INTEL 8051 MICRCONTROLLER

Introduction: A decade back the process and control operations were totally implemented by the Microprocessors only. But now a days the situation is totally changed and it is occupied by the new devices called Microcontroller. The development is so drastic that we can‟t find any electronic gadget without the use of amicrocontroller. This microcontroller changed the embedded system design so simple and advanced that the embedded market has become one of the most sought after for not only entrepreneurs but for design engineersalso.

What is a Microcontroller?

A single chip computer or A CPU with all the peripherals like RAM, ROM, I/O Ports, Timers , ADCs etc... on the same chip. For ex: Motorola‟s 6811, Intel‟s 8051, Zilog‟s Z8 and PIC 16X etc…

MICROPROCESSORS & MICROCONTROLLERS:

Microprocessor: A CPU built into a single VLSI chip is called a microprocessor. It is a general-purpose device and additional external circuitryare added to make it a microcomputer. Themicroprocessor contains arithmetic and logic unit (ALU), Instruction decoder and control unit, Instruction register, Program counter (PC), clock circuit (internal or external), reset circuit (internal or external) and registers. But the microprocessor has no on chip I/O Ports, Timers , Memory etc.

For example, Intel 8085 is an 8-bit microprocessor and Intel 8086/8088 a 16-bit microprocessor. The block diagram of the Microprocessor is shown in Fig.1

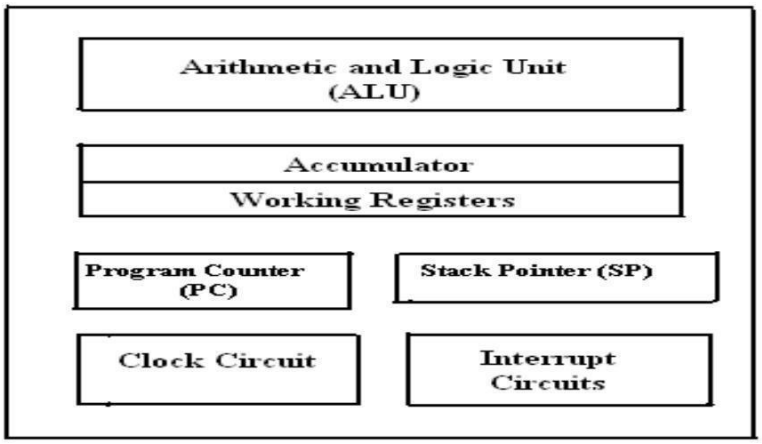


Fig.1 Block diagram of a Microprocessor.

MICROCONTROLLER :

A microcontroller is a highly integrated single chip, which consists of on chip CPU (Central Processing Unit), RAM (Random Access Memory), EPROM/PROM/ROM (Erasable Programmable Read Only Memory), I/O (input/output) – serial and parallel, timers, interrupt controller. For example, Intel 8051 is 8-bit microcontroller and Intel 8096 is 16-bit microcontroller. The block diagram of Microcontroller is shown in Fig.2.

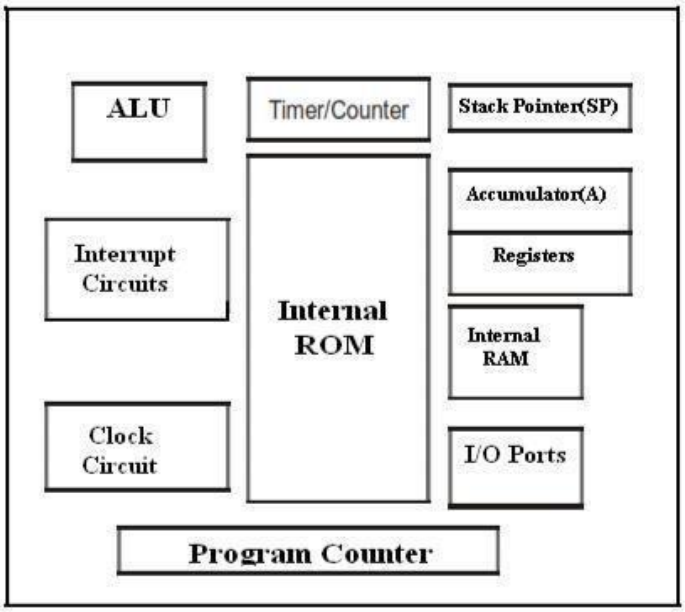


Fig.2.Block Diagram of a Microcontroller

Distinguish between Microprocessor and Microcontroller

S.No	Microprocessor	Microcontroller
1	A microprocessor is a general purpose device which is called a CPU	A microcontroller is a dedicated chip which is also called single chip computer.
2	A microprocessor donotcontain onchip I/O Ports,Timers,Memories etc..	A microcontroller includes RAM,ROM, serial and parallel interface,timers, interrupt circuitry (in addition to CPU) in a single chip.
3	Microprocessors are most commonlyused as the CPU in microcomputer systems	Microcontrollers are used in small, minimum component designs performing Control-oriented applications.
4	Microprocessor instructions are mainly nibble or byte addressable	Microcontroller instructions are bothbit Addressable as well as byte addressable.
5	Microprocessor instructionsetsare mainly intended for catering to Large volumesofdata.	Microcontrollers have instruction sets catering to the control of inputs and Outputs.
6	Microprocessor based system design is complexandexpensive	Microcontroller based system design is rather simple and costeffective
7	The Instruction set of microprocessoris complex with large numberofinstructions.	The instruction set of a Microcontroller is very simple with less number of instructions. For, ex: PICmicrocontrollers have only 35 instructions**.**
8	Amicroprocessor has zero status flag	A microcontroller has no zero flag.

INTEL 8051 MICRCONTROLLER:

The 8051 microcontroller is a very popular 8-bit microcontroller introduced by Intel in the year 1981 and it has become almost the academic standard now a days. The 8051 is based on an 8-bit CISC core with Harvard architecture. Its 8-bit architecture is optimized for control applications with extensive Boolean processing. It is available as a 40-pin DIP chip and works at +5 Volts DC. The salient features of 8051 controller are given below.

SALIENT FEATURES: The salient features of 8051 Microcontroller are

1. 4 KB on chip program memory (ROM orEPROM)).
2. 128 bytes on chip data memory(RAM).
3. 8-bit databus
4. 16-bit addressbus
5. 32 general purpose registers each of 8bits
6. Two -16 bit timers T_0 andT_1
7. Five Interrupts (3 internal and 2external).
8. Four Parallel ports each of 8-bits (PORT0, PORT1,PORT2,PORT3) with atotal of 32 I/Olines.
9. One 16-bit program counter and One 16-bit DPTR (datapointer)
10. One 8-bit stackpointer

ARCHITECTURE & BLOCK DIAGRAM OF 8051 MICROCONTROLLER:

The architecture of the 8051 microcontroller can be understood from the block diagram. It has Harward architecture with RISC (Reduced InstructionSetComputer) concept. The blockdiagram of 8051 microcontroller is shown in Fig 3.below1

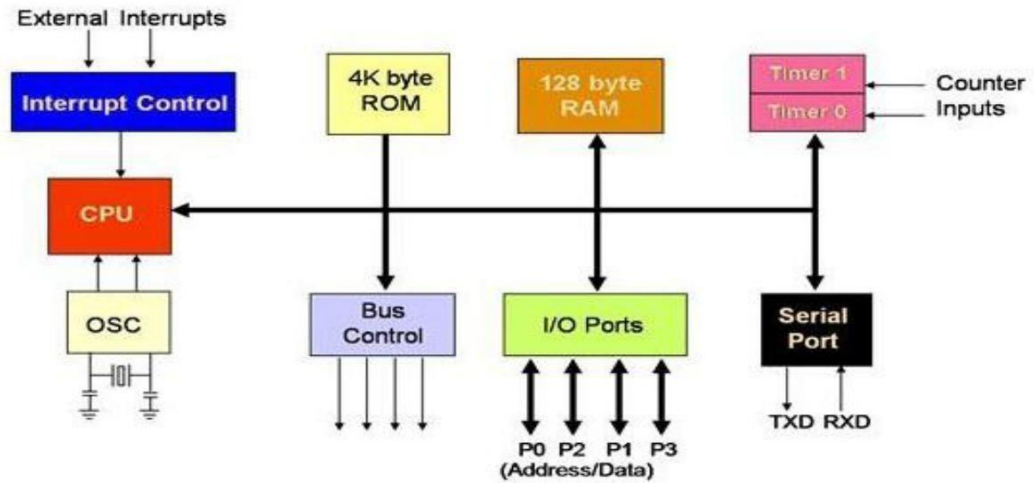
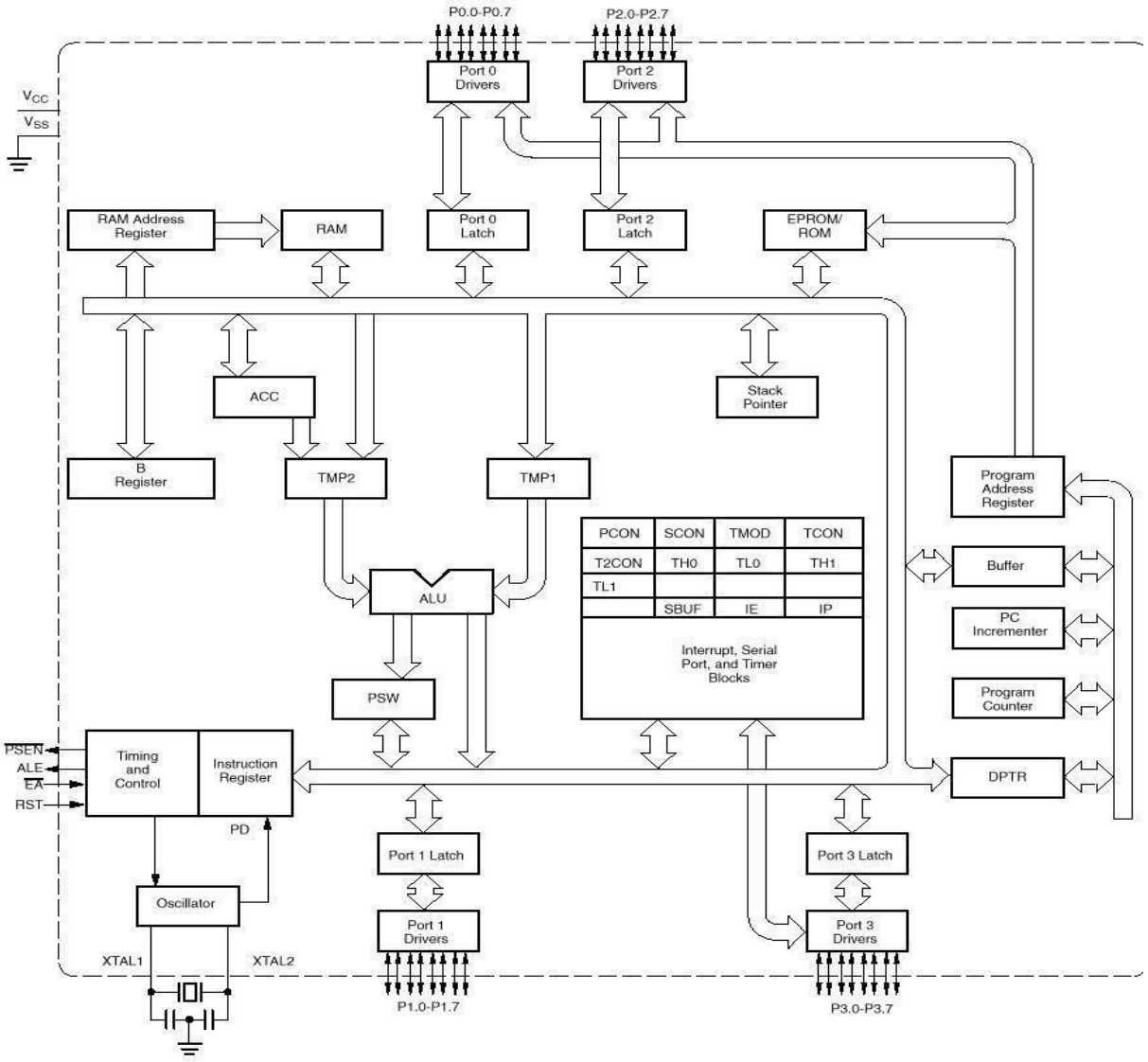


Fig.3. Block Diagram of 8051 Microcontroller.

It consists of an 8-bit ALU, one 8-bit PSW(Program Status Register), A and B registers , one 16-bit Program counter , one 16-bit Data pointer register(DPTR),128 bytes of RAM and 4kB of ROM and four parallel I/O ports each of 8-bit width.

8051 has 8-bit ALU which can perform all the 8-bit arithmetic and logical operations in one machine cycle. The ALU is associated with two registers A & B



A and B Registers : The A and B registers are special function registers which hold the results of many arithmetic and logical operations of 8051.The A register is also called the **Accumulator** and as it‟s name suggests, is used as a general register to accumulate the

results of a large number of instructions. By default it is used for all mathematical operations and also data transfer operations between CPU and any external memory. The B register is mainly used for multiplication and division operations along with A register. MULAB : DIVAB.

It has no other function other than as a location where data may be stored.

The R registers: The "R" registers are a set of eight registers that are named R0, R1, etc. up to and including R7. These registers are used as auxillary registers in manyoperations. The "R" registers are also used to temporarily storevalues.

Program Counter (PC) : 8051 has a 16-bit program counter .The program counter always points to the address of the next instruction to be executed. After execution of one instruction the program counter is incremented to point to the address of the next instruction to be executed. It is the contents of the PC that are placed on the address bus to find and fetch the desired instruction. Since the PC is 16-bit width ,8051 can access program addresses from 0000H to FFFFH ,a total of 6kB ofcode.

Stack Pointer Register (SP) : It is an 8-bit register which stores the address of the stack top. i.e the Stack Pointer is used to indicate where the next value to be removed from the stack should be taken from. When a value is pushed onto the stack, the 8051 first increments the value of SP and then stores the value at the resulting memory location. Similarly when a value is popped off the stack, the 8051 returns the value from the memory location indicated by SP, and then decrements the value of SP. Since the SP is only 8-bit wide it is incremented or decremented by two. SP is modified directly by the 8051 by six instructions: PUSH, POP, ACALL, LCALL, RET, and RETI. It is also used intrinsically whenever an interrupt is triggered.

STACK in 8051 Microcontroller : The stack is a part of RAM used by the CPU to store information temporarily. This information may be either data or an address .The CPU needs this storage area as there are only limited number of registers. The register used to access the stack is called the Stack pointer which is an 8-bit register..So,it can take values of 00 to FF H. When the 8051 is powered up ,the SP register contains the

value 07.i.e the RAM location value 08 is the first location being used for the stack by the 8051 controller

There are two important instructions to handle this stack. One is the PUSH and the other is the POP. The loading of data from CPU registers to the stack is done by PUSH and the loading of the contents of the stack back into a CPU register is done by POP.

EX : MOV R6 ,#35 H

MOV R1 ,#21 H

PUSH6

PUSH1

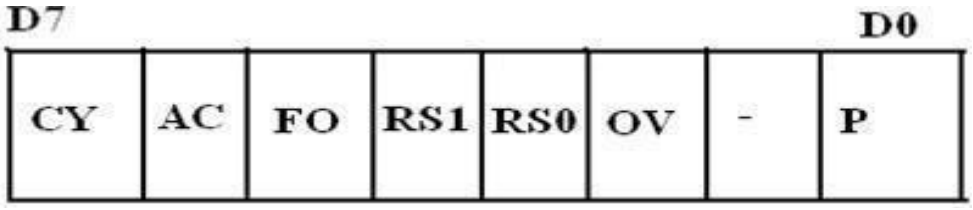
In the above instructions the contents of the Registers R6 and R1 are moved to stack and they occupy the 08 and 09 locations of the stack. Now the contents of the SP are incremented by two and it is 0A

Similarly POP 3 instruction pops the contents of stack into R3 register. Now the contents of the SP is decremented by 1

In 8051 the RAM locations 08 to 1F (24 bytes) can be used for the Stack. In any program if we need more than 24 bytes of stack ,we can change the SP point to RAM locations 30-7F H. this can be done with the instruction MOV SP,# XX.

Data Pointer Register (DPTR) : It is a 16-bit register which is the only user-accessible. DPTR, as the name suggests, is used to point to data. It is used by a number of commands which allow the 8051 to access external memory. When the 8051 accesses external memory it will access external memory at the address indicated by DPTR. This DPTR can also be used as two 8-registers DPH andDPL.

Program Status Register (PSW): The 8051 has a 8-bit PSW register which is also known as Flag register. In the 8-bit register only 6-bits are used by 8051.The two unused bits are user definable bits. In the 6-bits four of them are conditional flags .They are Carry –CY, Auxiliary Carry-AC, Parity-P, and Overflow-OV .These flag bits indicate some conditions that resulted after an instruction wasexecuted.



The bits PSW3 and PSW4 are denoted as RS0 and RS1 and these bits are used th select the bank registers of the RAM location. The meaning of various bits of PSW register is shown below.

CY	PSW.7	Carry Flag
AC	PSW.6	Auxiliary Carry Flag
FO	PSW.5	Flag 0 available for general purpose.
RS1	PSW.4	Register Bank select bit 1
RS0	PSW.3	Register bank select bit 0
OV	PSW.2	Overflow flag
---	PSW.1	User difinable flag
P	PSW.0	Parity flag .set/cleared by hardware.

The selection of the register Banks and their addresses are given below.

RS1	RS0	Register Bank	Address
0	0	0	00H-07H
0	1	1	08H-0FH
1	0	2	10H-17H
1	1	3	18H-1FH

Memory organization : The 8051 microcontroller has 128 bytes of Internal RAM and 4kB of on chip ROM .The RAM is also known as Data memory and the ROM is known as program memory. The program memory is also known as Code memory .This Code memory holds the actual 8051 program that is to be executed. In 8051 this

memory is limited to 64K .Code memory may be foundon-chip, as ROM or EPROM. It may also be stored completely off-chip in an external ROM or, more commonly, an external EPROM. The 8051 has only 128 bytes of Internal RAM but it supports 64kB of external RAM. As the name suggests, external RAM is any random access memory which is off-chip. Since the memory is off-chip it is not as flexible interms of accessing, and is also slower. For example, to increment an Internal RAM location by 1,it requires only 1 instruction and 1 instruction cyclebutto increment a 1-byte value stored in External RAM requires 4 instructions and 7 instruction cycles. So,herethe external memory is 7 timesslower.

Internal RAM OF 8051 : This Internal RAM is found on-chip on the 8051 .So it is the fastest RAM available, and it is also the most flexible in terms of reading, writing, and modifying it's contents. Internal RAM is volatile, so when the 8051 is reset this memory is cleared. The 128 bytes of internal RAM is organized as below.

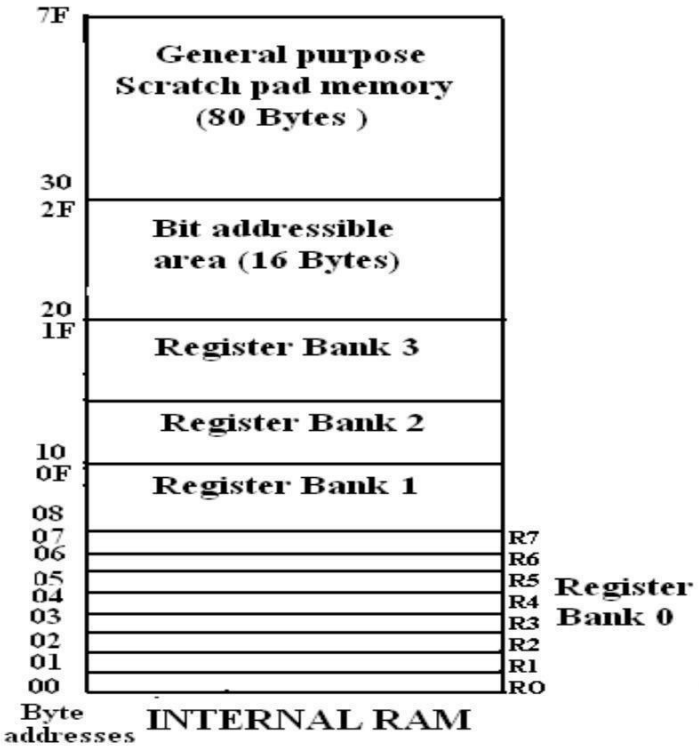
(i) Four register banks (Bank0, Bank1, Bank2 and Bank3) each of 8-bits (total 32 bytes). The default bank register is Bank0. The remaining Banks are selected with the help of RS0 and RS1 bits of PSWRegister.

(i) 16 bytes of bit addressable areaand

(ii) 80 bytes of general purpose area (Scratch pad memory) as shown in the diagram below. This area is also utilized by the microcontroller as a storage area for the operating stack.

The 32 bytes of RAM from address 00 H to 1FH are used as working registersorganized as four banks of eight registers each.The registers are named as R0-R7 .Each register can be addressed by its name or by its RAMaddress.

For EX: MOV A,R7 or MOVR7,#05H



Internal ROM (On –chip ROM): The 8051 microcontroller has 4kB of on chip ROM but it can be extended up to 64kB.This ROM is also called program memory or code memory. The CODE segment is accessed using the program counter (PC) for opcode fetches and by DPTR for data. The external ROM is accessed when the EA(active low) pin is connected to ground or the contents of program counter exceeds 0FFFH.When the Internal ROM address is exceeded the 8051 automatically fetches the code bytes from the external program memory.