MICROPROCESSOR AND ITS APPLICATIONS

Unit–I

Microcomputer – microprocessor architecture and its operations – memory input/output – addressing modes – instruction classification, format and timings.

Introduction to Microcomputer

The Microprocessor based system (single board microcomputer) consists of microprocessor as CPU, semiconductor memories like EPROM and RAM, input device, output device and interfacing devices. The memories, input device, output device and interfacing devices are called peripherals. The popular input devices are keyboard and floppy disk and the output devices are printer, LED/LCD displays, CRT monitor, etc.

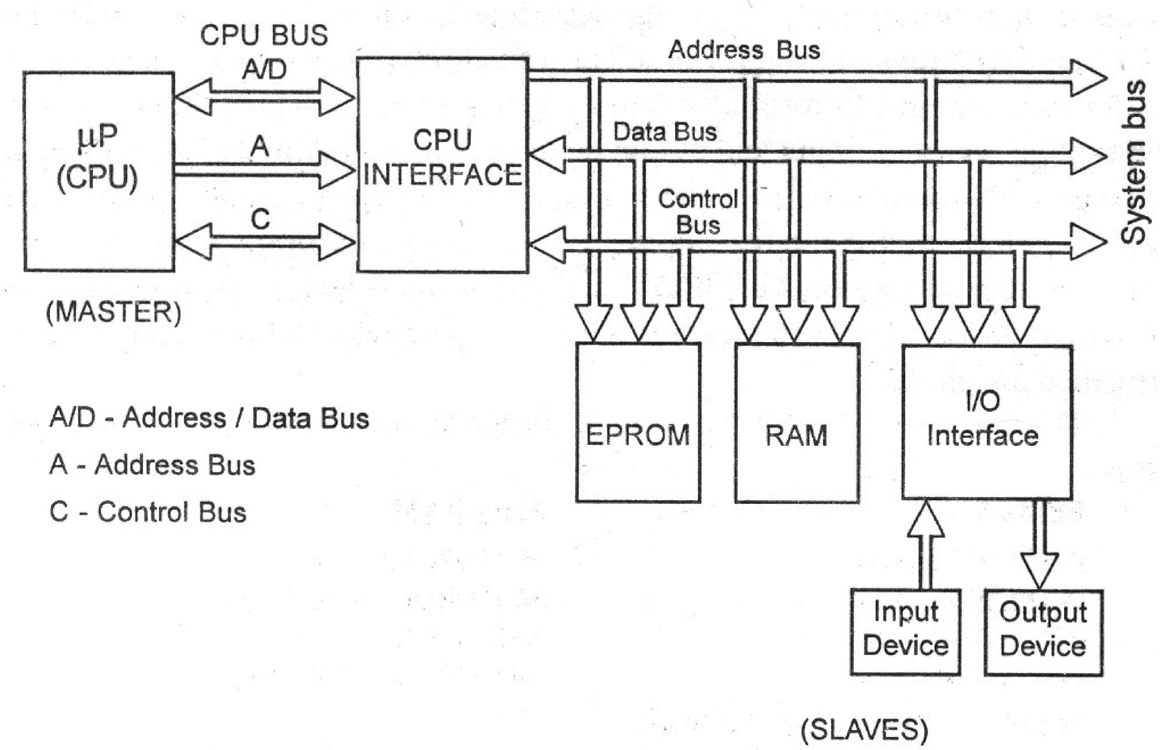


Fig : 1.1 Microprocessor Based System (organisation of microcomputer)

The above block diagram shows the organization of a microprocessor based system. In this system, the microprocessor is the master and all other peripherals are slaves. The master controls all the peripherals and initiates all operations.

The work done by the processor can be classified into the following three groups.

1. Work done internal to the processor
2. Work done external to the processor
3. Operations initiated by the slaves or peripherals.

The work done internal to the processors are addition, subtraction, logical operations, data transfer operations, etc. The work done external to the processor are reading/writing the memory and reading/writing the I/O devices or the peripherals. If the peripheral requires the attention of the master then it can interrupt the master and initiate an operation.

The microprocessor is the master, which controls all the activities of the system. To perform a specific job or task, the microprocessor has to execute a program stored in memory. The program consists of a set of instructions. It issues address and control signals and fetches the instruction and data from memory. The instruction is executed one by one internal to the processor and based on the result it takes appropriate action.

Input

The input section transfers data and instructions in binary from the outside world to the microprocessor. It includes devices such as keyboards, teletypes, and analog-to-digital converters. Typically, a microcomputer includes a keyboard as an input device. The key board has sixteen data keys (o to 9 and A to F) and some additional function keys to perform operations such as storing data and executing programs.

Output

The output section transfers data from the microprocessor to output devices such as light emitting diodes (LEDs), cathode-ray-tubes (CRTs), printers, magnetic tape, or another computer. Typically, single-board computers include LEDs and seven-segment LEDs as output devices.

Memory

Memory stores binary information such as instructions and data, and provides that information to the microprocessor whenever necessary. To execute programs, the microprocessor reads instructions and data from memory and performs the computing operations in its ALU section. Result are either transferred to the output section for display or stored in memory for later use. The memory block has two sections : Read - Only Memory (ROM) and Read / Write Memory (R/WM), popularly known as Random Access Memory (RAM).

The ROM is used to store programs that do not need alterations. The monitor program of a single - board microcomputer is generally stored in the ROM. Program stored in the ROM can only be read; they cannot be altered.

The Read / Write memory (R/WM) is also known as user memory. It is used to store user programs and data. The information stored in this memory can be read and altered easily.

System Bus

The system bus is a communication path between the microprocessor and the peripherals; it is nothing but a group of wires that carries bits. The microcomputer bus is in many ways similar to a one-track, express subway, the microcomputer bus carries bits between the microprocessor and only one peripheral at a time. The same bus is time - shared to communicate with various peripherals, with the timing provided by the control section of the microprocessor.

Address Bus

This is a unidirectional bus, because information flows over it in only one direction, from the CPU to the memory or I/O elements. The CPU alone can place logic levels on the lines of the address bus, thereby generating $2^{16} = 65{,}536$ different possible addresses. Each of these addresses corresponds to one memory location or one I/O element.

When the CPU wants to communicate (read or write) with a certain memory location or I/O device, it places the appropriate 16-bit address code on its 16 address pin outputs, A_0 through A_{15}, and onto the address bus. These address bits are then decoded to select the desired memory location or I/O device.

Data Bus

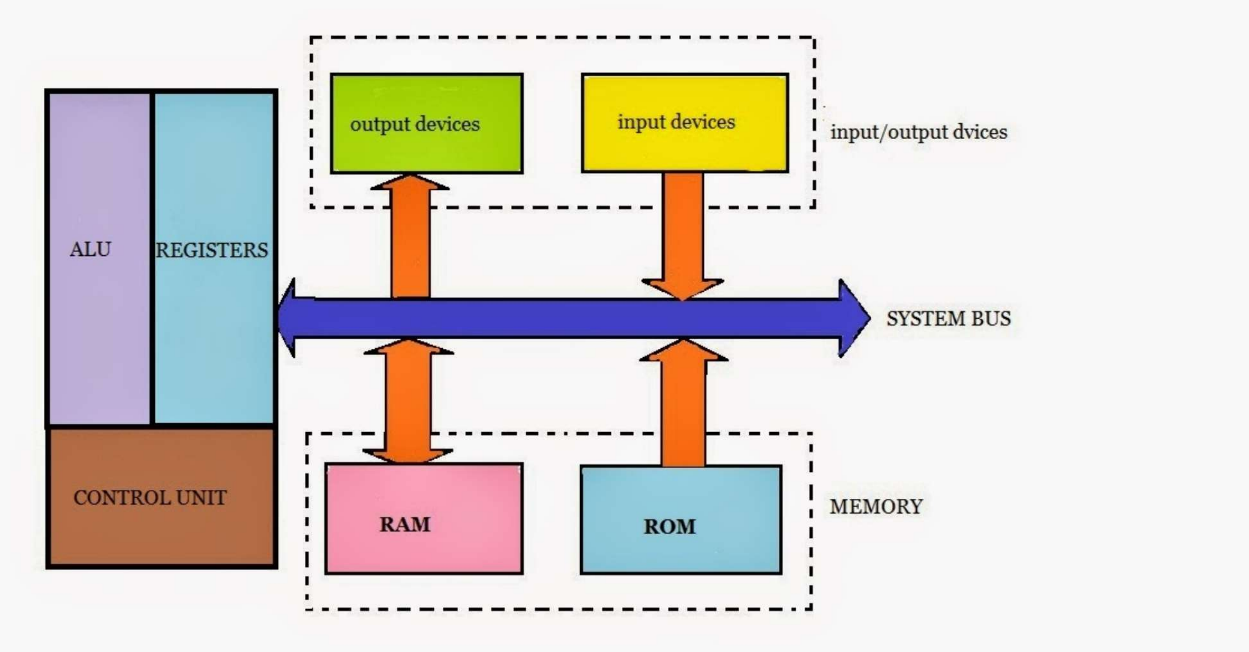
This is a bi-directional bus, because data can flow to or from the CPU. The CPU's eight data pins, D_0 through D_7,can be either inputs or outputs, depending on whether the CPU is performing a read or a write operation. During data bus by the memory or I/O element. During a write operation the CPU's data pins act as outputs and place data on the data bus, which are then sent to the selected memory or I/O element.

Control Bus

This is the set of signals that is used to synchronize the activities of the separate microcomputer elements. Some of these control signals, such as RD and WR are sent by the CPU to the other elements to tell them what type of operation is currently in progress. The I/O elements can send control signals to the CPU. An example is the rest input (RES) of the CPU which, when driven LOW, causes the CPU to reset to a particular starting stare.

Microprocessor

The microprocessor is a semiconductor device consisting of electronic logic circuits manufactured by using either a large-scale (LSI) or very large-scale integration (VLSI) technique. The microprocessor is capable of performing computing functions and making decisions to change the sequence of program execution. The microprocessor can be divided into three segments, arithmetic/logic unit (ALU), register unit, and control unit.



Block Diagram of Microprocessor

Arithmetic and Logic Unit : In this area of the microprocessor, computing functions are performed on data. The CPU performs arithmetic operations such as addition and subtraction, and logic operations such as AND, OR, and exclusive OR. Results are stored either in register or in memory or sent to output devices.

Register Unit : This area of the microprocessor consists of various registers. The register are used primarily to store data temporarily during the executing of a program. Some of the registers are accessible to the user through instructions.

Control Unit : The control unit provides the necessary timing and control signals to all the operations in the microcomputer. It controls the flow of data between the microprocessor and peripherals (including memory).

Microprocessor Architecture and its Operations

The MPU performs primarily four operations.

1. Memory Read: Reads data from memory.
2. Memory Write: Writes data into memory.
3. I/O read: Accepts data from input devices.
4. I/O Write: Sends data to output devices.

All these operations are part of the communication process between the MPU and peripheral devices (including memory). To communicate with a peripheral (or a memory location), the Microprocessor needs to perform the following steps:

Step 1 : Identify the peripheral or the memory location (with its address).
Step 2 : Transfer data
Step 3 : Provide timing or synchronization signals.

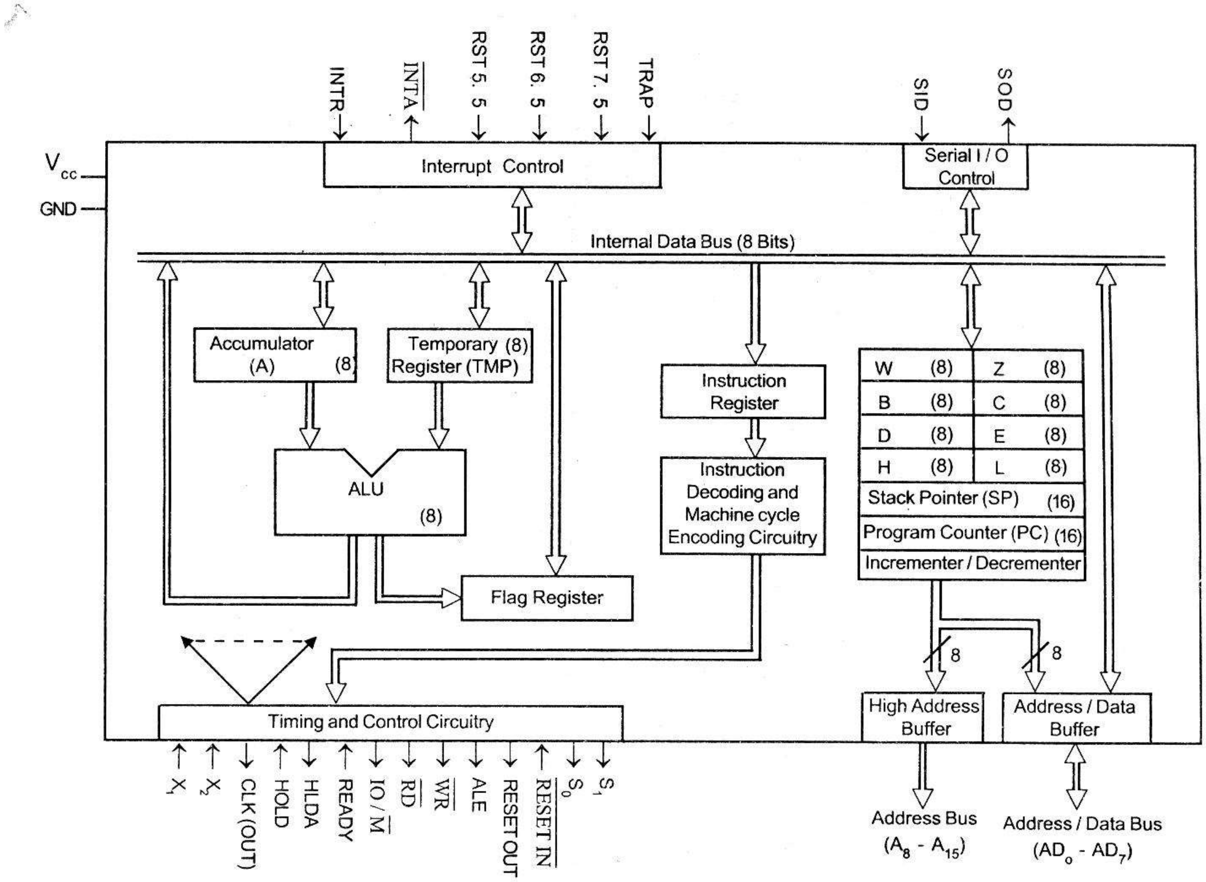
The internal operations can be performed by the microprocessor are

1. Store 8-bits 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 logic unit (ALU) and control logic, and internal buses (path for information flow).

INTEL 8085 ARCHITECTURE

The architecture of.8085 is shown in figure given below. The internal architecture of 8085 includes the ALU, timing and control unit, instruction register and decoder, register array, interrupt control and serial I/O control.



Operations performed by 8085

The ALU performs the arithmetic and logical operations.

The operations performed by ALU of 8085 are addition, subtraction, increment, decrement, logical AND, OR, EXCLUIVE -OR, compare, complement and left / right shift. The accumulator and temporary register are used to hold the data during an arithmetic / logical operation. After an operation the result is stored in the accumulator and the flags are set or reset according to the result of the operation.

Registers

The 8085 has six general - purpose registers to perform the first operation listed above, that is, to store 8-bit data during a program execution. These registers are identified as B, C, E, H, and L. They can be combined as register pairs - BC, DE, and HL - to perform some 16-bit operation.

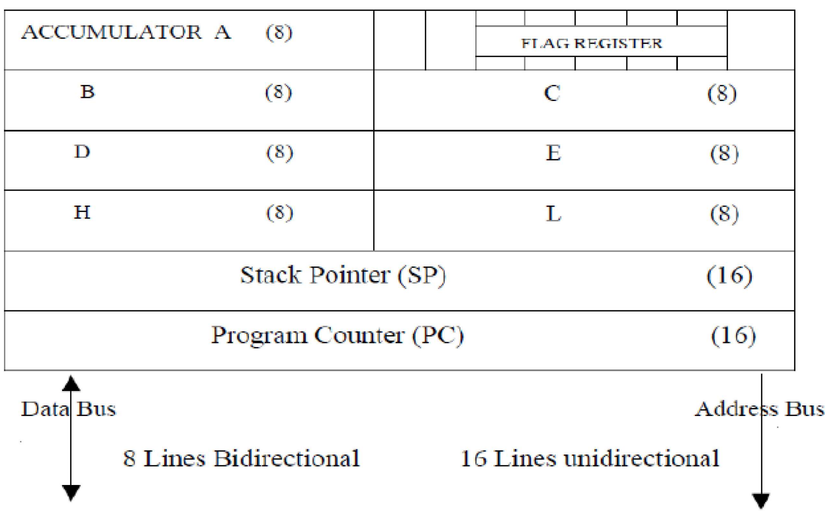


Fig. 3 Register organisation

These registers are programmable, meaning that a programmer can use them to load or transfer data from the registers by using instructions.

Accumulator

The accumulator is an 8-bit register that is part of the arithmetic logic unit (ALU). This register is used to store 8-bit data and to perform arithmetic and logical operations. The result of an operation is stored in the accumulator. The accumulator is also identified as register A.

Flags

The ALU includes five flip-flops that are set or reset according to data conditions in the accumulator and other registers. The microprocessor uses them to perform the third operation; namely testing for data conditions.

The bit position of the flip flop in flag register is:

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

All of the three flip flop set and reset according to the stored result in the accumulator.

For example, after an addition of two numbers, if the result in the accumulator is larger than 8-bit, the flip-flop uses to indicate a carry by setting CY flag to 1. When an arithmetic operation results in zero, Z flag is set to 1. The S flag is just a copy of the bit D7 of the accumulator. A negative number has a 1 in bit D7 and a positive number has a 0 in 2's complement representation. The AC flag is set to 1, when a carry result from bit D3 and passes to bit D4. The P flag is set to 1, when the result in accumulator contains even number of 1s.

Stack Pointer (SP)
The stack pointer SP, holds the address of the stack top. The stack is a sequence of RAM memory locations defined by the programmer. The stack is used to save the content of registers during the execution of a program.

Program Counter (PC):
The program counter (PC) keeps track of program execution. To execute a program the starting address of the program is loaded in program counter. The PC sends out an address to fetch a byte of instruction from memory and increment its content automatically. Hence, when a byte of instruction is fetched, the PC holds the address of the next byte of the instruction or next instruction.

Timing and Control Unit
It provides timing and control signal to the microprocessor to perform the various operation. It has three control signal. It controls all external and internal circuits. It operates with reference to clock signal. It synchronizes all the data transfers.
There are three control signal:

1.ALE-Address Latch Enable, It provides control signal to synchronize the components of microprocessor.
2.RD- This is active low used for reading operation.
3.WR-This is active low used for writing operation.

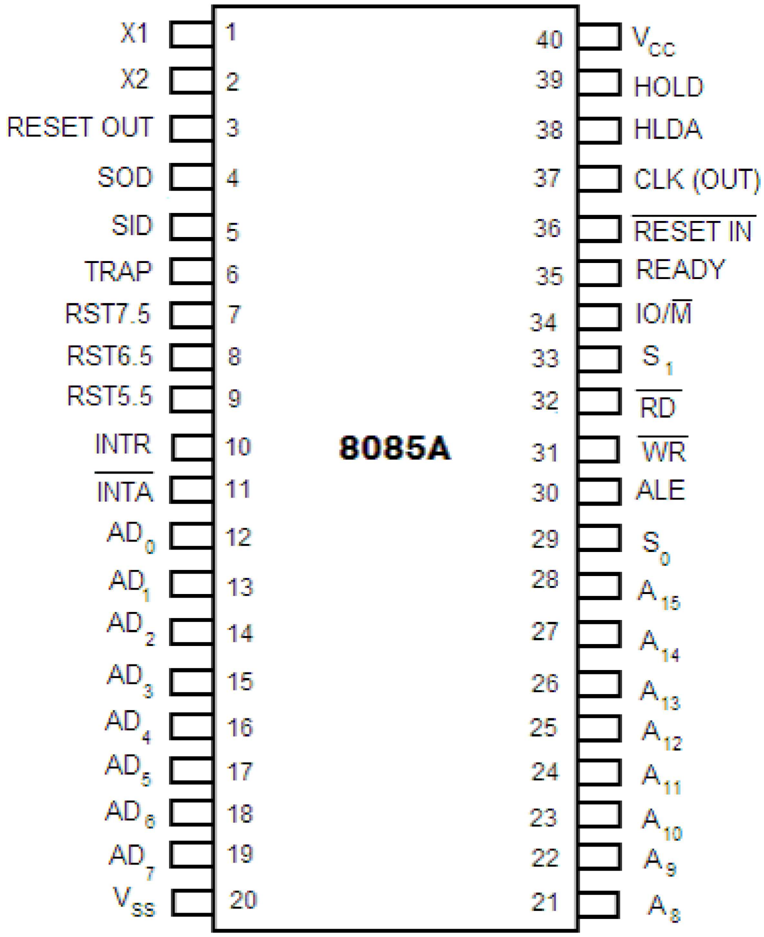
There are three status signal used in microprocessor S0, S1 and IO/M. It changes its status according the provided input to these pins.

Serial Input Output Control
There are two pins in this unit. This unit is used for serial data communication.

Interrupt Unit

There are 6 interrupt pins in this unit. Generally an external hardware is connected to these pins. These pins provide interrupt signal sent by external hardware to microprocessor and microprocessor sends acknowledgement for receiving the interrupt signal. Generally INTA is used for acknowledgement.

Pin Diagram and Pin description of 8085



The 8085 microprocessor is available on a 40-pin Dual-in-Line package (DIP). The following describes the function of each pin:

A8 – A15 (Output 3 State): Address Bus

The most significant 8 bits of the memory address or the 8 bits of the I/0 addresses, 3 stated during Hold and Halt modes.

AD0 - AD7 (Input/ Output 3 state): Multiplexed Address/Data Bus

Lower 8 bits of the memory address (or I/0 address) appear on the bus during the first clock cycle of a machine state. It then becomes the data bus during the second and third clock cycles. 3 stated during Hold and Halt modes.

ALE (Output): Address Latch Enable

It occurs during the first clock cycle of a machine state and enables the address to get latched into the on chip latch of peripherals. The falling edge of ALE is set to guarantee setup and hold times for the address information. ALE can also be used to strobe the status information.

SO, S1 (Output): Data Bus Status

Encoded status of the bus cycle:

S1	S0	status
0	0	HALT
0	1	WRITE
1	0	READ
1	1	FETCH

RD (Output 3state): READ

Indicates the selected memory or 1/0 device is to be read and that the Data Bus is available or the data transfer.

WR (Output 3state): WRITE

Indicates the data on the Data Bus is to be written into the selected memory or 1/0 location.

READY (Input):

If Ready is high during a read or write cycle, it indicates that the memory or peripheral is ready to send or receive data. If Ready is low, the CPU will wait for Ready to go high before completing the read or write cycle.

HOLD (Input):

Indicates that another Master is requesting the use of the Address and Data Buses. The CPU, upon receiving the Hold request. will relinquish the use of buses as soon as the completion of the current machine cycle. Internal processing can continue. The processor can regain the buses only after the Hold is removed. When the Hold is acknowledged, the Address, Data, RD, WR, and IO/M lines are 3stated.

HLDA (Output): HOLD ACKNOWLEDGE

Indicates that the CPU has received the Hold request and that it will relinquish the buses in the next clock cycle. HLDA goes low after the Hold request is removed. The CPU takes the buses one half clock cycle after HLDA goes low.

INTR (Input): INTERRUPT REQUEST

It is used as a general purpose interrupt. It is sampled only during the next to the last clock cycle of the instruction. If it is active, the Program Counter (PC) will be inhibited from incrementing and an INTA will be issued. During this cycle a RESTART or CALL instruction can be inserted to jump to the interrupt service routine. The INTR is enabled and disabled by software. It is disabled by Reset and immediately after an interrupt is accepted.

INTA (Output): INTERRUPT ACKNOWLEDGE

It is used instead of (and has the same timing as) RD during the Instruction cycle after an INTR is accepted. It can be used to activate the 8259 Interrupt chip or some other interrupt port.

RST 5.5, RST 6.5, RST 7.5 (Inputs): RESTART INTERRUPTS

These three inputs have the same timing as INTR except they cause an internal RESTART to be automatically inserted.

RST 7.5 --------- Highest Priority

RST 6.5

RST 5.5--------Lowest Priority

The priority of these interrupts is ordered as shown above. These interrupts have a higher priority than the INTR.

TRAP (Input):

Trap interrupt is a non-maskable restart interrupt. It is recognized at the same time as INTR. It is unaffected by any mask or Interrupt Enable. It has the highest priority of any interrupt.

RESET IN (Input):

Reset sets the Program Counter to zero and resets the Interrupt Enable and HLDA flip-flops. None of the other flags or registers (except the instruction register) are affected The CPU is held in the reset condition as long as Reset is applied.

RESET OUT (Output):

Indicates CPU is being reset. Can be used as a system RESET. The signal is synchronized to the processor clock.

X1, X2 (Input):

Crystal or RC network connections to set the internal clock generator X1 can also be an external clock input instead of a crystal. The input frequency is divided by 2 to give the internal operating frequency.

CLK (Output):

Clock Output for use as a system clock when a crystal or R/ C network is used as an input to the CPU. The period of CLK is twice the X1, X2 input period.

IO/M (Output):

IO/M indicates whether the Read/Write is to memory or l/O Tristated during Hold

and Halt modes.

SID (Input): Serial input data line

The data on this line is loaded into accumulator bit 7 whenever a RIM instruction is executed.

SOD (output): Serial output data line

The output SOD is set or reset as specified by the SIM instruction.

Vcc:

+5 volts supply.

Vss:

Ground Reference.

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.

Microprocessor	Microcontroller
Microprocessor is heart of Computer system.	Micro Controller is a heart of embedded system
General-Purpose	Single-Purpose (control-oriented)
It is just a processor. Memory and I/O components have to be connected externally	Micro controller has external processor along with internal memory and i/O components
Since memory and I/O has to be connected externally, the circuit becomes large.	Since memory and I/O are present internally, the circuit is small.
Cost of the entire system increases	Cost of the entire system is low
High Processing Power	Low Processing Power
Due to external components, the entire power consumption is high. Hence it is not suitable to used with devices running on stored power like batteries.	Since external components are low, total power consumption is less and can be used with devices running on stored power like batteries.
Since memory and I/O components are all external, each instruction will need external operation, hence it is relatively slower.	Since components are internal, most of the operations are internal instruction, hence speed is fast.
Microprocessor have less number of registers, hence more operations are memory based.	Micro controller have more number of registers, hence the programs are easier to write.
Microprocessors are based on von Neumann model/architecture where program and data are stored in same memory module	Micro controllers are based on Harvard architecture where program memory and Data memory are separate
Mainly used in personal computers	Used mainly in washing machine, MP3 players

The 8051 Microcontroller is one of the basic type of microcontroller, designed by Intel in 1980's. This microcontroller was based on Harvard Architecture and developed primarily for use in embedded systems technology. Normally, this microcontroller was developed using NMOS technology, which requires more power to operate. Therefore, Intel redesigned Microcontroller 8051 using CMOS technology and their updated versions came with a letter C in their name, for instance an 80C51 it is an 8 bit microcontroller. These latest Microcontrollers requires less power to operate as compared to their previous versions. The 8051 Microcontroller has two buses and two memory spaces of 64K X 8 size for program and data units. It has an 8 bit processing unit and 8 bit accumulator units.

Some of the features that have made the 8051 popular are: