A **microcontroller** is a small and low-cost microcomputer, which is designed to perform the specific tasks of embedded systems like displaying microwave's information, receiving remote signals, etc.

The general microcontroller consists of the processor, the memory (RAM, ROM, EPROM), Serial ports, peripherals (timers, counters), etc.

Difference between Microprocessor and Microcontroller

The following table highlights the differences between a microprocessor and a microcontroller −

Microcontroller	**Microprocessor**
Microcontrollers are used to execute a single task within an application.	Microprocessors are used for big applications.
Its designing and hardware cost is low.	Its designing and hardware cost is high.
Easy to replace.	Not so easy to replace.
It is built with CMOS technology, which requires less power to operate.	Its power consumption is high because it has to control the entire system.
It consists of CPU, RAM, ROM, I/O ports.	It doesn't consist of RAM, ROM, I/O ports. It uses its pins to interface to peripheral devices.

Types of Microcontrollers

Microcontrollers are divided into various categories based on memory, architecture, bits and instruction sets. Following is the list of their types −

Bit

Based on bit configuration, the microcontroller is further divided into three categories.

- **8-bit microcontroller** − This type of microcontroller is used to execute arithmetic and logical operations like addition, subtraction, multiplication division, etc. For example, Intel 8031 and 8051 are 8 bits microcontroller.

- **16-bit microcontroller** − This type of microcontroller is used to perform arithmetic and logical operations where higher accuracy and performance is required. For example, Intel 8096 is a 16-bit microcontroller.
- **32-bit microcontroller** − This type of microcontroller is generally used in automatically controlled appliances like automatic operational machines, medical appliances, etc.

Memory

Based on the memory configuration, the microcontroller is further divided into two categories.

- **External memory microcontroller** − This type of microcontroller is designed in such a way that they do not have a program memory on the chip. Hence, it is named as external memory microcontroller. For example: Intel 8031 microcontroller.
- **Embedded memory microcontroller** − This type of microcontroller is designed in such a way that the microcontroller has all programs and data memory, counters and timers, interrupts, I/O ports are embedded on the chip. For example: Intel 8051 microcontroller.

Instruction Set

Based on the instruction set configuration, the microcontroller is further divided into two categories.

- **CISC** − CISC stands for complex instruction set computer. It allows the user to insert a single instruction as an alternative to many simple instructions.
- **RISC** − RISC stands for Reduced Instruction Set Computers. It reduces the operational time by shortening the clock cycle per instruction.

Applications of 8051:

- Consumer Appliances (TV Tuners, Remote controls, Computers, etc.)
- Home Applications (TVs, VCR, Video Games, Music Instruments, Home Security Systems, etc.)
- Communication Systems (Mobile Phones, Intercoms, etc.)
- Office (Fax Machines, Printers, Copiers, Laser Printers, etc.)
- Automobiles (Air Bags, ABS, Engine Control, Temperature Control, Keyless Entry, etc)
- Aeronautical and Space
- Medical Equipment
- Defense Systems
- Robotics

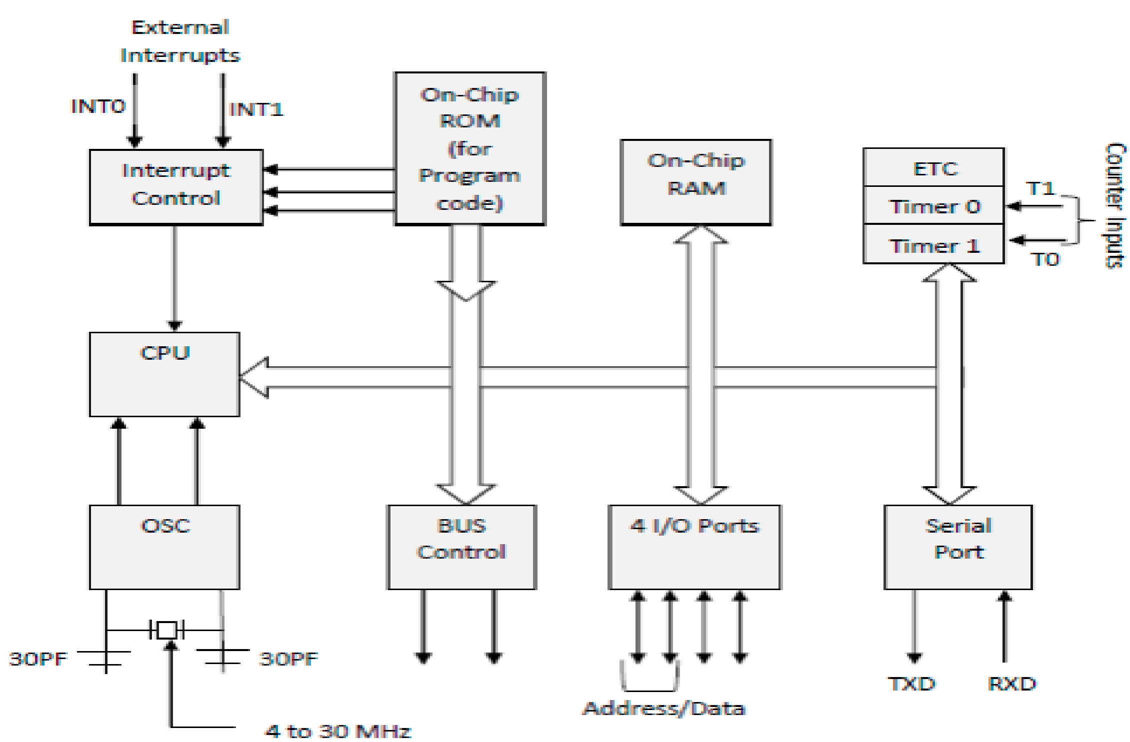
Features of 8051:

- 8-bit ALU, Accumulator, 8-bit Registers and 8-bit data bus; hence it is an 8-bit microcontroller
- 16-bit program counter (PC) and Data Pointer (DPTR)
- 8-bit Processor Status Word (PSW)
- 8-bit Stack Pointer
- Internal RAM of 128bytes
- Special Function Registers (SFRs) of 128 bytes
- On chip ROM is 4KB
- Special Function Registers (SFRs) of 128bytes
- 32 I/O pins arranged as four 8-bit ports (P0 -P3)
- Two 16-bit timer/counters : T0 andT1
- Two external and three internal vectored interrupts
- Full duplex UART (serial port)

8051 Microcontroller Architecture

8051 microcontroller is designed by Intel in 1981. It is an 8-bit microcontroller. It is built with 40 pins DIP (dual inline package), 4kb of ROM storage and 128 bytes of RAM storage, 2 16-bit timers. It consists of are four parallel 8-bit ports, which are programmable as well as addressable as per the requirement. An on-chip crystal oscillator is integrated in the microcontroller having crystal frequency of 12 MHz.

Following diagram is 8051 Microcontroller architecture . Let us have a look at each part or block of this Architecture of microcontroller.



8051 Microcontroller Architecture

1. **Central Processor Unit (CPU)**
2. **Interrupt Controller- INT0 ,INT1,TF0,TF1 and SI**
3. **Internal Memory– RAM (128 bytes) and ROM (4KB)**
4. **Bus Control- Data Bus(8-bit) and Address Bus(16-bit)**
5. **Timers/Counters- Timer0 and Timer1**
6. **Oscillator- 12KHZ clock Frequency**
7. **4 Parallel I/O ports- P0,P1,P2 and P3**
8. **Serial Port(UART)-TxD and Rxd**

Central Processor Unit (CPU)

As we know that the CPU is the brain of any processing device of the microcontroller. It monitors and controls all operations that are performed on the Microcontroller units. The User has no control over the work of the CPU directly . It reads program written in ROM memory and executes them and do the expected task of that application.

Interrupts

As its name suggests, Interrupt is a subroutine call that interrupts of the microcontrollers main operations or work and causes it to execute any other program, which is more important at the time of operation. The feature of Interrupt is very useful as it helps in case of emergency operations. An Interrupts gives us a mechanism to put on hold the ongoing operations, execute a subroutine and then again resumes to another type of operations.

The Microcontroller 8051 can be configured in such a way that it temporarily terminates or pause the main program at the occurrence of interrupts. When a subroutine is completed, Then the execution of main program starts. Generally, five interrupt sources are there in 8051 Microcontroller. There are 5 vectored interrupts are shown in below

- Timer 0 overflow interrupt - TF0
- Timer 1 overflow interrupt - TF1
- External hardware interrupt - INT0
- External hardware interrupt - INT1
- Serial communication interrupt - RI/TI

Out of these, $\overline{(INT0)}$ and $\overline{(INT1)}$ are external interrupts that could be negative edge triggered or low level triggered. When All these interrupts are activated, set the corresponding flogs except for serial interrupt,. The interrupt flags are cleared when the processor branches to the interrupt service routine (ISR). The external interrupt flags are cleared when the processor branches to the interrupt service routine, provides the interrupt is a negative edge triggered whereas the timers and serial port interrupts two of them are external interrupts, two of them are timer interrupts and one serial port interrupt terminal in general.

Memory

Microcontroller requires a program which is a collection of instructions. This program tells microcontroller to do specific tasks. These programs require a memory on which these can be saved and read by Microcontroller to perform specific operations of a particular task. The memory which is used to store the program of the microcontroller is known as code memory or Program memory of applications. It is known as ROM memory of microcontroller also requires a memory to store data or operands temporarily of the micro controller. The data memory of the 8051 is used to store data temporarily for operation is known RAM memory. 8051 microcontroller has 4K of code memory or program memory,that has 4KB ROM and also 128 bytes of data memory of RAM.

BUS

Basically Bus is a collection of wires which work as a communication channel or medium for transfer of Data. These buses consists of 8, 16 or more wires of the microcontroller. Thus, these can carry 8 bits,16 bits simultaneously. Hire two types of buses that are shown in below

- Address Bus
- Data Bus

Address Bus: Microcontroller 8051 has a 16 bit address bus for transferring the data. It is used to address memory locations and to transfer the address from CPU to Memory of the microcontroller. It has four addressing modes that are

- Immediate addressing modes.
- Bank address (or) Register addressing mode.
- Direct Addressing mode.
- Register indirect addressing mode.

Data Bus: Microcontroller 8051 has 8 bits of the data bus, which is used to carry data of particular applications.

Oscillator

Generally, we know that the microcontroller is a device, therefore it requires clock pulses for its operation of microcontroller applications. For this purpose, microcontroller 8051 has an on-chip oscillator which works as a clock source for

Central Processing Unit of the microcontroller. The output pulses of oscillator are stable. Therefore, it enables synchronized work of all parts of the 8051 Microcontroller.

Input/Output Port

Normally microcontroller is used in embedded systems to control the operation of machines in the microcontroller. Therefore, to connect it to other machines, devices or peripherals we require I/O interfacing ports in the microcontroller interface. For this purpose microcontroller 8051 has 4 input, output ports to connect it to the other peripherals

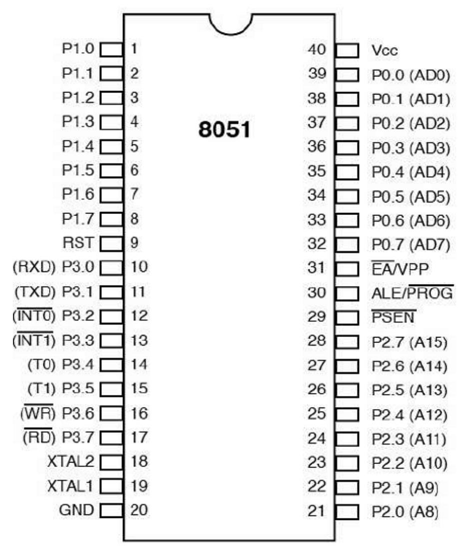
Timers/Counters

8051 microcontroller has two 16-bit timers and counters. These counters are again divided into a 8 bit register. The timers are used for measurement of intervals to determine the pulse width of pulses.

Serial Port

TXD and RXD are utilized for serial port. Each pin has separate buffer registers named as SBUF.

The pin diagram of 8051 microcontroller looks as follows −



- **Pins 1 to 8** − These pins are known as Port 1. This port doesn't serve any other functions. It is internally pulled up, bi-directional I/O port.
- **Pin 9** − It is a RESET pin, which is used to reset the microcontroller to its initial values.

- **Pins 10 to 17** − These pins are known as Port 3. This port serves some functions like interrupts, timer input, control signals, serial communication signals RxD and TxD, etc.
- **Pins 18 & 19** − These pins are used for interfacing an external crystal to get the system clock.
- **Pin 20** − This pin provides the power supply to the circuit.
- **Pins 21 to 28** − These pins are known as Port 2. It serves as I/O port. Higher order address bus signals are also multiplexed using this port.
- **Pin 29** − This is PSEN pin which stands for Program Store Enable. It is used to read a signal from the external program memory.
- **Pin 30** − This is EA pin which stands for External Access input. It is used to enable/disable the external memory interfacing.
- **Pin 31** − This is ALE pin which stands for Address Latch Enable. It is used to demultiplex the address-data signal of port.
- **Pins 32 to 39** − These pins are known as Port 0. It serves as I/O port. Lower order address and data bus signals are multiplexed using this port.
- **Pin 40** − This pin is used to provide power supply to the circuit.

Microcontrollers 8051 Input Output Ports

8051 microcontrollers have 4 I/O ports each of 8-bit, which can be configured as input or output. Hence, total 32 input/output pins allow the microcontroller to be connected with the peripheral devices.

- **Pin configuration**, i.e. the pin can be configured as 1 for input and 0 for output as per the logic state.
    - **Input/Output (I/O) pin** − All the circuits within the microcontroller must be connected to one of its pins except P0 port because it does not have pull-up resistors built-in.
    - **Input pin** − Logic 1 is applied to a bit of the P register. The output FE transistor is turned off and the other pin remains connected to the power supply voltage over a pull-up resistor of high resistance.
- **Port 0** − The P0 (zero) port is characterized by two functions −
    - When the external memory is used then the lower address byte (addresses A0A7) is applied on it, else all bits of this port are configured as input/output.
    - When P0 port is configured as an output then other ports consisting of pins with built-in pull-up resistor connected by its end to 5V power supply, the pins of this port have this resistor left out.

Input Configuration

If any pin of this port is configured as an input, then it acts as if it “floats”, i.e. the input has unlimited input resistance and in-determined potential.

Output Configuration

When the pin is configured as an output, then it acts as an “open drain”. By applying logic 0 to a port bit, the appropriate pin will be connected to ground (0V), and applying logic 1, the external output will keep on “floating”.

In order to apply logic 1 (5V) on this output pin, it is necessary to build an external pullup resistor.

Port 1

P1 is a true I/O port as it doesn’t have any alternative functions as in P0, but this port can be configured as general I/O only. It has a built-in pull-up resistor and is completely compatible with TTL circuits.

Port 2

P2 is similar to P0 when the external memory is used. Pins of this port occupy addresses intended for the external memory chip. This port can be used for higher address byte with addresses A8-A15. When no memory is added then this port can be used as a general input/output port similar to Port 1.

Port 3

In this port, functions are similar to other ports except that the logic 1 must be applied to appropriate bit of the P3 register.

Pins Current Limitations

- When pins are configured as an output (i.e. logic 0), then the single port pins can receive a current of 10mA.
- When these pins are configured as inputs (i.e. logic 1), then built-in pull-up resistors provide very weak current, but can activate up to 4 TTL inputs of LS series.
- If all 8 bits of a port are active, then the total current must be limited to 15mA (port P0: 26mA).
- If all ports (32 bits) are active, then the total maximum current must be limited to 71mA.

8051 Microcontroller Special Function Registers (SFRs)

The 8051 Microcontroller Special Function Registers act as a control table that monitor and control the operation of the 8051 Microcontroller. If you observe in Internal RAM Structure, the Address Space from 80H to FFH is allocated to SFRs.

Out of these 128 Memory Locations (80H to FFH), there are only 21 locations that are actually assigned to SFRs. Each SFR has one Byte Address and also a unique name which specifies its purpose.

Since the SFRs are a part of the Internal RAM Structure, you can access SFRs as if you access the Internal RAM. The main difference is the address space: first 128 Bytes (00H to 7FH) is for regular Internal RAM and next 128 Bytes (80H to FFH) is for SFRs.

TIP: As only 21 of the possible 128 SFR memory locations are assigned, it is recommended that the remaining registers or memory locations are not accessed during programming.

Before going further, get an idea on 8051 MICROCONTROLLER ARCHITECTURE.

List of 8051 Microcontroller Special Function Registers

- A or ACC
- B
- DPL
- DPH
- IE
- IP
- P0
- P1
- P2
- P3

- PCON
- PSW
- SCON
- SBUF
- SP
- TMOD
- TCON
- TL0
- TH0
- TL1
- TH1

Categories of 8051 Microcontroller Special Function Registers

All the 21 8051 Microcontroller Special Function Registers (SFRs) along with their functions and Internal RAM Address is given in the following table.

Name of the Register	*Function*	*Internal RAM Address (HEX)*
ACC	Accumulator	E0H
B	B Register (for Arithmetic)	F0H
DPH	Addressing External Memory	83H
DPL	Addressing External Memory	82H
IE	Interrupt Enable Control	A8H
IP	Interrupt Priority	B8H
P0	PORT 0 Latch	80H
P1	PORT 1 Latch	90H
P2	PORT 2 Latch	A0H
P3	PORT 3 Latch	B0H
PCON	Power Control	87H
PSW	Program Status Word	D0H
SCON	Serial Port Control	98H
SBUF	Serial Port Data Buffer	99H
SP	Stack Pointer	81H
TMOD	Timer / Counter Mode Control	89H
TCON	Timer / Counter Control	88H
TL0	Timer 0 LOW Byte	8AH
TH0	Timer 0 HIGH Byte	8CH
TL1	Timer 1 LOW Byte	8BH
TH1	Timer 1 HIGH Byte	8DH

There are many ways to categorize these 21 Special Function Registers but I find the following way as an appropriate one. The 21 Special Function Registers of 8051 Microcontroller are categorized in to seven groups. They are:

Math or CPU Registers: A and B

Status Register: PSW (Program Status Word)

Pointer Registers: DPTR (Data Pointer – DPL, DPH) and SP (Stack Pointer)

I/O Port Latches: P0 (Port 0), P1 (Port 1), P2 (Port 2) and P3 (Port 3)

Peripheral Control Registers: PCON, SCON, TCON, TMOD, IE and IP

Peripheral Data Registers: TL0, TH0, TL1, TH1 and SBUF

CPU or Math Registers

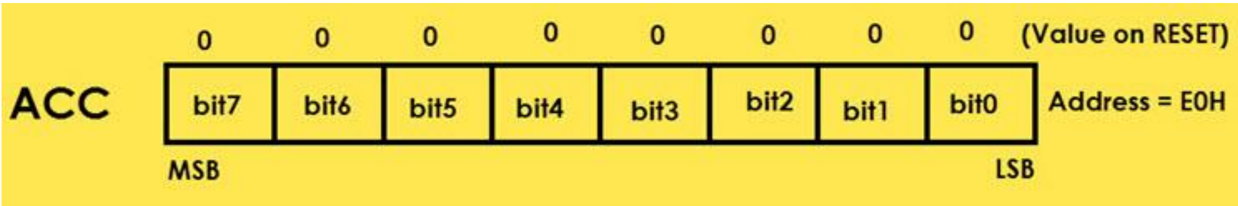
A or Accumulator (ACC)

The Accumulator or Register A is the most important and most used 8051 Microcontroller SFRs. The Register A is located at the address E0H in the SFR memory space. The Accumulator is used to hold the data for almost all the ALU Operations.

Some of the operations where the Accumulator is used are:

- Arithmetic Operations like Addition, Subtraction, Multiplication etc.
- Logical Operations like AND, OR, NOT etc.
- Data Transfer Operations (between 8051 and External Memory)

The name “Accumulator” came from the fact this register is used to accumulate (or store) the result of all Arithmetic and most of the Logical Operations.

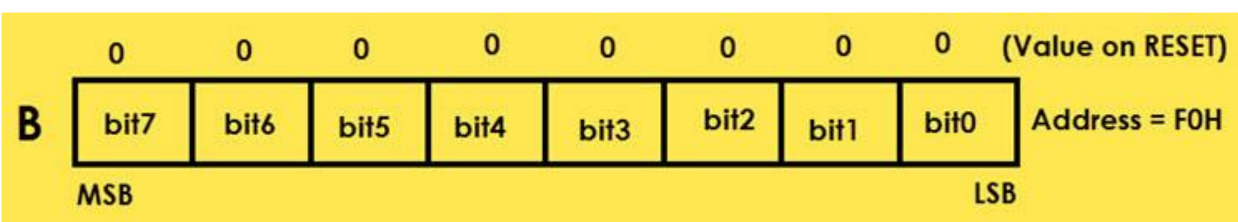


B (Register B)

The B Register is used along with the ACC in Multiplication and Division operations. These two operations are performed on data that are stored only in Registers A and B. During Multiplication Operation, one of the operand (multiplier or multiplicand) is stores in B Register and also the higher byte of the result.

In case of Division Operation, the B Register holds the divisor and also the remainder of the result. It can also be used as a General Purpose Register for normal operations and is often used as an Auxiliary Register by Programmers to store temporary results.

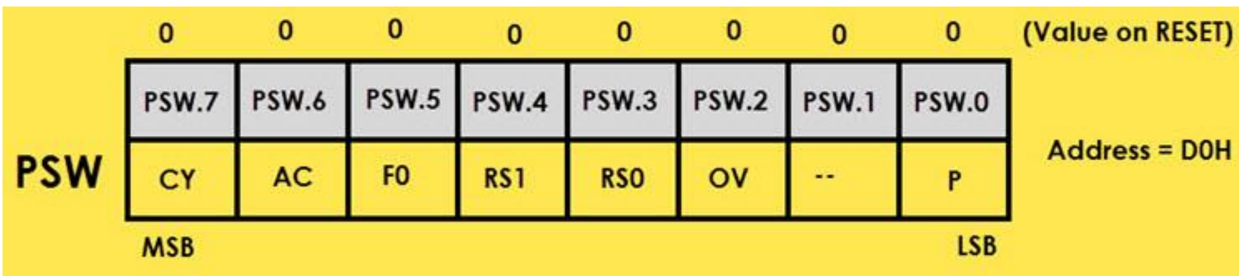
Register B is located at the address F0H of the SFR Address Space.



Program Status Word (PSW)

The PSW or Program Status Word Register is also called as Flag Register and is one of the important SFRs. The PSW Register consists of Flag Bits, which help the programmer in checking the condition of the result and also make decisions.

Flags are 1-bit storage elements that store and indicate the nature of the result that is generated by execution of certain instructions. The following image shows the contents of the PSW Register.



The following table describes the function of each flag.

BIT	SYMBOL	FLAG NAME			DESCRIPTION
7	C or CY	Carry			Used in Arithmetic, Logic & Boolean Operations
6	AC	Auxiliary Carry			Used in BCD Arithmetic
5	F0	Flag 0			General Purpose User Flag
4	RS1	Register Bank Selection Bit 1			
3	RS0	Register Bank Selection Bit 1			
		RS1	RS0	Bank	
		0	0	Bank 0	
		0	1	Bank 1	
		1	0	Bank 2	
		1	1	Bank 3	
2	OV	Overflow			Used in Arithmetic Operations
1	--	Reserved			May be used as a General Purpose Flag
0	P	Parity			Set to 1 if A has odd # of 1's; otherwise Reset

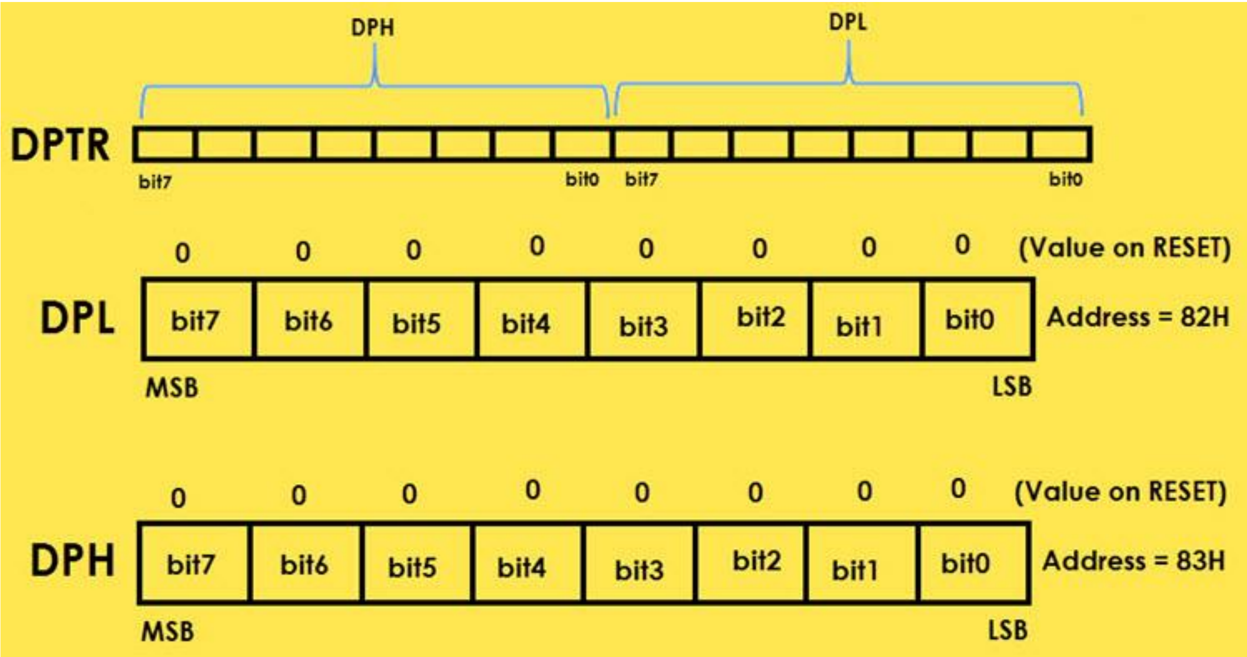
Pointer Registers

Data Pointer (DPTR – DPL and DPH)

The Data Pointer is a 16-bit Register and is physically the combination of DPL (Data Pointer Low) and DPH (Data Pointer High) SFRs. The Data Pointer can be used as a single 16-bit register (as DPTR) or two 8-bit registers (as DPL and DPH).

DPTR doesn't have a physical Memory Address but the DPL (Lower Byte of DPTR) and DPH (Higher Byte of DPTR) have separate addresses in the SFR Memory Space. DPL = 82H and DPH = 83H.

The DPTR Register is used by the programmer addressing external memory (Program – ROM or Data – RAM).



Stack Pointer (SP)

SP or Stack Pointer points out to the top of the Stack and it indicates the next data to be accessed. Stack Pointer can be accesses using PUSH, POP, CALL and RET Instructions. The Stack Pointer is an 8-bit register and upon reset, the Stack Pointer is initialized with 07H.

When writing a new data byte into the stack, the SP (Stack Pointer) is automatically incremented by 1 and the new data is written at an address SP+1. When reading data from stack, the data is retrieved from the Address in SP and after that the SP is decremented by 1 (SP-1).

I/O Port Registers (P0, P1, P2 and P3)

The 8051 Microcontroller four Ports which can be used as Input and/or Output. These four ports are P0, P1, P2 and P3. Each Port has a corresponding register with same names (the Port Registers are also P0, P1, P2 and P3). The addresses of the Port Registers are as follows: P0 – 80H, P1 – 90H, P2 – A0H and P2 – B0H.

Each bit in these SFRs corresponds to one physical Pin in the 8051 Microcontroller. All these Port Registers are both Bit Addressable and Byte Addressable. Writing 1 or 0 on a Port Register Bit will reflect as an appropriate voltage (5V and 0V) on the corresponding Pin.

If a Port Bit is SET (declared as 1), the corresponding Port Pin will be configured as Input and similarly if a Port Bit is CLEARED (declared as 0), the corresponding Port Pin is configured as Output. Upon reset, all the Port Bits are SET (1) and hence, all the Port Pins are configured as Inputs.

Peripheral Control Registers

PCON (Power Control)

The PCON or Power Control register, as the name suggests is used to control the 8051 Microcontroller's Power Modes and is located at 87H of the SFR Memory Space. Using two bits in the PCON Register, the microcontroller can be set to Idle Mode and Power Down Mode.

NOTE: PCON register is not bit addressable.

During Idle Mode, the Microcontroller will stop the Clock Signal to the ALU (CPU) but it is given to other peripherals like Timer, Serial, Interrupts, etc. In order to terminate the Idle Mode, you have to use an Interrupt or Hardware Reset.

In the Power Down Mode, the oscillator will be stopped and the power will be reduced to 2V. To terminate the Power Down Mode, you have to use the Hardware Reset.

Apart from these two, the PCON Register can also be used for few additional purposes. The SMOD Bit in the PCON Register is used to control the Baud Rate of the Serial Port.

There are two general purpose Flag Bits in the PCON Register, which can be used by the programmer during execution.

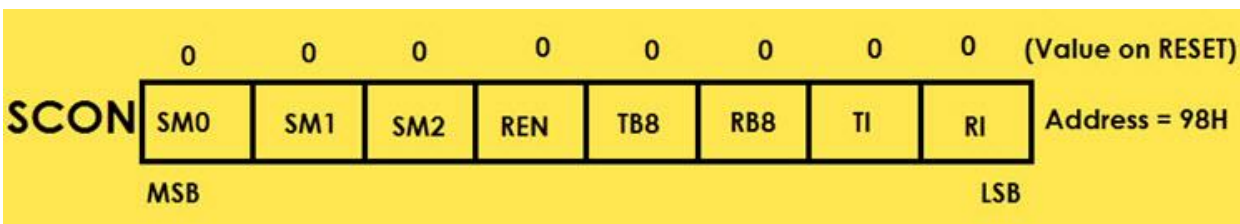
Bit	Symbol	Description	Additional Info
7	SMOD	Serial Comm. Baud Rate Modify Bit	If 1, doubles the baud rate using Timer 1. If 0, normal timer 1 baud rate.
6 – 4	—-	—	
3	GF1	General Purpose User Flag (Bit 1)	
2	GF0	General Purpose User Flag (Bit 0)	
1	PD	Power Down Bit	To enter Power Down Mode, set to 1
0	IDL	Idle Mode Bit	To enter Idle Down Mode, set to 1

The following table describes the function of each bit in the PCON Register.

SCON (Serial Control)

The Serial Control or SCON SFR is used to control the 8051 Microcontroller's Serial Port. It is located as an address of 98H. Using SCON, you can control the Operation Modes of the Serial Port, Baud Rate of the Serial Port and Send or Receive Data using Serial Port.

SCON Register also consists of bits that are automatically SET when a byte of data is transmitted or received.



The following table describes the function of each bit in the SCON Register.

Bit	Symbol	Description
7	SM0	Serial Port Mode Selection Bit 0
6	SM1	Serial Port Mode Selection Bit 1
5	SM2	Multiprocessor Comm. Bit

4	REN	Receive Enable Bit
3	TB8	Transmitted Bit 8
2	RB8	Received Bit 8
1	TI	Transmit Interrupt Flag
0	RI	Receive Interrupt Flag

The Serial Port Mode Selection Bits (SM0 and SM1) determine the mode of UART and also the baud rate. The following table gives an overview of how the Serial Port Mode Selection Bits can be used to configure Serial Port (UART) of 8051.

Serial Port Mode Selection Bits

SM0	SM1	Mode	Description	Baud Rate
0	0	0	8-Bit Synchronous Shift Register Mode	Fixed Baud Rate (Frequency of oscillator / 12)
0	1	1	8-bit Standard UART mode	Variable Baud Rate (Can be set by Timer 1)
1	0	2	9-bit Multiprocessor Comm. mode	Fixed Baud Rate

				(Frequency of oscillator / 32 or Frequency of oscillator / 64
1	1	3	9-bit Multiprocessor Comm. mode	Variable Baud Rate (Can be set by Timer 1)

TCON (Timer Control)

Timer Control or TCON Register is used to start or stop the Timers of 8051 Microcontroller. It also contains bits to indicate if the Timers has overflowed. The TCON SFR also consists of Interrupt related bits.

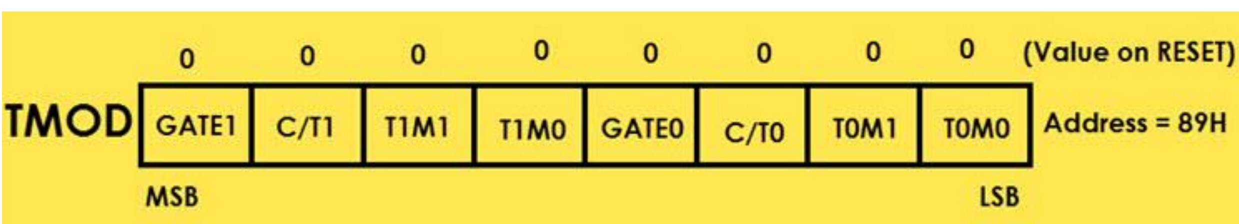
The following table gives the description of each bit in the TCON SFR.

Bit	Symbol	Description	Additional Info
7	TF1	Timer 1 Overflow Flag	Set when Timer 1 overflows (all 1s to 0). Cleared when processor executes ISR at 001BH.
6	TR1	Timer 1 Run Control Bit	To enable Timer/Counter, set to 1. Clear to halt the timer.
5	TF0	Timer 0 Overflow Flag	Set when Timer 0 overflows (all 1s to 0). Cleared when processor executes ISR at 000BH.

4	TR0	Timer 0 Run Control Bit	To enable Timer/Counter, set to 1. Clear to halt the timer.
3	IE1	Ext. Interrupt 1 Edge Flag	Set when HIGH to LOW is received on INT1 (P3.3). Cleared when processor executes ISR at 0013H.
2	IT1	Ext. Interrupt 1 Type Control Bit	If 1, Interrupt 1 occurs on falling edge. If 0, Interrupt 1 occurs on low level.
1	IE0	Ext. Interrupt 0 Edge Flag	Set to 1 when HIGH to LOW is received on INT0 (P3.2). Cleared when processor executes ISR at 0003H.
0	IT0	Ext. Interrupt 0 Type Control Bit	If 1, Interrupt 0 occurs on falling edge. If 0, Interrupt 0 occurs on low level.

TMOD (Timer Mode)

The TMOD or Timer Mode register or SFR is used to set the Operating Modes of the Timers T0 and T1. The lower four bits are used to configure Timer0 and the higher four bits are used to configure Timer1.



The following table gives a brief description of each bit in the TMOD SFR.

Bit	Symbol	Description

7 / 3	Gate	OR Gate Enable Bit
6 / 2	C/Tx	Select Timer or Counter Mode
5 / 1	TxM1	Timer / Counter Operating Mode Select Bit 1
4 / 0	TxM0	Timer / Counter Operating Mode Select Bit 0

The Gatex bit is used to operate the Timerx with respect to the INTx pin or regardless of the INTx pin.

- GATE1 = 1 ==> Timer1 is operated only if TR1 (in TCON) is SET and Signal on INT1 is HIGH.
- GATE1 = 0 ==> Timer1 is operated irrespective of Signal on INT1 pin but TR1 (in TCON) must be SET.
- GATE0 = 1 ==> Timer0 is operated only if TR0 (in TCON) is SET and Signal on INT0 is HIGH.
- GATE0 = 0 ==> Timer0 is operated irrespective of Signal on INT0 pin but TR0 (in TCON) must be SET.

The C/Tx bit is used selects the source of pulses for the Timer to count.

- C/T1 = 1 ==> Timer1 counts pulses from Pin T1 (P3.5) (Counter Mode)
- C/T1 = 0 ==> Timer1 counts pulses from internal oscillator (Timer Mode)
- C/T0 = 1 ==> Timer0 counts pulses from Pin T0 (P3.4) (Counter Mode)
- C/T0 = 0 ==> Timer0 counts pulses from internal oscillator (Timer Mode)

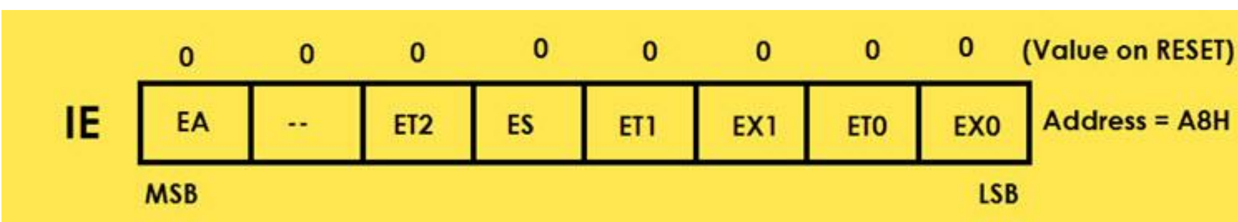
TxM0	**TxM1**	**Mode**	**Description**

0	0	0	13-bit Timer Mode (THx – 8-bit and TLx – 5-bit)
0	1	1	16-bit Timer Mode
1	0	2	8-bit Auto Reload Timer Mode
1	1	3	Two 8-bit Timer Mode or Split Timer Mode

NOTE: x = 0 for Timer 0 and x = 1 for Timer 1.

IE (Interrupt Enable)

The IE or Interrupt Enable Register is used to enable or disable individual interrupts. If a bit is SET, the corresponding interrupt is enabled and if the bit is cleared, the interrupt is disabled. The Bit7 of the IE register i.e., EA bit is used to enable or disable all the interrupts.



The following table describes the functions of each bit in the IE Register.

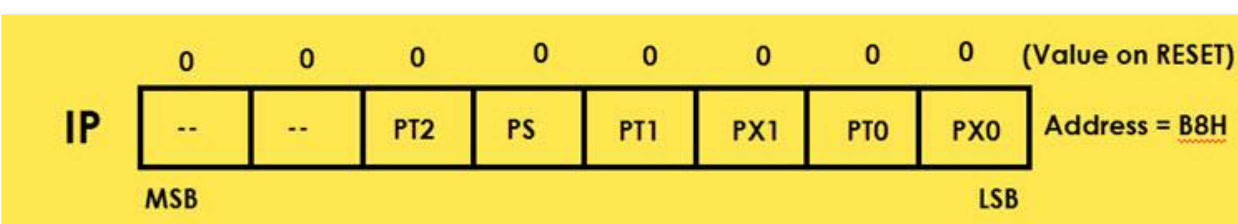
Bit	Symbol	Description	Additional Info
7	EA	Global Interrupt Enable Bit.	If set to 1, individual interrupts can be enabled. If set to 0, all interrupts are disabled.
6	—	—	

5	ET2	Reserved	
4	ES	Serial Port Interrupt Enable Bit	If set to 1, Serial Port interrupt is enabled. If set to 0, Serial Port interrupt is disabled.
3	ET1	Timer 1 Overflow Interrupt Enable Bit	If set to 1, Timer 1 Overflow interrupt is enabled. If set to 0, Timer 1 Overflow interrupt is disabled.
2	EX1	Ext. Interrupt 1 Enable Bit	If set to 1, Ext. Interrupt 1 is enabled. If set to 0, Ext. Interrupt 1 is disabled.
1	ET0	Timer 0 Overflow Interrupt Enable Bit	If set to 1, Timer 0 Overflow interrupt is enabled. If set to 0, Timer 0 Overflow interrupt is disabled.
0	EX0	Ext. Interrupt 0 Enable Bit	If set to 1, Ext. Interrupt 0 is enabled. If set to 0, Ext. Interrupt 0 is disabled.

NOTE: The Interrupt Enable (IE) SFR is bit addressable.

IP (Interrupt Priority)

The IP or Interrupt Priority Register is used to set the priority of the interrupt as High or Low. If a bit is CLEARED, the corresponding interrupt is assigned low priority and if the bit is SET, the interrupt is assigned high priority.



The following table describes the functions of each bit in the IP Register.

Bit	Symbol	Description
7	—	—
6	—	—
5	PT2	Reserved
4	PS	Priority of Serial Port Interrupt
3	PT1	Priority of Timer 1 Overflow Interrupt
2	PX1	Priority of Ext. Interrupt 1
1	PT0	Priority of Timer 0 Overflow Interrupt
0	PX0	Priority of Ext. Interrupt 0

NOTE: The Interrupt Priority (IP) SFR is bit addressable.

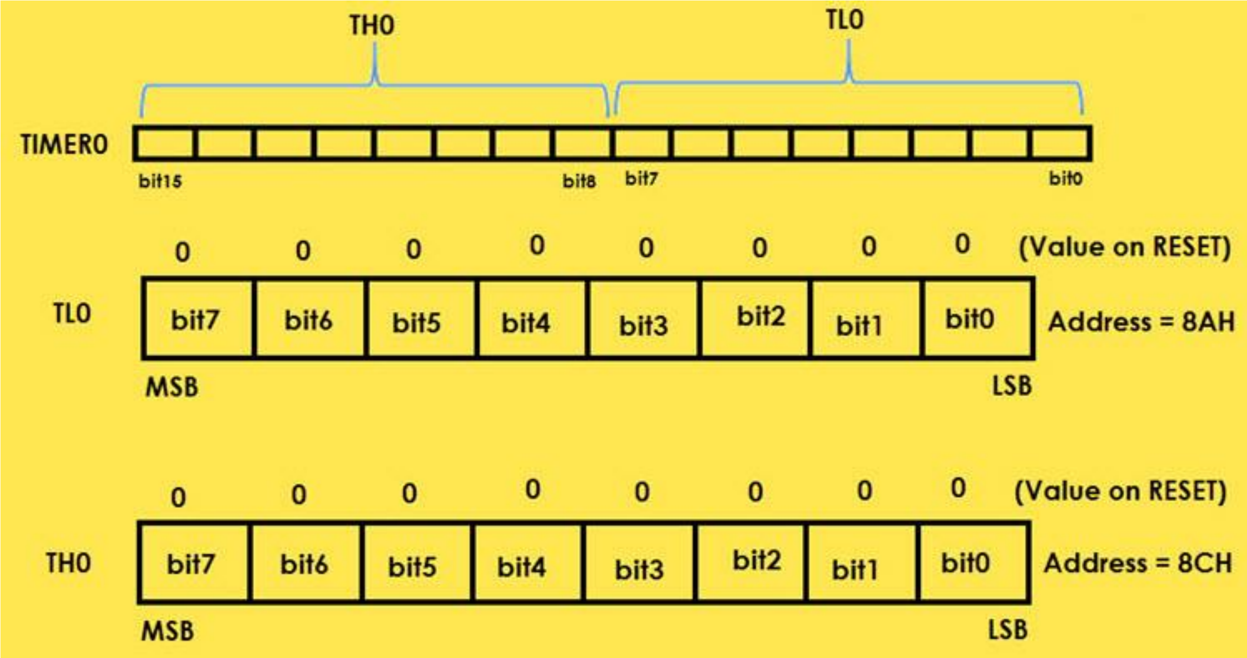
Peripheral Data Registers

SBUF (Serial Data Buffer)

The Serial Buffer or SBUF register is used to hold the serial data while transmission or reception.

TL0/TH0 (Timer 0 Low/High)

The Timer 0 consists of two SFRs: TL0 and TH0. The TL0 is the lower byte and the TH0 is the higher byte and together they form a 16-bit Timer0 Register.



TL1/TH1 (Timer 1 Low/High)

The TL1 and TH1 are the lower and higher bytes of the Timer 0.