Chapter – 2
Basic Computer Architecture (7 Hrs.)

2.1 8085 Microprocessor Architecture and Operations:

The microprocessor has a set of instructions, designed internally to manipulate data and communicate with peripherals. This process of data manipulation and communication is determined by the logic design of the microprocessor, called the architecture.

The microprocessor can be programmed to perform functions on given data by selecting necessary instruction from its sets. These instructions are given to microprocessor by writing them into its memory. The microprocessor can respond to external signals. The various function performed by microprocessor can be classified into three general categories:

- Microprocessor initiated operations.
- Internal operations.
- Peripherals (or externally initiated) operations.

To perform these functions, the microprocessor requires a group of logic circuits and a set of signals called control signals. Microprocessor primarily performs four operations:

- Memory Read: Reads data (or instruction) from memory.
- Memory Write: writes data (or instruction) into memory.
- I/O Read: Accepts data from input devices.
- I/O Write: Sends data to output device.

❖ Address, Data and Control Buses

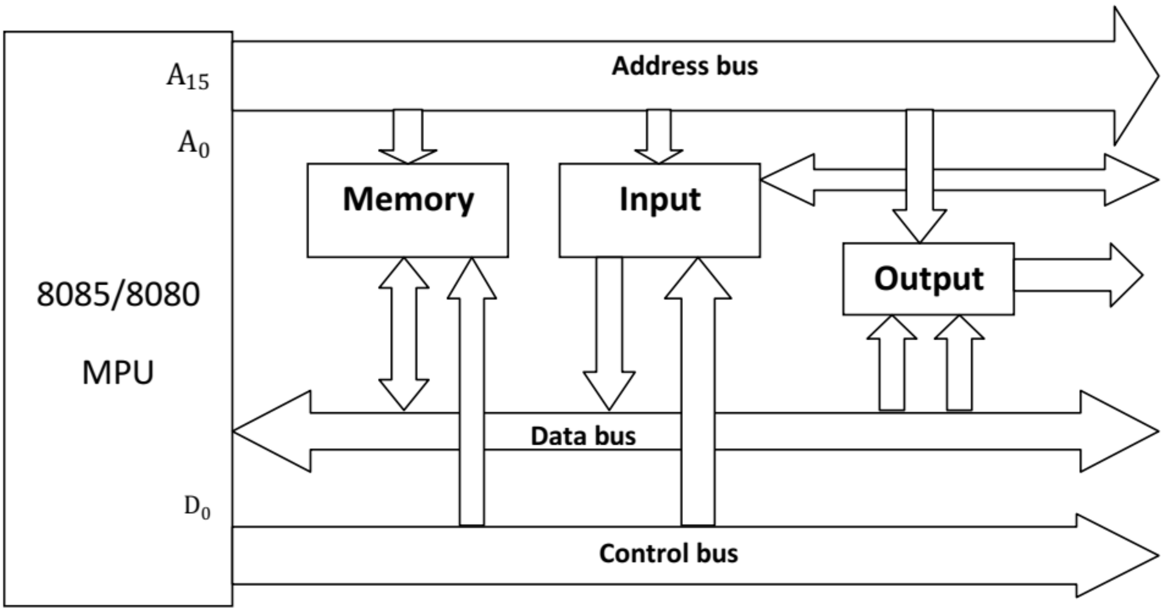

Fig: The 8085 Bus structure

Address Bus:

The address is a group of 16 lines generally identified as A_0 to A_{15}. The address bus is unidirectional: bits flow in one direction from microprocessor to peripheral devices. The microprocessor uses the address bus to identify a peripheral or memory location.

In a computer system, each peripheral or memory location is identified by a binary number, called an address, and the address bus is used to carry a 16 bit address. The 8085 microprocessor with its 16 address line is capable of addressing 2^{16} =65,536 (64K) memory location, so 8085 microprocessor has 64K memory.

Data Bus:

The data bus is a group of eight lines used for data flow. These lines are bidirectional-data flow in both directions between the microprocessor and memory and peripherals devices. The microprocessor uses data bus to transfer binary information.

The eight data lines enable the microprocessor to manipulate 8-bit data ranging from 00 to FF (2^8 = 256). The 8085 microprocessor is known as 8 bit microprocessor.

Control Bus:

The control bus is comprised of various single lines that carry synchronization signals. The microprocessor uses these lines for providing timing signals. The term bus, in relation to the control signals is somewhat confusing. These are not group of lines like address or data buses, but individual lines that provide a pulse to indicate microprocessor operation. The microprocessor generates specific control signals for every operation it performs. These signals are used to identify a device type with which the microprocessor intends to communicate.

❖ Internal data operation and Registers:

The internal architecture of the 8085 microprocessor determines how and what operations can be performed with the data. These operations are:

1. Store 8-bit data.
2. Perform arithmetic and logical operations.
3. Test for conditions.
4. Sequence the execution of instructions.
5. Store data temporarily during execution in the defined R/W memory locations called the stack.

To perform these operations, the microprocessor requires registers, an arithmetic/logical unit and control logic, and internal buses.

Register Array:

The 8085 has both 8 bit and 16 bit registers. It has 8 addressable 8 bit registers and three 16 bit registers. These registers can be classified as:

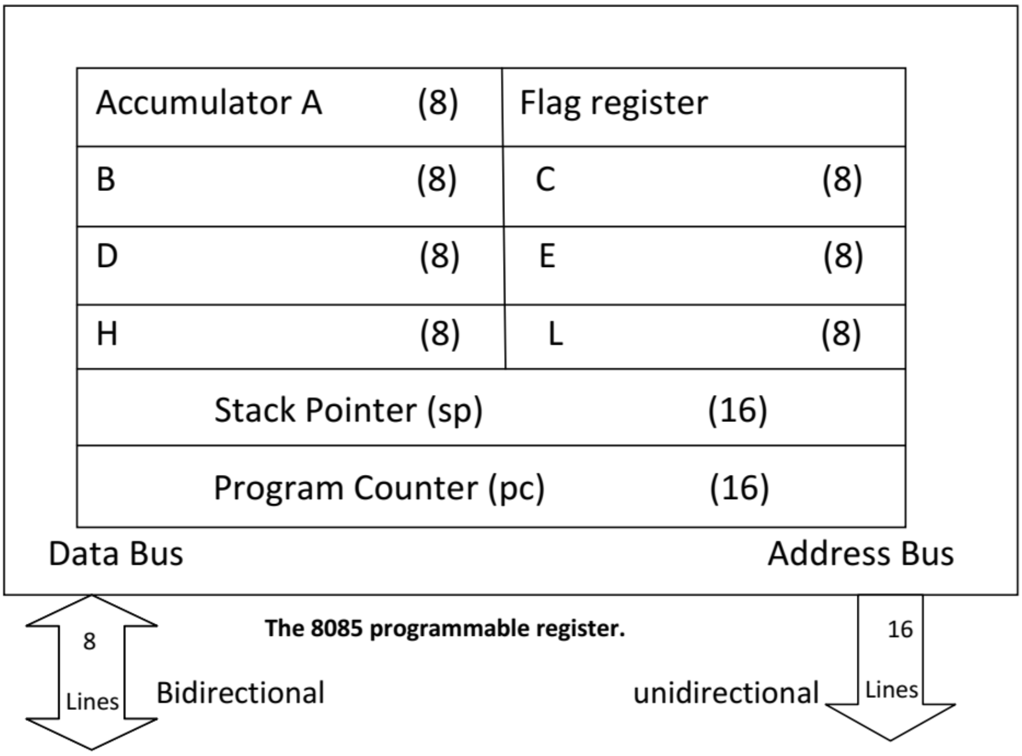

Fig: 8085 Programmable register

a. General Purpose Register:

The 8085 has 6 general purpose registers to store 8 bit data during program execution. B,C, D, E, H, L are 8 bit registers and can be used singly or 16 bit register pairs. BC, DE, HL. When used in register pairs, the high order byte resides in the 1st register that is B when BC is as register pair and low order byte in second (i.e. C when BC is used). The register pair Hl besides its possible use as to independent registers functions as a data pointer. It can hold memory addresses that are referred to in a number of instructions which use register indirect addressing.

b. Special Purpose Register:

Accumulator: It is an 8 bit register that is the part of ALU. This register is used to store the 8-bit data and to perform arithmetic and logic operations and 8085 microprocessor is called accumulator based microprocessor. When data is read from input port, it first moved to accumulator and when data is sent to output port, it must be first placed in accumulator.

Flags: The 8085 microprocessor has an ALU unit which includes 5 flip flops which are set or reset after operation according to the data conditions of the result. The different flags are used in the 8085 microprocessor are Zero (Z) flag, Sign (S) flag, Auxiliary Carry (AC) flag, Parity (P) flag and Carry (C) flags.

D7	D6	D5	D4	D3	D2	D1	D0
SIGN	ZERO		AUX. CARRY		PARITY		CARRY

The 8085 microprocessor uses these flags to test the data conditions.

- **Carry**: - If the last operation generates a carry its status will 1 otherwise 0. It can handle the carry or borrow from one word to another.
- **Zero**: - If the result of last operation is zero, its status will be 1 otherwise o. It is often used in loop control and in searching for particular data value.
- **Sign**: - If the most significant bit (MSB) of the result of the last operation is 1 (negative), then its status will be 1 otherwise 0.
- **Parity**: - If the result of the last operation has even number of 1's (even parity), its status will be 1 otherwise 0.
- **Auxiliary carry**: - If the last operation generates a carry from the lower half word (lower nibble), its status will be 1 otherwise 0. Used for performing BCD arithmetic.

Temporary register: It is 8 bit register not accessible to the programmer while executing the instruction. The 8085 places the data into temporary register for a brief period.

Program counter: The program counter acts as a pointer to the next instruction to be executed and always contains 16 bit address of the memory location of the next instruction. The program counter is updated by the processor and points to the next instruction after the processor has fetched the instruction.

Stack pointer: The stack is an area of read write memory in which temporary information is stored in first in last out basis. The stack pointer holds the address of last byte written on to the stack.

Instruction register and decoder: These are not accessible to the programmer after fetching an instruction from memory the processor load it in the instruction register. This instruction is decoded by the decoder and the sequences of events are established for the execution of instruction.

- **Externally Initiated Operations:**

External devices (or signals) can initiate the following operation for which individual pins on Mp chip are assigned: Reset, Interrupt, Ready, Hold.

- **Reset**: when reset is activated all internal operations are suspended and the program counter is cleared.

- **Interrupt**: Microprocessor can be interrupted from normal execution and asked to execute other instructions called "service routine"(emergency). Microprocessor resumes its operation after that.

- **Ready**: 8085 has pin called ready, if this signal is low microprocessor enters into wait state, this signal used to synchronized slower peripherals with microprocessor.

- **Hold**: when hold pin activated by external signal Mp relinquishes control buses and allows the external peripheral to use the.

  For example:

  Hold signal is used in direct memory access data transfer.

❖ **Addressing Modes:**

Instructions are command to perform a certain task in microprocessor. The instruction consists of op-code and data called operand. The operand may be the source only, destination only or both of them. In these instructions, the source can be a register, a memory or an input port. Similarly, destination can be a register, a memory location, or an output port. The various format (way) of specifying the operands are called addressing mode. So addressing mode specifies where the operands are located rather than their nature. The 8085 has 5 addressing mode:

1. **Direct addressing mode**:

   The instruction using this mode specifies the effective address as part of instruction. The instruction size either 2-bytes or 3-bytes with first byte op-code followed by 1 or 2 bytes of address of data.

   E. g. LDA 9500H A← [9500]
   IN 80H A← [80]

   This type of addressing is called absolute addressing.

2. **Register Direct addressing mode:**

   This mode specifies the register or register pair that contains the data.

   E g. MOV A, B

   Here register B contains data rather than address of the data. Other examples are: ADD, XCHG etc.

3. **Register Indirect addressing mode:**

   In this mode the address part of the instruction specifies the memory whose contents are the address of the operand. So in this type of addressing mode, it is the address of the address rather than address itself. (One operand is register)

   E. g. MOV R, M MOV M, R STAX, LDAX etc. STAX B
   B= 95 C =00
   [9500]← A

4. **Immediate addressing mode:**

   In this mode, the operand position is the immediate data. For 8-bit data, instruction size is 2 bytes and for 16 bit data, instruction size is 3 bytes.

   E.g. MVI A, 32H
   LXI B, 4567H

5. **Implied or Inherent addressing mode:**

   The instructions of this mode do not have operands.

   E.g. NOP: No operation
   HLT: Halt
   EI: Enable interrupt
   DI: Disable interrupt

❖ **8085 Pin Diagram and Functions:**

The 8085A (commonly known as 8085) is a 8-bit general purpose microprocessor capable of addressing 64K of memory. The device has 40 pins, require a +5V single power supply and can operate with a 3-MHZ, single phase clock.

The all the signals associated with 8085 can be classified into 6 groups:

(1) Address bus: The 8085 has 16 signal lines that are used as the address bus; however, these lines are split into two segments A15-A8 and AD7- AD0. The eight signals A15-A8 are unidirectional and used as high order bus.

(2) Data bus: The signal lines AD7- AD0 are bidirectional, they serve a dual purpose. They are used the low order address bus as well as data bus.

(3) Control and status signals: This group of signals includes two control signals ($\overline{RD}$ and $\overline{WR}$), three status signals (IO/$\overline{M}$, S1 and S0) to identify the nature of the operation, and one special signals (ALE) to indicate the beginning of the operation.

- **ALE-** Address Latch Enable: This is a positive going pulse generated every time the 8085 begins an operation (machine cycle): it indicates that the bits AD7-AD0 are address bits. This signal is used primarily to latch the low-order address from the multiplexed bus and generate a separate set of eight address lines A7 –A0 .
- **Read** ($\overline{RD}$): This is a read control signal(active low). This signal indicates that the selected I/O or memory device is to be read and data are available on the data bus.
- **Write** ($\overline{WR}$): This is a write control signal (active low) . This signal indicates that the data on the data bus are to be written into a selected memory or I/O location.

- **IO/$\overline{M}$**: This is a status signal used to differentiate between I/O and memory operations. When it is high , it indicates an I/O operation; When it is low indicates a memory operation. This signal is combined with $\overline{RD}$ (Read) and $\overline{WR}$ (Write) to generate I/O and memory signals.
- **S1 and S0** : These status signals, similar to **IO/$\overline{M}$** , can identify various operations, but they are rarely used in small systems.

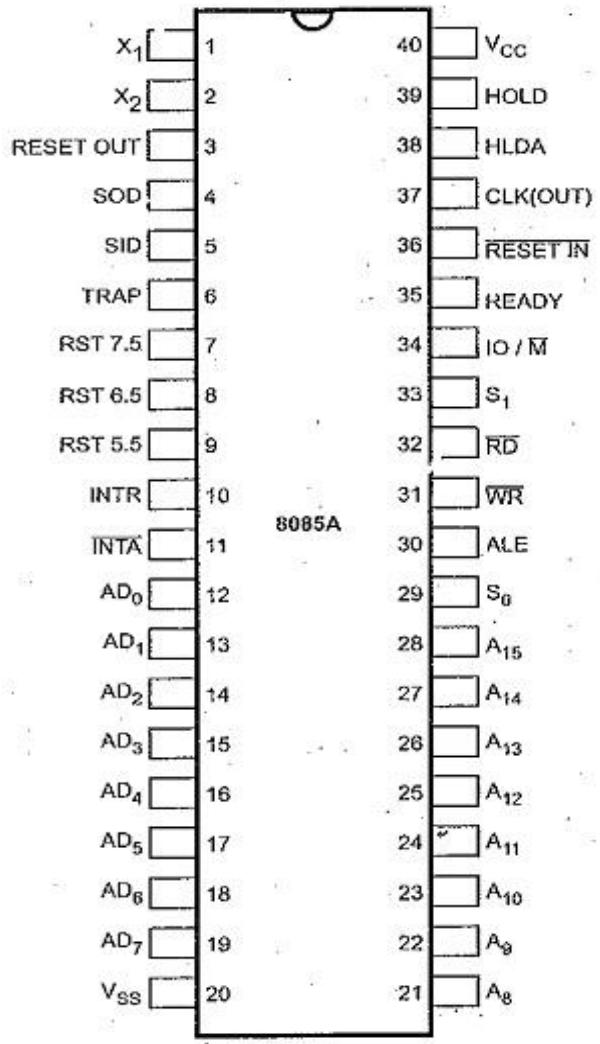

Fig. 1.3 (a) Pin configuration

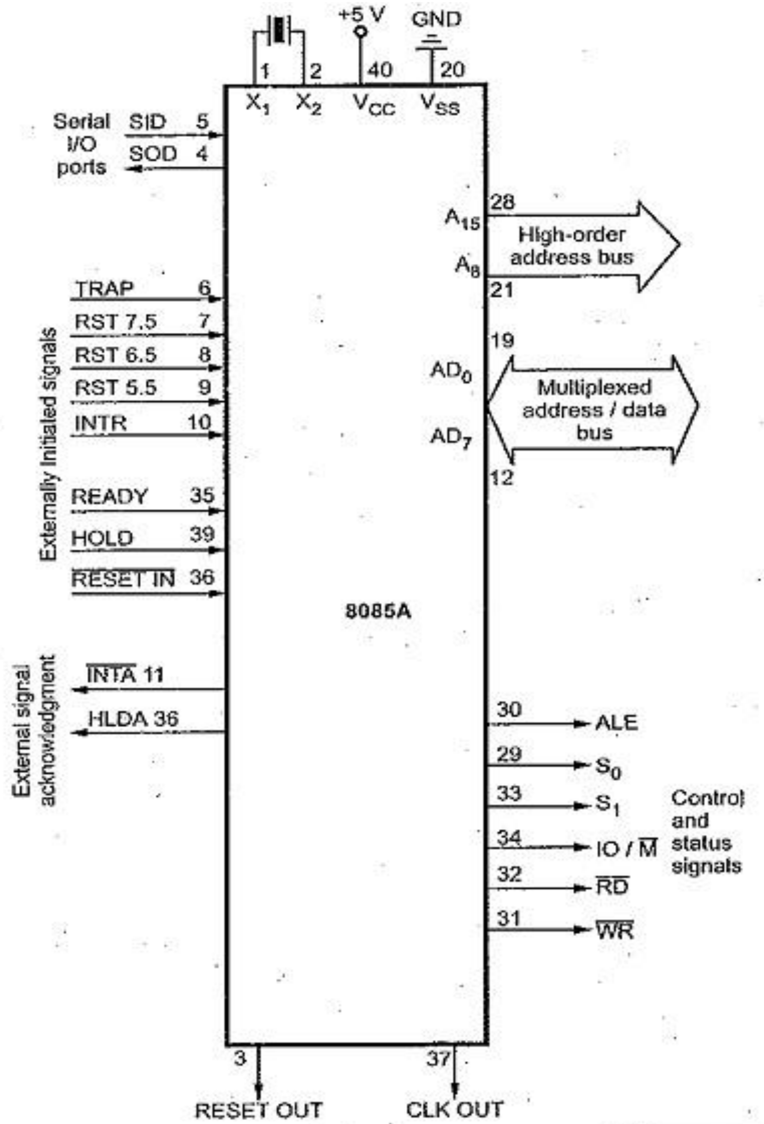

Fig. 1.3 (b) Functional pin diagram

(4) Power Signal and Clock Frequency:

- VCC: +5V power supply
- VSS: Ground reference
- X1 and X2: A crystal (RC or LC network) is connected at these two pins for frequency.
- CLK OUT: It can be used as the system clock for other devices.

(5) Externally Initiated signals:

- **INTR (input)**: interrupt request, used as a general purpose interrupt.
- $\overline{INTA}$**(Output):** This is used to acknowledge an Interrupt.
- **RST 7.5, 6.5, 5.5 (inputs):** These are vectored interrupts that transfer the program control to specific memory locations. They have higher priorities than INTR interrupt. Among these three, the priority order is 7.5, 6.5, and 5.5.
- **TRAP (input)**: This is a non-maskable interrupt with highest priority.
- **HOLD (input)**: This signal indicates that a peripheral such as a DMA (Direct Memory Access) controller is requesting use of Address and data bus.
- **HLDA (output)**: Hold Acknowledge: This signal acknowledges the HOLD request.
- **READY (Input)** : This signal is used to delay the microprocessor Read or Write cycles until a slow- responding peripheral is ready to send or accept data. When this signal goes low, the microprocessor waits for an integral number of clock cycles until it goes high.
- $\overline{\textbf{RESET IN}}$: When the signal on this pin goes low, the program counter is set to zero, the buses are tri-stated, and MPU is reset.
- **RESET OUT**: This signal indicates that the MPU is being reset. The signal can be used to reset other devices.
- **Serial I/O ports**: The 8085 has two signals to implement the serial transmission: SID (Serial Input Data) and SOD (Serial Output Data). In serial transmission, data bits are sent over a single line, one bit at a time, such as the transmission over telephone lines.

❖ **Multiplexing and De-multiplexing of address/data bus:**

The address bus has 8 signal lines A8 – A15 which are unidirectional. The other 8 address bits are multiplexed (time shared) with the 8 data bits. So, the bits AD0 – AD7 are bi-directional and serve as A0 – A7 and D0 – D7 at the same time. During the execution of the instruction, these lines carry the address bits during the early part, and then during the late parts of the execution, they carry the 8 data bits. In order to separate the address from the data, we can use a latch to save the value before the function of the bits changes.

From the above description, it becomes obvious that the AD7– AD0 lines are serving a dual purpose and that they need to be de-multiplexed to get all the information. The high order bits of the address remain on the bus for three clock periods. However, the low order bits remain for only one clock period and they would be lost if they are not saved externally. Also, notice that the low order bits of the address disappear when they are needed most. To make sure we have the entire address for the full three clock cycles, we will use an external latch to save the value of AD7–AD0 when it is carrying the address bits. We use the ALE signal to enable this latch. Given that ALE operates as a pulse during T1, we will be able to latch the address. Then when ALE goes low, the address is saved and the AD7–AD0 lines can be used for their purpose as the bi-directional data lines.

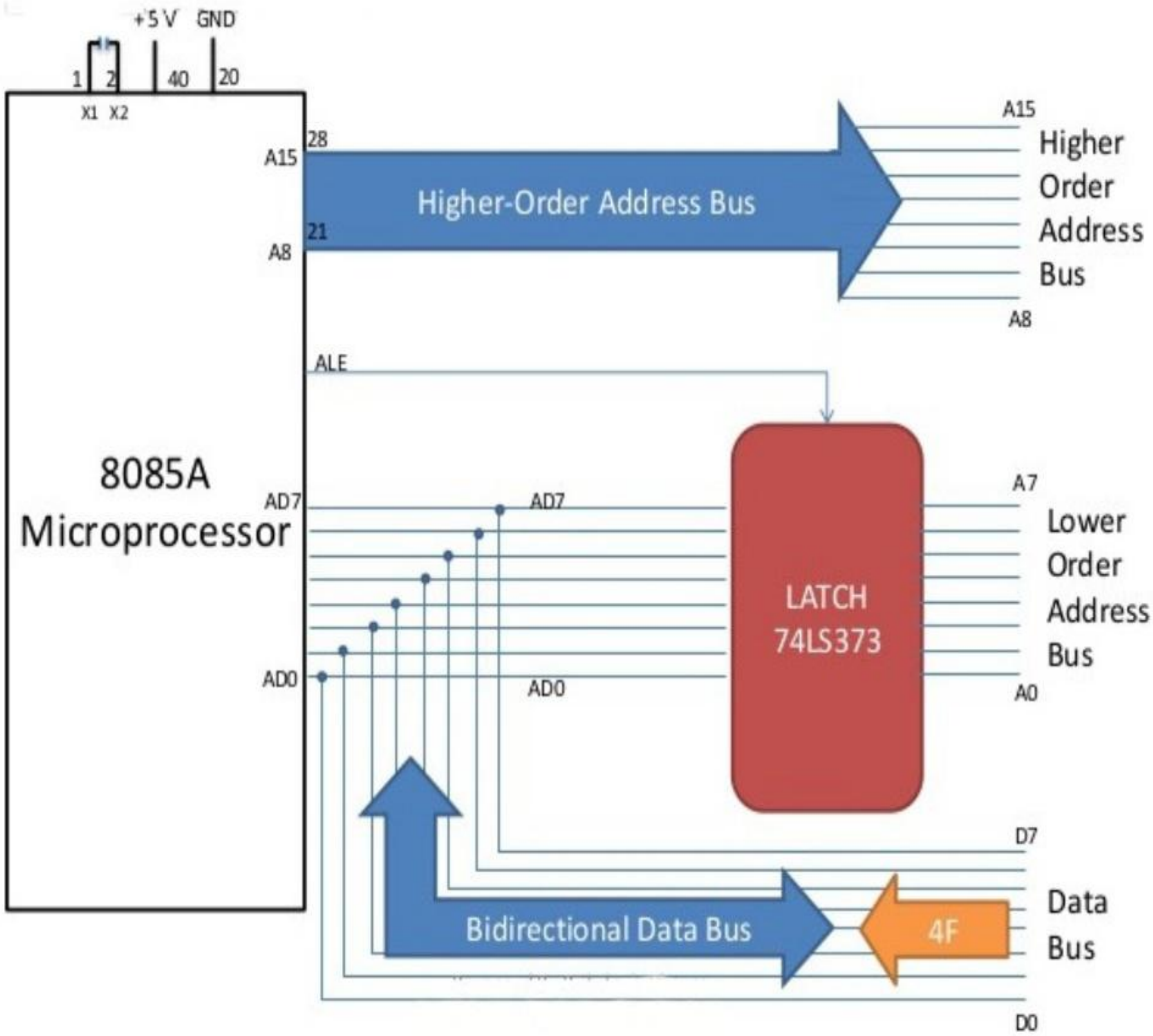

Fig: De-multiplexing of Address/Data Bus.

❖ **Generation Of Control Signals:**

Below figure shows the Read as control signal. Because this signal is used both for reading memory and for reading input device, it is necessary to generate two different read signals: one for memory and another for input. Similarly, two separate Write signals must be generated.

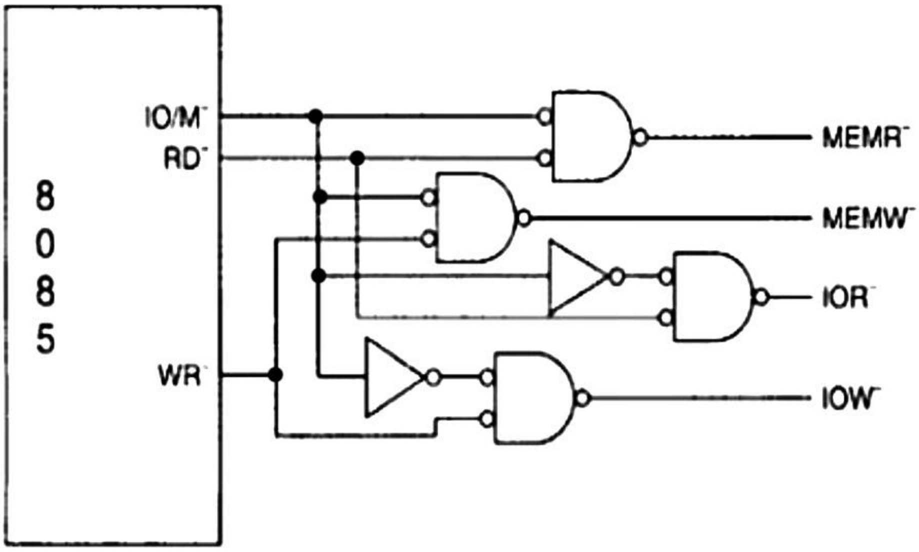

Fig: Generation of Control signals

❖ **A Detailed look at the 8085 MP and its Architecture:**

The Intel 8085 A is a complete 8 bit parallel central processing unit. The main components of 8085A are array of registers, the arithmetic logic unit, the encoder/decoder, and timing and control circuits linked by an internal data bus.

- **ALU:**- The arithmetic logic unit performs the computing functions, it includes the accumulator, the temporary register, the arithmetic and logic circuits and five flags. The temporary register is used to hold data during an arithmetic/logic operation. The result is stored in the accumulator; the flags (flip-flops) are set or reset according to the result of the operation.

- **Accumulator (register A):** It is an 8 bit register that is the part of ALU. This register is used to store the 8-bit data and to perform arithmetic and logic operations and 8085 microprocessor is called accumulator based microprocessor. When data is read from input port, it first moved to accumulator and when data is sent to output port, it must be first placed in accumulator.

- **Temporary registers(W & Z):** They are 8 bit registers not accessible to the programmer. During program execution, 8085A places the data into it for a brief period.

- **Instruction register(IR):** It is a 8 bit register not accessible to the programmer. It receives the operation codes of instruction from internal data bus and passes to the instruction decoder which decodes so that microprocessor knows which type of operation is to be performed.

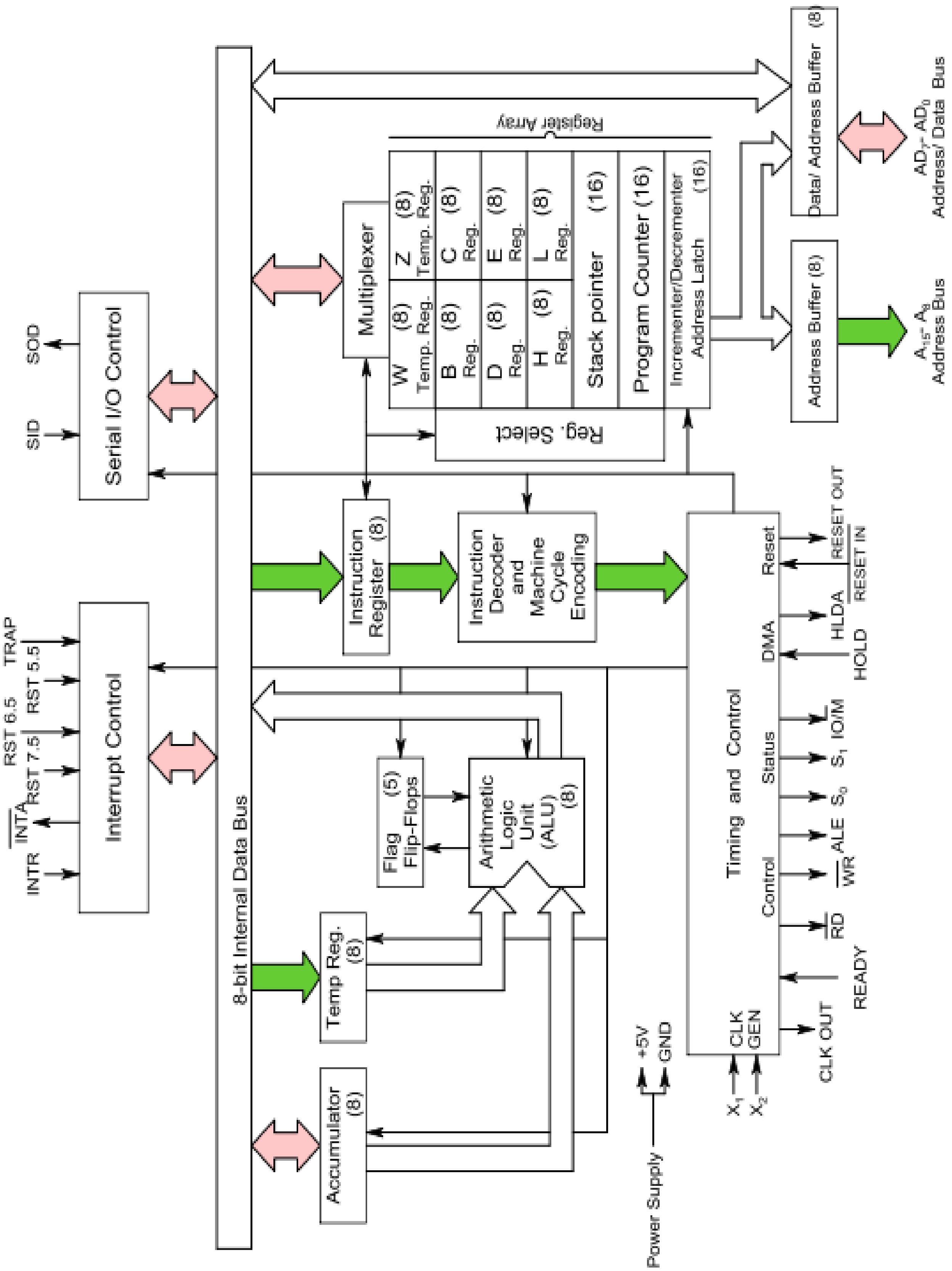

Fig: Functional Diagram of 8085MP

- **Register Array:** (Scratch pad registers B, C, D, E): It is a 8 bit register accessible to the programmers. Data can be stored upon it during program execution. These can be used individually as 8-bit registers or in pair BC, DE as 16 bit registers. The data can be directly added or transferred from one to another. Their contents may be incremented or decremented and combined logically with the content of the accumulator.

- **Register H & L**: - They are 8 bit registers that can be used in same manner as scratch pad registers.

- **Stack Pointer (SP)**: - It is a 16 bit register used as a memory pointer. It points to a memory location in R/W memory, called the stack. The beginning of the stack is defined by loading a 16- bit address in the stack pointer.

- **Program Counter (PC):** - Microprocessor uses the PC register to sequence the execution of the instructions. The function of PC is to point to the memory address from which the next byte is to be fetched. When a byte is being fetched, the PC is incremented by one to point to the next memory location.

- **Flags:** Flag Register consists of five flip flops, each holding the status of different states separately is known as flag register and each flip flop are called flags. 8085A can set or reset one or more of the flags and are sign(S), Zero (Z), Auxiliary Carry (AC) and Parity (P) and Carry (CY). The state of flags indicates the result of arithmetic and logical operations, which in turn can be used for decision making processes. Flags are discussed detailed previously in this chapter.

- **Timing and Control Unit:** This unit synchronizes all the microprocessor operations with the clock and generates the control signals necessary for communication between the microprocessor and peripherals. The control signals are similar to the sync pulse in an oscilloscope. The $\overline{RD}$ and $\overline{WR}$ signals are sync pulses indicating the availability of data on the data bus.

- **Interrupt controls**: The various interrupt controls signals (INTR, RST 5.5, RST 6.5, RST 7.5 and TRAP) are used to interrupt a microprocessor.

- **Serial I/O controls**: Two serial I/O control signals (SID and SOD) are used to implement the serial data transmission.