Microprocessor and Computer Architecture

Diploma in Computer Engineering

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CHAPTER ONE:

INTRODUCTION TO MICROPROCESSOR

OUTLINES

- Evolution of microprocessor and it’s types
- Microprocessor Bus Organization: Data Bus, address bus and Control Bus
- Operations of microprocessor: internal data manipulation, microprocessor initiated and peripheral or external initiated.
- Pin diagram and Internal architecture of 8085
- Internal register organization of 8085
- Limitations of 8085

History of x86 microprocessors

- The first microprocessor was introduced in the year of 1971 by Intel. It was 4 bit microprocessor named as Intel 4004. After that an enhanced version of Intel 4004 developed. Other companies like Toshiba, Rockwell also developed 4 bit microprocessors.
- In 1972 Intel introduced the first 8 bit microprocessor i.e. Intel 8008. It was used the P-MOS technology. These processors was slow and not compatible with TTL logic. So, Intel introduced a faster N-MOS microprocessor i.e. Intel 8080.
- But the main drawback of Intel 8080 was that it required three power supplies. Hence, in 1975 Intel developed an improved version of 8080 called Intel 8085.

- The first X86 processor was developed in 1978 by Intel and was called the Intel 8086. After that the Intel launched update version of 8086 i.e. 8088, 80186, 80286, 80386, 80486.
- After launching these processors, Intel launching Pentium processors which was a big step in the evolution of the microprocessors. After Pentium, Intel dual core, Intel core duo was introduced by Intel.
- Now, i3, i5, i7, i9 processors are ruling in present generation of microprocessors which is also introduced by Intel.

Microcomputer	Year	Data Bus Width (Bit)	Address Bus Width
4004	1971	4	10
8085A	1976	8	15
8086	1978	16	20
8088	1980	8	20
80186	1981	16	20
80188	1982	8	20
80286	1983	16	24
803865X	1984	16	24
80386EX	1985	16	26
80386DX	1986	32	32
Pentium	1993	64	32
Pentium overdrive	1994	32	32
Pentium pro	1995	64	36
Pentium II	1997	64	36
Pentium II-xenon	1998	64	36
Pentium III	1999	64	36
Pentium IV	2000	64	36
Intel Dual Core/core2 Duo	2006	32 / 64	32/36
Intel core 3	2009	64	36
I5	2010	64	36
I7	2008	64	36

Figure: Summary of History of x86 microprocessors

Microprocessor

- a complete computation engine that is fabricated on a single chip
- first microprocessor was the Intel 4004, introduced in 1971.
- the “brains” of the computer
- ➢ its job is to fetch instructions, decode them, and then execute them
- ➢ Microprocessor is a computer CPU on a single chip that contains millions of transistors connected by wires.
- It is a programmable, multipurpose, clock -driven, register-based electronic device that reads binary instructions from a storage device called memory, accepts binary data as input and processes data according to those instructions and provides results as output.

Together, these components work together to perform the operations required by the microprocessor.

Registers store data and instructions, the ALU performs calculations and logical operations, the control unit manages the flow of data and instructions, and the timing unit ensures that everything happens at the right time.

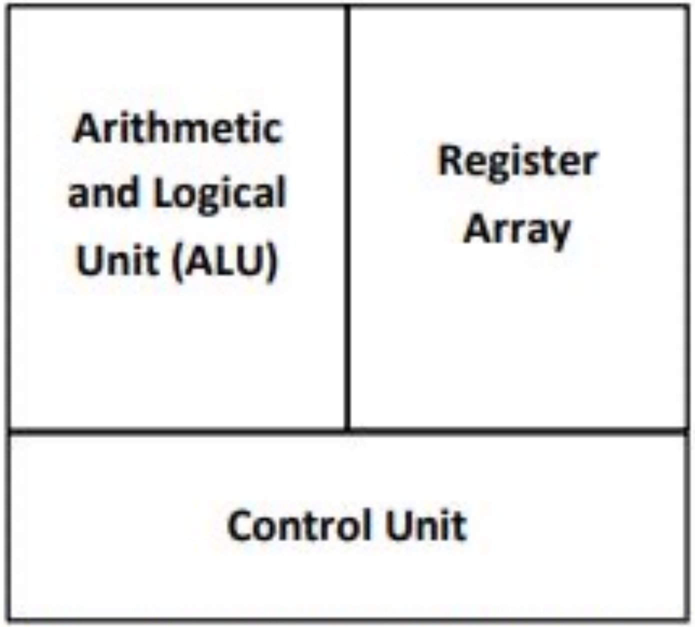


Figure: Components of Microprocessor

1. Registers: Registers are small, high-speed storage locations within the microprocessor used for temporary storage of data and instructions. These registers include the accumulator register, the instruction register, the program counter, and the stack pointer.

- ➢ Register array consists of registers identified by letters like B, C, D, E, H, L, and accumulator.

2. Arithmetic Logic Unit (ALU): The ALU is the part of the microprocessor responsible for performing arithmetic and logical operations on data. It is used to perform operations such as addition, subtraction, multiplication, division, AND, OR, and NOT.

➢ ALU performs arithmetical and logical operations on the data received from the memory or an input device.

3. Control Unit: The control unit is responsible for controlling the flow of data and instructions within the microprocessor. It retrieves instructions from memory and interprets them, then sends signals to other components within the microprocessor to execute the instructions.

- The control unit controls the flow of data and instructions within the computer.

4. Timing Unit: The timing unit is responsible for generating timing signals that synchronize the operation of the different components within the microprocessor. It ensures that instructions are executed in the correct order and at the correct time.

Features:

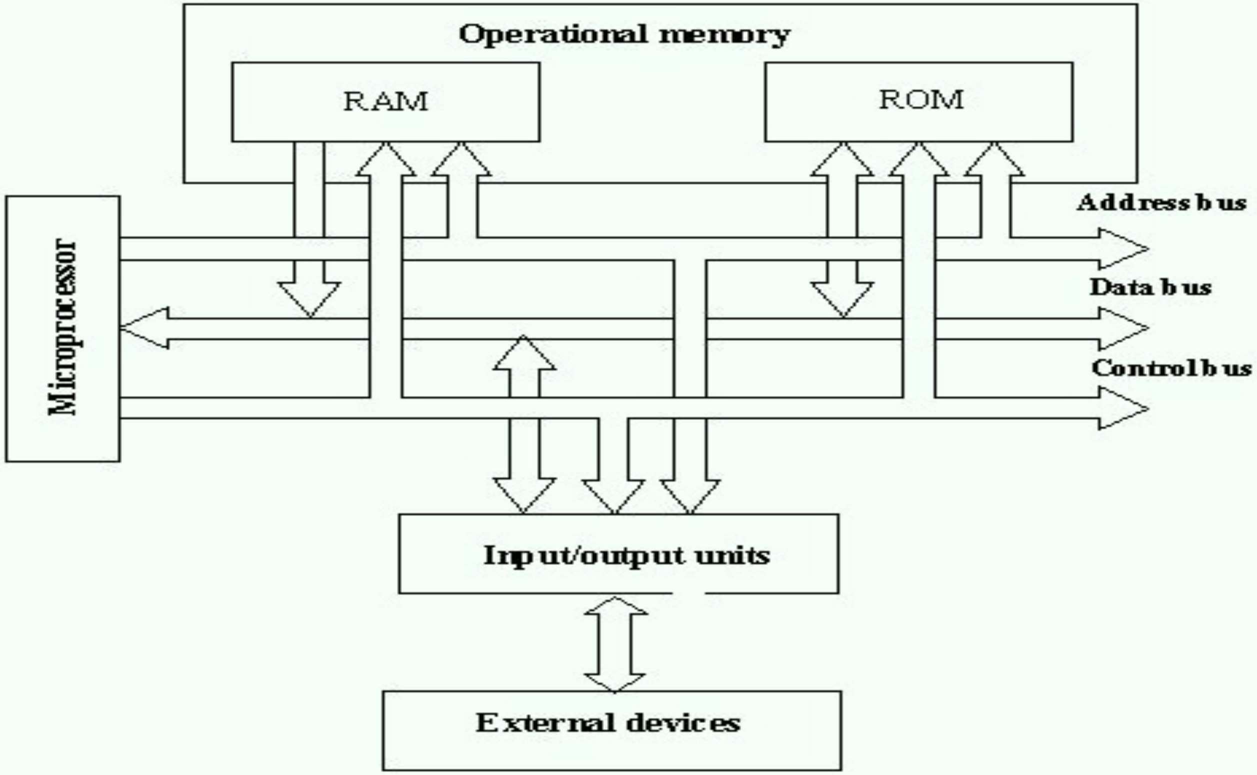
- ➢ General purpose central processor unit (CPU)
- ➢ Binary
- ➢ Register-based
- ➢ Clock-driven
- ➢ Programmable

Applications:

- Calculators
- Accounting system
- Games machine
- Complex industrial controllers
- Traffic light
- Control data
- Military applications
- Defense systems
- Computation systems

Microprocessor Bus Organization:

- Constructing of microcomputers consists connecting to the microprocessor buses with additional sub-systems such as memories and peripheral device controllers (input/output units).
- There is a microprocessor with three its busses going out:
- ➢ data bus,
- ➢ address bus
- ➢ control bus.
- devices connected to the bus: operational memory composed of RAM and ROM, as well as input/output units to which peripheral devices are connected.



Simplified general scheme of a simple microcomputer

Address Bus

- Group of **16** bits from $\mathbf{A_0}$ to $\mathbf{A_{15}}$.
- Carries the address of a particular location.
- **Unidirectional**– Data flows from microprocessor to peripheral devices only.
- **Function**– To identify a peripheral or a memory location.
- Capable of addressing 65536(2^{16}) memory locations. (Generally 64K)

Data Bus

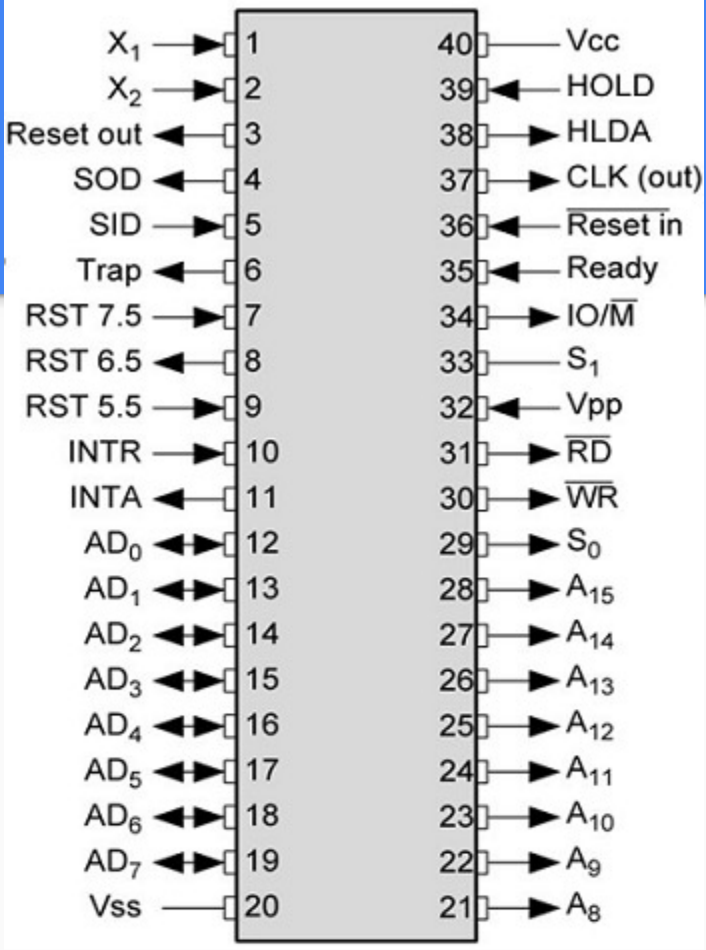
- Group of **8** lines used for data flow.
- Carries the data to be transfered.
- **Bidirectional**– Data flow in both direction between the microprocessor and memory / peripheral devices.
- **Function**– To transfer binary data and instruction.
- Enable the microprocessor to manipulate 8-bit data ranging from 00 to FF. (2^8=255)

Control Bus

- Group of various single lines that carry control signals.
- Microprocessor generate specific control signals for every operation.
- **Function**– To provide timing and synchronization signals.

8085 Pin Configuration

- 8085 is an 8-bit microprocessor as it operates on 8 bits.
- The size of the address bus in 8085 is 16 bits, can address 64 KB memory.
- pin diagram consists of 40 pins of the microprocessor and operates with **+5V** power supply.
- The pins can be categorized into seven groups-address and data bus, control signals, status signals, power supply, and serial input/output ports.



8085 pin configuration

Address and Data bus

- **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.

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.
- **CLK OUT** – This signal is used as the system clock for devices connected with the microprocessor.

Interrupts:

- The 8085 microprocessor supports five hardware interrupts, which are triggered by external devices to signal that they require immediate attention from the CPU.
- These interrupts are numbered from 0 to 4 and are assigned to specific pins on the microprocessor chip.
- When an interrupt occurs, the microprocessor suspends its current task and jumps to a pre-defined ISR to handle the interrupt.
- After the ISR is finished, the microprocessor resumes its previous task.

  Interrupt control: INTR, RST 7.5, RST 6.5, RST 5.5, TRAP

- 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.

- **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.

Internal architecture of 8085 microprocessor

8-bit microprocessor designed by Intel in 1977 using NMOS technology with the following configuration:

- 8-bit data bus
- 16-bit address bus, which can address up to 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
- It is used in washing machines, microwave ovens, mobile phones, etc.

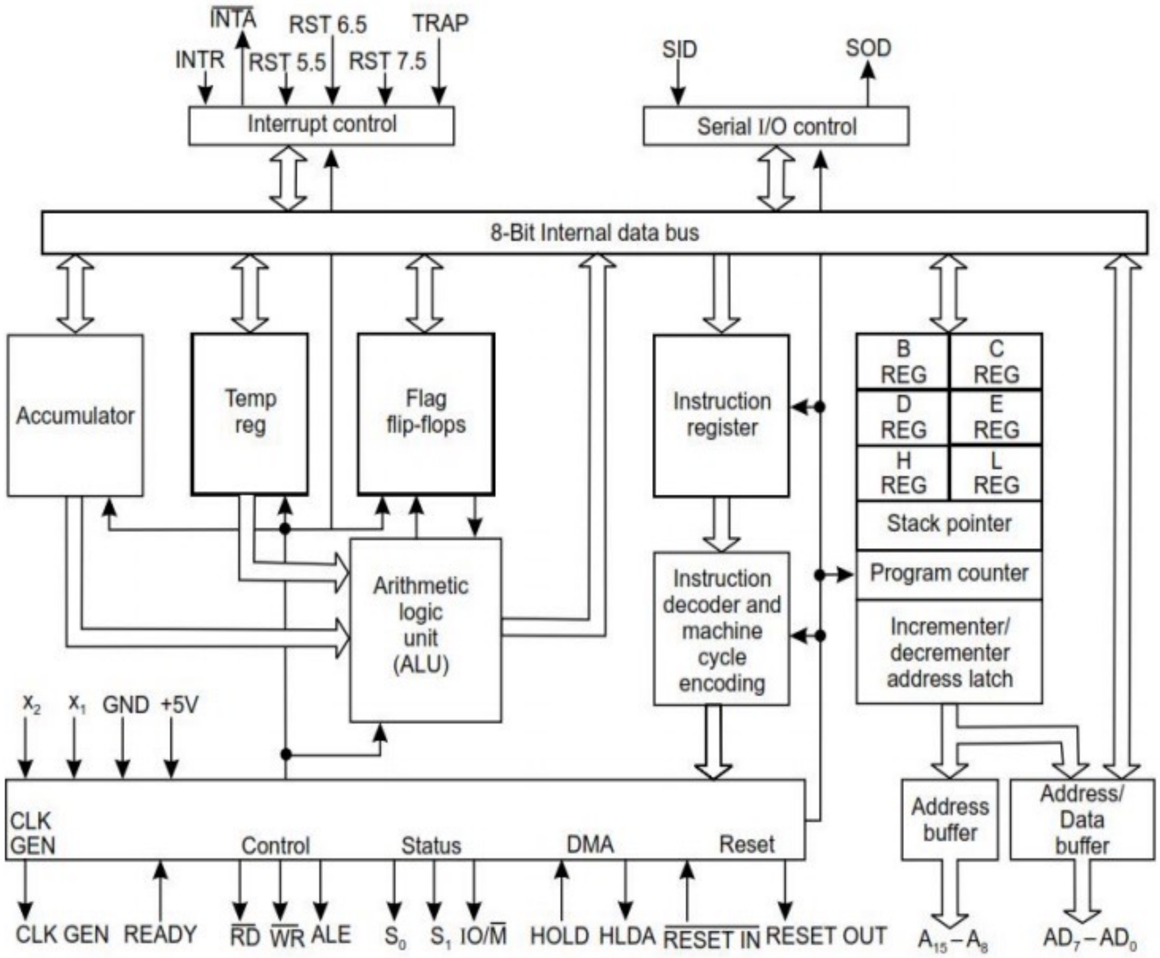


Fig 1.1 Hardware Architecture of 8085

- **Serial Input/output control**

controls the serial data communication using these two instructions: SID and SOD

- **Accumulator**

used to store 8-bit data and to perform arithmetic and logical operations.
The result of an operation is stored in the accumulator.

- **Temporary register**

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

- **Arithmetic Logic Unit**

performs the actual numerical and logic operation such as add, subtract, AND, OR, etc. Uses data from memory and from Accumulator to perform arithmetic.

- **Instruction Register/Decoder:**

Temporary store for the current instruction of a program.

Decoder then takes instruction and “decodes” or interprets the instruction.

- **Stack Pointer (SP):**

a 16-bit register used as a memory pointer.

points to a memory location in R/W memory, called the stack.

- **Program Counter (PC)**

a 16-bit register used to store the memory address location of the next instruction to be executed.

- **Address buffer and address-data buffer**

content stored in the stack pointer and program counter is loaded into the address buffer and address-data buffer to communicate with the CPU.

- **Address incrementor/ Decrementer**

responsible for incrementing or decrementing the content of PC so that it points to the next instruction.

Address bus and data bus

Address bus

- One wire for each bit. Total 16 bits= 16 wires.
- Memory consists of boxes, each with a unique address, the size of the address bus determines the size of memory, which can be used.
- To communicate with memory, the microprocessor sends an addresson the address bus eg: 0000000000000011(3 in decimal) to the memory.
- The memory selects the box number 3 for reading or writing data.
- Address is unidirectional.

Address bus and data bus

Data bus

- Carries data in binary form, between microprocessor and other external units.
- Typically data can be 8 bits or 16 bits.
- Consists of 8 wires.
- Data bus also carries the instructions from memory to the microprocessor.
- it is bidirectional.

- **Timing and Control Unit:**

An essential component that generates and manages the timing signals and control signals required to execute instructions.

Responsible for ensuring that the CPU executes instructions in a precise and controlled manner, while also handling external interrupts and managing the transfer of data between the CPU and other components of the computer.

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

- **Registers**

The 8085/8080A-programming mode includes 6 general purpose registers (B, C, D, E, H & L), one accumulator and one flag register.

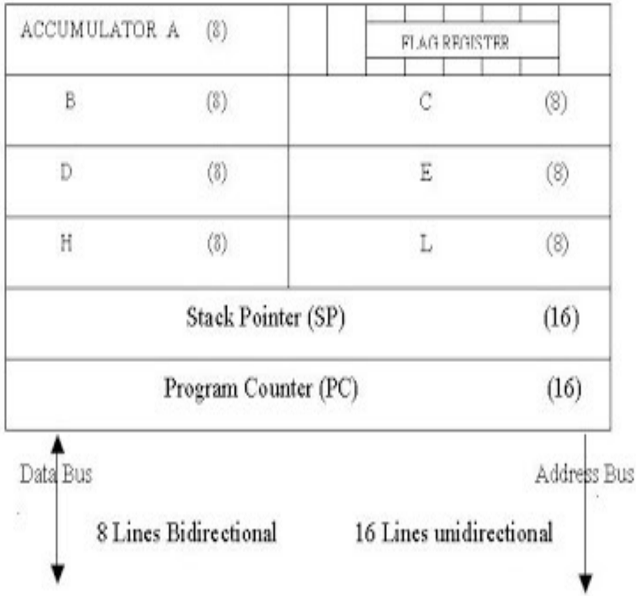
Additionally, has two 16-bit registers: the stack pointer and the program counter.

GPRs stores 8-bit data,but can work in pairs like B-C, D-E & H-L to perform 16-bit operations.

Programmers can use these registers to store or copy data into registers using data copy instructions.

Internal Register organization of 8085

- In 8085, there are six 8-bit registers (B, C, D, E, H, L), one accumulator, one flag register and two 16-bit registers: stack pointer and program counter.
- The programming model contains six GPRs and these can perform 16-bit operation by combining as BC, DE, HL.



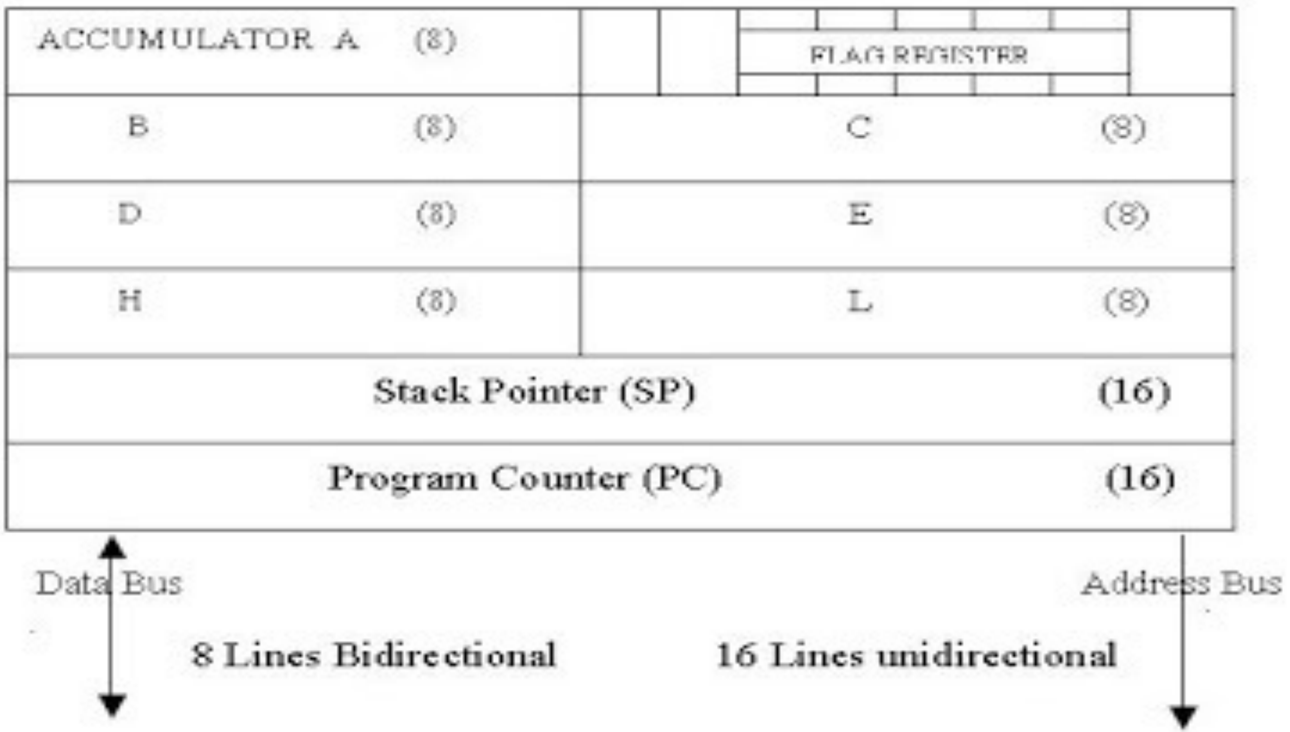


Figure: Programming model of 8085

- **Accumulator:** It is 8-bit register which is a part of ALU. This register is used to store 8-bit data and perform arithmetic and logical operation on it.
- **Stack Pointer:** The use of SP is to locate the top most location of stack or memory.
- **Program Counter:** The use of PC is to point the memory address from which next byte is to be fetched.
- **Flag:** The most commonly used flags are: sign flag, zero flag, etc.

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

- **Flags**

Includes five flip-flops set or reset after an operation according to data conditions of the result in the accumulator and other registers.

Zero(Z) flag: when the arithmetic operations result to zero, the flipflop called the zero flag is set to 1.

Sign(S) flag: After any operation if the MSB 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.

Carry(CY) flag: After the addition of two numbers, if the sum in the accumulator is larger than 8 bits, the carry flag is set.

Parity(P) flag: If after any arithmetic or logical operation, the result has an even number of 1 bit, the parity register becomes set, otherwise it becomes reset.

Auxiliary Carry(AC) flag: In BCD arithmetic, addition and subtraction are performed digit by digit, and the Auxiliary Carry flag is set if a carry-out or borrow-out occurs from the 4th bit of a digit to the 5th bit.

Limitations of 8085

- In 8 bit microprocessor, microprocessor can perform any arithmetic and logical operation only on 8 bit data at a time. For multi-byte numbers, microprocessor takes more time, as ALU is 8 bit.
- Due to the 16 bit address lines, we can address only up to 64 KB of memory, so we cannot use Intel 8085 in IBM Standard PC. Because, in IBM architecture standard, minimum 640KB of memory is required.
- 8085 has multiplexed address and data bus, so extra hardware is required to separate address signals from the data signals.
- Flags register has limited flags.
- Interrupts are very limited in 8085.
- Operating frequency is less, so the speed of execution is slow.
- While reading or writing 16 bit or more bytes of data from the memory or I/O device, the microprocessor needs more operation cycles.
- Using 8085, we cannot design multi-processor system.

For overcoming these limitations micro-processor with wider data buses and higher capacity registers were developed

Thank You ☺