Module - 3

Mother Board :

- Most essential parts of a computer system.
- All other boards are either attached or connected.
- It is the mother of all the boards
- All other boards are called "daughter board"
- It contains
  - CPU (central Processing Unit)
  - Memory (RAM & ROM)
  - Mathematics and Graphics Processor
  - System's Real Time clock
  - keyboard controller
  - Varias other chips for the CPU

- Made up of woven fibre glass material filled and strengthened with green coloured epoxy plastic material
- It is also called glass - epoxy board
- All other boards are connected or attached using copper tracks.

Components :-

- Expansion Slot
- CPU
- Coproccesor
- Memory
- BIOS - Basic I/O system
- Support circuit or chipsets for interrupt, DMA etc.

- **Expansion slot** - for adding extra component. (Graphics card, sound card, etc.)

> Various expansion card can be connected through data, address and control bus on the slots.

> It is connected to the data, address and control bus of the mother board.

Bus is an electronic path on which signals are send from one place to another.

Components of a ~~Mother Board~~

- > Bus width → (width)
  > Band width → (measure)

Bus width :-

- If a data bus is 8 bit wide then it can transfer 8 bits of information at a time and is called 8 bit data bus.
- An 8 bit data bus requires two data transfer for transfering 16 bit data.

Band width :-

- It is the measure of data that can fit in the bus at a given time.
- Data movement through a bus can

- CPU (Main Processor)

> Main component of a motherboard
> Controlls all the functions of the system
> It functions as the brain of the computer
> It is inserted into the a socket in the motherboard

Some CPU chips by Intel - 8088, 8085, 8086, 80286, 80386, 80484, Pentium, Pentium -II, Pentium -III pentium -4 etc..

some manufactures are :-

> Qualcomm
> NVIDIA
> IBM
> Samsung
> Motorola
> Hewlett Packard (HP)

- Co-processor

It assist the main processor by performing some of its task (special purpose) - It speed up the performance
> there are mainly two co-processer
* Math Co processor - performs mathematical operations
* Graphical Co processor - performs graphical operations

- Memory
- place where computer stores the program and data program - set of of instructions that used to perform a particular operation data - Helps the pgm in carrying out the operations

Types of m/y:

RAM - Random access m/y
ROM - Read Only m/y

» RAM

- It is a read-write m/y
- It is used by processor to keep pgm, data, intermediate results during program executions.
- Volatile m/y - content will be lost when the power is off.

RAM - card. (physical Installation)

- DIP
- SIMM
- DIMM

» ROM

It only reads m/y - read only type of m/y
we cannot write anything into a ROM

- Data is written by Manufacturer
- Non volatile m/y - data never lost when the power supply is switched off.
- A motherboard normally contains one or more chips

- BIOS - Basic Input Output System

* Important pgm stored in ROM (BIOS chip)
* BIOS let our application progm and hardware device to communicate with each other

* It also contains a program called POST (Power On Self Test)
* POST checks the motherboard and other device connected to compuler during the system power on time.
* BIOS program are avaible from Award, Phoenix, American Megatrends.

- CMOS - Complementary Metal Oxide Semiconductor.

It is an onboard (inbuilt in motherboard) battery powered semiconductor chip → stores information ie, system time, date to system hardware setting

ex: CMOS coin cell battery
panasonic CR 2032 3V

- support chips / Chipset.

* Group of interdependent motherboard chips or IC's that control flow of data and instructions b/w CPU or microprocessor, and external devices

* It controls external buses, cache m/y and some peripherals (I/O)

5/ EXPANSION SLOTS :-

> The I/O bus or Expansion slots enables CPU to communicate with peripheral devices

> The I/O bus is used to add many devices to compuler to expand its capabilities

> The expansion cards are connected to the motherboard through data, address and control lines / buses on the expansion slots.

> They are thin long connectors on the motherboard.

Types of Input - Output Buses:

> Number of bits they transfer at a time
> Speed
> Bus Architecture.

Various type:-

(i) 8 Bit - ISA (Industry Standard Architecture) - classic AT Bus

* It is capable of transfer 8 bit data at 1 unit time
It contains 8 line data bit line, 20 bit address line and power and control lines.

* It can handle 1MB of m/y
It supports connected cons for 6 interrupt (IRQ2 - IRQ7) and three DMA channels (DMA0 - DMA2)

* This bus runs at a system speed of 4.77 MHz
It contains a total of 62 contacts at the bottom of adapter card - 31 contals on both sides of the care

disadv { It requires many external device selling to connect a new devices (Jumpers and DIP switch)

(ii) 16-Bit ISA

Since 80286 have 16 bit dataline, AT MBs have 16 bit ISA bus.

IBM added 36 new connector slots (18 on each side) - 98 pins (total) to the existing 8 bit ISA slots - makes the 8 bit ISA compactible with 16 bit ISA slots.

(Direct m/y access)

(extra added to 8 bit ISA) 5 Interrupts and 4 DMA channels were included. 4 more address lines are provided and several more control signals are added

Limitations of ISA Bus Standard.

* Only 16 data line, limiting data transfer to 2 bytes at a time
* Only 8.33 MHz max clock speed
* No sharing of interrupts of DMA channels between cards in different slots.
* No provision for being disabled by the system in case of resource conflict.
* Peak transfer rate of 5 MB/s
* Many Jumper settings and DIP switches are required when a new device is added.

(iii) MCA - Microchannel Architecture (Not successful) failure

MCA had 32 bit bus to match the 386 CPU's external data bus with a speed of 12 MHz
(32 bit)
> May self configure devices
> IBM proporetary and expensive.

24/06

(iv) IS > Introduced by IBM for their PS/2 machines
Drawbacks > MCA is not completly new expansion card
>
• MCA is not compatible with existing ISA
- requires a completly new expansion card.

> MCA is proprietry system by IBM hence
hence expensive

> Two technologies were introduced by MCA:
Auto configure & Bus Mastering

1. Autoconfigures (Plug and play):

> This allows the user to connect any device to MCA bus without worrying about IRQ, Interrupt, DMA channel setup problems

> Device connected to these buses configure automatically - plug N - play.

it identify all the external devices connected which is supp

2. Bus Mastering. (Take out control from CPU)

> It allows an expansion card to directly transfer data to and from other bus mastered peripheral controller without the need to pass through CPU.
> It allows peripheral devices to take control of bus from the CPU for a short time and transfer data from periferal device directly to m/y
> This frees the CPU to perform other tasks making the sys effici
> This allows the device to transmit or receive large blocks of data in a short burst mode

(32 bit) (iv) EISA - Extended Industry Standard Architecture.

> Created by a group of 9 computers manufactures in response to IBM's MCA bus design

> It is a 32 bit bus technology compaitable with 8 bit, 16 bit ISA adapters

It allows auto configure and Bus mastering :

(V) Local Bus

> This slot allows the device connected to it to communica with the CPU at a speed the CPU is capable of
  - VESA local Bus / VL bus
  -

Video Electronic Standard Assosiation :-

It is an assosiation of video adapters and monitor

manufactures to standardize PC video specification

It connects to
> Video adapter
HDD adapter (Hard Disk)

These 2 devices require very fast access by the CPU

Specifications:

> Max speed limit - 33 MHz
> Transfer of data rate - 32 bit data at a time.
> Throughput - 130 MB/s which 16 times faster than a ISA.
> At a time only 3 VL bus should by be connected to the motherboard for avoiding overloading
> It is used in 486 Machines

PCI Local Bus

> Peripheral Component Interconnect bus
It was introduced with Intel pentium computer.
> Pentium processor have 64 bit data path and 60 - 200 MHz speed - Hence VL bus cannot be used Hence Intel provided a different local bus - PCI
> For pentium processor PCI is the standard local bus.

Specifications of PCI

> Band width - 133 MB/s

> supports 32 bit and 64 bit interfaces
> Plug and play capability
> Processor Independence - clocking and transfer on PCI bus is independent of processor clock.
> High Speed Bus - Earlier 33.33 MHz having throughput of 132 MB/s with 32 bit board. 264 MB/s for 64 bit board
> Later 66.66 MHz had a throughput of 533 MB/s with 64 bit PCI devices
> Retain support for ISA Bus
> Bus Mastering

Bus type	Max Speed MHz	No. of Data Bits	Software setup	Bus Mastering	Peak transfer Rate (MBps)
ISA	8.33	16	24	No	5
MCA	8.33	32	32	Yes	20
EISA	8.33	32	32	Yes	32
VESA	33	32	32	Yes	130
PCI	66	64	32	Yes	533

Form factor - Length, breadth (size).

PCI Express

* Very fast serial bus having backward compactibity with current PCI
* Physical connection over copper, optical or other physical media to allow for future encoding schemes
* High BW allows small form factors, reduced cost, simpler boaed design and reduced signal integrity issues
* Embedded clocking scheme enables easy speed changes as compared to sync clocking
* ~~Throup~~ Throughput increases with width.
* Isochronous data transfer.
* Hot swapping and plugging capabilities
* Advanced Power Management Capabalities.

AGP - Accelerated Grapics Port

* High speed bus for display boards / accelerating 3D graphics
* A single AGP can control a single device.
* Features :-

> It allows the video board to use the sys m/y (RAM
> AGP transfers 32 bits wide but uses 66 66 MHz clock speed
> AGP 1x transfers 1 bit per data line per clock cycle - 266 66 MB/s (similarly for 2x, 4x, 8x)
> It is 4-8 times faster than PCI.

AGP

~~Point connecting nodes~~
~~It is pipelined, req are executed~~

PCI

PCI is a bus.

Motherboard selection Critirea.

These are the several factor

- > Motherboard chipset
- > Processor socket
- > m/y
- > Form factor
- > Bus slots - no of slots
- > Onboard ATA interfaces
- > Other built in Interfaces
- > Good Documentation

»

Mother Board Chipset :-

* The motherboard is the backbone of a system and it affects and influences virtually every other component in the system

* So before buying, compare the features available chipsets to ensure that the board will do what you want.

for example, some chipset include support for faster m/y SATA 6Gbps drives

Processor Socket :-

* The processor socket on a M.B dictates about the processor models you will be able to install.
*
* In most cases you will have process in mind so choose a motherboard with a socket that supports the processor you want to use
* check the MB specifications for what specific

Memory :-

* The Type and amount of m/y compatible with a system depends on the MB you choose.
* The no of m/y socket support speeds and other variables also depend on the motherboard so check the board specification to see exactly what is supported.

Form factor :-

* It indicates the sizes and shape of the board and must be compatible with the chassis or case and power supply
* for max flexibility performance, reliability and ease of use, MB based on the ATX and micro ATX form factors are recommended.

* Larger form factors such as ATX offers more slots and room for additional integrated components and features

Bus slots :-

Make sure the board you choose has the number and types of slots you require.

keep in mind that PCI is fading away on the latest motherboards so if you want to use existing PCI cards make sure you choose a m B that has enough PCI slots or has integrated ports that replace the functionality of your PCI cards

ON Board ATA Interface :-

All MotherBoards on the market have included on board serial and parellel port ATA (Advanced Tech. Attachment) → std phy. Interface for connecting storage devices with in a computer) interfaces for some time now but not all are equal

Look for boards that includes at least four to six SATA connectors, with support for 6 GBps operation as well as optional RAID functionality (if desired)

Other built in Interfaces :-

Ideally a motherboard should contain as many built standard controllers and interfaces as possible. Most boards feature integrated USB, sound, computer po and LAN (look for those offering gigabit Ethernet)

where as others also have integrated video, Firewire eSATA, dual LAN adapters and more

Bus \& System Bus

BUS :-
A bus is a subsystem that is used to connect computer components and transfer data b/w them.
For example an internal bus connect computer internals to the motherboard.

A bus may be parellel or seriel
> Parellel bus tranit data across multiple wires
> serial bus transmit data in bit serial format

Types of Bus :-

There 3 types of bus

> Address Bus – Carries m/y address from the processor to other component such as primary storage and input/output devices
> Data Bus - Carries the data b/w processor and other component
> Control Bus - carries control signals from the processor to other components.

Functions of Buses :-

1. Data sharing :- All types of buses found in a computer transfer data between the computer peripherals connected to it.

The buses transfer or send data either in the serial or parellel method of data transfer. This allows for the exchange of 1, 2, 4 or even 8 byte, of data at a time. (A byte is a group of 8 bits) Buses are classified depending on how many bits they can move at the same time, which means that we have 8-bit, 16 bit, 32 bit or even 64 bit buses

2. **Addressing** :- A bus has addres lines, which match those of the processor. This allows data to be sent to or from specific m/y locations

System Bus :

A system bus is a single computer bus that connects the major components of a computer system, combining 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

⇒ Processor bus, Memory bus, I/O bus

Memory bus :-

The m/y bus transfers data between the RAM and the CPU. This bus can be the processor bus or will be implemented by a dedicated chipset that controls the m/y bus. In most computers that have a motherboard clock that is faster than 16MHz, a special memory controller chipset will control the m/y bus.

Processor Bus:

- The processor bus is communication paths b/w the CPU and the main bus
- It is also used for communications b/w the CPU and the processor support chipset.
- The processor support chipset includes chips such as external m/y cache and the bus controller chip found on some microcomputers

I/O Bus

The input/output or I/O bus is the pathway used for input and output devices to communicate with the computer processor

Types of I/O Bus:-

Expansion bus types:-

These are some of the common expansion bus types that have ever been used in computers

1.) ISA - Industry Standard Architecture
2) EISA - Extended Industry standard Architecture
3) MCA - Micro Channel Architecture
4) VESA - Video Electronics standards Assosiation
5) PCI - Peripheral Component Interconnect
6) AGIP - Accelerated Graphics port

super I/O chip :-

> short for super Input / Output or super I/O, (SIO) is an integrated circuit on a computer motherboad that handles the slower and less prominent input / output devices shown below

> when the super input / output was first introduced in the late 1980's it was found on an expansion card

> Later this's chip was embedded into the motherboard and communicated over the ISA bus or As ISA began to no longer be used with computers, SIO communicated over the PCI bus

Some devices that are handled iby the super I/O chip are:

- floppy disk controller
- Game port
- Infrared
- Intrustion detection
- keyboard and mouse (non USB)
- Parellel port
- RTC (Real time Clock)
- Serial Port UART
- Temperature sensor and fan speed

Notes-

Identifying the super I/O on your motherboard is often easy if you look for an integrated circuit that is labeled with a company's name that manufactures

Super I/O chips Some common super I/O manufacturers are fintek, ITE, National Semiconductor, Nuvoton, SMSC, VIA and Winbond

> Chipsets :-

A chipset is specifically designed for a motherboard The chipset and motherboard must be compatible with the CPU to prevent system failover Most chipset drivers are manually updated and installed

A chipset has two sections - southbridge and northbridge - with specific sets of functions that communicate between the CPU and external devices

Southbridge

The southbridge, which is not directly connected to the CPU, is also known as the input/output controller hub Southbridge handles the motherboard's slower connections, including input/output (I/O) devices and computer peripherals like expansion slot and hard disk drives.

Northbridge

The northbridge connects the southbridge to the CPU and is commonly known as the m/y controller hub The northbrige handles a computer's faster interaction requirements and controls communication between the CPU, RAM and ROM, the basic I/O system (BIOS) the ~~graphics~~ accelerated post (AGP) and SB chips graphics

1

Motherboard

Motherboard is the most important component in any personal computer. It contains almost every important elements of the computer system.

Normally, the motherboard contains the CPU or the brain of the computer, memory (ROM and RAM) and many other supporting circuits that make the computer function as a complete system.

Sometimes instead of the calling it "**motherboard**", IBM refers to it as "**system board**" or "**planer board**", some other manufacturer refer to this as the "**logic board**".

What is a Motherboard?

Motherboard is the largest circuit board inside the computer. It contains the computer's **CPU (Central Processing Unit)**, memory (**RAM & ROM**) and various support chips for the CPU.

Motherboard also contains many **Expansion Slots** on which you can connect smaller circuit boards to interface different devices such as monitor, printer, sound card etc. with the computer.

Motherboard History

Initially when the IBM decided to make personal computer, two different types of technology were being used to make personal computers.

They were

- Bus Based Computers
- Single Board Based Computers

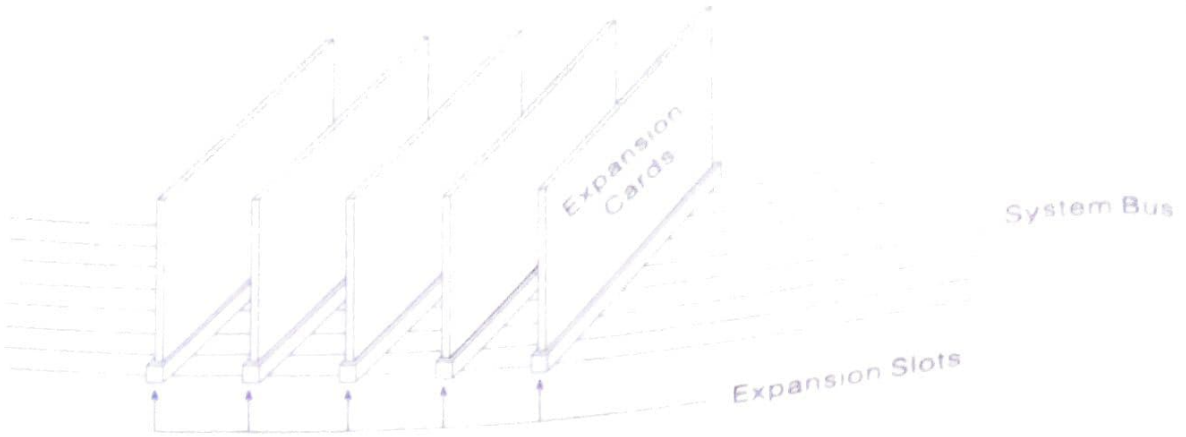

Fig. 1-1 : A Bus Based System.

Bus Based Computers

In this bus based approach a main board is used as the backbone of the computer system.

- This main board contains a number of buses or connecting lines along which electric/electronic signals can be sent from one place to another.
- It also contains a number of slots providing connection to these buses.
- Basically the data, address, control and power signals were provided on these buses.

When an expansion board is connected to any of these expansion slots, the board gets connected to the bus and becomes a part of the total system.

The main advantage of this type of approach is

- The system can be expanded as and when required,
- Different parts of the computer can be purchased as and when the need arises and connected to the bus through the expansion slots.
- This makes the maintenance of the system very easy, whenever any part fails, the board on which that part is located can be removed and easily replaced with a working board.

As a common bus links all the components together this system is called **bus-orientated system**.

In this type of computers different parts of a system such as main processor, memory, different i/o interface, display interface etc., are put on separate cards and connected to the main system bus through the expansion slots.

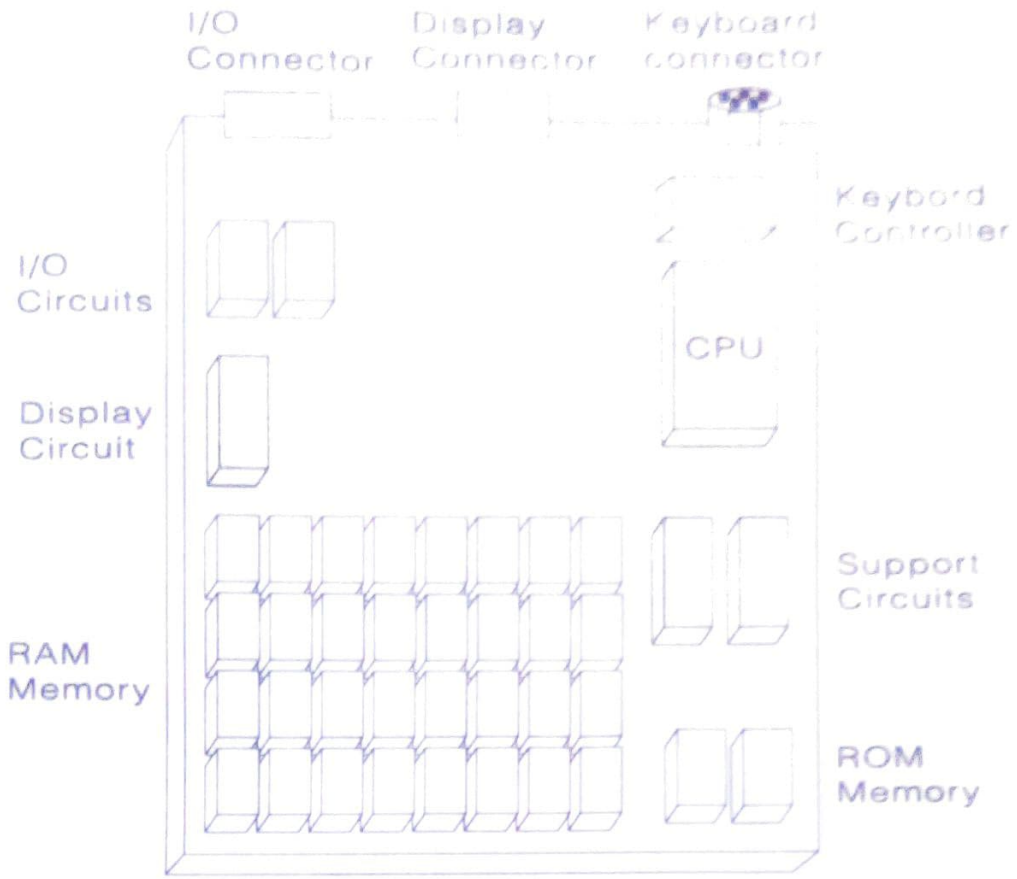

Fig. 1-2 : A Single Board Based System.

Single Board Based Computers

The other approach in the computer design is a single board based systems.

- On these systems a single board contain all the chips and circuits required to make a complete computer system.
- This type of systems are easy to design and manufacture, it cost less compared to the bus type computers.
- This type of system design was very common among the home computers and video game computers.

Disadvantage with this type of systems was

- Most of these systems had no option to connect any additional device, other than what is available on the board itself.
- There was no scope of upgrading or adding any new device introduced in the market into these systems.
- Being a single board systems they were difficult to maintain. Even if one component fails, the user had to either discard the complete motherboard or spend a lot of amount and time on troubleshooting and maintenance.

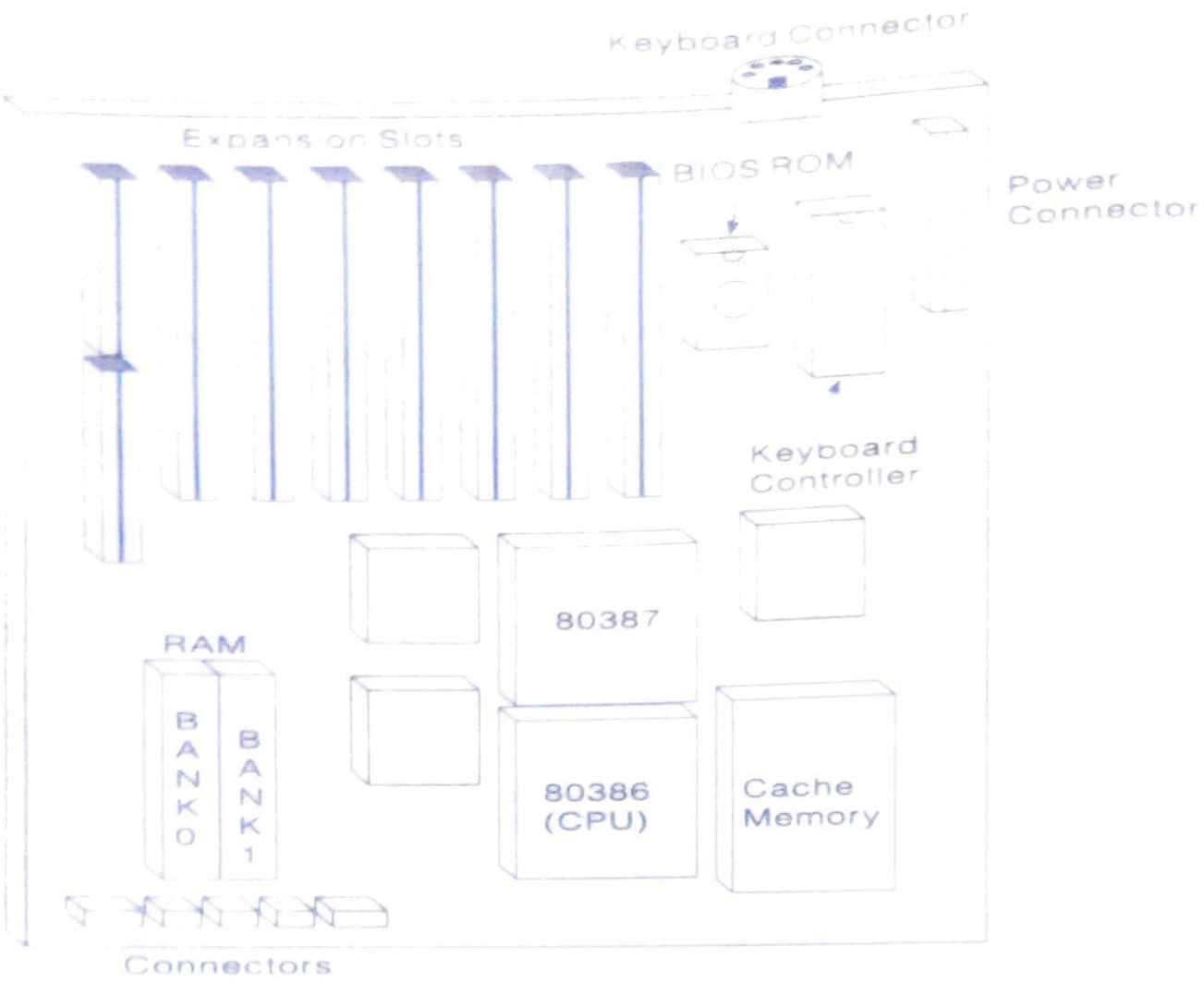

Fig. 1-3 : Motherboard of an IBM PC System.

The IBM Approach

When the IBM decided to make personal computers, they decided to use the good features of both bus based as well as single board based design.

The main board of the IBM computers follows the approach of a single board based computers. This board contains almost all the important parts of a computer, such as the main processor, memory etc.

But at the same time IBM has provided expansion slots on the main board to connect any additional device to the system.

This design concept gives best of the both worlds.

- Keeping most of the parts on the main board itself keeps the cost down and makes them more reliable, and
- The slots on the main board provide facility for future upgrade.

Personal Computer Motherboard

The main circuit board in the Personal Computer (PC) is called the **motherboard**

- We call it motherboard because all the other boards in the computer is attached or connected to this board i.e. it is the mother of all the boards.
- As this main board is called the **motherboard** all the other boards that connect to it are called "**daughterboard**".
- Sometimes the size of the daughterboard coluld be bigger than the size of the motherboard.

Most of the time motherboard is the largest circuit board inside a personal computer and it contains

- CPU (Microprocessor),
- Mathematics and Graphic coprocessor (optional),
- System's **Real Time Clock** circuit,
- BIOS ROM and RAM Memory,
- Keyboard Controller
- Chipset to help CPU to deal with Input/Output, Interrupts, DMA etc.

Motherboard printed circuit board (PCBs) is made of woven fiberglass material filled and strengthened with green colored epoxy plastic material.

- This type of board is called "**glass-epoxy board**".
- On this Printed Circuit Board, the components are placed and connected with the help of thin copper tracks.
- The modern PCBs contains many such tracks to make electrical connection between different parts of the system.

Generally these tracks are very fine, and hence one should never put excessive pressure on the board while inserting or removing cards or chips, otherwise it would cause the board to bend excessively and break a track.

Once a track is broken, because of the multiple layers of tracks, it is almost impossible to trace the broken area and repair it.

When evaluating the quality of the motherboard one should consider

- **The thickness of the board.** Most cheaper boards are quite thin and they cannot withstand careless handling or frequent insertion and removal of the expansion cards.
- **The quality of the soldering.** The soldered joints of a good motherboard should be bright not foggy.

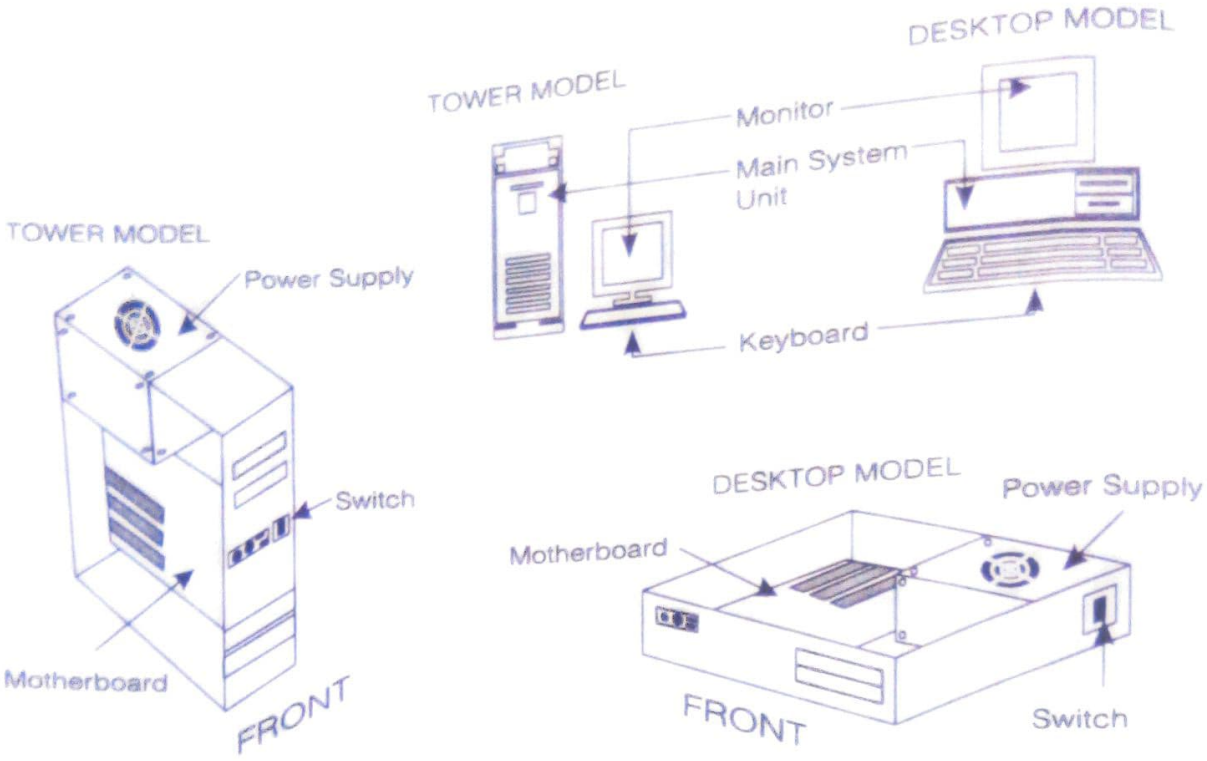

Fig. 1-4 : Position of Motherboard inside IBM PC System.

Position of the Motherboard

Inside the **Main System Unit** cabinet or the **Main System Box**, the position of the motherboard depends on the model/type of the cabinet being used.

- Inside a **Tower** model cabinet, the motherboard is generally attached on the right side of the system box, when you are looking at the system from the front,
  normally it is placed just below the power supply.
- On a **Desktop** model cabinet, the motherboard is placed inside the main system unit next to the power supply.

Motherboard is connected to the cabinet with about **1/2 inch high plastic spacer** in between the board and the cabinet at various places.

This is done to protect the components on the motherboard from touching the cabinet's metal surface and short circuiting themselves.

Motherboard Components

A conventional motherboard comprises of various components such as

- Expansion Slots
- CPU (Main Processor)
- Coprocessor
- Memory
- BIOS and
- Support circuits or chipset for interrupt, DMA etc.

Expansion Slots

What is Expansion Slot?

The expansion slots are long thin connectors on the motherboard, near the backside of the computer.

Various expansion cards are connected to the motherboard through the data, address and control lines/buses on these slots.

Bus is an **electronic path** on which signals are sent from one part of the computer to another.

- One can connect various expansion cards such as display card, hard drive controller, sound card, network card, modem card etc. on these slots.
- When an expansion card is connected to the expansion slot, it is actually connected to the data, address and control bus of the motherboard.

These buses are categorized according to the number of **binary digits** (bits) that they can transfer from one place to another at a time.

- If a data bus is 8 bit wide then it can transfer 8 bits of information at a time and is called an **8 bit data bus**.
- An 8 bit data bus transferring 16 bit data requires two data transfer operations.

Another very common term while talking about bus is, its "**Bandwidth**".

- The bandwidth of a bus is the measure of data that can fit in the bus at a given time.

You can increase the data movement through a bus either by increasing the **bus width** (from 8 bit to 16 bit) or by increasing the bus **bandwidth** (8MHz to 20MHz).

This is similar to the way you can increase water output from a pipe, either by increasing the pipe diameter or by increasing the water flow.

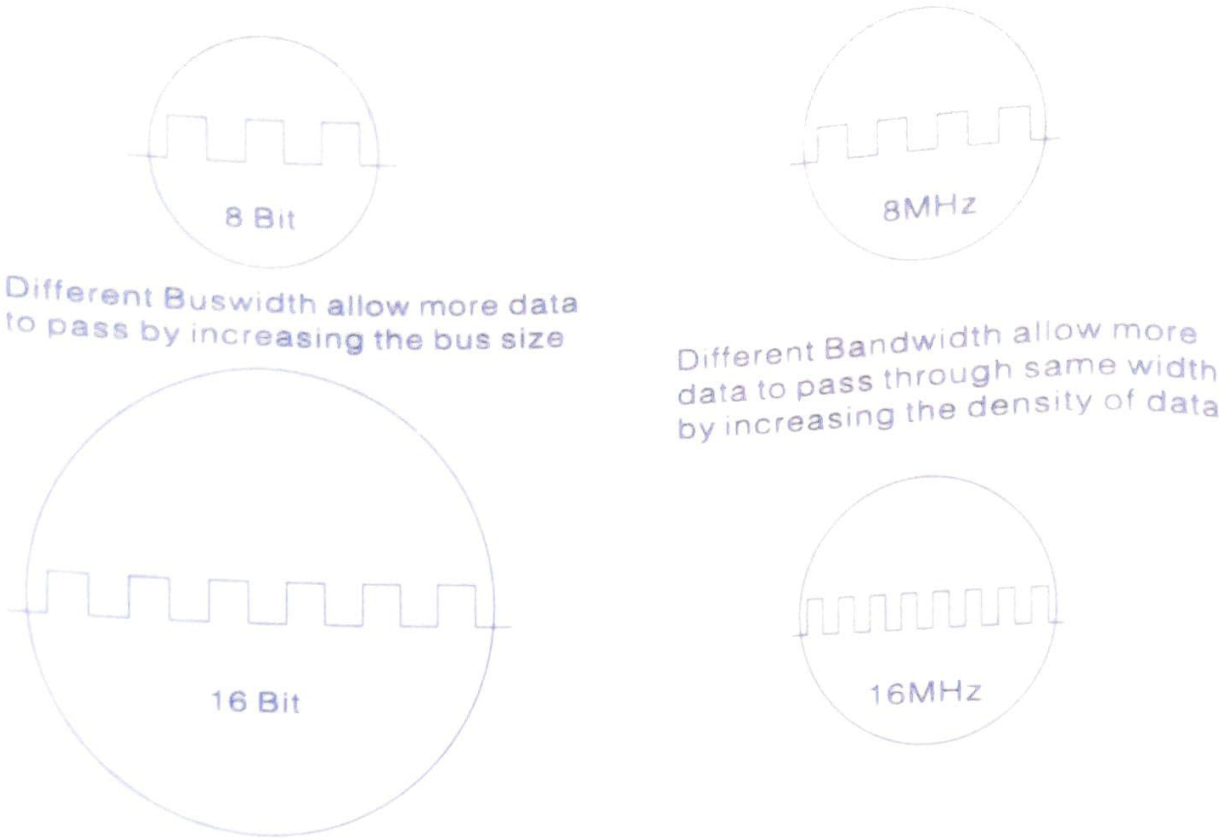

Fig. 1-5 : Buswidth and Bandwidth.

Depending on the width and the technology, the expansion slot bus can be divided into the following categories

- 8 bit ISA
- 16 bit ISA
- MCA
- EISA
- VESA Local Bus or VL Bus
- PCI Local Bus
- PCI Express Bus
- AGP Bus

CPU (Main Processor)

The main component of any motherboard is the main processor chip which controls all the inner functions of the system. The **Central Processing Unit** (CPU) functions as the brain of every PC.

The CPU is usually inserted into the socket provided for it on the motherboard, and is not soldered onto the motherboard, this makes its replacement, in case of any problem, very easy.

Another advanthage of having a socketed CPU is, one can choose the CPU according to ones requirement and budget.

Some of the common CPU chips by Intel are 8088, 8086, 80286, 80386, 80486, Pentium, Pentium-II, Pentium-III, Pentium-4 etc.

Coprocessor

What is a Coprocessor?

Coprocessor is a special purpose microprocessor which is used to speed up main processor job by taking over some of the main processor's work.
Most common type of coprocessor are math coprocessor and graphic coprocessor.

Coprocessor Chips are used to help the main processor in carrying out its functions.

- A math coprocessor helps main processor in performing mathematical calculations. A graphic coprocessor helps the main processor in carrying out video/graphic related operations.
- Older system (XT, AT, AT-386) required a coprocessor chips to be inserted into special socket on the motherboard, but the current generation of CPU's have math coprocessor built inside the main processor itself.

Memory

What is Memory?

Memory is the place where computer stores the **program** (set of instruction telling the computer what you want to do), and **data** that help the program in carrying out its operations.
For example, to print students marks sheets, the computer will require a marks sheet printing program, and student's roll number, name and marks obtained in various subjects as data. This program and data is kept in the memory.

There is basically two type of memory used in the computer

- RAM Memory
- ROM Memory

RAM Memory

RAM or **Random Access Memory** is a **read/write type** of memory which is used by the processor to keep program, data and intermediate results during the program executions.

It is a **volatile type** of memory, i.e. it lose its content when the power supply to it is switched off

The physical installation of RAM memory on the motherboard can take place in various ways

- **DIP** (Dual In-line Pin) memory chips were used on initial motherboards
- later the **SIMM** (Single Inline Memory Modules) became common
- currently **DIMM** (Dual Inline Memory Modules) are most common memory module.

Read Only Memory (ROM)

ROM or **Read Only Memory**, as its name suggest is a read only type of memory. One can not write into a ROM, data is written into it by the manufacturer.

- One major advantage with the ROM is, it is **nonvolatile** type of memory i.e. it does not lose its content when the power supply to it is switched off.
- A motherboard normally contains one or more of these ROM chips.
- The memory capacity of a ROM varies from one type of system to another. 64KiloByte (KB) was normally sufficient for a XT system, whereas a P4 based motherboard requires 2MegaByte (MB) or more ROM.

BIOS (Basic Input Output System)

What is BIOS?

BIOS is an abbreviation of **Basic Input Output System**. It is one of the most important program stored in the ROM.
BIOS program lets your application program and the hardware such as floppy disk, hard disk, video adapter etc. communicate with each other.
It is pronounced "**bye-os**".

- The BIOS also contains a program called **Power-On-Self-Test** or **POST**. This POST program check the motherboard and other devices connected to the computer during the system power-on time.

IBM made the original BIOS for their PCs, which is their copyrighted product, but many compatible BIOS program are available from **Award, Phoenix, American Megatrends Inc. (AMI)** etc. various manufacturers.

CMOS (Complementary Metal Oxide Semiconductor) Memory

In old IBM XT or compatible system, BIOS with the help of jumpers detected what all components are connected to the computer system.

- IBM AT and higher systems do not contain these jumper switches and instead use a **CMOS memory** to store the system configuration, date, time etc. information.
- This CMOS memory receives power from a battery accompanying it, this battery helps it retains the information stored in it even when the system is switched off.

When an AT or higher system is switched on, BIOS matches the information stored inside the CMOS with the components connected to the system and if it

finds some mismatch or error the BIOS displays relevant error message, explaining the problem.

Support Chips/Chipsets

Apart from the CPU, memory and BIOS, motherboard also contains many controller chips and other devices to bind everything together.

- A typical system requires Interrupt controller, DMA Controller, Timer chip, Clock chip, Bus controller chip, I/O peripheral interface chip etc. to make the computer work as a complete unit.
- Modern developments in electronics have made it possible to produce very large scale integrated circuits (VLSIC), and now just two or three of these VLSIC chips can do all these works mentioned above, which were previously performed by dozens of individual chips.
- This set of VLSIC chips are called "**Chipsets**".
- A typical chipset contains one or two VLSIC chips with all the support logics required by the processor to function as a complete system.
- Currently these chipset include serial and parallel ports, floppy and hard disk controllers, USB support, LAN and audio support, and display support on the motherboard itself.

Large scale integration along with high-capacity memory chips, has led to even fewer components on a PC's motherboard.

Motherboard Configuration

A typical motherboard can be setup for different combinations of CPU, memory, input/out devices etc., one is required to select a proper setup.

- Most of the PC and XT class motherboards are set using jumpers or switches on the motherboard
- In the AT and later machines, the configuration options are stored in **CMOS RAM** and are set using the **SETUP** utility of the **BIOS ROM**.

The motherboard setup should always be perfect, as an incorrectly setup motherboard can cause the system to malfunction or even crash.

2

Expansion Bus/Slots

Expansion slot is the backbone of the computer. Without the expansion slots computer will not be of much use. If you want to add a new device to your computer–other than what is on the motherboard–you need an expansion slot.

- Address, data and control buses on the motherboard are connected to different expansion cards through the expansion slots on the motherboard.
- A new device can be connected to your basic computer system using these expansion cards.
- The wide range of possible expansion options make it impossible to actually figure out the exact number of expansion slots required in a motherboard.

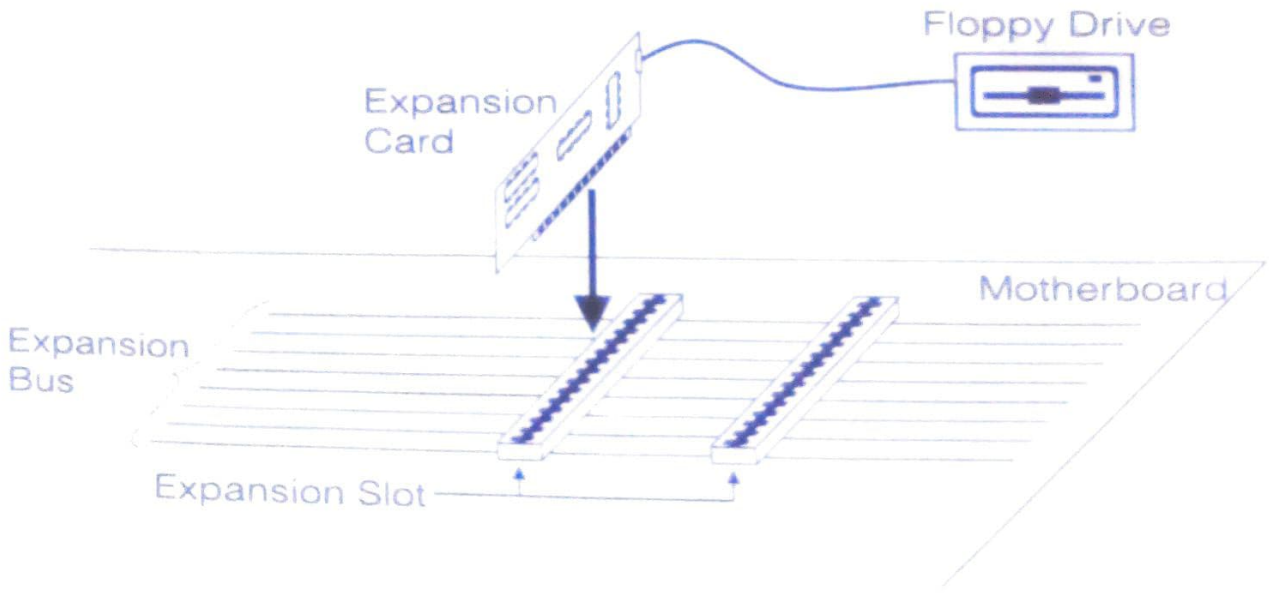

Fig. 2-1 : Expansion Bus and Expansion Slots on the Motherboard

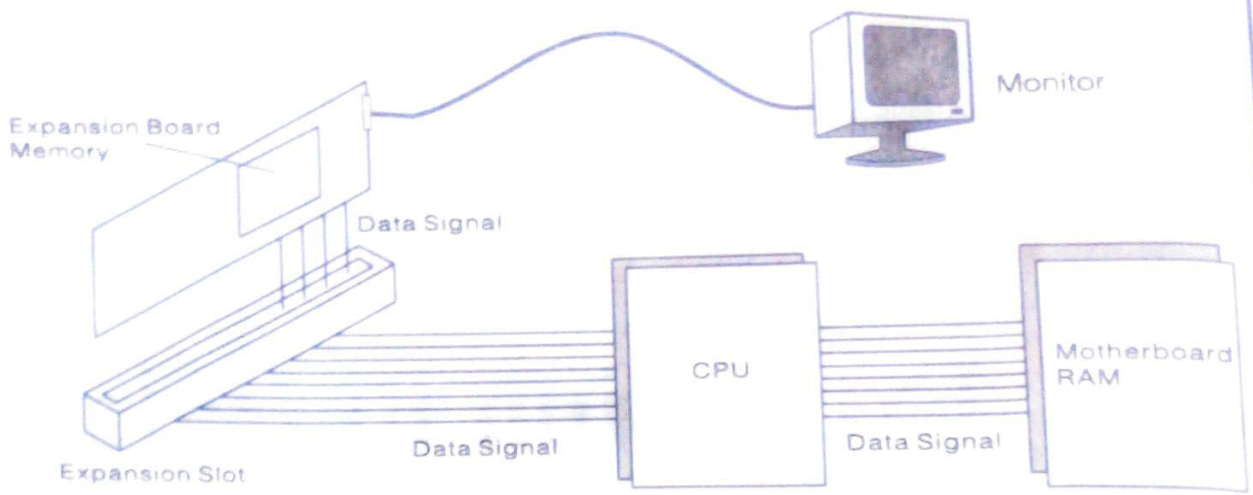

Fig. 2-2 : Data Dus on the Motherboard.

For example, if a system is using separate expansion slots for the

- floppy and hard disk controller,
- a serial card,
- a parallel card,
- a mouse card, and
- a video display card,

then a total of six different slots are required on the motherboard.

On the other hand if the motherboard contains built-in hard disk/floppy disk controller, serial & parallel I/O port, video and sound option then only one or two expansion slots are enough.

In this type of motherboards, it is safe in most cases to assume that a total of tow to three slots will be more than enough as spare for any new devices that one wants to connect to the computer.

Data Bus

What is Data Bus?

Data bus is a set of wires or tracks on the motherboard, which is used to transfer data from one part of the computer to another.

- The number of the data lines provided on the expansion bus is one very important factor that determines the speed of this data transfer.
- If the width of the data lines on the expansion bus is equal to the width of the data lines of the processor then the processor can move data through the expansion bus at the processor's maximum capacity.

- For example, if you have a 16 bit processor which can read and write 16 bit of data at a time, and if the expansion bus in your system is only 8 bit wide, then the processor will have to do two read operations to read a 16 bit data from memory.

Address Bus

What is Address Bus?

Address bus is a set of wires or tracks on the motherboard, which is used to specify address of a memory location.

The maximum memory that the CPU can address depends on the size of its **Address Bus**.

Address bus with one address line can address two locations, a binary 0 on the address line will select first location and binary 1 on the address line will select the second location.

A bus with 2 address lines can address 4 locations, as shown below

1st line	2nd line	Addressed location
0	0	1st
0	1	2nd
1	0	3rd
1	1	4th

A bus with 3 address lines can address 8 different locations

1st line	2nd line	3rd line	Addressed location
0	0	0	1st
0	0	1	2nd
0	1	0	3rd
0	1	1	4th
1	0	0	5th
1	0	1	6th
1	1	0	7th
1	1	1	8th

So, the relation between the number of addressable locations and the number of address lines is

Addressable locations = $2^{\text{Number of Address Lines}}$

i.e. if you have 3 address lines total addressable locations will be $2^3 = 8$.

- The 32 bit PCI Local bus uses 32 address lines and it can address 2^{32} = 4,294,967,296 different locations i.e. 4096 Mega Bytes of memory locations.

Fig. 2-3 . 8-Bit ISA Expansion Card.

Type of Expansion Slots

Expansion slots are long thin connectors on the motherboard, on which one can connect various expansion cards such as display card, floppy drive/hard drive controller card, sound card, network card etc.

These slots are categorized according to the number of bits that they can transfer at a time and the bus architecture used.

The expansion slots can be divided into the following categories

- 8-bit ISA
- 16-bit ISA
- MCA
- EISA
- VESA Local or VL Bus
- PCI Local Bus
- AGP
- PCI Express

Modern Pentium based motherboards manufacturers stopped using ISA slots, they provide only PCI, AGP and PCI Express slots.

Let us see these different bus architectures in some more detail

The 8-Bit ISA

ISA stands for **Industry Standard Architecture**, and this is the first and the most common bus architecture for the PCs.

- This bus is also referred to as "**Classic AT Bus**".
- This type of adapters have total 62 contacts at the bottom of the adapter card, i.e. 31 contacts on each side of the card.
- These contacts contains 8-bit data line, 20-bit address line, and power and control lines.

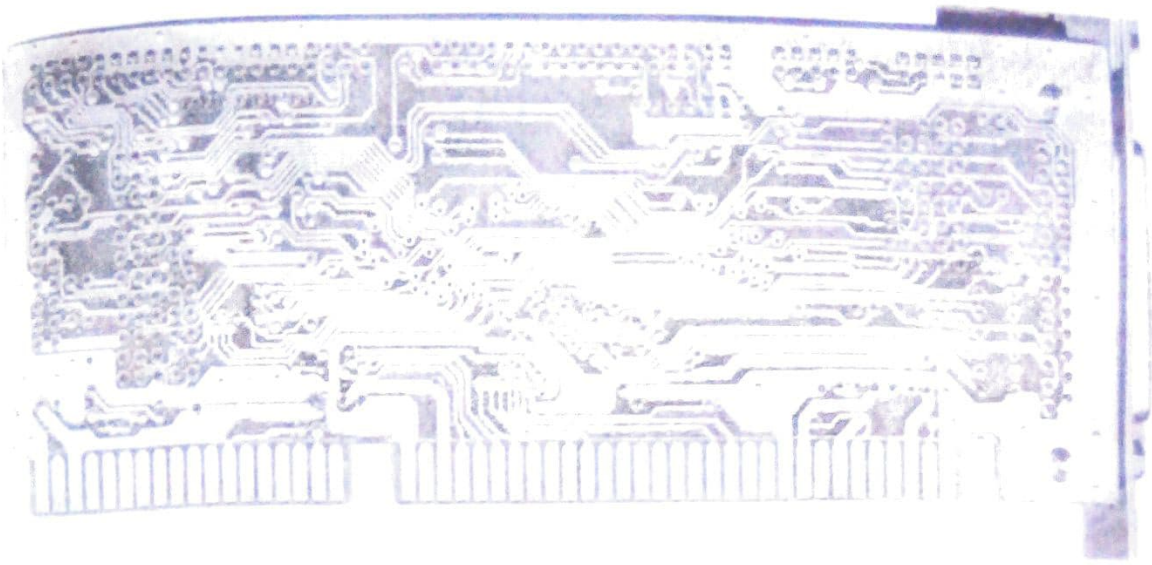

Fig. 2-4 : 16-Bit ISA Card.

- The main disadvantage of this bus is, whenever a new device is connected to this bus, various jumper and DIP switch settings are required.

The 16-Bit ISA

Because of the 16-bit data line available in the 80286 processor (used in the AT machines), AT motherboard's are equipped with 16-bit ISA bus.

- When designing these 16-bit ISA slots, IBM had added another 36 new connector (i.e. 18 on each side) to the existing 8-bit ISA slots.
- This makes the 16-bit ISA slots compatible with the existing 8 bit ISA card.
- An 8-bit ISA card can be used in the 16-bit ISA slot without any change or modification in the 8-bit card
- Even though one can physically connect all the 8-bit cards to the 16-bit slot, some 8-bit cards may not work properly in the AT environment.

MCA

MCA or "**Micro Channel Architecture**" bus technology is based on a completely new bus design introduced by the IBM for their PS/2 range of machines.

The MCA never became a popular bus architecture because of two main reasons.

- First reason is that MCA was not compatible with the existing ISA technology, it required completely new expansion cards.
  All your existing ISA cards will become useless when you upgrade from an ISA motherboard to MCA motherboard.
- The second reason is IBM had made the earlier 8 bit and 16 bit ISA bus system as an **Open System**, i.e. anybody could make and sell ISA cards.
  But the MCA architecture was made a **Proprietary System** by the IBM, and

they allowed only a few manufacturer to make MCA adapters and charged high license fee from them.
This made the MCA adapters very expensive compared to the ISA cards.

The MCA is available in 16 bit and 32 bit architecture.

Two new concept introduced with the MCA is now being used by many newer bus technologies such as PCI etc., they are

- Auto configure
- Bus mastering

Auto Configure

This allow the user to connect any device to the MCA bus without worrying about the IRQ, INTerrupt and DMA channel setup problems.

- Devices connected to these buses automatically configure themselves based on the settings of other devices in the system.
- There was no need for the user to set any jumpers or switches on these cards or the motherboard.
- "Auto configure" is another name for Plug-and-Play.

Bus Mastering

Bus mastering allows the peripheral device to take the control of the bus from the CPU for a short time.

Using this facility the device can transmit or receive large blocks of data in a short burst modes.

EISA

EISA or **Extended Industry Standard Architecture**, is a bus architecture created by a group of nine computer manufacturers in response to the MCA bus design introduced by the IBM.

- One big plus point in favor of the EISA was that even though it was a 32 bit bus technology, it was fully compatible with the 8 bit ISA and 16 bit ISA adapters.
- When one buys a 32 bit EISA motherboard, all the old 8 bit and 16 bit ISA cards can be used into the new motherboard.
- The EISA adapters have 90 new connections, but the size of the EISA card is same as the size of 16 bit ISA card.
- This is achieved by using two rows of connector on the EISA cards, the top connectors are same as the 16 bit ISA connectors and the bottom row has 55 new signals.

- The edge connector of the EISA adapter is longer than the connector on the 8 bit and 16 bit ISA connectors. This makes it impossible for the user to force an ISA connector down into the EISA slot and short circuit the EISA signals.
- When an EISA card is fully inserted into the EISA slot, both the upper and the lower contacts are made and the card works in EISA mode.
- The EISA card runs at a fixed frequency between 6 to 8.33 MHz, this is done to make it compatible with the ISA bus.

Like the MCA architecture, the EISA technology allows "**bus mastering**" and "**auto configure**" options.

LOCAL BUS

One major drawback of the ISA or even the EISA bus is they do not allow the devices connected to them to communicate with the CPU at the maximum speed that the CPU can offer.

If you have a motherboard with 33 MHz CPU and your expansion slot is a 8 MHz, 8 or 16 bit ISA slot, than the device such as video or the hard disk connected to these slots, can not operate at their full capability.

This situation is somewhat like trying to send the water coming in a 6 inch diameter pipe through a 1 inch pipe.

- A **local bus** slot on the ISA/EISA motherboard allows the device connected to it to communicate with the CPU at the speed, the CPU is capable of.
- There are many local bus design in the market. Most of the proprietary designs from one manufacturer will not work with the card from other manufacturers.

VESA Local Bus is an industry standard local bus fr 486 CPU based motherboard, Whereas a Pentium based motherboard use PCI Local Bus slots.

VESA Local Bus / VL Bus

VESA stands for **Video Electronics Standard Association**, which is an association of video adapters and monitor manufacturers to standardize the PC video specifications.

Two main use of the VL bus slot is for connecting

- Video adapter and
- Hard disk drive adapter,

as these two devices requires very fast access by the CPU.

The network adapter card can also be connected to the Local Bus expansion slot to gain the speed improvement.

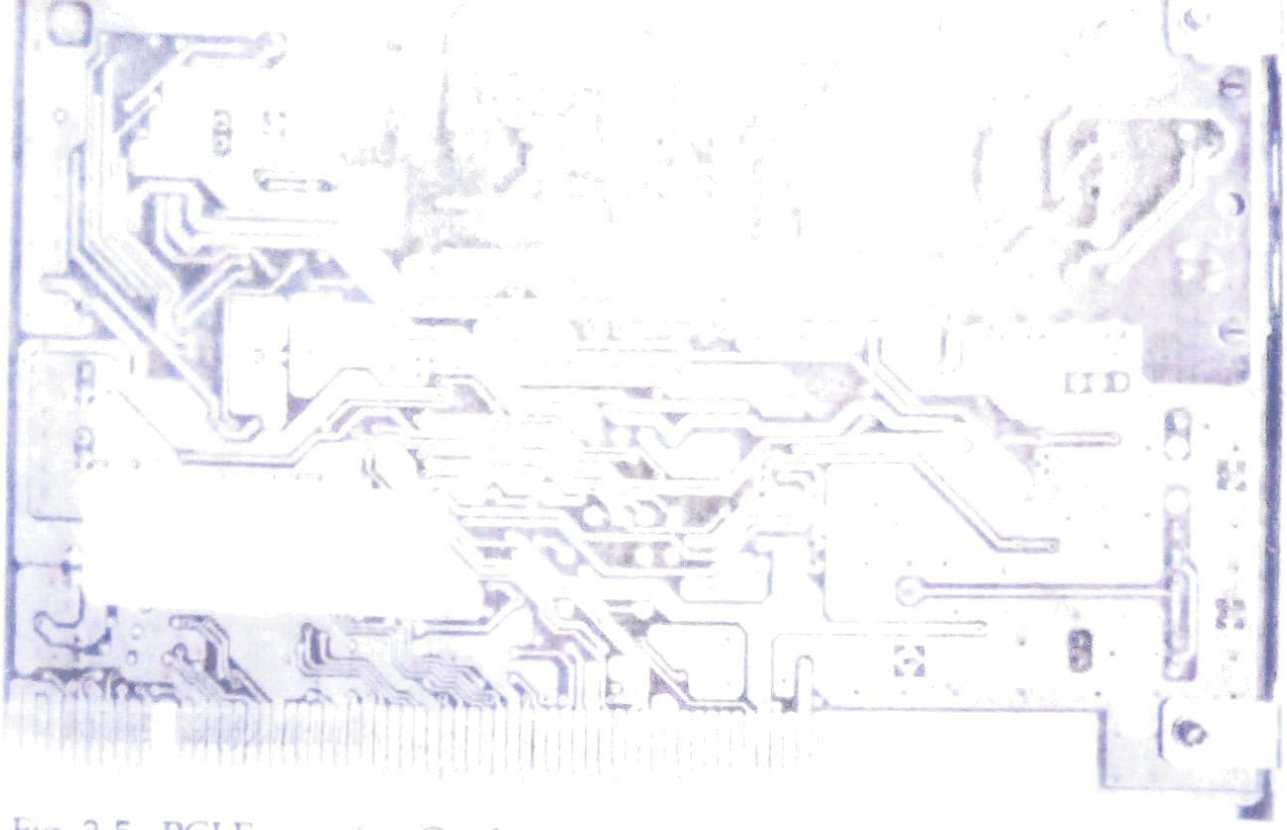

Fig. 2-5 : PCI Expansion Card.

GUI's (**Graphical User Interface**) like Windows operating system will show a great deal of speed improvement with a VL Bus video adapter.

- The maximum speed limit for the VL Bus specification is 33MHz without any wait state.
- The VL Bus can move data between the processor and the video or any other device connected to the VL Bus at the 32 bit data at a time.
- The maximum throughput of the VL Bus is rated to be about 130 Mega bytes per second, which is about **16 times faster than ISA**.
- Physically the VESA Local Bus slot is an extension to the 16 bit ISA slot, i.e. a VL Bus slot can be used either for an 8 bit ISA card, 16 bit ISA card or for a VL Bus compatible card.

The VESA standard specify that at a time not more than 3 VL Bus devices should be connected to the motherboard.

This is done to avoid putting too much load on these buses, which will slow them down.

PCI Local Bus

Even though the VL Bus is the best option for a 486 machine, when the Intel introduced the Pentium CPU, with the 64 bit data path and 60-200 MHz speed, the VL Bus could not take complete advantage of these improvements.

The VL Bus had the limitation of 32 bit path and 33MHz maximum speed.

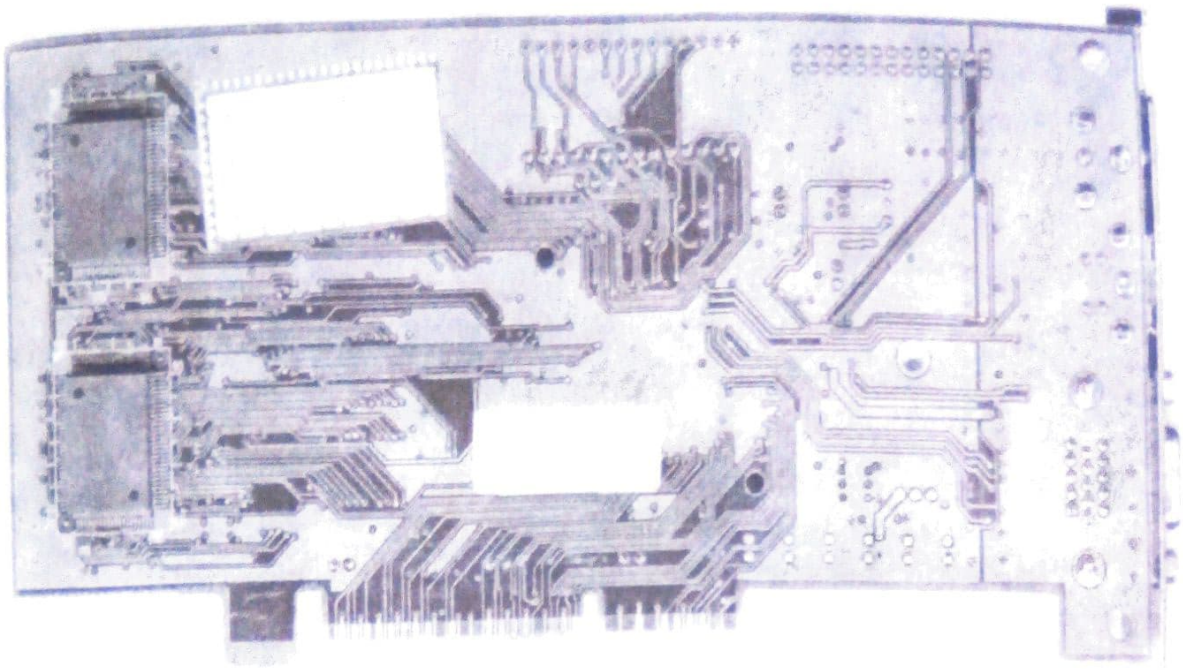

Fig. 2-6 : AGP Expansion Card.

To overcome these limitations Intel provided a completely different local bus specification called **PCI** or **Peripheral Component Interconnect**.

- With the Pentium or the 586 processor the PCI is standard local bus.
- PCI supports 130 megabyte per second bandwidth, and it takes full advantage of the 64 bit data path of the Pentium processor.
- The PCI bus can communicate with the devices connected to it at 60 to 66MHz speed compared to the maximum 33MHz speed of the VESA Local bus.
- It supports 10 devices compared to the maximum 3 by the VL Bus.
- PCI originally operated at 33 MHz using a 32-bit-wide path. Currently, PCI-X provides for 64-bit transfers at a speed of 133 MHz for 1-GBps (gigabyte per second) transfer rate.

AGP

AGP or Accelerated Graphics Port is a high speed bus for the display boards. Some of the features of AGP bus are

- If allows the video board to use system memory (RAM), as video memory.
- It is four to eight times faster than the PCI.

AGP slot on the motherboard can be easily distinguished because it is slightly offset from the other PCI slots, is usually darker in color.

As this slot is used only for display card, motherboards have only one AGP slot. First AGP's speed was 1X, todays latest P4 systems offer 8X and higher AGP.

PCI Express

PCI Express is the successor to today's PCI expansion bus. It was under development for years as 3GIO (3rd generation input/output bus).

PCI Express represents a radical change from current generation of expansion bus architectures. Instead of using low-speed parallel lines, PCI Express use high-speed serial signaling.

It basically works as a switched design for point-to-point communications between devices. With each device getting the full bandwidth of the system during transfers.

It does not use any control signals such as interrupts, instead, it uses a packet-based system to exchange both data and commands. All data and commands for PCI Express devices are contained in packets, which incorporate error correction to ensure the integrity of transfers.

In its initial implementation, PCI Express uses a four-wire interconnection system, two wires each (a balanced pair) for separate sending and receiving channels.

For devices that require higher data rates, PCI Express allows for multiple lanes within a single channel. The PCI Express hardware divides the data between the multiple lanes for transmission and reconstructs it at the other end of the connection.

PCI Express specifications allow for channels with 1, 2, 4, 8, 12, 16, or 32 lanes.

While designing PCI Express specification the designers had to accommodate the conflicting needs of compatibility while keeping up with advancing technology. So, they chose a layered approach with the top "software layer" designed to match current PCI protocols, while the lowest "physical layer", permits multiple variations.

In the PCI Express there are five layers:

- Config/OS - Handles configuration at the operating system level based on the current PCI Plug-and-Play specifications.
- Software - This layer uses the same drivers as the standard PCI bus. This is the main layer that interacts with the host operating system.
- Transaction - This is a packet-based protocol for passing data between the devices. This layer handles the send and receive functions.
- Data Link - This layer ensures the integrity of the transfers with full error-checking using a CRC code.
- Physical - This is the PCI Express hardware itself.