8085 Microprocessor

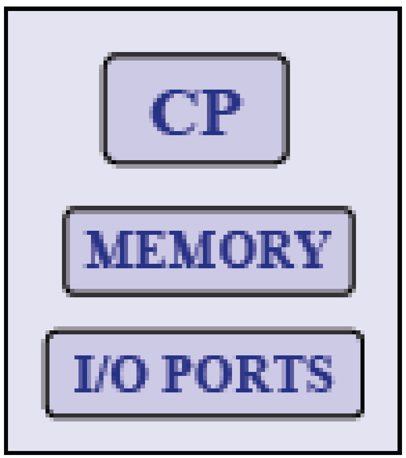
Noble P. Abraham

- **Microprocessor: A silicon chip that contains a CPU. In the world of personal computers, the terms *microprocessor and CPU are used interchangeably.***
- A **microprocessor (sometimes abbreviated µP) is a digital electronic component with miniaturized transistors on a single semiconductor integrated circuit (IC).**
- One or more microprocessors typically serve as a central processing unit (CPU) in a computer system or handheld device.
- Microprocessors made possible the advent of the microcomputer.
- At the heart of all personal computers and most working stations sits a microprocessor.
- Microprocessors also control the logic of almost all digital devices, from clock radios to fuel-injection systems for automobiles.
- Three basic characteristics differentiate microprocessors:
  - **Instruction set: The set of instructions that the microprocessor can execute.**
  - **Bandwidth: The number of bits processed in a single instruction.**
  - **Clock speed: Given in megahertz (MHz), the clock speed determines how many instructions per second the processor can execute.**

- **Microcontroller: A highly integrated chip that contains all the components comprising a controller.**
- Typically this includes a CPU, RAM, some form of ROM, I/O ports, and timers.
- Unlike a general-purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task - to control a particular system.
- A microcontroller differs from a microprocessor, which is a general-purpose chip that is used to create a multi-function computer or device and requires multiple chips to handle various tasks.
- A microcontroller is meant to be more self-contained and independent, and functions as a tiny, dedicated computer.
- The great advantage of microcontrollers, as opposed to using larger microprocessors, is that the parts-count and design costs of the item being controlled can be kept to a minimum.
- They are typically designed using CMOS (complementary metal oxide semiconductor) technology, an efficient fabrication technique that uses less power and is more immune to power spikes than other techniques.
- Microcontrollers are sometimes called *embedded microcontrollers, which just means that they are part of an embedded system that is, one part of a larger device or system.*

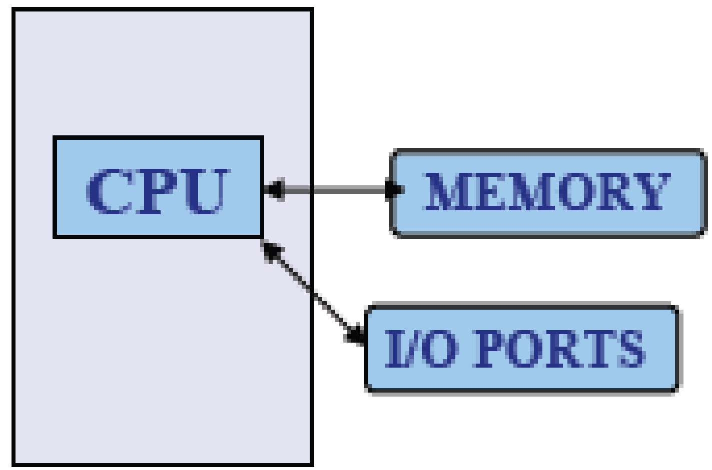
MICRO CONTROLLER

- It is a single chip
- Consists Memory, I/o ports



MICRO PROCESSER

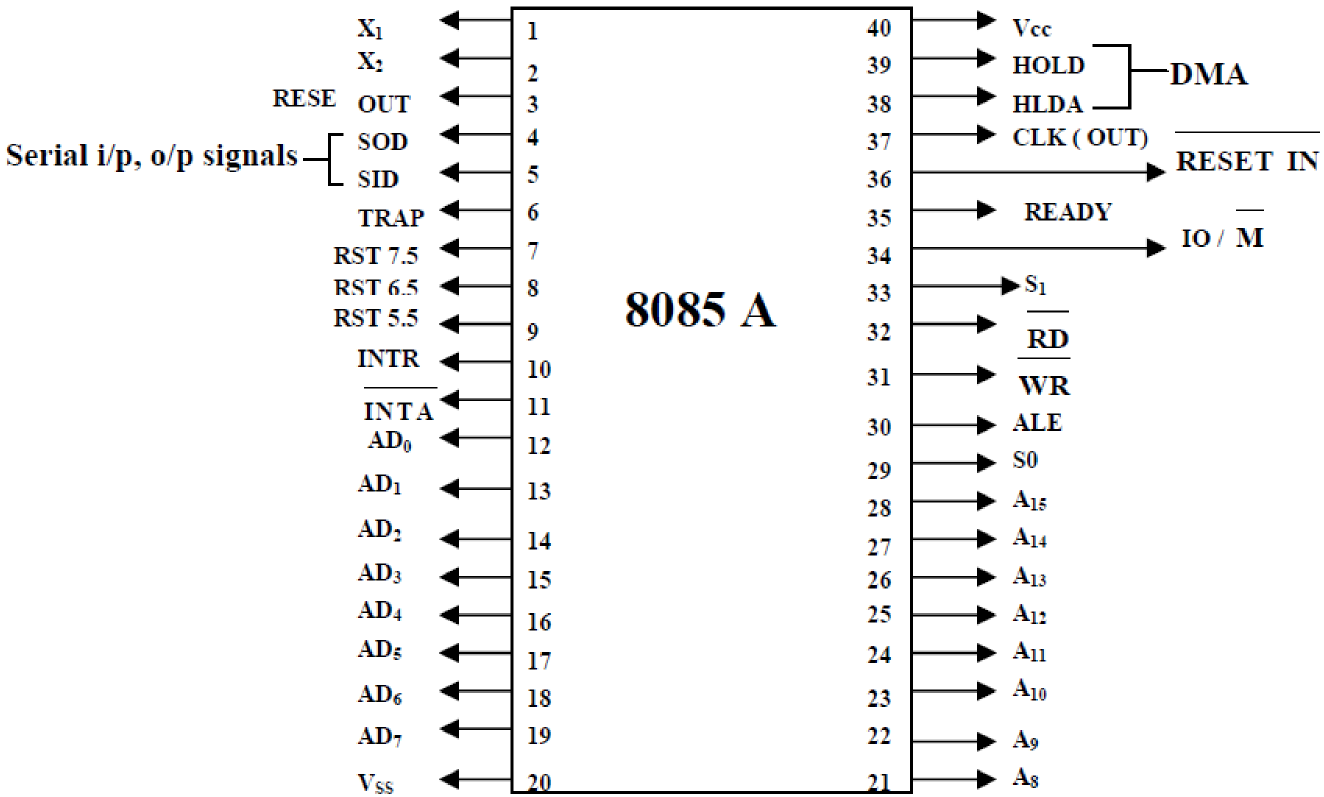
- It is a CPU
- Memory, I/O Ports to be connected externally



8085 µp

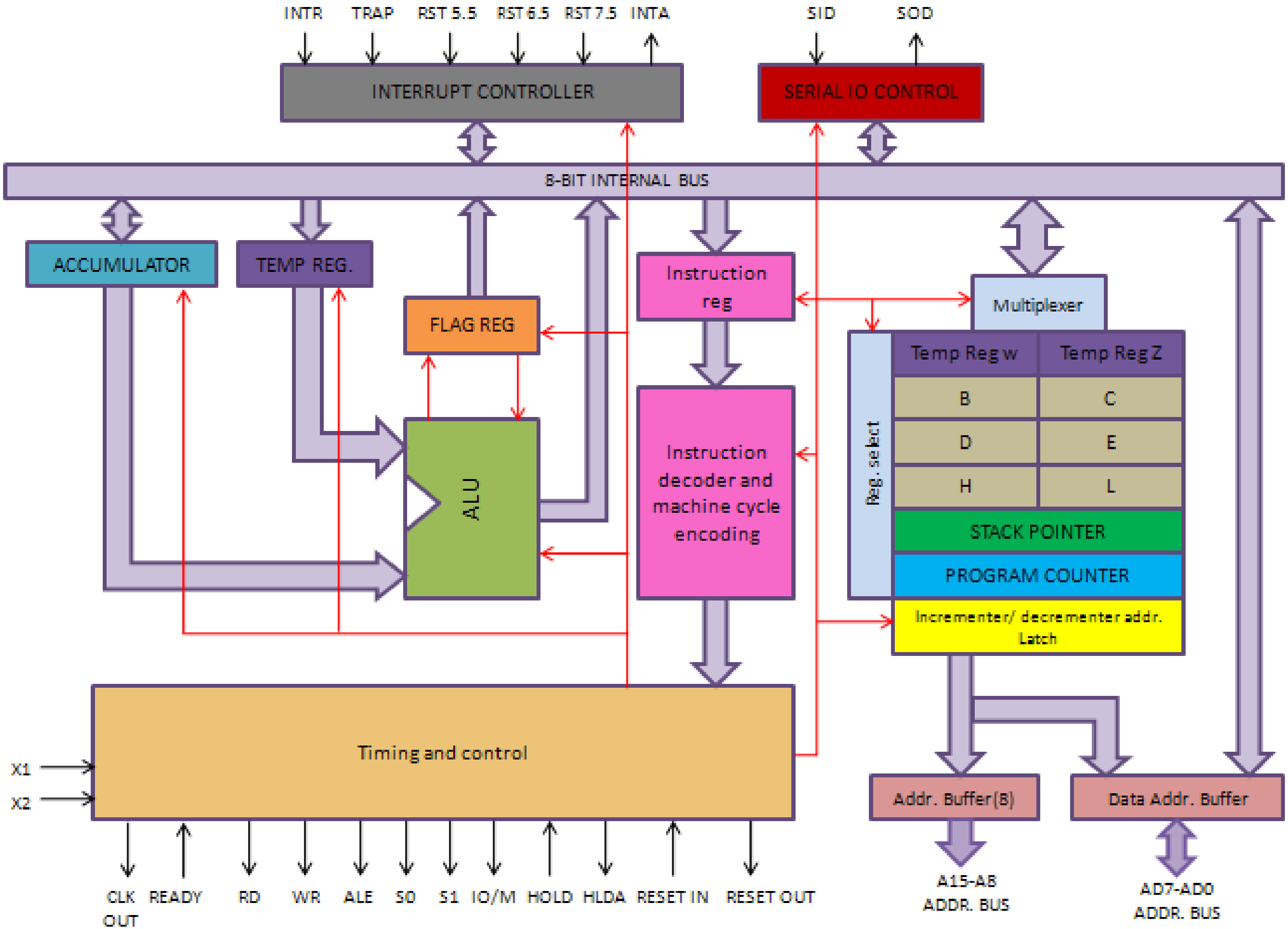
- It is a 8 bit microprocessor.
- It is manufactured with N-MOS technology.
- It has 16-bit address bus and hence can address up to 2^{16} = 65536 bytes (64KB) memory locations through A^0-A^{15}.
- The first 8 lines of address bus and 8 lines of data bus are multiplexed AD^0 – AD^7.
- Data bus is a group of 8 lines D^0 – D^7.
- It supports external interrupt request.
- A 16 bit program counter (PC)
- A 16 bit stack pointer (SP)
- Six 8-bit general purpose register arranged in pairs: BC, DE, HL.
- It requires a signal +5V power supply and operates at 3.2 MHZ single phase clock.
- It is enclosed with 40 pins DIP (Dual in line package).

Pin Diagram



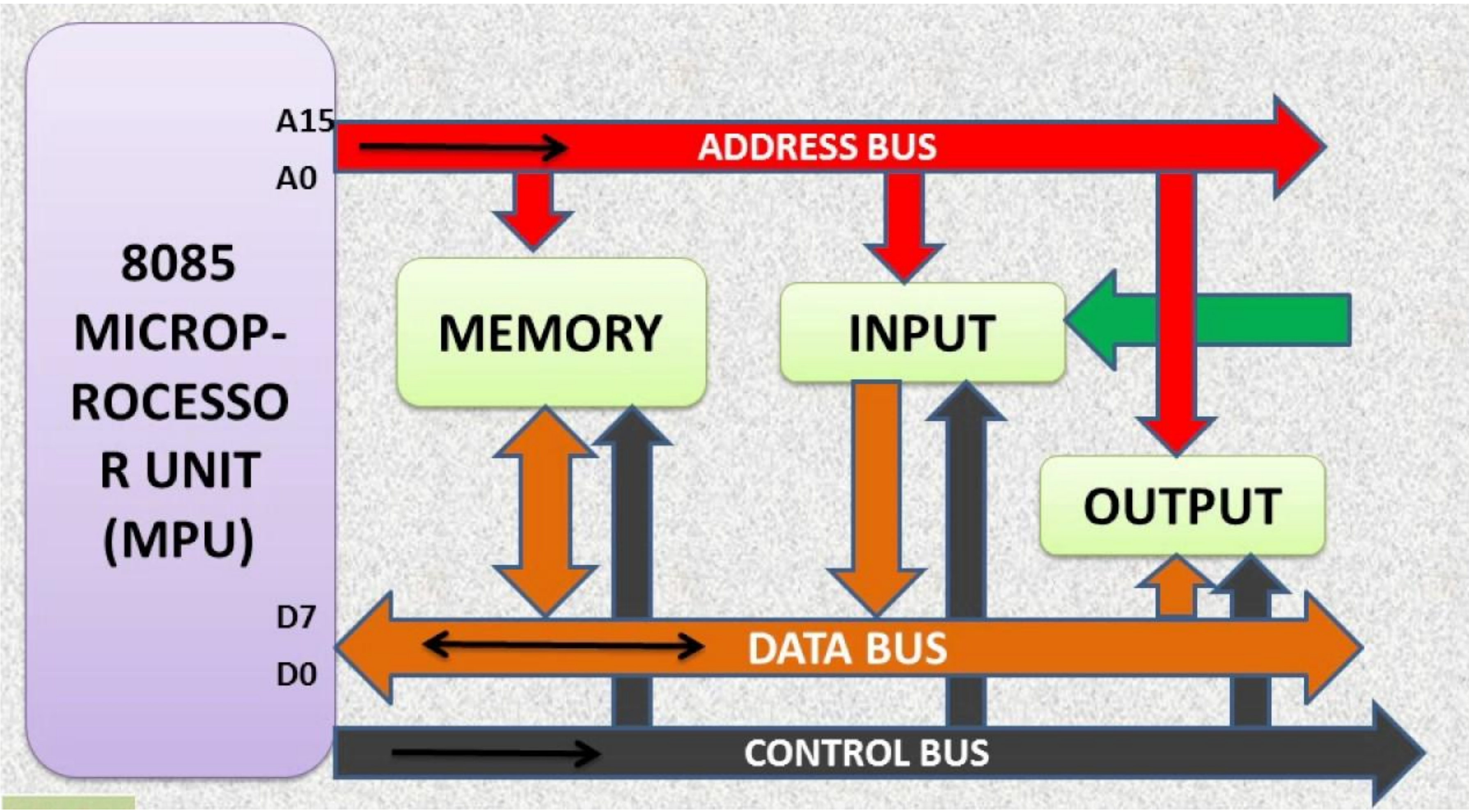
X1
X2
RESE OUT
Serial i/p, o/p signals
SOD
SID
TRAP
RST 7.5
RST 6.5
RST 5.5
INTR
INTA
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
VSS
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
8085 A
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
Vcc
HOLD
HLDA
DMA
CLK (OUT)
RESET IN
READY
IO / M
S1
RD
WR
ALE
S0
A15
A14
A13
A12
A11
A10
A9
A8

8085 Architecture



- The microprocessor can be programmed to perform functions on given data by writing specific instructions into its memory.
- The microprocessor reads one instruction at a time, matches it with its instruction set, and performs the data manipulation specified.
- The result is either stored back into memory or displayed on an output device.

Bus Structure



- The 8085 uses three separate busses to perform its operations
  - The address bus.
  - The data bus.
  - The control bus.

The Address Bus

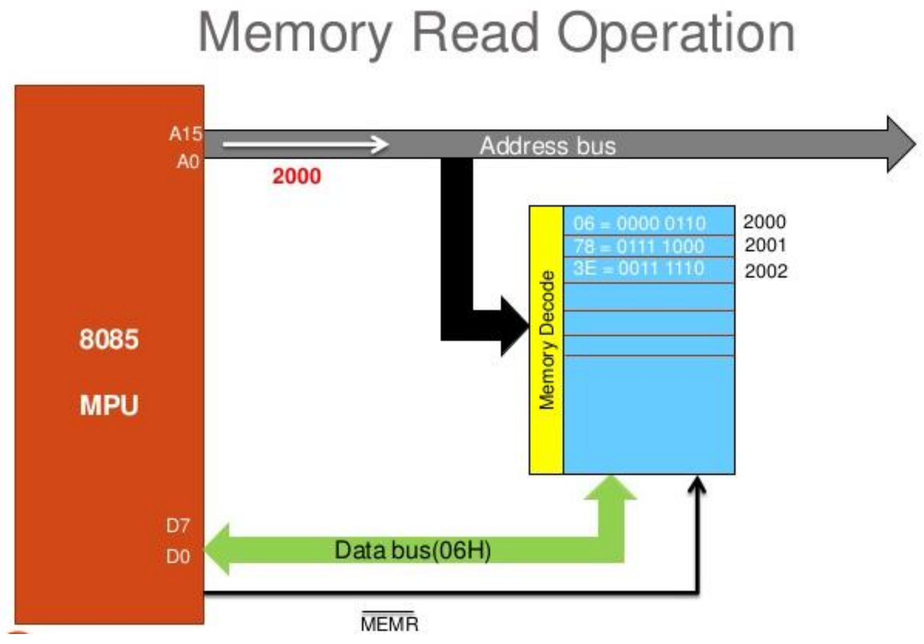
- 16 bits wide (A0 A1…A15)
- Therefore, the 8085 can access locations with numbers from 0 to 65,536. Or, the 8085 can access a total of 64K addresses.
- “Unidirectional”.
- Information flows out of the microprocessor and into the memory or peripherals.
- When the 8085 wants to access a peripheral or a memory location, it places the 16-bit address on the address bus and then sends the appropriate control signals.

The Data Bus

- 8 bits wide (D0 D1…D7)
- “Bi-directional”.
- Information flows both ways between the microprocessor and memory or I/O.
- The 8085 uses the data bus to transfer the binary information.
- Since the data bus has 8-bits only, then the 8085 can manipulate data 8 bits at-a-time only.

The Control Bus

- There is no real control bus. Instead, the control bus is made up of a number of single bit control signals.
- To communicate with a memory, for example as shown figure, to read an instruction from a memory location
  - The MPU places the 16-bits address on the address bus.
  - The address on the bus is decoded by external logic circuits and memory location is identified.
  - MPU sends a pulse called Memory Read as the control signal.
  - The pulse activates the memory chip, and the contents of the memory location i.e. (8-bit Data) are placed on the data bus and brought inside the microprocessor.



Operation Types in a Microprocessor

- All of the operations of the microprocessor can be classified into one of three types:
  - Microprocessor Initiated Operations
  - Internal Operations
  - Peripheral Initiated Operations

Microprocessor Initiated Operations

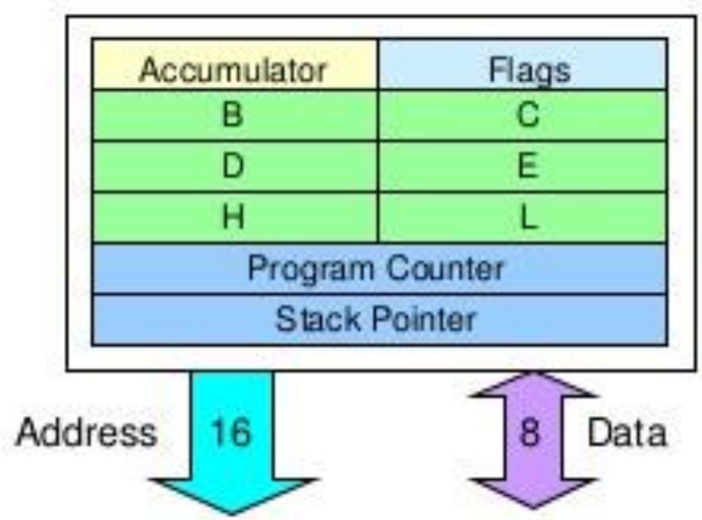
- These are operations that the microprocessor itself starts.
- These are usually one of 4 operations:
  - Memory Read
  - Memory Write
  - I/O Read (Get data from an input device)
  - I/O write (Send data to an output device)
- It is important to note that the microprocessor treats memory and I/O devices the same way.

Microprocessor Initiated Operations

- Input and output devices simply look like memory locations to the microprocessor.
  - For example, the keyboard may look like memory address A3F2H. To get what key is being pressed, the microprocessor simply reads the data at location A3F2H.
- The communication process between the microprocessor and peripheral devices consist of the following three steps:
  - Step 1: Identify the peripheral or the memory location (with its address).
  - Step 2: Transfer the binary information (Data and Instruction).
  - Step 3: Provide timing or synchronization signals.

Internal Data Operations

- The 8085 can perform a number of internal operations. Such as: storing data, Arithmetic & Logic operations, Testing for condition, etc.
  – To perform these operations, the microprocessor needs an internal architecture similar to the following:



Externally Initiated Operations

- External devices can initiate (start) one of the 4 following operations:
- **Reset**
  - All operations are stopped and the program counter is reset to 0000.
- **Interrupt**
  - The microprocessor’s operations are interrupted and the microprocessor executes what is called a “service routine”.
  - This routine “handles” the interrupt, (perform the necessary operations). Then the microprocessor returns to its previous operations and continues.
- **Ready**
  - The 8085 has a pin called RDY. This pin is used by external devices to stop the 8085 until they catch up.
  - As long as the RDY pin is low, the 8085 will be in a wait state.
- **Hold**
  - The 8085 has a pin called HOLD. This pin is used by external devices to gain control of the busses.
  - When the HOLD signal is activated by an external device, the 8085 stops executing instructions and stops using the busses.
  - This would allow external devices to control the information on the busses.

The Design and Operation of Memory

- Memory in a microprocessor system is where information (data and instructions) is kept. It can be classified into two main types:
  - Main memory (RAM and ROM)
  - Storage memory (Disks , CD ROMs, etc.)
- The simple view of RAM is that it is made up of registers that are made up of flip-flops (or memory elements).
- The number of flip-flops in a “memory register” determines the size of the memory word.
- ROM on the other hand uses diodes instead of the flip-flops to permanently hold the information.

Registers

- **Accumulator** or A register is an 8-bit register used for arithmetic, logic, I/O and load/store operations.
- **Flag** Register has five 1-bit flags.
  - Sign - set if the most significant bit of the result is set.
  - Zero - set if the result is zero.
  - Auxiliary carry - set if there was a carry out from bit 3 to bit 4 of the result.
  - Parity - set if the parity (the number of set bits in the result) is even.
  - Carry - set if there was a carry during addition, or borrow during subtraction/comparison/rotation.

Accumulator and Flag Register can be combined as a register pair called **Program Status Word** (PSW)

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

- **The Program Counter (PC)**
  - This is a register that is used to control the sequencing of the execution of instructions.
  - This register always holds the address of the next instruction.
  - Since it holds an address, it must be 16 bits wide.
- **The Stack pointer**
  - The stack pointer is also a 16-bit register that is used to point into memory.
  - The memory this register points to is a special area called the stack.
  - The stack is an area of memory used to hold data that will be retrieved soon.
  - The stack is usually accessed in a Last In First Out (LIFO) fashion.
  - **This register is always decremented/incremented by 2 during push and pop.**

General Purpose Registers

- 8-bit **B** and 8-bit **C** registers can be used as one 16-bit BC register pair. When used as a pair the C register contains low-order byte. Some instructions may use BC register as a data pointer.
- 8-bit **D** and 8-bit **E** registers can be used as one 16-bit DE register pair. When used as a pair the E register contains low-order byte. Some instructions may use DE register as a data pointer.
- 8-bit **H** and 8-bit **L** registers can be used as one 16-bit HL register pair. When used as a pair the L register contains low-order byte. HL register usually contains a data pointer used to reference memory addresses.

INDIVIDUAL	B, C, D, E, H, L
COMBININATON	B & C, D & E, H & L

Memory

- Program, data and stack memories occupy the same memory space. The total addressable memory size is 64 KB.
- **Program memory -** program can be located anywhere in memory. Jump, branch and call instructions use 16-bit addresses, i.e. they can be used to jump/branch anywhere within 64 KB. All jump/branch instructions use absolute addressing.
- **Data memory -** the processor always uses 16-bit addresses so that data can be placed anywhere.
- **Stack memory** is limited only by the size of memory. Stack grows downward.
- First 64 bytes in a zero memory page should be reserved for vectors used by RST instructions.

Tri-State Buffers

- An important circuit element that is used extensively in memory.
- This buffer is a logic circuit that has three states:
  - Logic 0, logic1, and high impedance.
- When this circuit is in high impedance mode it looks as if it is disconnected from the output completely

Instruction Set

- 8085 instruction set consists of the following instructions:
  - Data moving instructions.
  - Arithmetic - add, subtract, increment and decrement.
  - Logic - AND, OR, XOR and rotate.
  - Control transfer - conditional, unconditional, call subroutine, return from subroutine and restarts.
  - Input/Output instructions.
  - Other - setting/clearing flag bits, enabling/disabling interrupts, stack operations, etc.

Addressing mode

- **Register -** references the data in a register or in a register pair.
- **Register indirect -** instruction specifies register pair containing address, where the data is located.
- **Direct, Immediate -** 8 or 16-bit data.

Interrupts

- **INTR** is maskable 8080A compatible interrupt. When the interrupt occurs the processor fetches from the bus one instruction, usually one of these instructions:
- One of the 8 RST instructions (RST_0 - RST_7). The processor saves current program counter into stack and branches to memory location N * 8 (where N is a 3-bit number from 0 to 7 supplied with the RST instruction).
- **CALL** instruction (3 byte instruction). The processor calls the subroutine, address of which is specified in the second and third bytes of the instruction.
- **RST5.5** is a maskable interrupt. When this interrupt is received the processor saves the contents of the PC register into stack and branches to 2CH (hexadecimal) address.
- **RST6.5** is a maskable interrupt. When this interrupt is received the processor saves the contents of the PC register into stack and branches to 34H (hexadecimal) address.
- **RST7.5** is a maskable interrupt. When this interrupt is received the processor saves the contents of the PC register into stack and branches to 3CH (hexadecimal) address.
- **TRAP** is a non-maskable interrupt. When this interrupt is received the processor saves the contents of the PC register into stack and branches to 24H (hexadecimal) address.
- All maskable interrupts can be enabled or disabled using EI and DI instructions. RST 5.5, RST6.5 and RST7.5 interrupts can be enabled or disabled individually using SIM instruction.

References

- Microprocessor architecture, programming and applications- Ramesh S. Gaonkar
- Fundamentals of Microprocessors and microcomputers- B. Ram (Dhanpat Rai Pub.)
- Microcomputers and Microprocessors- John Uffenbeck (PHI Pub.)