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 a microcontroller. 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 engineers also.

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 circuitry are added to make it a microcomputer. The microprocessor 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

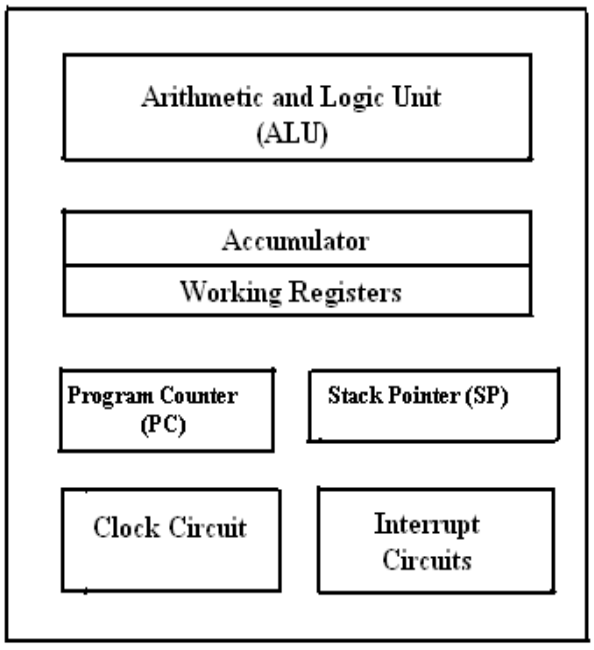
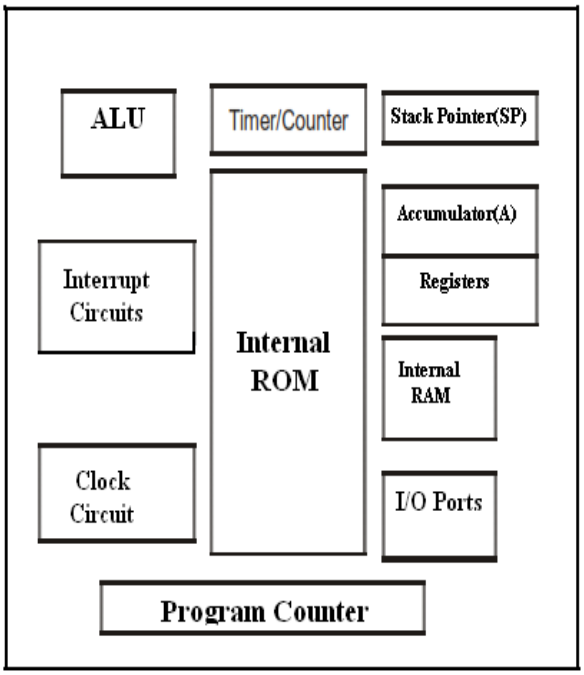


Fig (1)

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)

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 do not contain onchip I/OPorts, 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 commonly used 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 both bit addressable as well as byte addressable.
5	Microprocessor instruction sets are mainly intended for catering to large volumes of data.	Microcontrollers have instruction sets catering to the control of inputs and outputs.

6	Microprocessor based system design is complex and expensive	Microcontroller based system design is rather simple and cost effective
7	The Instruction set of microprocessor is complex with large number of instructions.	The instruction set of a Microcontroller is very simple with less number of instructions. For, ex: PIC microcontrollers have only 35 instructions**.**
8	A microprocessor has zero status flag	A microcontroller has no zero flag.

EVOLUTION OF MICROCONTROLLERS :

The first microcontroller TMS1000 was introduced by Texas Instrumentsin the year 1974. In the year 1976, Motorola designed a Microprocessor chip called 6801 which replaced its earlier chip 6800 with certain add-on chips to make a computer. This paved the way for the new revolution in the history of chip design and gave birth to a new entity called "**Microcontroller".** Later **t**he Intel company produced its first Microcontroller 8048 with a CPU and 1K bytes of EPROM, 64 Bytes of RAM an 8-Bit Timer and 27 I/O pins in 1976. Then followed the most popular controller 8051 in the year 1980 with 4K bytes of ROM,128 Bytes of RAM , a serial port, two 16-bit Timers , and 32 I/O pins. The 8051 family has many additions and improvements over the years and remains a most acclaimed tool for today's circuit designers. INTEL introduced a 16 bit microcontroller 8096 in the year 1982 . Later INTEL introduced 80c196 series of 16-bit Microcontrollers for mainly industrial applications. Microchip, another company has introduced an 8-bit Microcontroller PIC 16C64 in the year 1985.The 32-bit microcontrollers have been developed by IBM and Motorola. MPC 505 is a 32-bit RISC controller of Motorola. The 403 GA is a 32 -bit RISC embedded controller of IBM.

In recent times ARM company (Advanced RISC machines) has developed and introduced 32 bit controllers for high-end application devices like mobiles , Ipods etc...

TYPES OF MICROCONTROLLERS:

Microcontrollers can be classified on the basis of internal bus width, architecture, memory and instruction set as 4-bit,8-bit,16-bit and 32-bit micrcontrollers.

4-bit Microcontrollers: These 4-bit microcontrollers are small size, minimum pin count and low cost controllers which are widely used for low end applications like LED & LCD display drivers ,portable battery chargers etc.. Their power consumption is also low. The popular 4-bit controllers are Renasa M34501 which is a 20 pin DIP chip with 4kB of ROM, 256 Bytes of RAM,2-Counters and 14 I/O Pins. Similarly ATAM862 series from ATMEL.

8-bit Microcontrollers : These are the most popular and widely used microcontrollers .About 55% of all CPUs sold in the world are 8-bit microcontrollers only.The 8-bit microcontroller has 8-bitinternal bus and the ALU performs all the arithmetic and logical operations on a byte instruction. The well known 8-bit microcontroller is 8051 which was designed by Intel in the

year 1980 for the use in embedded systems. Other 8-bit microcontrollers are Intel 8031/8052 and Motorola MC68HC11 and AVR Microcontrollers, Microchip's PIC Microcontrollers 12C5XX ,16C5X and 16C505 etc...

16-bit Microcontrollers: When the microcontroller performs 16-bit arithmetic and logical operations at an instruction, the microcontroller is said to be a 16-bit microcontroller. The internal bus width of 16-bit microcontroller is of 16-bit. These microcontrollers are having increased memory size and speed of operation when compared to 8-bit microcontrollers.These are most suitable for programming in Highlevel languages like C or C^{++} .They find applications in disk drivers,modems,printers,scanners and servomotor control. Examples of 16-bit microcontrollers are Intel 8096 family and Motorola MC68HC12 and MC68332 families, The performance and computing capability of 16 bit microcontrollers are enhanced with greater precision as compared to the 8-bit microcontrollers.

32-Bit Microcontrollers: These microcontrollers used in highend applications like Automative control, Communication networks,Robotics,Cell phones,GPRS & PDAs etc..For EX:PIC32, ARM 7,ARM9 ,SHARP LH79520 ,ATMEL 32 (AVR), Texas Instrument's –. TMS320F2802x/2803x etc.are some of the popular 32-bit microcontrollers.

INTEL MCS 51 Family

Microcontroller	On chip RAM (Bytes)	On chip program memory	Timers/Counters	Interrupts	Serial ports
8031	128	None	2	5	1
8032	256	None	3	6	1
8051	128	4K ROM	2	5	1
8052	256	8K ROM	3	6	1
8751	128	4K EPROM	2	5	1
8752	256	8K EPROM	3	6	1

ARCHITECTURE & BLOCK DIAGRAM OF 8051 MICROCONTROLLER

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.

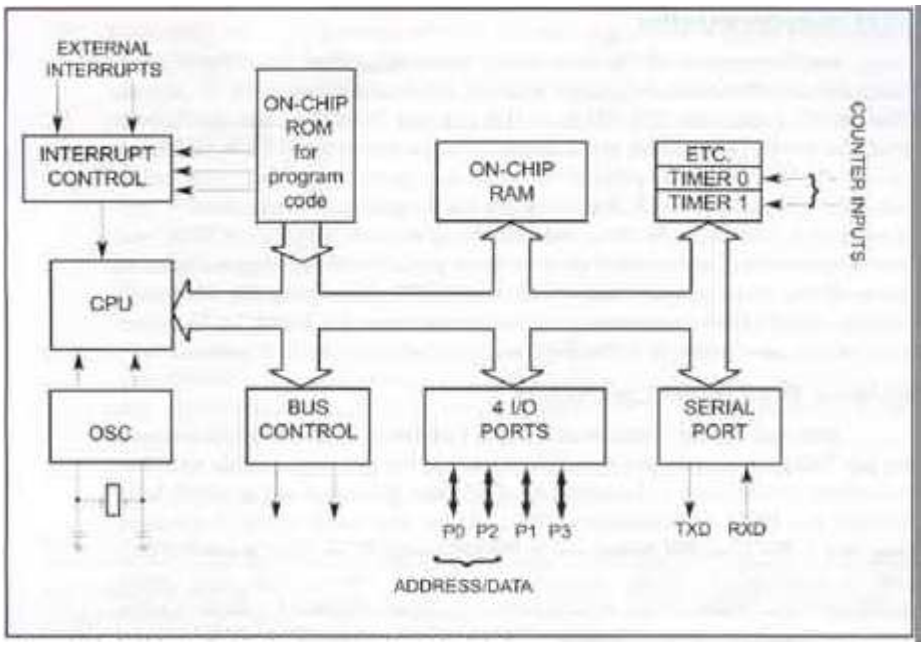


Fig 3: Block diagram of 8051 Microcontroller

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

SALIENT FEATURES : The salient features of 8051 Microcontroller are

i. Two 8-bit registers, A (accumulator) and B register.
ii. Two 16-bit registers, program counter and (data pointer) DPTR
iii. 8-bit flag register or Program Status Word (PSW)
iv. One 8-bit stack pointer
v. Inter ROM of 4 KB
vi. 128 bytes on chip data memory (RAM).
Internal RAM consists of
   - ➔ Four register banks, each containing eight registers
   - ➔ 16-bytes of Bit Address
   - ➔ 80 bytes of general purpose data memory.

vii. 8-bit data bus
viii. 16-bit address bus
ix. Four Parallel ports each of 8-bits (PORT0, PORT1,PORT2,PORT3) with a total of 32 I/O lines
x. Two -16 bit timers: T_0 and T_1
xi. Serial Data Reciever and Serial Data Transmitter.

xii. Control registers TCON, TMOD, SCON, PCON, IP and IE.
xiii. Five Interrupts (3 internal and 2 external).
xiv. Oscillator and Clock circuits.
.

Register A: The register A is an 8-bit register that is part of the ALU. This register is used to store 8-bit data and to perform arithmetic and logical operations. The result of an operation is strored in the register A. Register A is also identified as Accumulator. Its address is 0E0H.

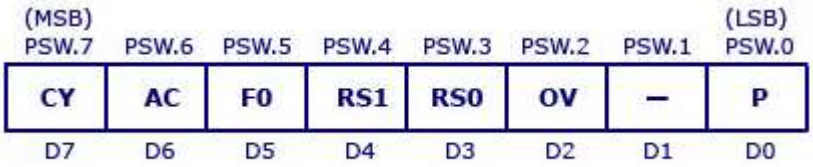
Register B: The register B is an 8-bit register. It is used with the register A for multiplication and division operations. In otherwords it holds the 1-byte of data during multiplication and division. Register B holds high order byte of the result in the multiplication and remainder in the division operation.

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. Since the PC is 16-bit width,8051 can access program addresses from 0000H to FFFFH, a total of 64 kB of code.

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. 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.

Data Pointer (DPTR): As the name indicates, the Data Pointer register points to the data in the memory. It is 16-bit register. It can be used as two 8-bit registers DPH and DPL. DPH holds the high order address and DPL holds the low order address.

Program Status Word (PSW): The 8051 has a 8-bit PSW register which is alsoknown 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 SET or RESET after an operation according to data conditions of the result in the register A and other registers. As shown below figure PSW.3 and PSW.4 are designed as RS0 and RS1 and are used to select the register banks.



CY:	PSW.7	Carry Flag
AC:	PSW.6	Auxiliary Carry Flag
F0:	PSW.5	General Purpose flag bit
RS1:	PSW.4	Register Bank selector bit 1
RS0:	PSW.3	Register Bank selector bit 0
OV:	SW.2	Over flow flag
----:	PSW.1	User defined bit
P:	SW.0	Parity Flag

Carry Flag (CY): If an operation results in a carry at D7(MSB) position, then the carry flag is SET or else it is RESET. It can also be set or reset directly by instruction such as “SETB C” and “CLR C”, where “SETB C” stands for “Set Bit Carry” and “CLR C” for “Clear Carry”.

Auxiliary Flag (AC): If there is a carry form D3 to D4 during addition operation, this bit is set other wise it is reset.

Parity Flag (P): The parity flag reflects the number of 1’s in the accumulator. If the register A contains an odd number of 1’s the parity flag is set. If A has an even number of 1’s, the parity flag is reset.

Overflow Flag (OV): This flag is set whenever the result of a signed number operation is too large, causing the high order bit to overflow in to the sign bit. The overflow flag is only used to detect errors in signed aithemetic operations. If OV=1, the result is erraneous, If=0, the result is valid.

The Register Bank Selection: The following table shows register bank selection.

RS1	RS0	Register Bank
0	0	0
0	1	1
1	0	2
1	1	3