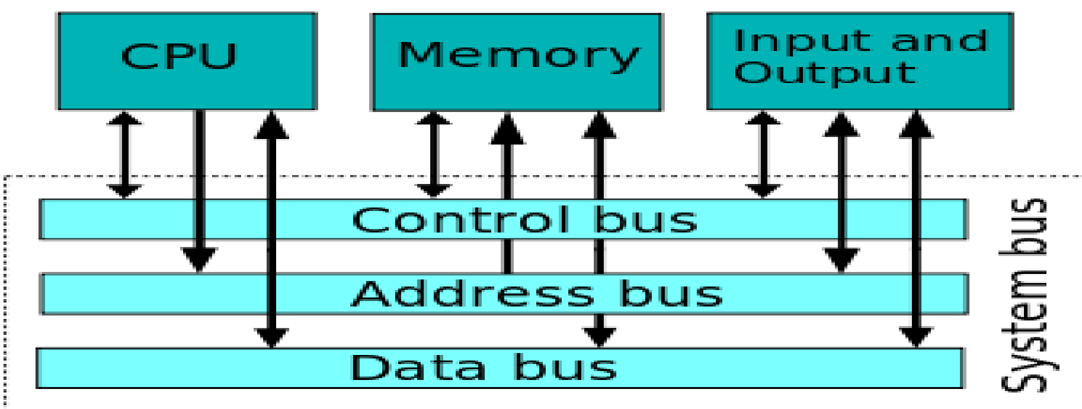


FIGURE: BLOCK DIAGRAM OF SYSTEM BUS

Computer systems generally consist of three main parts, the central processing unit (CPU) to process data, main memory to hold the data to be processed, and a variety of peripherals to communicate that data with the outside world. An early computer might use a hand-wired CPU of vacuum tubes, a magnetic drum for main memory, and a punch tape and printer for reading and writing data. In a modern system we might find a multi-core CPU, DDR3 SDRAM for memory, a hard drive for secondary storage, a graphics card and LCD display as a display system, a mouse and keyboard for interaction, and a Wi-Fi connection for networking. In both examples, computer buses of one form or another move data between all of these devices.

1.4.1 OVERVIEW OF BUSES

Name of Bus	Created By	Year Created	Width	Frequency	Style
ISA	IBM	1981/1984	8/16 bits	4.77/8.33 MHz	PARALLEL
MCA	IBM	1987	16 bits	10 MHz	PARALLEL
EISA	GANG OF NINE	1988	32 bits	8.33 MHz	PARALLEL
VLB	VESA	1992	32 bits	33 MHz	PARALLEL
PCI	INTEL	1993	32 bits	33 MHz	PARALLEL
AGP	INTEL	1996	32 bits	66 MHz	PARALLEL
PCI EXPRESS	INTEL,DELL, HP,IBM	2004	1-32 bits	2.5 GT/s	SERIAL

1.4.2 ISA BUS

Industry Standard Architecture (ISA) is a computer bus standard for IBM PC compatible computers introduced with the IBM Personal Computer to support its Intel 8088 microprocessor's 8-bit external data bus and extended to 16 bits for the IBM Personal Computer/AT's Intel 80286 processor.

FIGURE: ISA SLOTS

IBM designed the 8-bit version as a buffered interface to the external bus of the Intel 8088 (16/8 bit) CPU used in the original IBM PC and PC/XT, and the 16-bit version as an upgrade for the external bus of the Intel 80286 CPU used in the IBM AT.

Limitations of 8-bit ISA bus

- Low data transfer rates.
- Very limited IRQ (Interrupt Request).
- The bus provide very limited System Resources like IRQ (3 Requests at a time).
- Very limited DMA channel. Out of 3 DMA channel, two channels are used by floppy and Hard Drive. So only one DMA channel is left for expansion cards.
- Hardwired and complex configuration with no conflict resolving.

Features of 16-bit ISA bus:

- Additional address and data lines- 8 more data lines and 4 more address lines provide high speed functionality.

- Interrupt- 5 more IRQ level have been provided to generate more I/O device connectivity.
- DMA channel- 2 more sets (4 DMA) of DMA channel can be used in cascade to attach 7 DMA channel.

1.4.3 EISA BUS

The Extended Industry Standard Architecture (in practice almost always shortened to EISA) is a bus standard for IBM PC compatible computers. It was announced in September 1988 by a consortium of PC clone vendors (the "Gang of Nine") as a counter to IBM's use of its proprietary Micro Channel architecture (MCA) in its PS/2 series.

EISA was much favoured by manufacturers due to the proprietary nature of MCA, and even IBM produced some machines supporting it. It was somewhat expensive to implement (though not as much as MCA), so it never became particularly popular in desktop PCs.

Some of the key features of the EISA bus:

- ISA Compatibility: ISA cards will work in EISA slots.
- 32 Bit Bus Width: Like MCA, the bus was expanded to 32 bits.
- Bus Mastering: The EISA bus supports bus mastering adapters for greater efficiency, including proper bus arbitration.
- Plug and Play: EISA automatically configures adapter cards, similar to the Plug and Play standards of modern systems.

EISA-based systems have today been mostly relegated to a specialty role; they are sometimes found in network fileservers. The EISA bus is virtually non-existent on desktop systems for several reasons. First, EISA-based systems tend to be much more expensive than other types of systems. Second, there are few EISA-based cards available. Finally, the performance of this bus is quite low compared to the popular local buses like the VESA Local Bus and PCI. EISA is not totally dead as a platform the way MCA is, but it is pretty close.

Although the EISA bus had a slight performance disadvantage over MCA (bus speed of 8.33 MHz, compared to 10 MHz), EISA contained almost all of the technological benefits that MCA boasted, including bus mastering, burst mode, software configurable resources, and 32-bit data/address buses. These brought EISA nearly to par with MCA from a performance standpoint, and EISA easily defeated MCA in industry support.

1.4.4 LOCAL BUSES

The I/O buses discussed so far have one thing in common :Relatively slow speed but next buses are of local bus type and they have much more speed than that of another buses.

The speed problem becomes acute when graphical user interface become prevalent. The system requires processing of so much data that I/O buses become a literal bottle neck for entire computer system.

The arrangement becomes known as Local Bus because the external devices now could access the bus that is local to bus of CPU (processor bus).

In computer science, a local bus is a computer bus that connects directly, or almost directly, from the CPU to one or more slots on the expansion bus. The significance of direct connection to the CPU is avoiding the bottleneck created by the expansion bus, thus providing fast throughput. There are several local buses built into various types of computers to increase the speed of data transfer. Local buses for expanded memory and video boards are the most common.

VESA Local Bus is an example of a local bus design.

1.4.5 VESA LOCAL BUS (VLB)

VLB was introduced in 1992. The major reason for the development of VLB was to improve the video performance in PCs.VLB was 32 bit bus and it runs at the speed of 33MHz.

It was extension of ISA, so VLB worked alongside the ISA bus; it acted as a high-speed conduit for memory-mapped I/O and DMA, while the ISA bus handled interrupts and port-mapped I/O. So ISA card can be used in VLB slots but we should use ISA slot first and leave VLB slot open for VLB cards which will not work on ISA slots.

VLB video cards provide, in general, much better performance than ISA cards. This is primarily due to the fact that the 32-bit local bus used by VLB cards allows for several times more data throughput between the card and the processor than ISA allows. VLB has however had its own share of problems. In particular, VLB video cards may cause reliability problems in motherboards running at 40 or 50 MHz.

Limitations of VESA bus:

- The design was strongly based on the 486 processor, and adapting it to the Pentium caused a host of compatibility and other problems.
- The bus itself was tricky electrically, for example, the number of cards that could be used on the bus was low (often only two or even one).
- The bus did not support bus mastering properly since there was no good arbitration scheme ,and did not support plug and play.

1.4.6 AGP BUS

The Accelerated Graphics Port (often shortened to AGP) is a high-speed point-to-point channel for attaching a video card to a computer's motherboard, primarily to assist in the acceleration of 3D computer graphics.

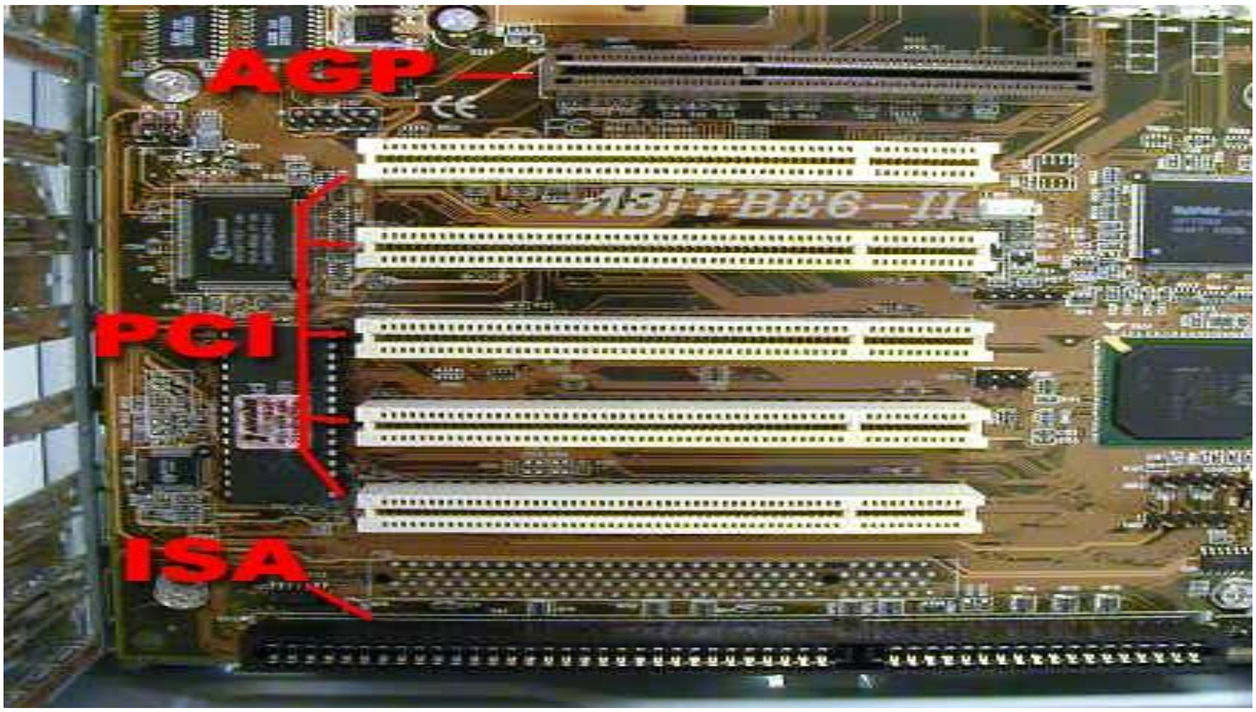


FIGURE: AGP SLOTS

Features of AGP bus:

- Width: 32 bits
- Speed : 66 MHz
- Provides DMA.
- Directly connects to FSB of microprocessor and uses same frequency with a higher bandwidth.
- Uses sideband addressing.

- Covers very little space on motherboard measures only 8cm in length.

Advantages of AGP over PCI:

- The primary advantage of AGP over PCI is that it provides a dedicated pathway between the slot and the processor rather than sharing the PCI bus. In addition to a lack of contention for the bus, the direct connection allows for higher clock speeds.
- AGP also uses sideband addressing, meaning that the address and data buses are separated so the entire packet does not need to be read to get addressing information. This is done by adding eight extra 8-bit buses which allow the graphics controller to issue new AGP requests and commands at the same time with other AGP data flowing via the main 32 address/data (AD) lines. This results in improved overall AGP data throughput.
- It has a feature called DMA ("Direct Memory Access") allowing you to work directly with the devices and RAM memory without involving the microprocessor.
- AGP makes multiple requests for data during a bus or memory access, while PCI makes one request, and does not make another until the data it requested has been transferred.
- AGP doesn't share bandwidth with other devices, whereas the PCI bus does share bandwidth.
- AGP have pipelined requests while PCI requests are non-pilelined.

1.4.7 PCI BUS

PCI is a bus for attaching peripheral hardware devices (expansion cards) to a computer's motherboard. PCI is most popular local I/O bus. PCI was developed by Intel in 1992. Revised twice into version 2.1 which is the 64-bit standard that it is today.

Devices connected to the bus appear to the processor to be connected directly to the processor bus. Attached devices can take either the form of an integrated circuit fitted onto the motherboard itself, called a planar device in the PCI specification, or an expansion card that fits into a slot. The PCI Local Bus was first implemented in IBM PC compatibles, where it displaced the combination of ISA plus one VESA Local Bus as the bus configuration. It has subsequently been adopted for other computer types.

It offers local bus performance and solves many of the problems associated with VLB, and introduces a host of new features including Plug and Play and bus mastering.

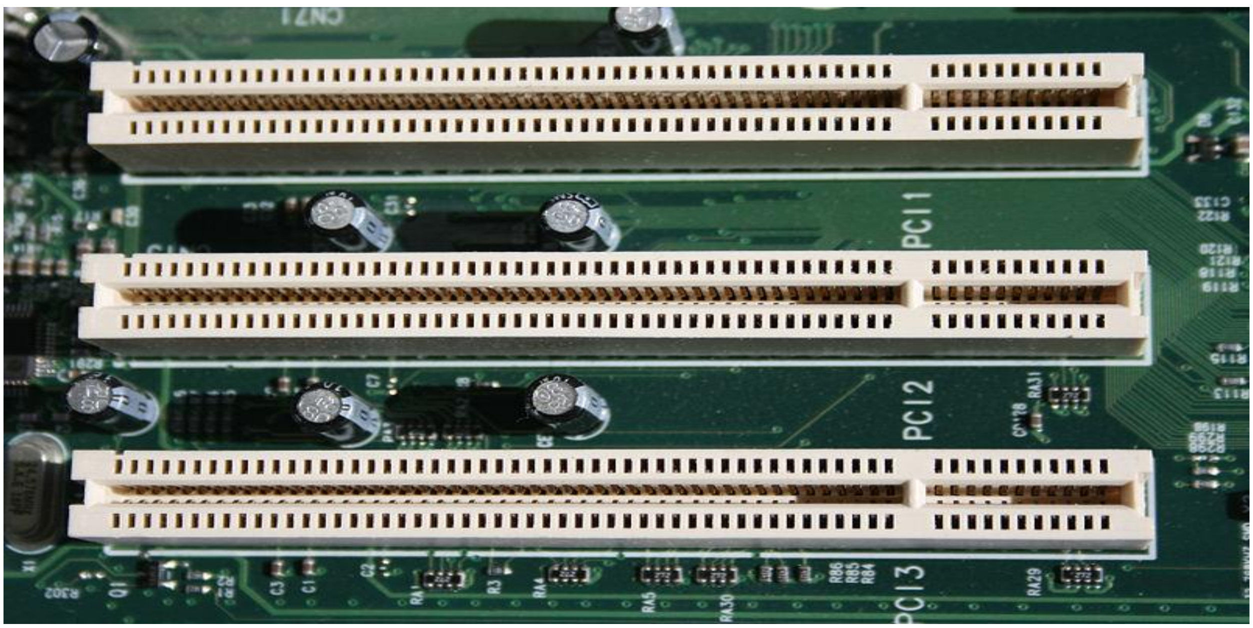


FIGURE: PCI SLOTS

Features of PCI bus:

- Size : 32-bit.
- Speed : 33MHz.
- Cache Support.
- 5 or 3.3 volt operation.

- PCI provides direct access to system memory for the devices that are connected to the bus which is then connected through a bridge that connects to the front side bus.
- This configuration allowed for higher performance without slowing down the processor.
- PCI chipset provides many kind of bridges that enable PCI bus to act as primary bus to act as primary bus, by creating supplementary bus slots that are slaves to PCI bus.

PCI Revision 2.1 features:

- Low-power consumption
- Size : 64-bit
- Speed : 66MHz
- Concurrent bus operation
- Bus master support
- Auto configuration

What makes the PCI bus one of the fastest I/O bus used today?

Three features make this possible:

- Burst Mode: allows multiple sets of data to be sent.
- Full Bus Mastering: the ability of devices on the PCI bus to perform transfers directly.
- High Bandwidth Options: allows for increased speed of the PCI.

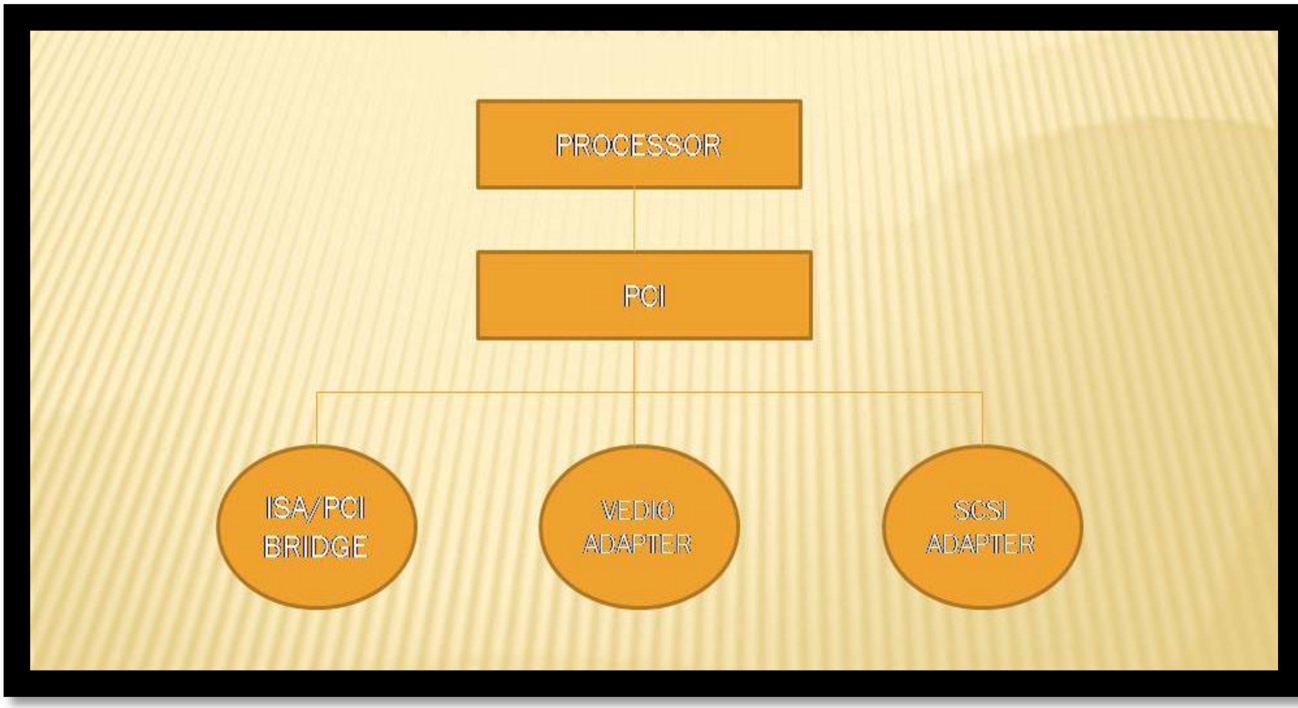


FIGURE: BLOCK DIAGRAM OF PCI

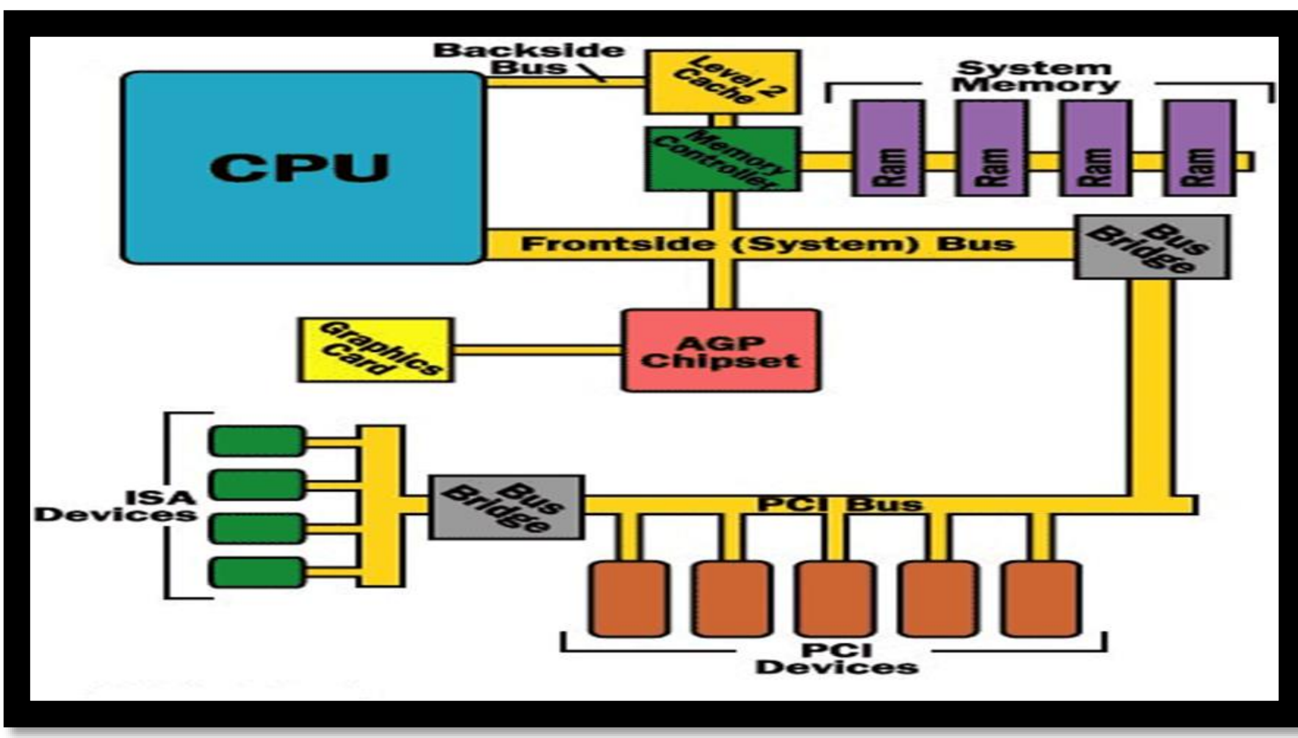


FIGURE: BUS ARCHITECTURE

Typical PCI cards used in PCs include: network cards, sound cards, modems, extra ports such as USB or serial, TV tuner cards and disk controllers.

FIGURE: PCI CARD

1.4.8 PCI EXPRESS

PCI Express (Peripheral Component Interconnect Express), officially abbreviated as PCIe, is a high-speed serial computer expansion bus standard designed to replace the older PCI, PCI-X, and AGP bus standards. PCIe has numerous improvements over the aforementioned bus standards, including higher maximum system bus throughput, lower I/O pin count and smaller physical footprint, better performance-scaling for bus devices, a more detailed error detection and reporting mechanism, and native hot-plug functionality. More recent revisions of the PCIe standard support hardware I/O virtualization.

Applications

PCI Express operates in consumer, server, and industrial applications, as a motherboard-level interconnect (to link motherboard-mounted peripherals), a passive backplane interconnect and as an expansion card, interface for add-in boards.

In virtually all modern (as of 2012) PCs, from consumer laptops and desktops to enterprise data servers, the PCIe bus serves as the primary motherboard-level interconnect, connecting the host system-processor with both integrated-peripherals (surface-mounted ICs) and add-on peripherals (expansion cards.) In most of these systems, the PCIe bus co-exists with one or more legacy PCI buses, for backward compatibility with the large body of legacy PCI peripherals.

A key difference between PCIe bus and the older PCI is the bus topology. PCI uses a shared parallel bus architecture, where the PCI host and all devices share a common set of address/data/control lines. In contrast, PCIe is based on point-to-point topology, with separate serial links connecting every device to the root complex (host). Due to its shared bus topology, access to the older PCI bus is arbitrated (in the case of multiple masters), and limited to one master at a time, in a single direction. Furthermore, the older PCI clocking scheme limits the bus clock to the slowest peripheral on the bus (regardless of the devices involved in the bus transaction). In contrast, a PCIe bus link supports full-duplex communication between any two endpoints, with no inherent limitation on concurrent access across multiple endpoints.

PCIe devices communicate via a logical connection called an interconnect or link. A link is a point-to-point communication channel between two PCIe ports, allowing both to send/receive ordinary PCI-requests (configuration read/write, I/O read/write, memory read/write) and interrupts (INTx, MSI, MSI-X). At the physical level, a link is composed of 1 or more lanes. Low-speed peripherals (such as an 802.11 Wi-Fi card) use a single-lane (×1) link, while a graphics adapter typically uses a much wider (and thus, faster) 16-lane link.

Features of PCI Express:

• Serial communication over the interconnect uses packet-based transactions, and the PCI-X split-transaction protocol.

• Quality Of Service (QoS) features provide differentiated transmission performance for varied applications.

• Hot Plug/Hot Swap support enables “always-on” systems.

• Advanced power management features allow for low-power (mobile) applications.

• Robust error detection and handling features make PCI Express ideal for high-end server applications.

• Hot plug, power management, error handling and interrupt signaling can all be sent in-band using packet-based messaging rather than side-band signals, helping reduce pin count and system cost.

• The configuration address space available per function is extended to 4KB, allowing designers to define additional registers. However, new software is required to access this extended configuration register space.

• PCI-like card and connectors of various sizes are defined for PCI Express. In addition, a mini-PCI Express card and connector as well as a PCMCIA-like Express card and connector are defined.

1.5 RESOLVING CONFLICTS OF RESOURCES

The resources of system are limited but the demands on those resources are unlimited. So resource conflict can occur any of the following event could act as resource conflict. For example:

- A system frequently locks up.
- Sound card does not sound light.

- When you click Start, click Shut Down, and then click either Restart or Shut Down in the Shut Down Windows dialog box, the computer may begin to shut down but then stop responding (hang). When this occurs, the computer stops at a blank screen. The mouse pointer is displayed, but you cannot move it. The computer does not respond to mouse movements or keyboard input.
- If a hardware device in the computer shares the same I/O port as another device that would result in a hardware conflict.

Resolving the conflicts:

- Make sure that your motherboard's BIOS is the latest version of that BIOS. Check the web site of the motherboard manufacturer for any BIOS update for your motherboard. They may have an updated BIOS to download, plus a utility that installs it, and instructions how to install it.
- Go into the BIOS setup screen. (This is usually done by pressing the Delete key while the computer is just starting to boot). Disable any unneeded devices. Note that your mouse may not work in selecting items in the BIOS setup, so you typically have to use the arrow keys to move between selections, and the Page UP and Page DOWN keys to change the value of a selection.
- If you have uncooperative devices sharing an IRQ, go into the BIOS PnP configuration page. Choose a manual setup (rather than an automatic one). Select different IRQs for those devices. Alternately, use a PnP-aware operating system such as Windows. Use Device Manager to check for any hardware conflicts, and to change the resources so that sharing is resolved.
- Make sure that you have the latest versions of all drivers for your cards. Check the web site of each card's manufacturer for any driver update for that card. They may have an updated driver to download, plus instructions how to install it.
- On Windows computers, you can identify which components are causing the problem by opening the Device Manager. Components with a hardware resource conflict will usually have a black exclamation point on a yellow field or a red "x".

- The introduction of Plug and Play (PnP) in the late 1990s eliminated most hardware resource conflicts.

To resolve conflicts for devices in your PC, follow the steps below:

1.) Go to the My Computer icon and right click on it. Choose Properties.

2.) When the System Properties window appears, click on the tab at the top that says Device Manager.

3.) When the Device Manager opens, scroll through the list, looking for any yellow triangles with exclamation points (!) on them. You may need to expand the various lists to check each and every device. If a conflict is present, the exclamation point will be displayed next to the device having the issue.

4.) Click on the device that is having the issue once you find it. If there are more than one devices with issues, then click on the first one.

5.) When the small menu pops up, click on the Properties button.

6.) When the window for the device appears, click on the Resources tab towards the top.

7.) Towards the bottom of the Resources window, you will find a box called Conflicting Device List. This will let you know which device the conflicted device you are looking at is having an issue with.

8.) Uncheck the “Use automatic settings” box.

9.) Click on the box next to “Setting based on” and then select each of the configurations in the resulting list until the Conflicting Device List says no conflicts are present. Then click on OK.

Reboot your PC and then repeat the process for any other devices having conflicts as needed.

1.6 PORTS

In computer hardware, a port serves as an interface between the computer and other computers or peripheral devices. Physically, a port is a specialized outlet on a piece of equipment to which a plug or cable connects. Electronically, the several conductors making up the outlet provide a signal transfer between devices.

There are two main types of **computer ports**:

- Physical ports.
- Virtual ports.

1.6.1 PHYSICAL PORTS

Physical ports are used for connecting a computer trough a cable and a socket to a peripheral device. Physical computer ports list includes serial ports (DB9 socket), USB ports (USB 2.0 or 3.0 socket / connector), parallel ports (DB25 socket / connector), ethernet / internet ports (RJ45 socket / connector).

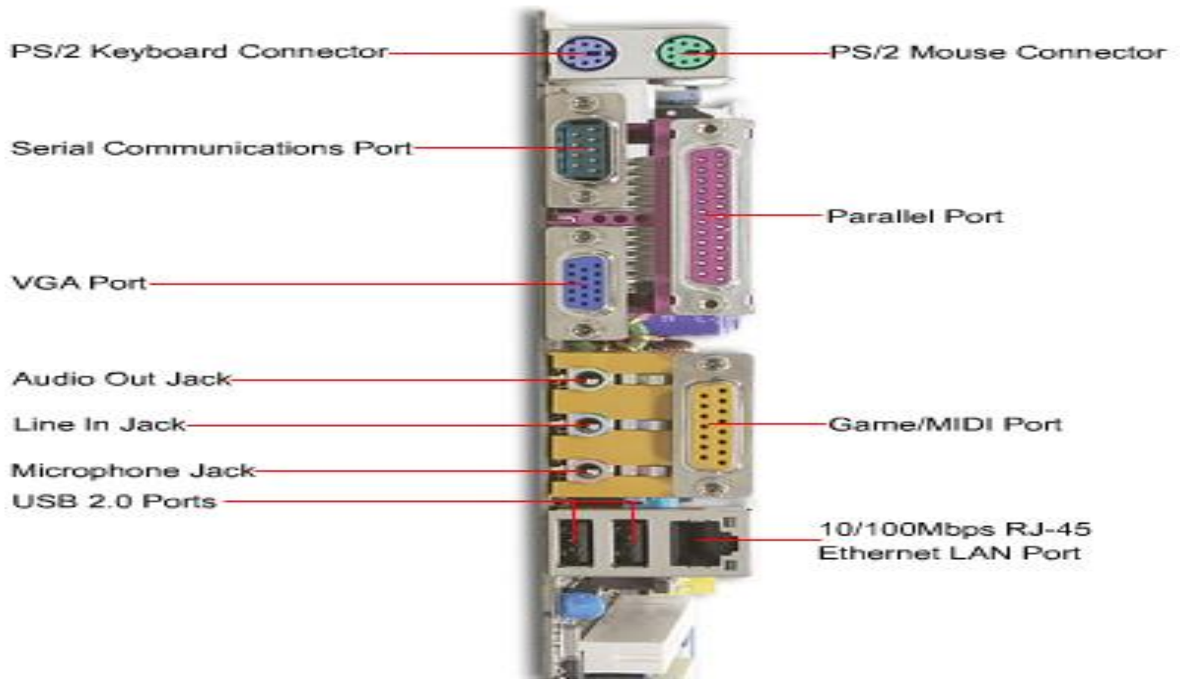


FIGURE: PHYSICAL PORTS

1.6.2 VIRTUAL PORTS

Virtual ports are data gates that allow software application (network) to use hardware resources without any interfering. This computer ports (network ports) are defined by IANA (Internet Assigned Numbers Authority) and are used by TCP (Transmission Control Protocol), UDP (User Datagram Protocol), DCCP (Datagram Congestion Control Protocol) and SCTP (Stream Control Transmission Protocol).

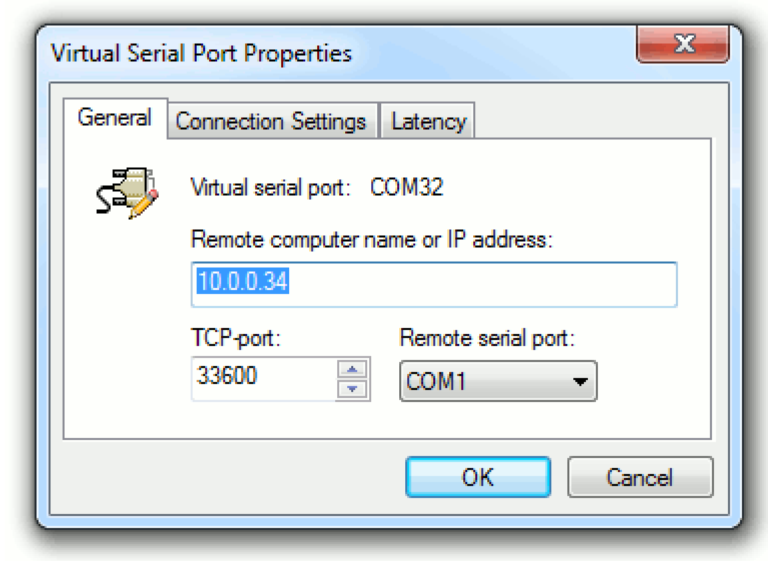


FIGURE: VIRTUAL PORT PROPERTIES

1.6.3 TYPES OF PORTS

Ports are basically categorized in two categories:

- Parallel ports
- Serial ports

PARALLEL PORTS

Parallel ports send multiple bits at a the same time over several sets of wires.

Parallel ports can be used to connect a host of popular computer peripherals:

- Printers
- Scanners
- CD burners

- External hard drives
- Iomega Zip removable drives
- Network adapters
- Tape backup drives

SERIAL PORTS

Serial ports send and receive one at a time via a single wire pair.

Although many of the newer systems have done away with the serial port completely in favor of USB connections, most modems still use the serial port, as do some printers, PDAs and digital cameras.

1.6.4 .USB

Universal Serial Bus (USB) is an industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication, and power supply between computers and electronic devices.

USB was designed to standardize the connection of computer peripherals (including keyboards, pointing devices, digital cameras, printers, portable media players, disk drives and network adapters) to personal computers, both to communicate and to supply electric power. It has become commonplace on other devices, such as smartphones, PDAs and video game consoles. USB has effectively replaced a variety of earlier interfaces, such as serial and parallel ports, as well as separate power chargers for portable devices.

FIGURE: USB

CABLING

The data cables for USB 1.x and USB 2.x use a twisted pair to reduce noise and crosstalk. USB 3.0 cables contain twice as many wires as USB 2.x to support Super Speed data transmission, and are thus larger in diameter.

The USB 1.1 Standard specifies that a standard cable can have a maximum length of 3 meters with devices operating at Low Speed (1.5 Mbit/s), and a maximum length of 5 meters with devices operating at Full Speed 12 Mbit/s.

POWER

The USB 1.x and 2.0 specifications provide a 5 V supply on a single wire to power connected USB devices. The specification provides for no more than 5.25 V and no less than 4.75 V (5 V±5%) between the positive and negative bus power lines. For USB 3.0, the voltage supplied by low-powered hub ports is 4.45–5.25 V.

FEATURES

The Universal Serial Bus has the following features:

- The computer acts as the host.
- Up to 127 devices can connect to the host, either directly or by way of USB hubs.
- Individual USB cables can run as long as 5 meters; with hubs, devices can be up to 30 meters (six cables' worth) away from the host.
- With USB 2.0,the bus has a maximum data rate of 480 megabits per second (10 times the speed of USB 1.0).
- A USB 2.0 cable has two wires for power (+5 volts and ground) and a twisted pair of wires to carry the data. The USB 3.0 standard adds four more wires for data transmission. While USB 2.0 can only send data in one direction at a time (downstream or upstream), USB 3.0 can transmit data in both directions simultaneously.
- On the power wires, the computer can supply up to 500 milliamps of power at 5 volts. A USB 3.0 cable can supply up to 900 milliamps of power.
- Low-power devices (such as mice) can draw their power directly from the bus. High-power devices (such as printers) have their own power supplies and draw minimal power from the bus. Hubs can have their own power supplies to provide power to devices connected to the hub.
- USB devices are hot-swappable, meaning you can plug them into the bus and unplug them any time. A USB 3.0 cable is compatible with USB 2.0 ports -- you won't get the same data transfer speed as with a USB 3.0 port but data and power will still transfer through the cable.
- Many USB devices can be put to sleep by the host computer when the computer enters a power-saving mode.
- The devices connected to a USB port rely on the cable to carry power and data.

The USB connection also provides power to the devices.
USB 1 transfer speed 12 megabits per second
USB 2 transfer speed 480 megabits per second

1.6.5 ETHERNET PORT

Ethernet / internet ports was first introduced in 1980 to standardize the local area networks (LAN). Internet ports use RJ45 connectors and have speeds between 10 Mb/sec, 100 Mb/sec and 1 Gb/sec, 40 Gb/sec and 100 Gb/sec.

1.6.6 VGA PORT

VGA ports (Video Graphics Array) has 15 pins displayed on three rows and it is mainly used for connecting the monitor with the video adapter from the computer motherboard; adapters :

· HDMI (High-Definition Multimedia Interface)

· SCART

· DVI (Digital Visual Interface)

1.6.7 .FIREWIRE

IEEE 1394 ports, this technology is developed by Apple between 1980 and 1990 with the name FireWire and it is the equivalent of the USB for Apple computers.

The designers of FireWire had several particular goals in mind when they created the standard:

- Fast transfer of data

- Ability to put lots of devices on the bus
- Ease of use
- Hot-pluggable ability
- Provision of power through the cable
- Plug-and-play performance
- Low cabling cost
- Low implementation cost

It allows hot swapping and up to 63 Firewire devices can be connected at the same time
It can supply modest power services to devices
FireWire 400 transfer speed 400 megabits per second
FireWire 800 transfer speed 800 megabits per second.
IEEE 1394b transfer speed 3.2 gigabits per second

1.7 PLUG AND PLAY (PnP)

Plug and Play (PnP) means that you can connect a device or insert a card into your computer and it is automatically recognized and configured to work in your system. PnP is a simple concept, but it took a concerted effort on the part of the computer industry to make it happen. Intel created the PnP standard and incorporated it into the design for PCI. But it wasn't until several years later that a mainstream operating system, Windows 95, provided system-level support for PnP. The introduction of PnP accelerated the demand for computers with PCI, very quickly supplanting ISA as the bus of choice.

To be fully implemented, PnP requires three things:

- PnP BIOS - The core utility that enables PnP and detects PnP devices. The BIOS also reads the ESCD for configuration information on existing PnP devices.
- Extended System Configuration Data (ESCD) - A file that contains information about installed PnP devices.
- PnP operating system - Any operating system, such as Windows XP, that supports PnP. PnP handlers in the operating system complete the configuration process started by the BIOS for each PnP device. PnP automates several key tasks that

were typically done either manually or with an installation utility provided by the hardware manufacturer. These tasks include the setting of:

- Interrupt requests (IRQ) - An IRQ, also known as a hardware interrupt, is used by the various parts of a computer to get the attention of the CPU. For example, the mouse sends an IRQ every time it is moved to let the CPU know that it's doing something. Before PCI, every hardware component needed a separate IRQ setting. But PCI manages hardware interrupts at the bus bridge, allowing it to use a single system IRQ for multiple PCI devices.
- Direct memory access (DMA) - This simply means that the device is configured to access system memory without consulting the CPU first.
- Memory addresses - Many devices are assigned a section of system memory for exclusive use by that device. This ensures that the hardware will have the needed resources to operate properly.
- Input/Output (I/O) configuration - This setting defines the ports used by the device for receiving and sending information.
- While PnP makes it much easier to add devices to your computer, it is not infallible.

Variations in the software routines used by PnP BIOS developers, PCI device manufacturers and Microsoft have led many to refer to PnP as "Plug and Pray." But the overall effect of PnP has been to greatly simplify the process of upgrading your computer to add new devices or replace existing ones.

1.8 BUS MASTERING

In computing, bus mastering is a feature supported by many bus architectures that enables a device connected to the bus to initiate transactions. It is also referred to as "first-party DMA", in contrast with "third-party DMA" where a system DMA controller (also known as peripheral processor, I/O processor, or channel) actually does the transfer.

Some types of buses allow only one device (typically the CPU, or its proxy) to initiate transactions. Most modern bus architectures, such as PCI, allow multiple devices to bus master because it significantly improves performance for general purpose operating systems. Some real-time operating systems prohibit peripherals from becoming bus masters, because the scheduler can no longer arbitrate for the bus and hence cannot provide deterministic latency.

While bus mastering theoretically allows one peripheral device to directly communicate with another, in practice almost all peripherals master the bus exclusively to perform DMA to main memory.

If multiple devices are able to master the bus, there needs to be an arbitration scheme to prevent multiple devices attempting to drive the bus simultaneously. A number of different schemes are used for this; for example SCSI has a fixed priority for each SCSI ID. PCI does not specify the algorithm to use, leaving it up to the implementation to set priorities.

1.9 BUS ARBITRATION

In a single bus architecture when more than one device requests the bus, a controller called bus arbiter decides who gets the bus, this is called the bus arbitration. Arbitration is mostly done in favour of a master micro processor with the highest priority.

1.10 CHIPSET

A chipset is the component which routes data between the computer's buses, so that all the components which make up the computer can communicate with each other. The chipset originally was made up of a large number of electronic chips, hence the name. It generally has two components:

- The NorthBridge (also called the memory controller) is in charge of controlling transfers between the processor and the RAM, which is way it is located physically near the processor. It is sometimes called the GMCH, for Graphic and Memory Controller Hub.
- The SouthBridge (also called the input/output controller or expansion controller) handles communications between peripheral devices. It is also called the ICH (I/O Controller Hub). The term bridge is generally used to designate a component which connects two buses.

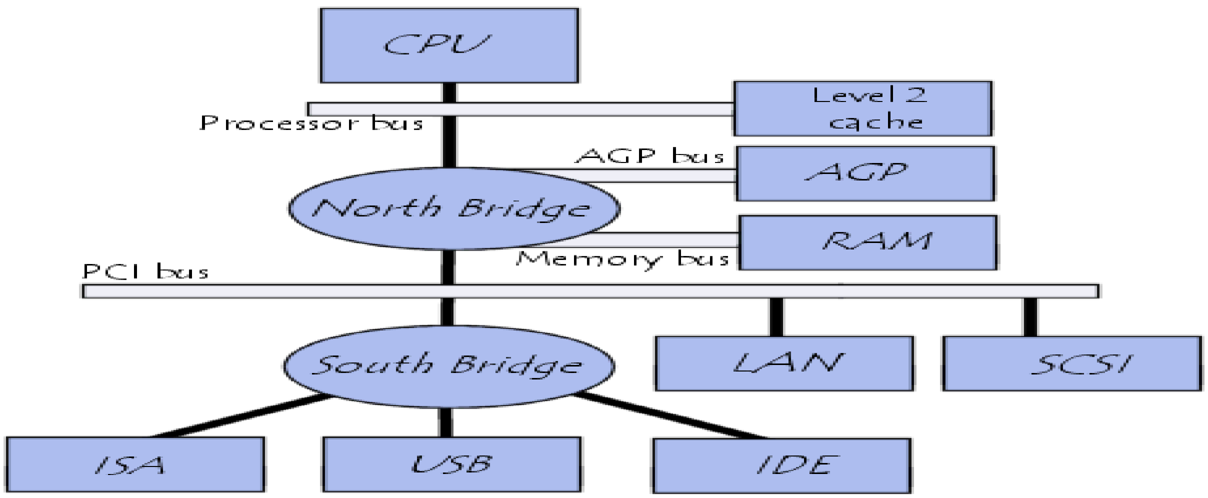


FIGURE: NORTH AND SOUTH BRIDGE

CHAPTER 2

IDE & SCSI INTERFACES

SYLLABUS

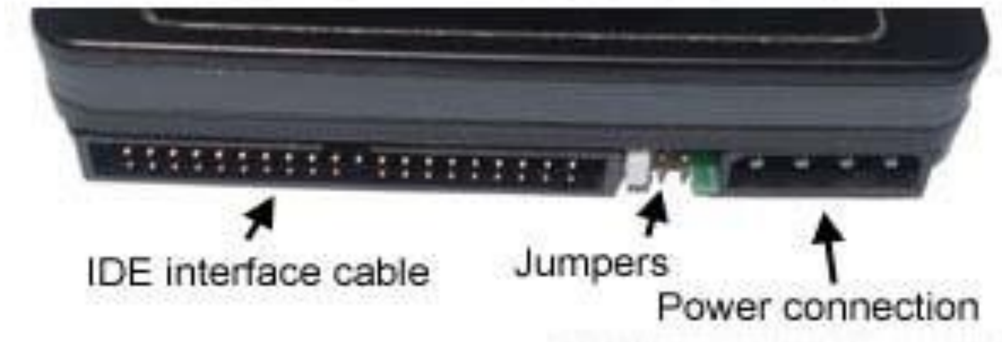
IDE origin, IDE Interface ATA standards ATAI To ATA7. ATA features, ATA RAID and SCSI RAID, SCSI Cable and pin Connector pin outs SCSI V/s IDE Advantages and limitation.

2.1 IDE

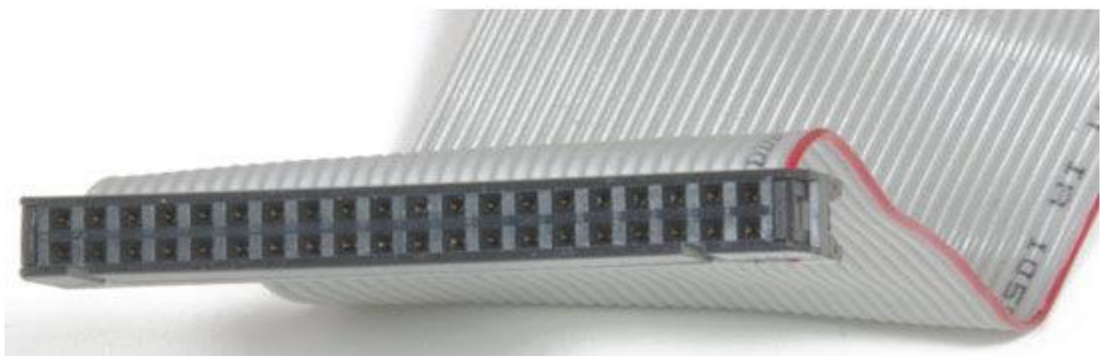
Short for Integrated Drive Electronics or IBM Disc Electronics, IDE is more commonly known as ATA or Parallel ATA (PATA) and is a standard interface for IBM compatible hard drives. IDE is different from the Small Computer Systems Interface (SCSI) and Enhanced Small Device Interface (ESDI) because its controllers are on each drive, meaning the drive can connect directly to the motherboard or controller. IDE and its updated successor, Enhanced IDE (EIDE), are the most common drive interfaces found in IBM compatible computers today. Below, is a picture of the IDE connector on the back of a hard drive, a picture of what an IDE cable looks like, and the IDE channels it connects to on the motherboard.

Any drive with an integrated controller could be called an IDE drive, although normally when we say IDE, we really mean the specific version of IDE called ATA. No matter what you call it, combining the drive and controller greatly simplifies installation because no separate power or signal cables run from the controller to the drive. Also, when the controller and drive are assembled as a unit, the number of total components is reduced, signal paths are shorter, and the electrical connections are more noise-resistant. This results in a more reliable and less expensive design than is possible when a separate controller, connected to the drive by cables, is used.

Back of IDE hard disk drive



40-Pin IDE IDC Connector and cable



There have been four main types of IDE interfaces:

- Serial ATA attachment.
- Parallel ATA attachment.
- MCA IDE.
- XT IDE.

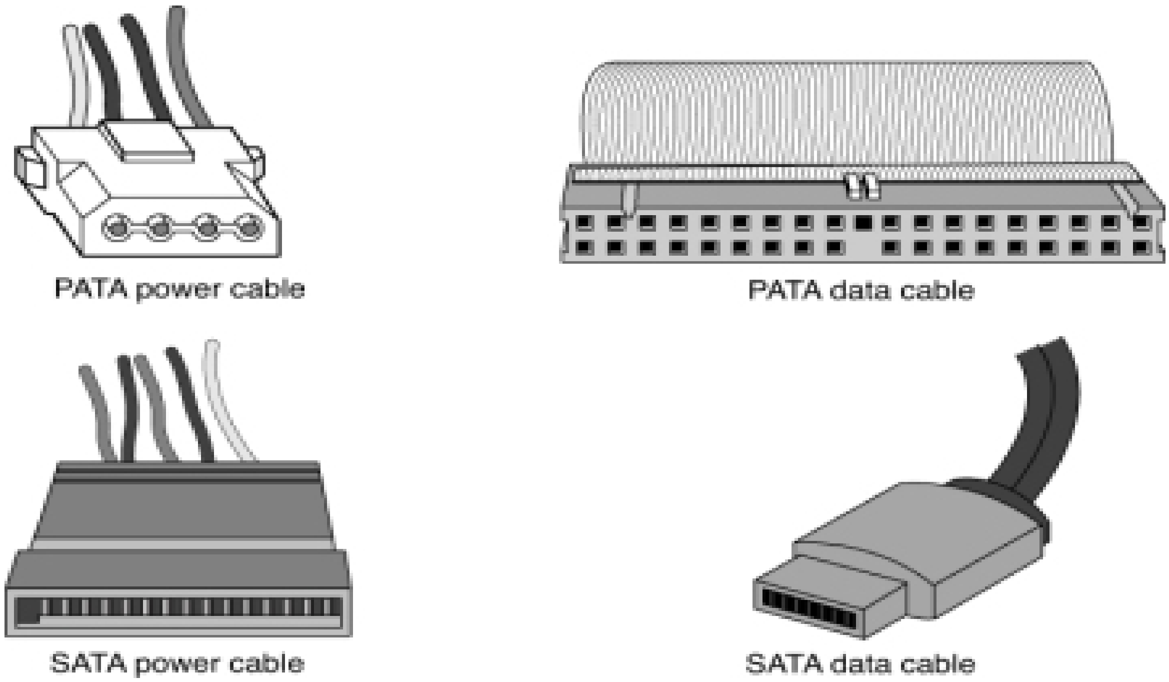


Figure: SATA data cables are much smaller than those used by PATA, whereas the power cables are similar in size.

2.1.1 PARALLEL ATA ATTACHMENT

Parallel ATA (PATA), originally AT Attachment, is an interface standard for the connection of storage devices such as hard disks, floppy drives, and optical disc drives in computers. The standard is maintained by X3/INCITS committee. It uses the underlying AT Attachment (ATA) and AT Attachment Packet Interface (ATAPI) standards.

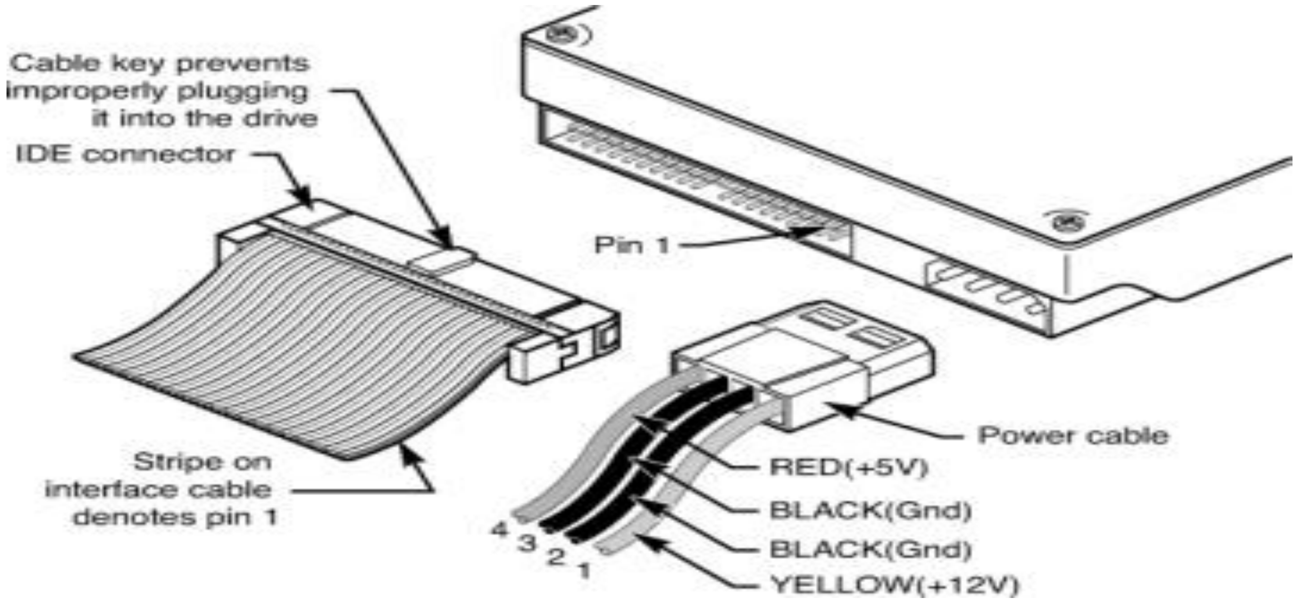


Figure: Typical PATA (IDE) hard drive connectors.

2.1.2 SERIAL ATA ATTACHMENT

Serial ATA (Advance Technology Attachment)(SATA) is a computer bus interface that connects host bus adapters to mass storage devices such as hard disk drives and optical drives. Serial ATA replaces the older AT Attachment standard (ATA later referred to as Parallel ATA or PATA), offering several advantages over the older interface: reduced cable size and cost (seven conductors instead of 40), native hot swapping, faster data transfer through higher signaling rates, and more efficient transfer through an (optional) I/O queuing protocol.

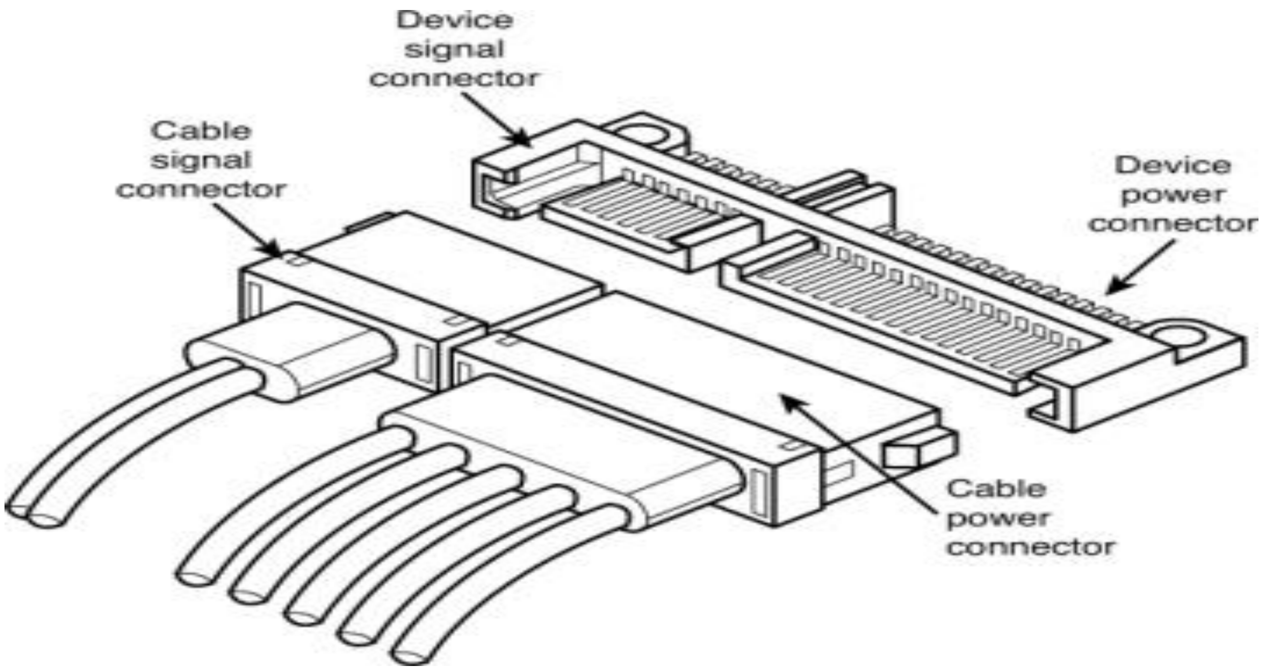


Figure: SATA signal and power connectors on a typical SATA hard drive.

Advantages

- Increased data transfer rate
- The primary reason SATA is used over PATA is because of the increased data transfer speeds with that SATA. PATA is capable of data transfers speeds of 66/100/133 MBs/second, whereas SATA is capable of 150/300/600 MBs/second. The speed differences are due to the various flavors of PATA and SATA, with the fastest speeds being the latest version of each currently available. You'll notice that SATA's slowest speed is still faster than PATA's fastest speed. The improved speed of SATA allows for programs to load faster, as well as pictures and larger documents. For video game enthusiasts, faster data transfer speeds can mean better gaming experiences (i.e. smoother game-play).

- Easy cable management and cable length
- Another advantage of SATA over PATA is the length of the cable connecting the hard drive to the computer motherboard. The max length of a PATA cable is 18-inches, whereas a SATA cable can be up to 3.3 feet (1 meter) in length. This allows for more flexibility on where a hard drive can be mounted in a computer case.
- Increased airflow
- SATA cables are also smaller in size than a PATA cable, allowing for increased airflow inside the computer case and decreased heat buildup. This can help improve the overall life of a computer.
- Support for more drives
- There are typically four to six SATA connections on a computer motherboard, allowing for multiple SATA hard drives to be hooked up. There are usually only two PATA connections on a computer motherboard that supports a total of four PATA hard drives.

Disadvantages

- **Drivers and support-** There are only a few small disadvantages of SATA over PATA. One disadvantage is that SATA hard drives will sometimes require a specific driver to be loaded to a computer when installing an operating system, in order for the computer to utilize the SATA hard drive. This has more recently been rectified by allowing a SATA hard drive to act like a PATA hard drive, thus eliminating the need for the specific driver to be loaded. However, some SATA functionality will be lost in order to gain this mimic functionality. Older operating systems such as Windows 95 and 98 that were released long before SATA was introduced will also not support SATA drives.
- **One drive per cable** -Another disadvantage with SATA is that the cable allows for only one SATA hard drive to be connected at a time. Whereas a PATA cable allows for hooking up two PATA hard drives per cable.

2.1.3 MCA IDE

MCA IDE use different 72 pin connector design for MCA bus system.

2.1.4 XT IDE

XT ATA version has standard 40 pin connectors and cables

2.2 ADVANCED TECHNOLOGY ATTACHMENT (ATA)

ATA versions are handled by T13 company, which is responsible for all standards related to parallel and serial interfaces. T13 is a part of International Committee on Information Technology Standards which operate on under rules approved by American National Standard Institute (ANSI).

2.2.1 ATA VERSIONS

ATA, ATA-1, and IDE

ATA was first developed by Control Data Corporation, Western Digital, and Compaq and first utilized an 8-bit or 16-bit interface with a transfer rate of up to 8.3MBps, and support for PIO modes 0, 1, and 2 and single word DMA mode 0,1,2 and multi word DMA mode 0. Today, ATA and ATA-1, are considered obsolete. It used 40 pin connectors and cablings.

These major features were introduced and documented in the ATA-1 specification:

- 40/44-pin connectors and cabling
- Master/slave or cable select drive configuration options
- Signal timing for basic Programmed I/O (PIO) and direct memory access (DMA) modes
- Cylinder, head, sector (CHS) and logical block address (LBA) drive parameter translations supporting drive capacities up to 228–220 (267,386,880) sectors, or 136.9GB

ATA-2, EIDE, Fast ATA, Fast IDE, and Ultra ATA

ATA-2, more commonly known as EIDE, and sometimes known as Fast ATA or Fast IDE, is a standard approved by ANSI in 1996 under document number X3.279-1996. ATA-2 introduces new PIO modes of 3 and 4, transfer rates of up to 16.6MBps, DMA modes 1 and 2, LBA support, and supports drives up to 8.4GB. Today, ATA-2 is also considered obsolete.

The major features added to ATA-2 compared to the original ATA standard include the following:

- Faster PIO and DMA transfer modes
- Support for power management
- Support for removable devices
- PCMCIA (PC Card) device support
- Identify Drive command that reports more information
- Defined standard CHS/LBA translation methods for drives up to 8.4GB in capacity

ATA-3, and EIDE

ATA-3 is a standard approved by ANSI in 1997 under document number X3.298-1997. ATA-3 added additional security features and the new S.M.A.R.T feature.

The most major changes included the following:

- Eliminated single-word (8-bit) DMA transfer protocols
- Added S.M.A.R.T. (Self-Monitoring, Analysis, and Reporting Technology) support for prediction of device performance degradation
- Made LBA mode support mandatory (previously, it had been optional)
- Added ATA Security mode, allowing password protection for device access
- Provided recommendations for source and receiver bus termination to solve noise issues at higher transfer speeds

ATA-4, ATAPI-4, and ATA/ATAPI-4

ATA-4 is a standard approved by ANSI in 1998 under document NCITS 317-1998. ATA-4 includes the ATAPI packet command feature, introduces UDMA/33, also known as ultra-DMA/33 or ultra-ATA/33, which is capable of supporting data transfer rates of up to 33MBps.It provides CRC (Cycle Redundancy Check).

The major revisions added in ATA-4 were as follows:

- Ultra-DMA (UDMA)or Ultra-ATA/33) transfer modes up to Mode 2, which is 33MBps (called UDMA/33 or Ultra-ATA/33)
- Integral ATAPI support
- Advanced power management support
- An optional 80-conductor, 40-pin cable defined for improved noise resistance
- Host protected area (HPA) support

- Compact Flash Adapter (CFA) support
- Enhanced BIOS support for drives over 9.4ZB (zettabytes or trillion gigabytes) in size (even though ATA was still limited to 136.9GB)

ATA-5 and ATA/ATAPI-5

ATA-5 is a standard approved by ANSI in 2000 under document NCITS 340-2000. ATA-5 adds support for Ultra-DMA/66, which is capable of supporting data transfer rates of up to 66MBps, and has the capability of detecting between 40 or 80-wire cables.

The major additions in the ATA-5 standard include the following:

- Ultra-DMA (UDMA) transfer modes up to Mode 4, which is 66MBps (called UDMA/66 or Ultra-ATA/66).
- The 80-conductor cable now mandatory for UDMA/66 operation.
- Automatic detection of 40- or 80-conductor cables.
- UDMA modes faster than UDMA/33 enabled only if an 80-conductor cable is detected.

ATA-6 and ATA/ATAPI-6

ATA-6 is a standard approved by ANSI in 2001 under document NCITS 347-2001. ATA-6 added support for Ultra-DMA/100 and has a transfer rate of up to 100MBps.

The major changes or additions in the standard include the following:

- Ultra-DMA (UDMA) Mode 5 added, which allows 100MBps (called UDMA/100, Ultra-ATA/100, or just ATA/100) transfers.

- Sector count per command increased from 8 bits (256 sectors, or 131KB) to 16 bits (65,536 sectors, or 33.5MB), allowing larger files to be transferred more efficiently.
- LBA addressing extended from 228 to 248 (281,474,976,710,656) sectors, supporting drives up to 144.12PB (petabytes = quadrillion bytes). This feature is often referred to as 48-bit LBA or greater than 137GB support by vendors; Maxtor referred to this feature as Big Drive.
- CHS addressing was made obsolete; drives must use 28-bit or 48-bit LBA addressing only.

ATA-7

ATA-6 standard is called NCITS 361-2002. The primary addition to ATA-7 is another transfer mode i.e. Ultra DMA mode 6 that allows data transfer upto 133MBps.

The primary additions to ATA-7 include the following:

- Ultra-DMA (UDMA) Mode 6 was added. This allows for 133MBps transfers (called UDMA/133, Ultra-ATA/133, or just ATA/133). As with UDMA Mode 5 (100MBps) and UDMA Mode 4 (66MBps), the use of an 80-conductor cable is required.
- Added support for long physical sectors. This allows a device to be formatted so that there are multiple logical sectors per physical sector. Each physical sector stores an ECC field, so long physical sectors allow increased format efficiency with fewer ECC bytes used overall.
- Added support for long logical sectors. This enables additional data bytes to be used per sector (520 or 528 bytes instead of 512 bytes) for server applications. Devices using long logical sectors are not backward compatible with devices or applications that use 512-byte sectors, such as standard desktop and laptop systems.
- SATA 1.0 incorporated as part of the ATA-7 standard. This includes the SATA physical interconnection as well as the related features and commands.

- The ATA-7 document split into three volumes. Volume 1 covers the command set and logical registers, which apply to both Serial and Parallel ATA. Volume 2 covers the parallel transport protocols and interconnects (PATA), and Volume 3 covers the serial transport protocols and interconnects (SATA).

8-Bit DMA Mode	Bus Width (Bits)	Cycle Speed (ns)	Bus Speed (MHz)	Cycles per Clock	Transfer Rate (MBps)	ATA Specification
0	16	960	1.04	1	2.08	ATA-1*
1	16	480	2.08	1	4.17	ATA-1*
2	16	240	4.17	1	8.33	ATA-1*

Table : Singleword (8-Bit) DMA Modes and Transfer Rates

16-Bit DMA Mode	Bus Width (Bits)	Cycle Speed (ns)	Bus Speed (MHz)	Cycles per Clock	Transfer Rate (MBps)	ATA Specification

16-Bit DMA Mode	Bus Width (Bits)	Cycle Speed (ns)	Bus Speed (MHz)	Cycles per Clock	Transfer Rate (MBps)	ATA Specification
0	16	480	2.08	1	4.17	ATA-1
1	16	150	6.67	1	13.33	ATA-2*
2	16	120	8.33	1	16.67	ATA-2*

Table: Multiword (16-Bit) DMA Modes and Transfer Rates

Ultra DMA Mode	Bus Width (Bits)	Cycle Speed (ns)	Bus Speed (MHz)	Cycles per Clock	Transfer Rate (MBps)	ATA Specification
0	16	240	4.17	2	16.67	ATA-4
1	16	160	6.25	2	25.00	ATA-4
2	16	120	8.33	2	33.33	ATA-4
3	16	90	11.11	2	44.44	ATA-5
4	16	60	16.67	2	66.67	ATA-5

Ultra DMA Mode	Bus Width (Bits)	Cycle Speed (ns)	Bus Speed (MHz)	Cycles per Clock	Transfer Rate (MBps)	ATA Specification
5	16	40	25.00	2	100.00	ATA-6
6	16	30	33.00	2	133.00	ATA-7

Table: Ultra-DMA Support in ATA-4 Through ATA-7

TABLE: ATA STANDARDS

Standard	Other names	New transfer modes	Maximum disk size (512 byte sector)	Other new features
IDE (pre-ATA)	IDE	PIO 0	2 GiB (2.1 GB)	22-bit logical block addressing (LBA)
ATA-1	ATA, IDE	PIO 0, 1, 2 Single-word DMA 0, 1, 2 Multi-word DMA 0	128 GiB (137 GB)	28-bit logical block addressing (LBA)
ATA-2	EIDE, Fast ATA, Fast IDE, Ultra ATA	PIO 3, 4 Multi-word DMA 1, 2		PCMCIA connector. Identify drive command.[29]
ATA-3	EIDE	Single-word DMA modes dropped[30]		S.M.A.R.T., Security, 44 pin connector for 2.5" drives
ATA/ATAPI-4	ATA-4, Ultra ATA/33	Ultra DMA 0, 1, 2 aka UDMA/33		AT Attachment Packet Interface (ATAPI) (support for CD-ROM, tape drives etc.), Optional overlapped and queued command set features, Host Protected Area (HPA), CompactFlash Association (CFA) feature set for solid state drives
ATA/ATAPI-5	ATA-5, Ultra ATA/66	Ultra DMA 3, 4 aka UDMA/66		80-wire cables; CompactFlash connector
ATA/ATAPI-6	ATA-6, Ultra ATA/100	UDMA 5 aka UDMA/100	128 PiB (144 PB)	48-bit LBA, Device Configuration Overlay (DCO), Automatic Acoustic Management (AAM)
ATA/ATAPI-7	ATA-7, Ultra ATA/133	UDMA 6 aka UDMA/133 SATA/150		SATA 1.0, Streaming feature set, long logical/physical sector feature set for non-packet devices
ATA/ATAPI-8	ATA-8	—		Hybrid drive featuring non-volatile cache to speed up critical OS files

2.3 FEATURES OF ATA

- Hot pluggable: no
- External: no
- Width: 16 bits
- Bandwidth: 16 MB/s originally, later 33, 66, 100 and 133 MB/s
- Max devices: 2 (master/slave)
- Protocol: Parallel
- Cable: 40 wire ribbon cable
- Pins40
- Today, ATA is used to connect not only hard disks but also CD and DVD drives, high-capacity SuperDisk floppy drives and tape drives.
- ATA interface is directly integrated into virtually all motherboard chipsets, therefore ATA is primary storage interface used by most PCs, including both desktops and portables.
- The primary advantage of ATA drives over older is separate controller-based interfaces and newer host bus interface.

ATA Commands

One of the best features of the ATA interface is the enhanced command set. The ATA command interface was modeled after the WD1003 controller IBM used in the original AT system. All ATA drives must support the original WD command set (eight commands) with no exceptions, which is why ATA drives are so easy to install in systems today. All IBM-compatible systems have built-in ROM BIOS support for the WD1003, so they essentially support ATA as well.

In addition to supporting all the WD1003 commands, the ATA specification added numerous other commands to enhance performance and capabilities. These commands are an optional part of the ATA interface, but several of them are used in most drives available today and are important to the performance and use of ATA drives in general.

Perhaps the most important is the IDENTIFY DEVICE command. This command causes the drive to transmit a 512-byte block of data that provides all details about the drive. Through this command, any program (including the system BIOS) can find out exactly which type of drive is connected, including the drive manufacturer, model number, operating parameters, and even serial number of the drive. Many modern BIOSs use this information to automatically receive and enter the drive's parameters into Complementary Metal Oxide Semiconductor (CMOS) memory, eliminating the need for the user to enter these parameters manually during system configuration. This arrangement helps prevent mistakes that can later lead to data loss when the user no longer remembers what parameters he used during setup.

The Identify Device data can tell you many things about your drive, including the following:

- Whether the drive has rotating media (and if so, how fast), or whether it is a solid-state drive (SSD) instead
- Whether the TRIM command is supported (or not) on SSDs
- Number of logical block addresses available using LBA mode
- Number of physical cylinders, heads, and sectors available in P-CHS mode
- Number of logical cylinders, heads, and sectors in the current translation L-CHS mode
- Transfer modes (and speeds) supported
- Manufacturer and model number
- Internal firmware revision
- Serial number
- Buffer type/size, indicating sector buffering or caching capabilities

- What security functions are available, and much, much more

Many other enhanced commands are available, including room for a given drive manufacturer to implement what are called vendor-unique commands. Certain vendors often use these commands for features unique to that vendor. Often, vendor-unique commands control features such as low-level formatting and defect management. This is why low-level format or initialization programs can be so specific to a particular manufacturer's ATA drives and why many manufacturers make their own LLF programs available.

ATA Security Mode

Support for drive passwords (called ATA Security Mode) was added to the ATA-3 specification in 1995. The proposal adopted in the ATA specification was originally from IBM, which had developed this capability and had already begun incorporating it into ThinkPad systems and IBM 2.5-inch drives. Because it was then incorporated into the official ATA-3 standard (finally published in 1997), most other drive and system manufacturers have also adopted this, especially for laptop systems and 2.5-inch and smaller drives. Note that these passwords are very secure. If you lose or forget them, they usually cannot be recovered, and you will never be able to access the data on the drive.

More recently, ATA security has been augmented by drives that support internal encryption/decryption using the Advanced Encryption Standard (AES). Drives supporting AES automatically encrypt all data that is written and automatically decrypt the data when it is read. When combined with a password set via ATA Security mode commands, the data on the drive will be unrecoverable even if the HDD password is bypassed or the media (that is, platters or flash memory chips) are removed from the drive and read directly. When AES encryption is employed on a drive with a strong HDD password, without knowing the HDD password there is essentially no way to recover the data. This type of security is recommended for laptops that can easily be lost or stolen.

Drive security passwords are set via the BIOS Setup, but not all systems support this feature. Most laptops support drive security, but many desktops do not. If supported, two types of drive passwords can be set, called user and master. The user password locks and unlocks the drive, whereas the master password is used only to unlock. You can set a user password only, or you can set user+master, but you cannot set a master password alone.

When a user password is set (with no master), or when both user+master passwords are set, access to the drive is prevented (even if the drive is moved to a different system), unless the user (or master) password is entered upon system startup.

The master password is designed to be an alternative or backup password for system administrators as a master unlock. With both master and user passwords set, the user is told the user password but not the master password. Subsequently, the user can change the user password as desired; however, a system administrator can still gain access by using the master password.

If a user or user+master password is set, the disk must be unlocked at boot time via a BIOS-generated password prompt. The appearance of the prompt varies from system to system. For example, in ThinkPad systems, an icon consisting of a cylinder with a number above it (indicating the drive number) next to a padlock appears onscreen. If the drive password prompt appears, you must enter it; otherwise, you will be denied access to the drive, and the system will not boot.

As with many security features, a workaround might be possible if you forget your password. In this case, at least one company can either restore the drive to operation (with all the data lost) or restore the drive and the data. That company is Nortek. (See www.nortek.on.ca for more information.) The password-removal procedure is relatively expensive (more than the cost of a new drive in most cases), and you must provide proof of ownership when you send in the drive. As you can see, password restoring is worthwhile only if you absolutely need the data back. Note that even this will not work if the drive employs internal AES encryption. In that case, without the password, the data simply cannot be recovered.

Passwords are not preset on a new drive, but they might be preset if you are buying a used drive or if the people or company you purchased the drive or system from entered them. This is a common ploy when selling drives or systems (especially laptops) on eBay—for example, the seller might set supervisor or drive passwords and hold them until payment is received. Or he might be selling a used (possibly stolen) product "as is," for which he doesn't have the passwords, which renders them useless to the purchaser. Be sure that you do not purchase a used laptop or drive unless you are certain that no supervisor or drive passwords are set.

Most systems also support other power-on or supervisor passwords in the BIOS Setup. In most systems, when you set a supervisor password, it automatically sets the drive password to the same value. In most cases, if a supervisor password is set and it matches the drive user or master password, when you enter the supervisor password, the BIOS automatically enters the drive password at the same time. This means that even though a drive password is set, you might not even know it because the drive password is entered automatically at the same time that you enter the supervisor password; therefore, you won't see a separate prompt for the drive password. However, if the drive is later separated from the system, it will not work on another system or be readable until you enter the correct drive password. Without the services of a company such as Nortek, you can remove a drive password only if you know the password to begin with.

Host Protected Area

Most PCs sold on the market today include some form of automated product recovery or restoration feature that allows a user to easily restore the operating system and other software on the system to the state it was in when the system was new. Originally, this was accomplished via one or more product-recovery discs containing automated scripts that reinstalled all the software that came preinstalled on the system when it was new.

Unfortunately, the discs could be lost or damaged, they were often problematic to use, and including them by default cost manufacturers a lot of money. This prompted PC manufacturers to move the recovery software to a hidden partition of the boot hard drive. However, this does waste some space on the drive—usually several gigabytes. With 60GB or larger drives, this amounts to 5% or less of the total space. Still, even the hidden partition was less than satisfactory because the partition could easily be damaged or overwritten by partitioning software or other utilities, so there was no way to make it secure.

In 1996, Gateway proposed a change to the ATA-4 standard under development that would allow the HPA to be reserved on a drive. This change was ratified, and the HPA feature set was incorporated into the ATA-4 specification that was finally published in 1998. A separate BIOS firmware interface specification called Protected Area Run Time Interface Extension Services (PARTIES) was initiated in 1999 that defined services an operating system could use to access the HPA. The PARTIES standard was completed and published in 2001 as “NCITS 346-2001, Protected Area Run Time Interface Extension Services.”

The HPA works by using the optional ATA SET MAX ADDRESS command to make the drive appear to the system as slightly smaller. Anything from the new max address (the newly reported end of the drive) to the true end of the drive is considered the HPA and is accessible only using PARTIES commands. This is more secure than a hidden partition because any data past the end of the drive simply cannot be seen by a normal application or even a partitioning utility. Still, if you want to remove the HPA, you can use some options in the BIOS Setup or separate commands to reset the max address, thus exposing the HPA. At that point, you can run something such as Parted Magic or Partition Commander to resize the adjacent partition to include the extra space that was formerly hidden and unavailable.

Starting in 2003, some systems using Phoenix BIOS have included recovery software and diagnostics in the HPA. Most if not all current drives support the HPA command set; however, because of the complexity in dealing with the hidden area, I have seen most manufacturers back away from using the HPA and revert to a more standard (and easier to deal with) hidden partition instead.

2.4 ATA RAID

RAID is an acronym for redundant array of independent (or inexpensive) disks and was designed to improve the fault tolerance and performance of computer storage systems. RAID was developed at the University of California at Berkeley in 1987 and was designed so that a group of smaller, less expensive drives could be interconnected with special hardware and software to make them appear as a single larger drive to the system. By using multiple drives to act as one drive, increases in fault tolerance and performance could be realized.

Initially, RAID was conceived to simply enable all the individual drives in the array to work together as a single, larger drive with the combined storage space of all the individual drives, which is called a JBOD (Just a Bunch of Disks) configuration. Unfortunately, if you had four drives connected in a JBOD array acting as one drive, you would be four times more likely to experience a drive failure than if you used just a single larger drive. And because JBOD does not use striping, performance would be no better than a single drive either. To improve both reliability and performance, the Berkeley scientists proposed six levels (corresponding to different methods) of RAID. These levels provide varying emphasis on fault tolerance (reliability), storage capacity, performance, or a combination of the three.

Although it no longer exists, an organization called the RAID Advisory Board (RAB) was formed in July 1992 to standardize, classify, and educate on the subject of RAID. The RAB developed specifications for RAID, a conformance program for the various RAID levels, and a classification program for RAID hardware.

The RAID Advisory Board defined seven standard RAID levels, called RAID 0–6. Most RAID controllers also implement a RAID 0+1 combination, which is usually called RAID 10. The levels are as follows:

RAID Level 0—Striping-File data is written simultaneously to multiple drives in the array, which act as a single larger drive. 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 or more drives are required for greater than 50% efficiency, and no commercial RAID 2 controllers or drives without ECC are available.

RAID Level 3—Striped with parity-Combines RAID Level 0 striping with an additional drive used for parity information. This RAID level is really an adaptation of RAID Level 0 that sacrifices some capacity, for the same number of drives. However, it also achieves a high level of data integrity or fault tolerance because data usually can be rebuilt if one drive fails. 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).

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 (two or more for data and one for parity).

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 (two or more for data and two for parity).

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. Most PC implementations allow four drives only. 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. This is not generally recommended because RAID 10 offers more redundancy and performance.

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. A minimum of four drives is required, and the total number of drives must be an even number. Most PC implementations allow four drives only. 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 10 arrays can tolerate a single drive failure and many (but not all) combinations of multiple drive failures. This is similar to RAID 01, except with somewhat increased reliability because more combinations of multiple drive failures can be tolerated, and rebuilding an array after a failed drive is replaced is much faster and more efficient.

Additional custom or proprietary RAID levels exist that were not originally supported by the RAID Advisory Board. For example, from 1993 through 2004, “RAID 7” was a trademarked marketing term used to describe a proprietary RAID implementation released by the (now defunct) Storage Computer Corp.

When set up for maximum performance, arrays typically run RAID Level 0, which incorporates data striping. Unfortunately, RAID 0 also sacrifices reliability such that if any one drive fails, all data in the array is lost. The advantage is in extreme performance. With RAID 0, performance generally scales up with the number of drives you add in the array. For example, with four drives you won't necessarily have four times the performance of a single drive, but many controllers can come close to that for sustained transfers. Some overhead is still involved in the controller performing the striping, and issues still exist with latency—that is, how long it takes to find the data—but performance will be higher than any single drive can normally achieve.

When set up for reliability, arrays generally run RAID Level 1, which is simple drive mirroring. All data written to one drive is written to the other. If one drive fails, the system can continue to work on the other drive. Unfortunately, this does not increase performance, and it also means you get to use only half of the available drive capacity. In other words, you must install two drives, but you get to use only one. (The other is the mirror.) However, in an era of high capacities and low drive prices, this is not a significant issue.

Combining performance with fault tolerance requires using one of the other RAID levels, such as RAID 5 or 10. For example, virtually all professional RAID controllers used in network file servers are designed to use RAID Level 5. Controllers that implement RAID Level 5 used to be very expensive, and RAID 5 requires at least three drives to be connected, whereas RAID 10 requires four drives.

With four 500GB drives in a RAID 5 configuration, you would have 1.5TB of total storage, and you could withstand the failure of any single drive. After a drive failure, data could still be read from and written to the array. However, read/write performance would be exceptionally slow, and it would remain so until the drive was replaced and the array was rebuilt. The rebuild process could take a relatively long time, so if another drive failed before the rebuild completed, all data would be lost.

With four drives in a RAID 10 configuration, you would have only 1TB of total storage. However, you could withstand many cases of multiple drive failures. In addition, after a drive failure, data could still be read from and written to the array at full speed, with no noticeable loss in performance. In addition, once the failed drive is replaced, the rebuild process would go relatively quickly as compared to rebuilding a RAID 5 array. Because of the advantages of RAID 10, many are recommending it as an alternative to RAID 5 where maximum redundancy and performance are required.

Many motherboards include SATA RAID capability as a built-in feature. For those that don't, or where a higher performance or more capable SATA RAID solution is desired, you can install a SATA RAID host adapter in a PCIe slot in the system. A typical PCIe SATA RAID controller enables up to four, six, or eight drives to be attached, and you can run them in RAID Level 0, 1, 5, or 10 mode. Most PCIe SATA RAID cards use a separate SATA data channel (cable) for each drive, allowing maximum performance. Motherboard-based RAID controllers almost exclusively use SATA drives.

If you are considering a SATA RAID controller (or a motherboard with an integrated SATA RAID controller), here are some things to look for:

- RAID levels supported. (Most support 0, 1, 5, and 10. A lack of RAID 5/6 or RAID 10 support indicates a very low-end product.)

- Support for four, six, or eight drives.
- Support for 6Gbps SATA transfer rates.
- PCIe card with onboard controller (provides best performance and future compatibility; note that low-cost PCIe cards are host-based and rely on the CPU).

2.5 SMALL COMPUTER SYSTEMS INTERFACE (SCSI)

The second-most popular hard disk interface used in PCs today is the Small Computer Systems Interface, abbreviated SCSI and pronounced "skuzzy". SCSI is a much more advanced interface than its chief competitor, IDE/ATA, and has several advantages over IDE that make it preferable for many situations, usually in higher-end machines. It is far less commonly used than IDE/ATA due to its higher cost and the fact that its advantages are not useful for the typical home or business desktop user.

In terms of standards, SCSI suffers from the same problem that IDE/ATA does: there are too many different ones and it can be hard to understand what is what. Fortunately, this situation is coming under control now. Also, SCSI standards aren't as much of a problem as they are for IDE/ATA, because in the SCSI world, each SCSI protocol has a name that indicates rather clearly what its capabilities are, and there is much less reliance on using the name of the standard to infer transfer rates and other characteristics. Unfortunately, there is still a lot of confusion if you try to figure out the standards themselves and what each one means. And there are still manufacturers playing fast and loose with how they label their drives.

SCSI is a much higher-level protocol than IDE is. In fact, while IDE is an interface, SCSI is really a system-level bus, with intelligent controllers on each SCSI device working together to manage the flow of information on the channel. SCSI supports many different types of devices, and is not at all tied to hard disks the way IDE/ATA is--ATAPI supports non-hard-disk IDE devices but it is really a kludge of sorts. Since it has been designed from the ground up as almost an additional bus for peripherals, SCSI offers performance, expandability and compatibility unmatched by any other current PC interface.

2.6 SCSI CABLES AND CONNECTORS

There are many different aspects about SCSI that can be confusing to someone new to the technology--and even someone not new to it. Of all of the aspects of SCSI that sometimes cause a bit of difficulty, cables and connector issues are probably the worst. Unlike the IDE/ATA world, where there are a handful of different cable types, with SCSI there are literally dozens of different types of cables! It is difficult to even describe all of the options available. This is a result of the flexibility of the SCSI interface--more choice means more options, and hence, more decisions.

The main reason why there are so many types of SCSI cables is simply that there are so many types of SCSI--and so many different ways of implementing them. This great flexibility is actually one of the key strengths of the interface. The design of any SCSI cable is based on a combination of different attributes chosen to implement a particular kind of SCSI bus.

Each SCSI cable must meet the specific electrical requirements associated with the SCSI signaling speeds and methods it supports. This refers not just to obvious matters--such as how many pins are on a particular connector type, or which signals are carried on which wires--but the more complex factors that are the domain of electrical engineering professionals. For example, the thickness of each wires in a cable, the characteristic impedance of the cable, materials used for the wires, connectors and covers, and so on.

The following are other factors that have an impact on the design of SCSI cables, as well as on the selection of cables to meet a particular application:

- **Cable Type:** SCSI is different from most PC interfaces in that it supports both internal and external devices. These use drastically different types of cabling, because the environment inside the PC is very different from that outside it. Both internal and external cables come in a variety of styles themselves. .
- **Connector Type:** Different types of connectors are used for different kinds of SCSI. These are only partially dependent on the type of physical cable used; to some extent, connector types are "mixed and matched" with cable technologies to make particular cables..
- **Cable Length:** The maximum length of a SCSI cable is dictated by the signaling type and signaling speed of the interface; shows the length limits for all the different types of SCSI. However, not all cables are built to the maximum length. Cables of all different lengths are made to suit different needs and budgets (most people don't need 12-meter-long cables for LVD devices, for example, even though they are legal.)
- **Number of Connectors:** Cables vary in terms of the number of connectors they include. Generally speaking, longer cables have more connectors, allowing more devices to be attached to the same SCSI bus segment. Specialized cables may have fewer connectors; for example, LVD cables can be 25m in length instead of the usual 12m if they are used "point to point"--just two devices on the cable.
- **Connector Spacing:** Some types of SCSI have limits regarding how closely two connectors can appear on the cable. If the cable has many connectors you may have to leave some of the connectors unused for maximum performance. In all cases, it is recommended that devices be evenly spaced across the cable.
- **Termination:** Some cables have a built-in terminator at the end of the cable while others require the addition of a separate terminator. .
- **General Quality:** The overall quality of a SCSI cable is very important, but is not something tangible that can be easily measured or quantified. Remember that not all cables are created equal. SCSI cables are often the culprits in problematic SCSI buses, so don't skimp on the quality of your cables.

2.6.1 CABLE TYPES

The term "SCSI cable" usually refers to a complete cable, including the wire, connectors and possibly a terminator as well. Start by looking at the cable itself, the actual wires that make up the "overall cable". There are a number of different types of cables available; these are combined with various connector types to create specific cable implementations.

SCSI cables come in two distinct varieties: external and internal. External cables are used to connect SCSI devices that do not reside inside the PC, but rather have their own enclosures and power supplies; internal cables connect SCSI devices installed within the PC system box. These cables are totally different in construction, primarily because the external environment represents much more of a risk to data corruption. This means external cables must be designed to protect the data traveling on the cable. Internal cables don't have this problem because the metal case of the PC shields the components inside from most of the electromagnetic and radio frequency noise and interference from the "outside world". Thus, internal cables can be made more simply and cheaply than external ones.

Let's start by looking at external cables. These are commonly called shielded cables because they are made specifically to protect the data they carry from outside interference. They have a very specific design in order to ensure that data traveling on the cable is secured, including the following properties:

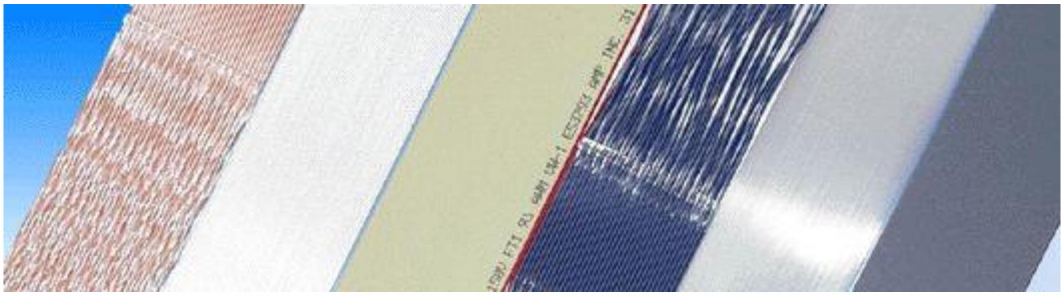
- **Twisted Pair Wiring:** All the wires in the cable are formed into pairs, consisting of a data signal paired with its complement. For single-ended signaling, each signal is paired with a "signal return" wire--a fancy name for a ground wire. For differential signaling, each "positive" signal is paired with its corresponding "negative" signal. The two wires in each pair are then twisted together. This twisting improves signal integrity compared to running all the wires in parallel to each other. So an external narrow cable with 50 wires actually contains 25 pairs; a 68-wire cable 34 pairs. (This sort of wiring is also commonly used in other applications, such as network cabling, for the same reason.)
- **Shielding:** The entire cable is wrapped with a metallic shield, such as aluminum or copper foil or braid, to block out noise and interference.
- **Layered Structure:** The pairs of wires aren't all just tossed into the cable at random; instead, a structure of layers is used. The "core layer" of the cable contains the pairs

carrying the most important control signals: REQ and ACK (request and acknowledge). Around that core, pairs of other control signals are arranged in a "middle layer". The outer layer of the cable contains the data and other signals. The purpose of this three-layer structure is to further insulate the most important signals to improve data integrity.

External cables have a round cross-section, reflecting the circular layers mentioned just above. Needless to say, these cables aren't simple to manufacture! All this precise engineering doesn't come without a cost: external SCSI cables are generally quite expensive. For internal cables all these special steps are not required to protect the data in the wires from external interference. Therefore, instead of special shielded, multiple-layer construction, internal devices use unshielded cables, which are flat ribbon cables similar to those used for floppy drives and IDE/ATA devices. These are much cheaper than external cables to make.

Close-up view of an external SCSI cable. Note the round shape of the cable's cross-section, and the labeling, which indicates that this is LVD-compliant, shielded cable, using AWG 28 conductors.

Even with internal cables, there are differences in construction (beyond the width issue, 50 wires for narrow SCSI or 68 wires for wide SCSI). One issue is the thickness of the wires used; another is the insulation that goes over the wires. Better cables generally use Teflon as a wire insulation material, while cheaper ones may use PVC (polyvinyl chloride; vinyl). Regular flat cables are typically used for single-ended SCSI applications up to Ultra speeds (20 MHz).



An assortment of different internal ribbon cables used for connecting SCSI hardware. Note that some are strictly flat cables, but the one on the far left and the one third from the right are partially flat and partially twisted pair cable.

For Ultra2 or faster internal cables using LVD signaling, the poor electrical characteristics of cheap flat ribbon cables begin to become an issue in terms of signal integrity even within the PC. Therefore, a new type of internal ribbon cable was created for these cables, which actually combines some of the characteristics of regular internal and external cables. With these ribbon cables, pairs are twisted between the connectors on the cable--just like in external cables--but the ribbon remains flat near where the connectors go, for easier attachment. The return to pair twisting improves performance for high-speed SCSI applications, while increasing cost somewhat, though not as much as if external cables are used. This technology is sometimes called "Twist-N-Flat" cable, since it is partially flat and partially twisted-pair.

2.6.2 SCSI CONNECTORS

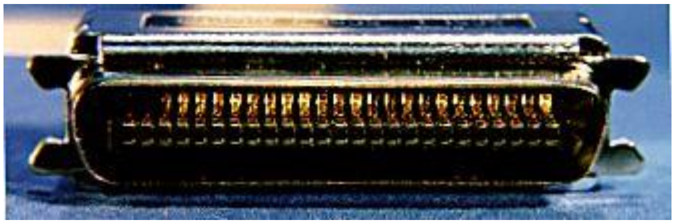
Connectors are of course the physical devices that are used to attach a SCSI cable to a SCSI device. Several different types of SCSI connectors are used to construct SCSI cables. This is in itself unfortunate in a way; whenever there are multiple types of connectors for an interface, this means the potential exists for mismatched connectors between devices. Different connector types have evolved over the years as the SCSI interface has matured. In particular, the desire for miniaturization has been a driving force in the creation of new connector types--the oldest SCSI connectors were large, and creating smaller connectors improves the usability of SCSI cables and devices.

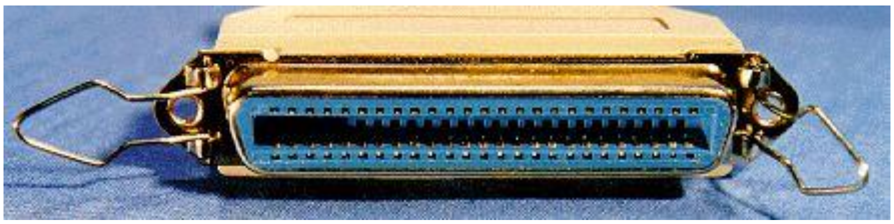
Below are the connector types most commonly seen used with SCSI cables in the PC world. Note that this list is not exhaustive, in part because there are several obscure variations used for some proprietary SCSI implementations. However, most of the cables you will find in the SCSI world use one of these connector types. The SCSI standards call different connector types "alternatives" (not really a good name since the "alternatives" describe different devices types and not really "choices" as that word implies). Since external and internal cables generally use different connectors, each has four different "alternatives".External connector types:

- **D-Shell (D-Sub, DD):** The earliest SCSI standard, SCSI-1, defined a 50-pin D-shell connector for narrow SCSI implementations. The name of this connector comes from the "D-shaped" metal shell that goes around the pins on the male half of the connector. The design is identical to the 25-pin and 9-pin D-shell connectors used for parallel and serial connections on PCs, but bigger. This connector type was very large and cumbersome, never really caught on. However, an alternative 25-pin version of the D-shell was widely used in the Apple hardware world. (Apple "stripped out" the 25 signal return and ground wires that normally would be paired with the true SCSI signals, to save cost). This also never became a standard in the PC world and is not generally seen unless you go looking for it.

A male DD-50 SCSI connector. Note the "D-shaped" metal shell around the pins.

- **Centronics:** The other external connector type defined by the SCSI-1 standard is a 50-pin connector that is commonly called a Centronics connector, after a formerly-popular printer that first used this type of connector. In Centronics connectors, instead of thin pins, two rows of flat contacts are used. Two latches on either side are used to hold the connector in place. Centronics connectors are still used for PC printer cables, on the end that attaches to the printer; SCSI Centronics connectors are the same, just with a different number of pins. These 50-pin connectors are still present in the current SCSI specification and are called "Alternative 2" external connectors.





Male (above) and female 50-pin Centronics connectors. As you can see, there are no pins; the contacts are flat. Note the tabs on the sides of the male connector and the latches on the sides of the female connector, which snap into the tabs to secure the connector in place.

- **High-Density (HD):** The D-shell connectors defined in the SCSI-1 standard were replaced by newer, high-density shielded connectors in SCSI-2. These are really not all that different from the older D-shell connectors, but the space between pins was reduced, making the connectors smaller, cheaper to make and easier to use. The narrow, 50-pin version is called "Alternative 1", and the wide, 68-pin version "Alternative 3". These connectors use a "squeeze to release" latching mechanism instead of Centronics-style latches, and are still used by hardware devices today.

Male 50-pin (above) and 68-pin external high density connectors.

- **Very High Density Cable Interconnect (VHDCI):** To further improve the flexibility of SCSI hardware, a new type of external connector was defined as part of the SPI-2 standard. This connector is wide only (68 pins) and is sometimes called a "micro-Centronics" connector, because it uses the same design as the Centronics connectors, only with the contacts much smaller and closer together. This is "Alternative 4" for external connectors and is growing in popularity because of its small size. One way that VHDCI is useful; for example, is that two of these connectors can be squeezed side-by-side within the width of a single SCSI host adapters back edge (expansion slot insert). This doubles the number of external connectors that can be crammed onto a high-end SCSI host adapter.

A male 68-pin VHDCI connector.

OK, now let's look at internal (unshielded) connectors:

- **Regular Density:** The SCSI-1 standard defined a single connector type for internal narrow (8-bit) devices. This is a rectangular connector with two rows of 25 pins. This connector type is very similar to that used for IDE/ATA devices, except that there are five extra pins in each row. It is most often seen in older devices and also some newer, slower drives. It is called unshielded "Alternative 2" in the current SCSI standards.

Male (above) and female 50-pin regular density internal connectors. Note the gap in the plastic shield around the male connector, and the tab on the female connector, for keying.

- **High Density:** SCSI-2 defined two new connector types, which are both called high density because their pin spacing is half that of the older SCSI-1 connectors, making them much smaller. These are the most common SCSI connectors used today within the PC box. The narrow, 50-pin version is unshielded connector "Alternative 1" and the 68-pin version is "Alternative 3".

A male, internal, high-density 68-pin connector. The 50-pin connector is the same, just narrower. (It is much less common than the 68-pin version.)

- **Single Connector Attachment (SCA):** "Alternative 4" in the SCSI standards for unshielded connectors doesn't actually refer to cable connectors, but the connector used for the single connector attachment system for backplane-connection of SCSI drives. .

A female 80-pin SCA connector. This is the connector that would be found on a backplane designed for SCA SCSI drives.

2.7 ADVANTAGES OF SCSI

The following are advantages of the small computer system interface (SCSI):

- Unlike other interfaces, when you interface with different device types using SCSI, the interfacing is done through the same cable. In a non-SCSI environment, devices such as a proprietary tape controller, disk controller, and so on, must be used to connect their respective devices to the system bus.
- SCSI peripheral devices of the same type have similar characteristics (this makes it easy to replace old devices with new ones).
- SCSI peripheral devices are intelligent and independent: a controller is built onto each SCSI device. This allows the computer to do other work.
- SCSI I/O is independent of the system bus. This allows peripheral devices to work with different computer types, which preserves a company's hardware investment.
- SCSI is fast (10 megabytes (MB)/second on 8 bit bus, 20 MB/second on 16 bit bus).
- Multi-threaded operating systems, such as Windows NT, can take full advantage of the multi-tasking capabilities of the SCSI bus.
- Longer cable lengths allowed (up to 12 meters using LVD).
- Flexible device attachment (up to 7 or 15 devices per SCSI bus).
- Support for any peripheral type (disks,tape,CD-ROM,scanner etc).
- All commands can overlap with commands on other devices .Usually uses DMA to transfer data (which frees CPU for other tasks).

- Largest, highest performance devices are available in SCSI before IDE.
- Maximum drive capacity of 2048 GB.

2.8 SCSI v/s IDE

- Generally more expensive than IDE/ATA, due to more complex firmware and extra testing required.
- Slightly more complicated to install than IDE/ATA due to termination requirements.
- Seems scary to novice users because of amount of terminology and connector / protocol options.
- IDE/EIDE allows 2 two devices per channel(Most computers have 2 channels) whereas SCSI is capable of supporting up to 7 or 15 devices.
- IDE is commonly a much easier product to setup than SCSI.
- Today, the latest IDE and SCSI drives running at the same RPM are very close. However, 10,000+ RPM drives are often only available for SCSI.
- All motherboards today have an ATA/IDE interface and unless additional drives are needed no additional resources need to be taken. Unlike IDE, SCSI requires an interface expansion card in most cases (unless the motherboard already has it). This means additional system resources will be required.
- SCSI needs only single IRQ, IDE needs two.