Basic Structure of Computers

Objective: To Understand the structure of computer

Outcomes: Students will be able to:

1. Describe various structures of computer and how the data is represented in the computer.

Syllabus:

Computer Types (Brief History-First Generation, Second Generation, Third Generation), Functional unit-ALU, Control unit, Memory Unit, I/O Unit , Basic OPERATIONAL concepts-, Bus structures, Software, Performance, multiprocessors and multi computers, Data Representation (Data Types, Complements, Fixed Point Representation-Integer, Arithmetic addition and subtraction, overflow, Decimal Fixed- point representation)Floating – Point Representation, Error Detection codes-Parity bit generation.

Computer Types

- Computer is a fast electronic calculating machine which accepts digital input, processes it according to the internally stored instructions (Programs) and produces the result on the output device.
- The computers can be classified into various categories as given below.

1. Micro Computer
2. Laptop Computer
3. Work Station
4. Super Computer
5. Main Frame
6. Hand Held
7. Multi core

1. ***Micro Computer****:* A personal computer is designed to meet the computer needs of an individual, providing access to a wide variety of computing applications, such as word processing, photo editing, e-mail, and internet.

2. ***Laptop Computer****:* A portable, compact computer that can run on power supply or a battery unit. All components are integrated as one compact unit. It is generally more expensive than a comparable desktop. It is also called a Notebook.

3. ***Work Station:*** Powerful desktop computer designed for specialized tasks. Generally used for tasks that requires a lot of processing speed. Can also be an ordinary personal computer attached to a LAN (local area network).

4. ***Super Computer:*** A computer that is considered to be fastest in the world. It is used to execute tasks that would take lot of time for other computers. For Eg: Modeling weather systems, genome sequence, etc.

5. ***Main Frame****:* Large expensive computer capable of simultaneously processing data for hundreds or thousands of users. Used to store, manage, and process large amounts of data that need to be reliable, secure, and centralized.

6. ***Hand Held:*** It is also called a PDA (Personal Digital Assistant). A computer that fits into a pocket, runs on batteries, and is used while holding the unit in your hand. Typically used as an appointment book, address book, calculator and notepad.

7. ***Multi Core****:* Have Multiple Cores – parallel computing platforms. Many Cores or computing elements are present in a single chip. Typical Examples: Sony Play station, Core 2 Duo, i3, i7 etc.

Functional Unit

- A computer in its simplest form comprises of five functional units namely input unit, output unit, memory unit, arithmetic & logic unit and control unit. Below figure depicts the functional units of a comp**uter system.**

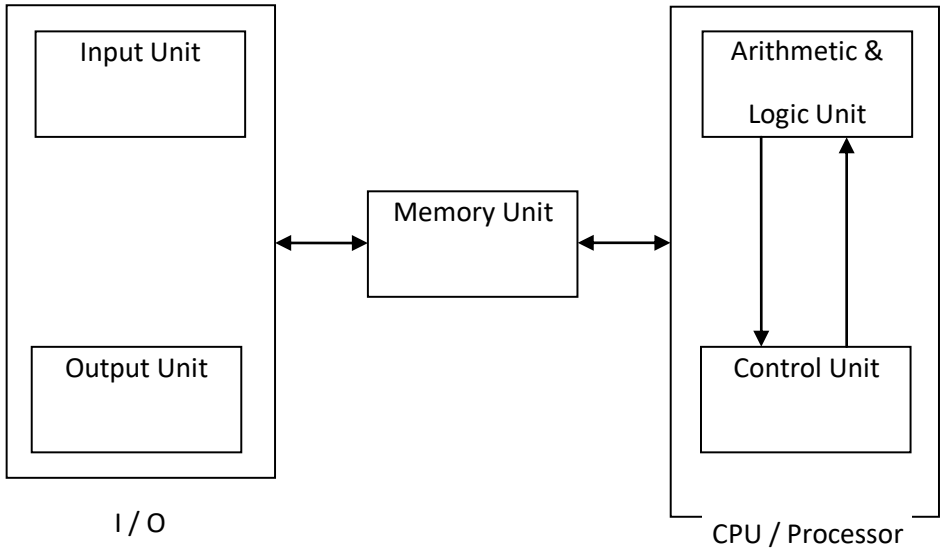


Figure 1: Basic functional units of a computer

1. Input Unit: Computer accepts encoded information through input unit. The standard input device is a keyboard. Whenever a key is pressed, keyboard controller sends the code to CPU/Memory.

Examples include Mouse, Joystick, Tracker ball, Light pen, Digitizer, Scanner etc.

2. Output Unit*:* Computer after computation returns the computed results, error messages, etc. via output unit. The standard output device is a video monitor, LCD/TFT monitor. Other output devices are printers, plotters etc.

3. Memory Unit: Memory unit stores the program instructions (Code), data and results of computations etc.

Memory unit is classified as:

- Primary /Main Memory
- Secondary /Auxiliary Memory

4. Arithmetic and logic unit*:* ALU consist of necessary logic circuits like adder, comparator etc., to perform operations of addition, multiplication, comparison of two numbers etc.

5. Control Unit: Control unit co-ordinates activities of all units by issuing control signals. Control signals issued by control unit govern the data transfers and then appropriate operations take place.

Control unit interprets or decides the operation/action to be performed.

Basic OPERATIONAL concepts:

The operations of a computer can be summarized as follows:

1. A set of instructions called a program resides in main memory.
2. The CPU fetches those instructions sequentially one by one from main memory and decodes them and performs specified operation on associated data operands in ALU.
3. Processed data and results will be displayed on output unit.
4. All activities pertaining to processing and data movement inside the computer are governed by control unit.

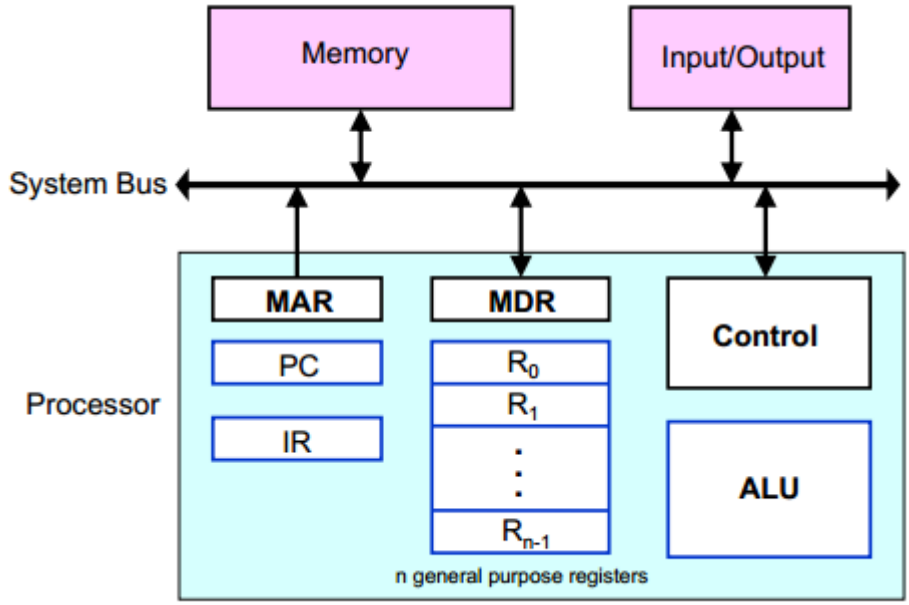
An instruction consists of two parts:

1. Operation code (opcode)
2. Operand

Opcode	Operand

1. Operation code (opcode): It denotes the operation to be performed. Beside the opcode itself, most instructions also specify the data they will process, in the form of operands.

eg: ADD Loc A, R_0



Bus Interconnection:

Bus is a communication part connecting two or more devices .It is a shared transmission medium where multiple

Devices are connected to the bus and signal is transmitted by one device is received by other devices attached to the bus.

In bus each line is capable of sending signals which are nothing but binary zero and binary one.

Several lines of a bus can be used to transmit binary digits simultaneously.

Eg: 8bits bus can transfer 8bits at a time there are 2types of buses.

1) Internal bus (System bus) 2) External bus.

External bus: It is used to connect the external devices of CPU or peripheral devices such as key board, Mouse, etc to the CPU.

In internal class we have 3 types of signals.

1. Data lines
2. Address lines
3. Control lines

1**) Data lines:** They provide the path for Moring the data between system modules. These lines collectively called data bus.

2) Address lines: They are used to designate the source and destination of the data on the data bus.

For ex: Of a processor wants to read a word from memory then the processor will put the address of the word on the address line.

3) Control lines: These are used to control the data and address lines access.

Control signals are divided in to 2 types.

1) Timing signals: Which indicate the validity of the data and address information.

2**) Command signals**: They specify operations to be performed.

Typical control lines include the following:

1) Memory Write
2) Memory Read
3) I/O Read
4) I/O Write
5) Transfer Ack(Acknowledgement)
6) Bus request
7) Bus Grant
8) Interrupt request
9) Interrupt Ack
10) Clock

11) Reset

1) **Memory Write:** It causes the data on the bus to be written in to the address location.
2) **Memory read**: It causes the data on the address location to be placed on the bus.
3) **I/O Read**: It causes the data form address I/O port to be placed on the bus.
4) **I/O Write:** It causes data on the bus to be output to the address I/O port.
5) **Transfer Ack:** Indicates that data have been accepted form or placed on the bus.
6) **Bus requests**: Indicates that a module needs to gain control of the bus.
7) Bus grant: Indicates requesting module has been granted control of the bus.
8) **Interrupt requests:** Indicates that an interrupt is pending.
9) **Interrupt Ack**: Acknowledges that the pending interrupt has been recognized.
10) **Clock:** used to synchronize operations.
11) **Reset:** Initializes all modules.

Data representation :

Data itself has no meaning, but becomes information when it is assigned a meaning or interpreted. Information is a collection of facts or data that is communicated.

The data types found in registers in digital computers may be classified as being one of the following categories:

1) numbers used in arithmetic computations
2) letters of the alphabet used in data processing
3) other discrete symbols used for specific purposes

Number System:

radix:radix is denoted by ' r'. It is a system that uses distinct symbols. It is also called base and it is the number of unique digits including zero.

Decimal number system: In decimal radix =10, it includes ten symbols 0,1,2,3,4,5,6,7,8,9.

ex: the string of digits 724.5 is represented as

$7 \times 10^2 + 2 \times 10^1 + 4 \times 10^0 + \times 10^{-1}$

binary number system:

in binary radix =2,it includes 2 symbols 0 and 1.

octal number system:

in octal radix =8,it includes 8 symbols 0,1,2,3,4,5,6,7.

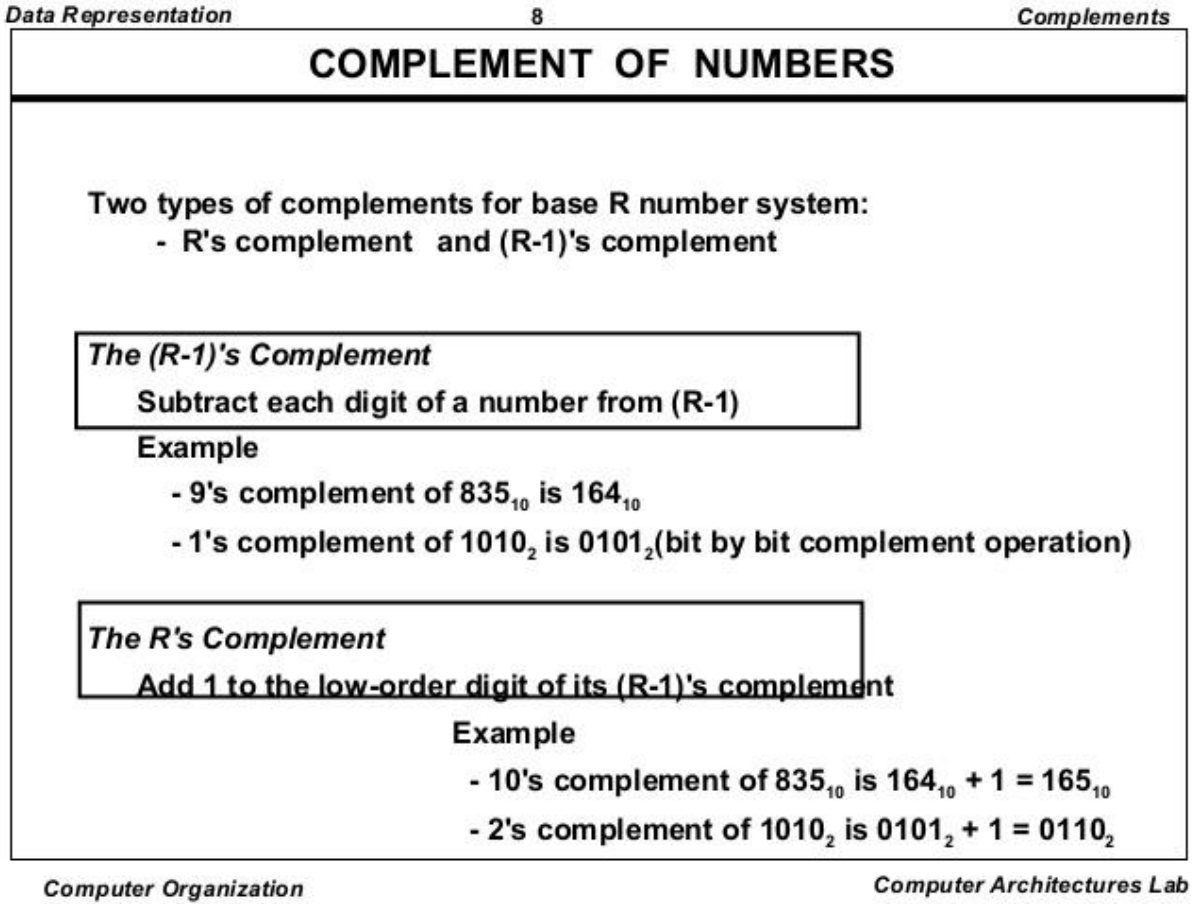
hexa-decimal number system:

in hexa-decimal radix =16,it includes 16 symbols 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F.

alpha-numeric representation: The alphanumeric character set is set of elements that includes 10 decimal digits, the 26 letters of the alphabet and a number of special characters, such as $,+ and =.

ASCII:(American Standard Code for Information Interchange)

it contains 128 characters .it uses 7 bits of code which includes digits (0 to 9),alphabets (a to z ,A to Z) and symbols include ($,+,*,&...)



FIXED POINT NUMBERS

Numbers: Fixed Point Numbers and Floating Point Numbers

Binary Fixed-Point Representation

$X = x_n x_{n-1} x_{n-2} \ldots x_1 x_0 . x_{-1} x_{-2} \ldots x_{-m}$

Sign Bit(x_n): 0 for positive - 1 for negative

Remaining Bits($x_{n-1} x_{n-2} \ldots x_1 x_0 . x_{-1} x_{-2} \ldots x_{-m}$)

- Following 3 representations

  Signed magnitude representation
  Signed 1's complement representation
  Signed 2's complement representation

Example: Represent +9 and -9 in 7 bit-binary number

Only one way to represent +9 ==> 0 001001

Three different ways to represent -9:

In signed-magnitude: 1 001001
In signed-1's complement: 1 110110
In signed-2's complement: 1 110111

In general, in computers, fixed point numbers are represented either integer part only or fractional part only.

FLOATING POINT NUMBER REPRESENTATION

* The location of the fractional point is not fixed to a certain location
* The range of the representable numbers is wide

$F = EM$

m_n	$e_k e_{k-1} \ldots e_0$	$m_{n-1} m_{n-2} \ldots m_0 . m_{-1} \ldots m_{-m}$
sign	exponent	mantissa

- Mantissa
  Signed fixed point number, either an integer or a fractional number

- Exponent
  Designates the position of the radix point

Decimal Value

$V(F) = V(M) * R^{V(E)}$

M: Mantissa
E: Exponent
R: Radix

A. Questions testing the remembering / understanding level of students

I) Objective Questions

1. A collection of lines that connects several devices is called..... ( )

A) bus

B) peripheral connection wires

C) Both a and b

D) internal wires

2. A complete microcomputer system consists of..... ( )

A) Microprocessor

B) memory

C) peripheral equipment

D) all of the above

3. Program Counter (PC) is also called..... ( )

A) Instruction pointer

B) memory pointer

C) data counter

D) file pointer

4. CPU does not perform the operation..... ( )

A) data transfer

B) logic operation

C) arithmetic operation

D) all of the above

5. The original ASCII code used…bits of each byte, reserving that last bit for error checking ( )

a. 5 b. 6 c. 7 d. 8

6. What are the three decisions making operations performed by the ALU of a computer? ( )

a. Greater than

b. Less than

c. Equal to

d. All of the above

II) Descriptive Questions

1. Discuss three representations of Signed integers with suitable examples.
2. Explain the components of the Computer system.
3. List and explain the steps involved in the execution of a complete instruction.
4. What are 2's Compliment? Give its Significance?
5. Explain the functional architecture of the computer system.
6. Discuss the concept of compliments used to represent signed numbers.
7. What is instruction cycle? Briefly explain with the help of state diagram?
8. Describe the connections between the processor and memory with a neat structure diagram
9. What Sign magnitude representation? Give an example?
10. Draw the structure of basic computer system?
11. Discuss about fixed point and floating point representations
12. What are functions of ALU and explain.

B. Question testing the ability of students in applying the concepts.

I) Multiple Choice Questions

1. The _____ format is usually used to store data. [ ]

a) BCD

b) Decimal

c) Hexadecimal

d) Octal

2. The ALU makes use of _____ to store the intermediate results .

a) Accumulators

b) Registers

c) Heap

d) Stack

3. The control unit controls other units by generating ____ .

a) Control signals

b) Timing signals

c) Transfer signals

d) Command Signals

4. To reduce the memory access time we generally make use of _____ .

a) Heaps

b) higher capacity RAM's

c) SDRAM's

d) Cache's

5. _____ bus structure is usually used to connect I/O devices.

a) Single bus

b) multiple bus

c) Star bus

d) Rambus

6. The 8-bit encoding format used to store data in a computer is _____ .

a) ASCII

b) EBCDIC

c) ANCI

d) USCII

7. The decoded instruction is stored in _____ .

a) IR

b) PC

c) Registers

d) MDR

8. Which registers can interact with the secondary storage?

a) MAR

b) PC

c) IR

d) R0

II) Application Oriented Questions

1. Find 2's complement of the following

i) 10010 ii) 111000 iii) 0101010 iv) 111111

2. Perform the subtraction with the following unsigned decimal numbers by taking the 10's complement of the subtrahend.

a) 5250-1321 b)1753-8640.

c) 20-100 d) 1200-250.