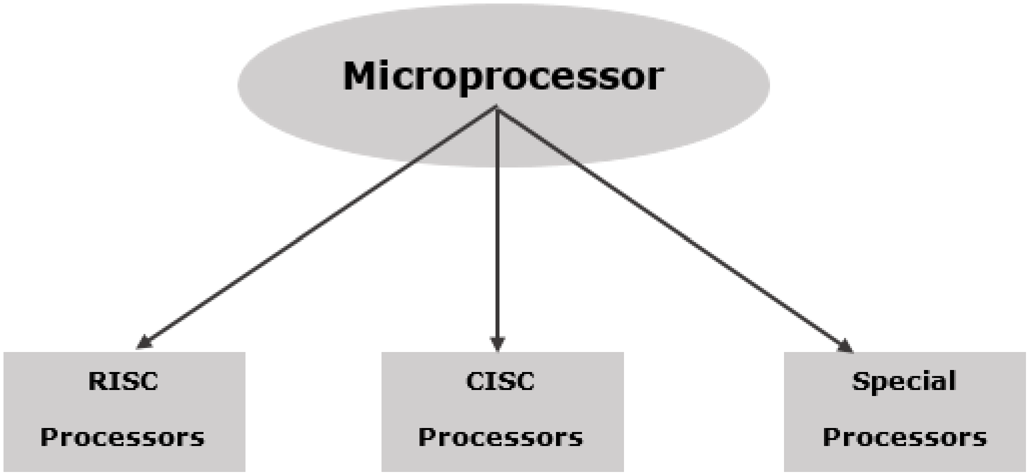
Features of a Microprocessor

Here is a list of some of the most prominent features of any microprocessor −

- **Cost-effective** − The microprocessor chips are available at low prices and results its low cost.
- **Size** − The microprocessor is of small size chip, hence is portable.
- **Low Power Consumption** − Microprocessors are manufactured by using metaloxide semiconductor technology, which has low power consumption.
- **Versatility** − The microprocessors are versatile as we can use the same chip in a number of applications by configuring the software program.
- **Reliability** − The failure rate of an IC in microproce



ssors is very low, hence it is reliable.

Classification of Microprocessor:-

A microprocessor can be classified into three categories −

RISC Processor

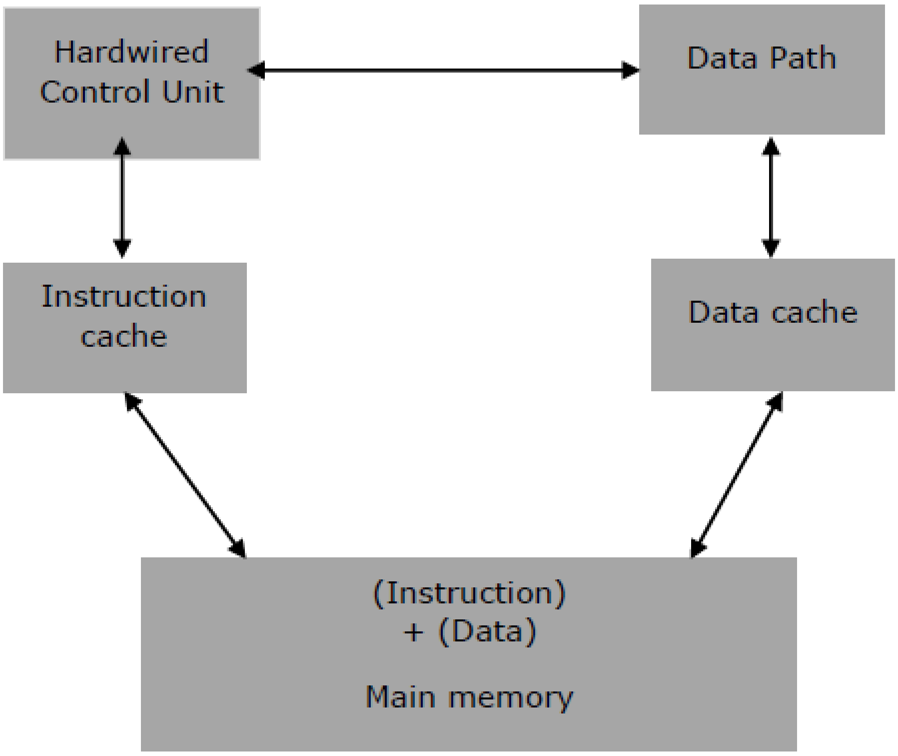
RISC stands for **Reduced Instruction Set Computer**. It is designed to reduce the execution time by simplifying the instruction set of the computer. Using RISC processors, each instruction requires only one clock cycle to execute results in uniform execution time. This reduces the efficiency as there are more lines of code, hence more RAM is needed to store the instructions. The compiler also has to work more to convert high-level language instructions into machine code.

Some of the RISC processors are −

- Power PC: 601, 604, 615, 620
- DEC Alpha: 210642, 211066, 21068, 21164
- MIPS: TS (R10000) RISC Processor
- PA-RISC: HP 7100LC

Architecture of RISC

RISC microprocessor architecture uses highly-optimized set of instructions. It is used in portable devices like Apple iPod due to its power efficiency.



Characteristics of RISC

The major characteristics of a RISC processor are as follows −

- It consists of simple instructions.
- It supports various data-type formats.
- It utilizes simple addressing modes and fixed length instructions for pipelining.
- It supports register to use in any context.
- One cycle execution time.
- “LOAD” and “STORE” instructions are used to access the memory location.
- It consists of larger number of registers.
- It consists of less number of transistors.

CISC Processor

CISC stands for **Complex Instruction Set Computer**. It is designed to minimize the number of instructions per program, ignoring the number of cycles per instruction. The emphasis is on building complex instructions directly into the hardware.

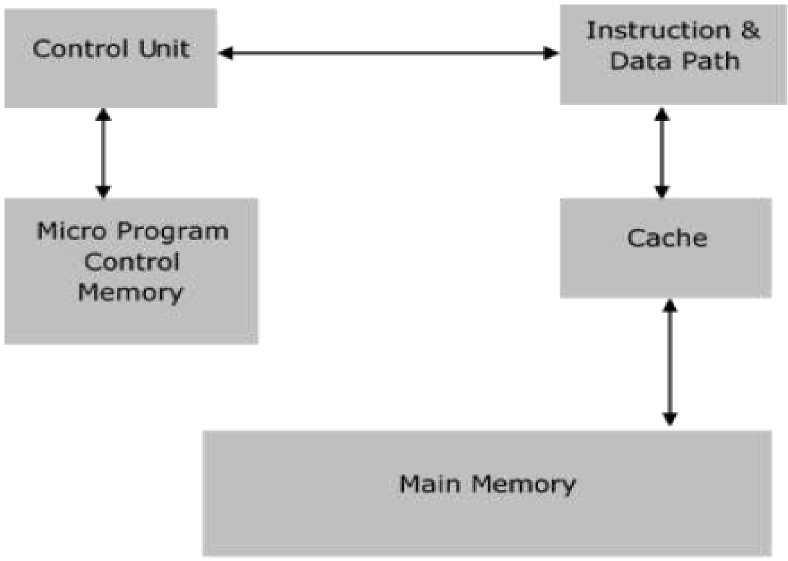
The compiler has to do very little work to translate a high-level language into assembly level language/machine code because the length of the code is relatively short, so very little RAM is required to store the instructions.

Some of the CISC Processors are −

- IBM 370/168
- VAX 11/780
- Intel 80486

Architecture of CISC:-

Its architecture is designed to decrease the memory cost because more storage is needed in larger programs resulting in higher memory cost. To resolve this, the number of instructions per program can be reduced by embedding the number of operations in a single instruction.



Characteristics of CISC

- Variety of addressing modes.
- Larger number of instructions.
- Variable length of instruction formats.
- Several cycles may be required to execute one instruction.
- Instruction-decoding logic is complex.
- One instruction is required to support multiple addressing modes.

Special Processors

These are the processors which are designed for some special purposes. Few of the special processors are :-

Coprocessor:-

A coprocessor is a specially designed microprocessor, which can handle its particular function many times faster than the ordinary microprocessor.

For example − Math Coprocessor.

Some Intel math-coprocessors are −

- 8087-used with 8086
- 80287-used with 80286
- 80387-used with 80386

Input/Output Processor:-

It is a specially designed microprocessor having a local memory of its own, which is used to control I/O devices with minimum CPU involvement.

For example −

- DMA (direct Memory Access) controller
- Keyboard/mouse controller
- Graphic display controller
- SCSI port controller

Transputer (Transistor Computer):-

A transputer is a specially designed microprocessor with its own local memory and having links to connect one transputer to another transputer for inter-processor communications. It was first designed in 1980 by Inmos and is targeted to the utilization of VLSI technology.

A transputer can be used as a single processor system or can be connected to external links, which reduces the construction cost and increases the performance.

For example − 16-bit T212, 32-bit T425, the floating point (T800, T805 & T9000) processors.

DSP (Digital Signal Processor):-

This processor is specially designed to process the analog signals into a digital form. This is done by sampling the voltage level at regular time intervals and converting the voltage at that instant into a digital form. This process is performed by a circuit called an analogue to digital converter, A to D converter or ADC.

A DSP contains the following components −

- **Program Memory** − It stores the programs that DSP will use to process data.
- **Data Memory** − It stores the information to be processed.
- **Compute Engine** − It performs the mathematical processing, accessing the program from the program memory and the data from the data memory.
- **Input/Output** − It connects to the outside world.

Its applications are −

- Sound and music synthesis
- Audio and video compression
- Video signal processing
- 2D and 3d graphics acceleration.

For example − Texas Instrument's TMS 320 series, e.g., TMS 320C40, TMS320C50.

Architecture of 8085 Microprocessor:-

It is an 8-bit microprocessor designed by Intel in 1977 using NMOS technology.

It has the following configuration −

- 8-bit data bus
- 16-bit address bus, which can address upto 64KB
- A 16-bit program counter
- A 16-bit stack pointer
- Six 8-bit registers arranged in pairs: BC, DE, HL
- Requires +5V supply to operate at 3.2 MHZ single phase clock

It is used in washing machines, microwave ovens, mobile phones, etc.

8085 Microprocessor – Functional Units

8085 consists of the following functional units −

Accumulator

It is an 8-bit register used to perform arithmetic, logical, I/O & LOAD/STORE operations. It is connected to internal data bus & ALU.

Arithmetic and logic unit

As the name suggests, it performs arithmetic and logical operations like Addition, Subtraction, AND, OR, etc. on 8-bit data.

General purpose register

There are 6 general purpose registers in 8085 processor, i.e. B, C, D, E, H & L. Each register can hold 8-bit data.

These registers can work in pair to hold 16-bit data and their pairing combination is like B-C, D-E & H-L.

Program counter

It is a 16-bit register used to store the memory address location of the next instruction to be executed. Microprocessor increments the program whenever an instruction is being executed, so that the program counter points to the memory address of the next instruction that is going to be executed.

Stack pointer

It is also a 16-bit register works like stack, which is always incremented/decremented by 2 during push & pop operations.

Temporary register

It is an 8-bit register, which holds the temporary data of arithmetic and logical operations.

Flag register

It is an 8-bit register having five 1-bit flip-flops, which holds either 0 or 1 depending upon the result stored in the accumulator.

These are the set of 5 flip-flops −

- Sign (S)
- Zero (Z)
- Auxiliary Carry (AC)
- Parity (P)
- Carry (C)

Its bit position is shown in the following table −

D7	D6	D5	D4	D3	D2	D1	D0
S	Z		AC		P		CY

Instruction register and decoder

It is an 8-bit register. When an instruction is fetched from memory then it is stored in the Instruction register. Instruction decoder decodes the information present in the Instruction register.

Timing and control unit

It provides timing and control signal to the microprocessor to perform operations. Following are the timing and control signals, which control external and internal circuits −

- Control Signals: READY, RD’, WR’, ALE
- Status Signals: S0, S1, IO/M’
- DMA Signals: HOLD, HLDA

- RESET Signals: RESET IN, RESET OUT

Interrupt control

As the name suggests it controls the interrupts during a process. When a microprocessor is executing a main program and whenever an interrupt occurs, the microprocessor shifts the control from the main program to process the incoming request. After the request is completed, the control goes back to the main program.

There are 5 interrupt signals in 8085 microprocessor: INTR, RST 7.5, RST 6.5, RST 5.5, TRAP.

Serial Input/output control

It controls the serial data communication by using these two instructions: SID (Serial input data) and SOD (Serial output data).

Address buffer and address-data buffer

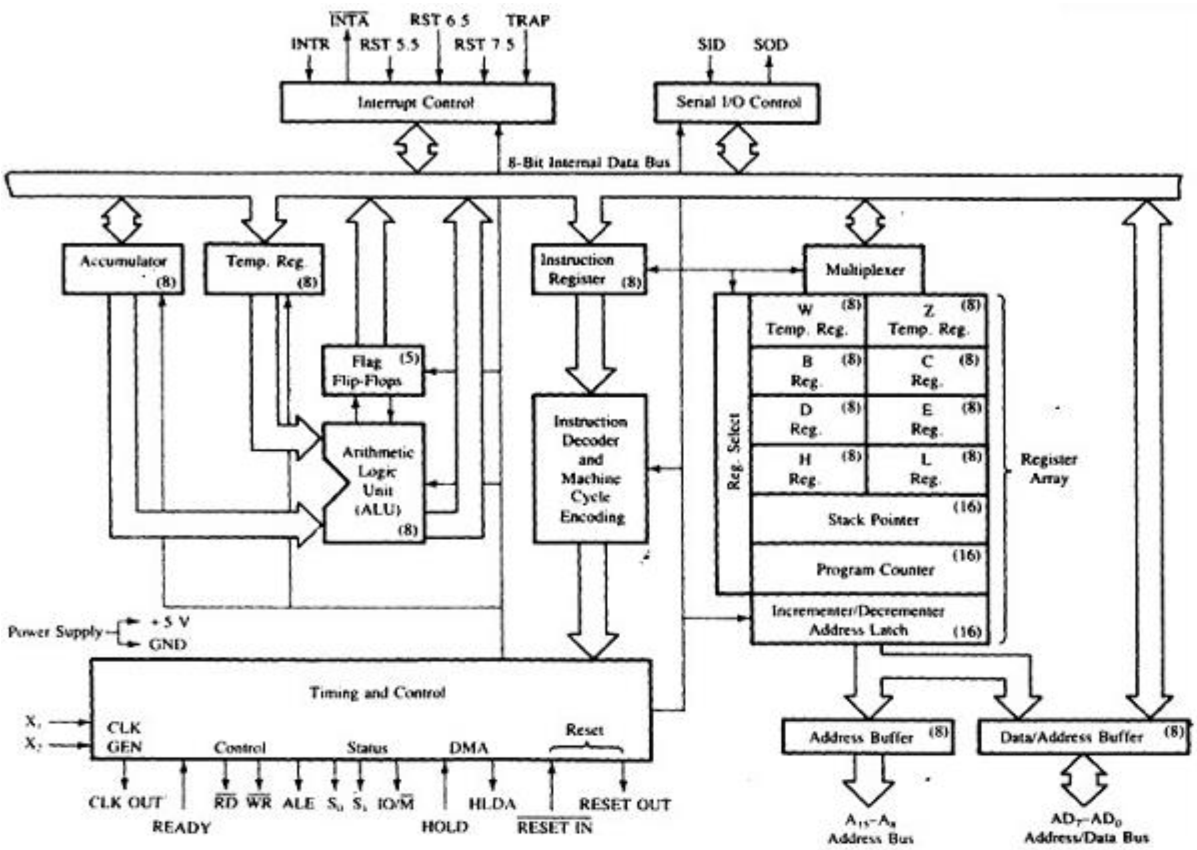
The content stored in the stack pointer and program counter is loaded into the address buffer and address-data buffer to communicate with the CPU. The memory and I/O chips are connected to these buses; the CPU can exchange the desired data with the memory and I/O chips.

Address bus and data bus

Data bus carries the data to be stored. It is bidirectional, whereas address bus carries the location to where it should be stored and it is unidirectional. It is used to transfer the data & Address I/O devices.

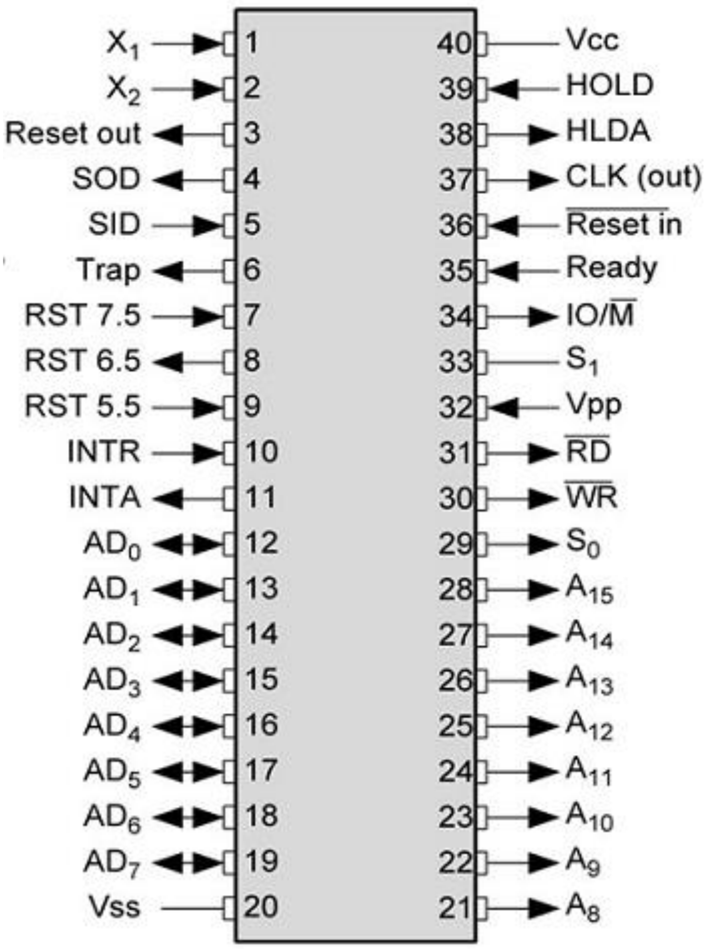
8085 Architecture

We have tried to depict the architecture of 8085 with this following image –



PIN Diagram of 8085 Microprocessor:-

The pin diagram of 8085 Microprocessor −



The pins of a 8085 microprocessor can be classified into seven groups −

Address bus

A15-A8, it carries the most significant 8-bits of memory/IO address.

Data bus

AD7-AD0, it carries the least significant 8-bit address and data bus.

Control and status signals

These signals are used to identify the nature of operation. There are 3 control signal and 3 status signals.

Three control signals are RD, WR & ALE.

- **RD** − This signal indicates that the selected IO or memory device is to be read and is ready for accepting data available on the data bus.
- **WR** − This signal indicates that the data on the data bus is to be written into a selected memory or IO location.
- **ALE** − It is a positive going pulse generated when a new operation is started by the microprocessor. When the pulse goes high, it indicates address. When the pulse goes down it indicates data.

Three status signals are IO/M, S0 & S1.

IO/M

This signal is used to differentiate between IO and Memory operations, i.e. when it is high indicates IO operation and when it is low then it indicates memory operation.

S1 & S0

These signals are used to identify the type of current operation.

Power supply

There are 2 power supply signals − VCC & VSS. VCC indicates +5v power supply and VSS indicates ground signal.

Clock signals

There are 3 clock signals, i.e. X1, X2, CLK OUT.

- **X1, X2** − A crystal (RC, LC N/W) is connected at these two pins and is used to set frequency of the internal clock generator. This frequency is internally divided by 2.
- **CLK OUT** − This signal is used as the system clock for devices connected with the microprocessor.

Interrupts & externally initiated signals

Interrupts are the signals generated by external devices to request the microprocessor to perform a task. There are 5 interrupt signals, i.e. TRAP, RST 7.5, RST 6.5, RST 5.5, and INTR. We will discuss interrupts in detail in interrupts section.

- **INTA** − It is an interrupt acknowledgment signal.
- **RESET IN** − This signal is used to reset the microprocessor by setting the program counter to zero.
- **RESET OUT** − This signal is used to reset all the connected devices when the microprocessor is reset.
- **READY** − This signal indicates that the device is ready to send or receive data. If READY is low, then the CPU has to wait for READY to go high.
- **HOLD** − This signal indicates that another master is requesting the use of the address and data buses.
- **HLDA (HOLD Acknowledge)** − It indicates that the CPU has received the HOLD request and it will relinquish the bus in the next clock cycle. HLDA is set to low after the HOLD signal is removed.

Serial I/O signals

There are 2 serial signals, i.e. SID and SOD and these signals are used for serial communication.

- **SOD** (Serial output data line) − The output SOD is set/reset as specified by the SIM instruction.
- **SID** (Serial input data line) − The data on this line is loaded into accumulator whenever a RIM instruction is executed.

Instruction and Instruction Format:-

An instruction is a command to the microprocessor to perform a given task on a specified data. Each instruction has two parts:

1. One is task to be performed, called the operation code (opcode).
2. The second is the data to be operated on, called the operand. The operand (or data) can be specified in various ways. It may include 8-bit (or 16-bit) data, an internal register, a memory location, or 8-bit (or 16-bit) address. In some instructions, the operand is implicit.

Instruction Formats:

The Instruction Format of 8085 Instruction set consists of :

1. One byte instructions (The first byte is always the opcode)
2. Two byte instructions (In two-byte instructions the second byte is usually data)
3. Three byte instructions. (In three byte instructions the last two bytes present address or 16-bit data.)

1. **One byte instruction:** In 1-byte instruction, the opcode and the operand of an instruction are represented in one byte.

FORMAT:-

OPCODE

1 Byte

For Example: MOV A, B

Whose opcode is 78H which is one byte. This Instruction and Data Format of 8085 copies the contents of B register in A register.

```
MOV A,B
Opcode- MOV
Operand- A,B
```

2. Two byte instruction: Two-byte instruction is the type of instruction in which the first 8 bits indicates the opcode and the next 8 bits indicates the operand.

FORMAT:-

OPCODE	OPERAND

2- Byte Instruction.

For Example: MVI B, 02H. (Opcode is MVI and Operand is B, 02H)

```
Opcode- MVI
Operand- A, 02H
```

The opcode for this instruction is 06H and is always followed by a byte data (02H in this case). This instruction is a two byte instruction which copies immediate data into B register.

3. Three byte instruction: Three-byte instruction is the type of instruction in which the first 8 bits indicates the opcode and the next two bytes specify the 16-bit address. The low-order address is represented in second byte and the high-order address is represented in the third byte.

FORMAT:-

OPCODE	OPERAND	OPERAND

3 Byte Instruction

For Example: JMP 2085H.

```
Opcode- JMP
Operand- 2085H
JMP C3 (in Hexadecimal code),1100 0011 (In Binary)
85 (in Hexa), 1000 0101 (In binary)
20 (In Hexa), 0010 0000 (In Binary)
```

The opcode for this instruction is JMP (C3 in Hexadecimal) and is always followed by 16 bit address (2085H in this case). This instruction is a three byte instruction which loads 16 bit address into program counter.

Addressing Mode:-

There is a method in which the instructions address the data to be operated. The method of specifying the data to be operated by the instruction is known as **addressing**.
The way by which the microprocessor identifies the operands for a particular instruction is known as **Addressing mode**.

Using mnemonics without any alteration in the content, data can be transferred in three different cases –

- From one register to another register
- From the memory to the register and
- From the register to the memory

These can be guided by addressing modes. Addressing modes in 8085 can be classified into 5 groups −

- Immediate addressing mode
- Register addressing mode
- Direct addressing mode
- Indirect addressing mode
- Implied addressing mode

Immediate addressing mode

In this mode, the 8/16-bit data is specified in the instruction itself as one of its operands. For example, MVI E, ABH means ABH is copied into register A.

- MVI E ABH, it means that ABH will be moved or copied to the register E. And, as a result, the previous value of E will get overwritten.

Register addressing mode

In this mode, the data is copied from one register to another.

For example, MOV A, B: means data in register B is copied to register A.

- MOV E, H

It occupies only 1-Byte in memory.

MOV E, H is an example instruction of this type. It is a 1-Byte instruction.

Suppose E register content is AB H, and H register content is 9C H. When the 8085 executes this instruction, the contents of E register will change to 9C H.

Register E= AB H

Register H= 9C H

After execution of instruction MOV E, H

Register E = 9C H

Direct addressing mode

In this mode, the data is directly copied from the given address to the register.

For example LDA 3000H: means the data at address 3000H is copied to register A.

- LDA 4050H

Let us consider **LDA 4050**

It is a 3-Byte instruction. The initial content of memory address 4050H is ABH. initial accumulator content is CDH. As after execution A will be initialized with value ABH. Memory location 4050H will still remain with the content ABH.

Content of 4050 = AB H

Initially Content of A= CD H

After execution of LDA 4050

Content of A=AB H

Indirect addressing mode

In this mode, the data is transferred from one register to another by using the address pointed by the register.

For example, MOV A, M: means data is transferred from the memory address pointed by the register pair HL to the register A.

- MOV E, M

It occupies only 1-Byte in memory. **MOV E, M** is an example instruction of this type. It is a 1-Byte instruction. Suppose E register content is DBH, H register content is 40H, and L register content is 50H. Let us say location 4050H has the data value AAH. When the 8085 executes this instruction, the contents of E register will change to AAH,

H Register

L Register

Content of H= 40

Content of L=50 H

So the address location is 4050 H has the data value AAH, after execution content of register E= AA H.

Implied addressing mode

This mode doesn't require any operand; the data is specified by the opcode itself. For example: CMA, CMP.

- CMP E

It is a 1-Byte instruction so during execution of this instruction it will occupy only a single Byte in memory.

CMA (finds and stores the 1's complement of the contains of accumulator A in A).

Flag register in 8085 microprocessors: -

The **Flag register** is a Special Purpose Register. Depending upon the value of result after any arithmetic and logical operation the flag bits become set (1) or reset (0). In 8085 microprocessor, flag register consists of 8 bits and only 5 of them are useful. The 5 flags are:

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
S	Z		AC		P		CY

1. **Sign Flag (S) –** After any operation if the MSB (B(7)) of the result is 1, it indicates the number is negative and the sign flag becomes set, i.e. 1. If the MSB is 0, it indicates the number is positive and the sign flag becomes reset i.e. 0.
   from 00H to 7F, sign flag is 0
   from 80H to FF, sign flag is 1
   1- MSB is 1 (negative)
   0- MSB is 0 (positive)

   Example:
   MVI A 30 (load 30H in register A)
   MVI B 40 (load 40H in register B)
   SUB B (A = A – B)
   These set of instructions will set the sign flag to 1 as 30 – 40 is a negative number.

   Example:
   MVI A 40 (load 40H in register A)
   MVI B 30 (load 30H in register B)
   SUB B (A = A – B)
   These set of instructions will reset the sign flag to 0 as 40 – 30 is a positive number.

2. **Zero Flag (Z) –** After any arithmetical or logical operation if the result is 0 (00)H, the zero flag becomes set i.e. 1, otherwise it becomes reset i.e. 0.
   00H zero flag is 1.
   from 01H to FFH zero flag is 0
   1- zero result
   0- non-zero result

Example:
MVI A 10 (load 10H in register A)
SUB A (A = A – A)
These set of instructions will set the zero flag to 1 as 10H – 10H is 00H

3. **Auxiliary Carry Flag (AC) –** This flag is used in BCD number system (0-9). If after any arithmetic or logical operation D (3) generates any carry and passes on to B (4) this flag becomes set i.e. 1, otherwise it becomes reset i.e. 0. This is the only flag register which is not accessible by the programmer
   1-carry out from bit 3 on addition or borrow into bit 3 on subtraction
   0-otherwise

   Example:
   MOV A 2B (load 2BH in register A)
   MOV B 39 (load 39H in register B)
   ADD B (A = A + B)
   These set of instructions will set the auxiliary carry flag to 1, as on adding 2B and 39, addition of lower order nibbles B and 9 will generate a carry.

4. **Parity Flag (P) –** If after any arithmetic or logical operation the result has even parity, an even number of 1 bit, the parity register becomes set i.e. 1, otherwise it becomes reset i.e. 0.
   1-accumulator has even number of 1 bits
   0-accumulator has odd parity

   Example:
   MVI A 05 (load 05H in register A)
   This instruction will set the parity flag to 1 as the BCD code of 05H is 00000101, which contains even number of ones i.e. 2.

5. **Carry Flag (CY) –** Carry is generated when performing n bit operations and the result is more than n bits, then this flag becomes set i.e. 1, otherwise it becomes reset i.e. 0. During subtraction (A-B), if A>B it becomes reset and if (A<B) it becomes set.
   Carry flag is also called borrow flag.
   1-carry out from MSB bit on addition or borrow into MSB bit on subtraction
   0-no carry out or borrow into MSB bit

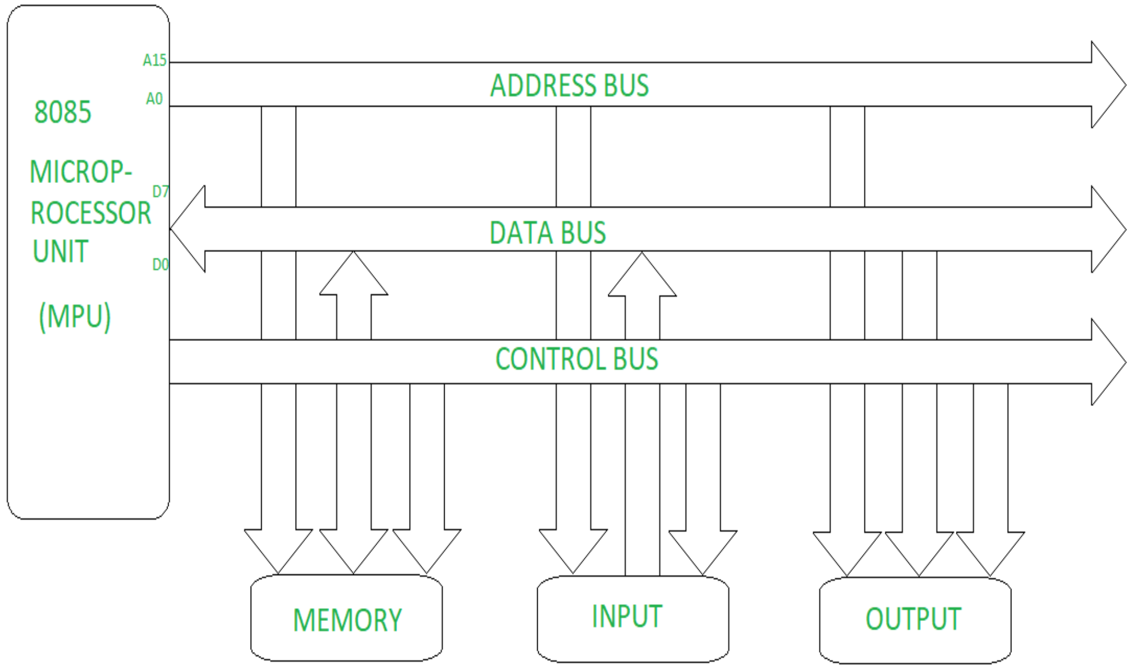
   Example:
   MVI A 30 (load 30H in register A)
   MVI B 40 (load 40H in register B)
   SUB B (A = A – B)
   These set of instructions will set the carry flag to 1 as 30 – 40 generates a carry/borrow.

   MVI A 40 (load 40H in register A)
   MVI B 30 (load 30H in register B)
   SUB B (A = A – B)
   These set of instructions will reset the sign flag to 0 as 40 – 30 does not generate any carry/borrow.

Bus organization of 8085 microprocessor

Bus is a group of conducting wires which carries information, all the peripherals are connected to microprocessor through Bus.

Diagram to represent bus organization system of 8085 Microprocessor.



Bus organization system of 8085 Microprocessor

There are three types of buses.

1. **Address bus –**
   It is a group of conducting wires which carries address only. Address bus is unidirectional because data flow in one direction, from microprocessor to memory or from microprocessor to Input/output devices.
   Length of Address Bus of 8085 microprocessor is 16 Bit (That is, Four Hexadecimal Digits), ranging from 0000 H to FFFF H. The microprocessor 8085 can transfer maximum 16 bit address which means it can address 65, 536 different memory location.

   The Length of the address bus determines the amount of memory a system can address. Such as a system with a 32-bit address bus can address 2^32 memory locations. If each memory location holds one byte, the addressable memory space is 4 GB.

2. **Data bus –**
   It is a group of conducting wires which carries Data only. Data bus is bidirectional because data flow in both directions, from microprocessor to memory or Input/Output devices and from memory or Input/Output devices to microprocessor.

   Length of Data Bus of 8085 microprocessor is 8 Bit (That is, two Hexadecimal Digits), ranging from 00 H to FF H.

   When it is write operation, the processor will put the data on the data bus, when it is read operation, the memory controller will get the data from specific memory block and put it into the data bus.

3. **Control bus –**
   It is a group of conducting wires, which is used to generate timing and control signals to control all the associated peripherals. Microprocessor uses control bus to process data, that is what to do with selected memory location. Some control signals are:
   - Memory read
   - Memory write
   - I/O read
   - I/O Write
   - Opcode fetch

If one line of control bus may be the read/write line. If the wire is low (no electricity flowing) then the memory is read, if the wire is high (electricity is flowing) then the memory is written.