THE 8051 MICROCONTROLLER ARCHITECTURE, PROGRAMMING AND APPLICATIONS

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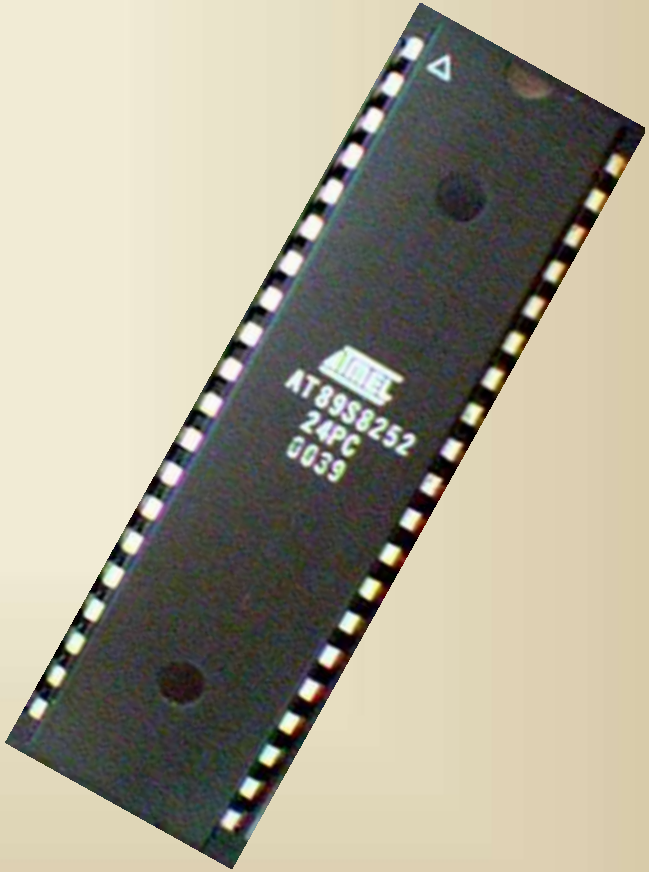
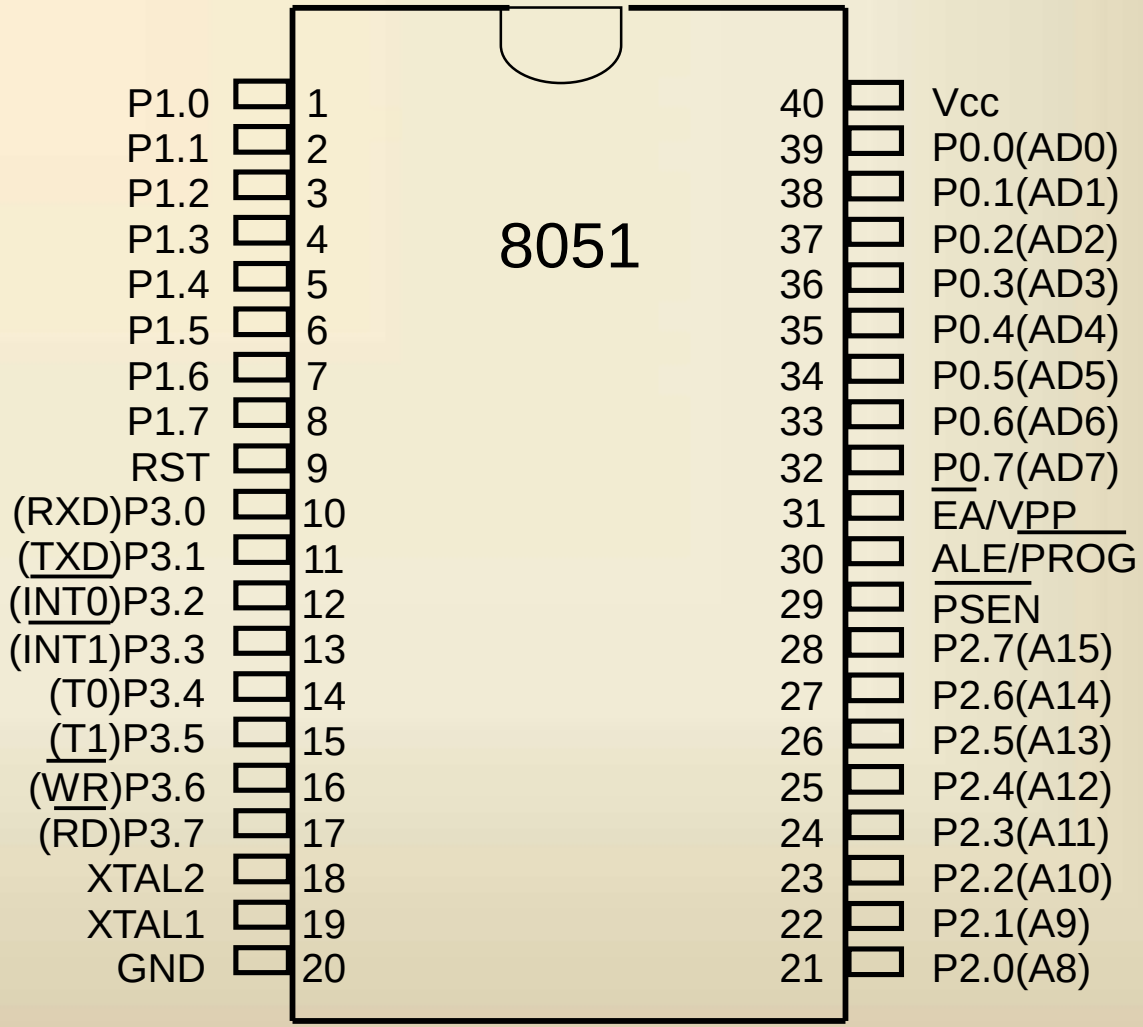


Introduction

- *An example for CISC Processor.*
- *Harvard Architecture*
- *Collection of 8 and 16 bit registers and 8 bit memory locations.*
- *External Memory can be interfaced.*

Pin Description of the 8051



Pins of 8051（1/4）

- Vcc（pin 40）：
  - Vcc provides supply voltage to the chip.
  - The voltage source is +5V.
- GND（pin 20）：ground
- XTAL1 and XTAL2（pins 19,18）：
  - These 2 pins provide external clock.

Pins of 8051（2/4）

- RST（pin 9）：reset
  - It is an input pin and is active high（normally low）.
    - Upon applying a high pulse to RST, the microcontroller will reset and all values in registers will be lost.

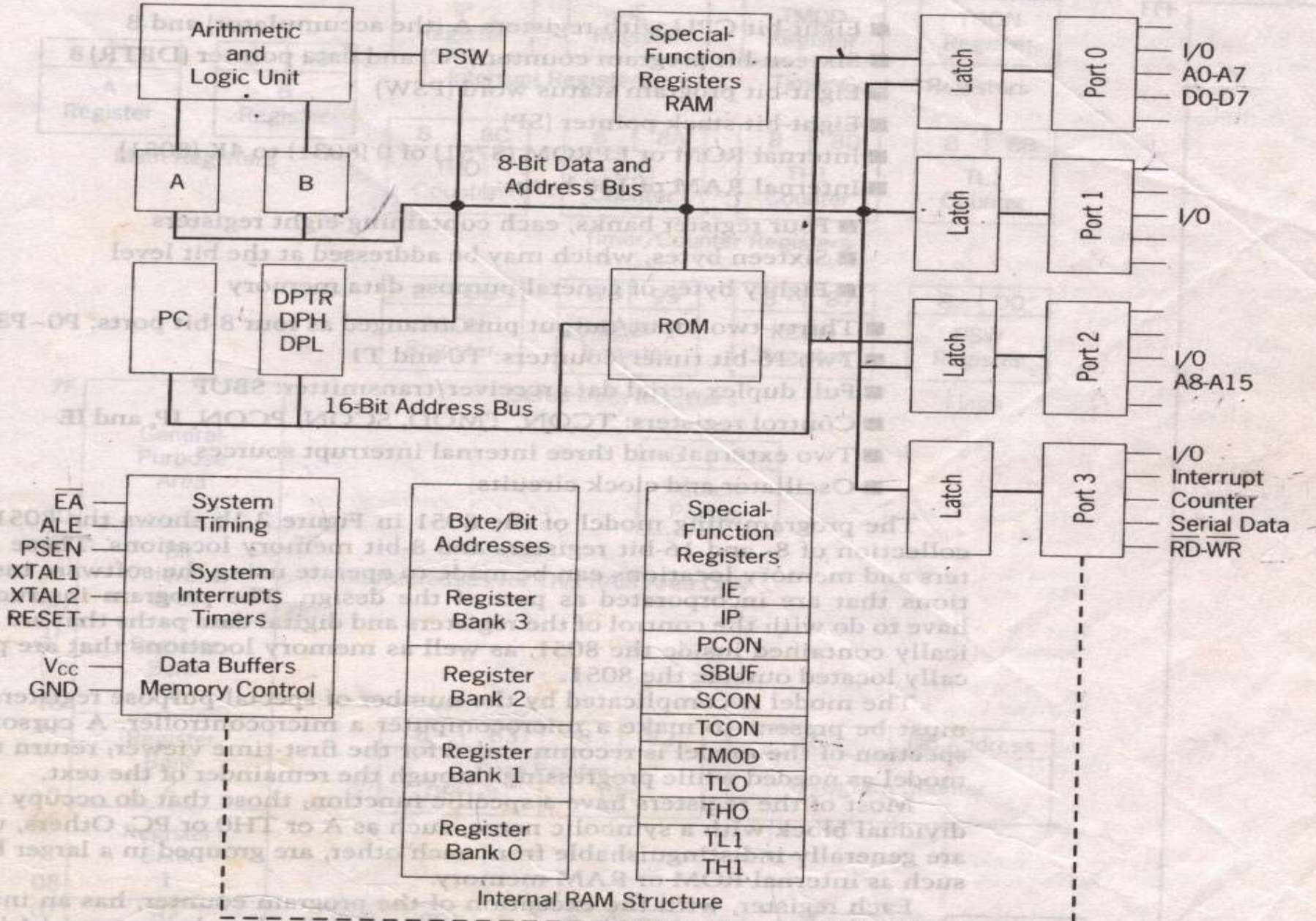
Pins of 8051（3/4）

- /EA（pin 31）：external access
  - The /EA pin is connected to GND to indicate the code is stored externally.
  - For 8051, /EA pin is connected to Vcc.
  - “/” means active low.
- /PSEN（pin 29）：program store enable
  - This is an output pin and is connected to the OE pin of the ROM

Pins of 8051（4/4）

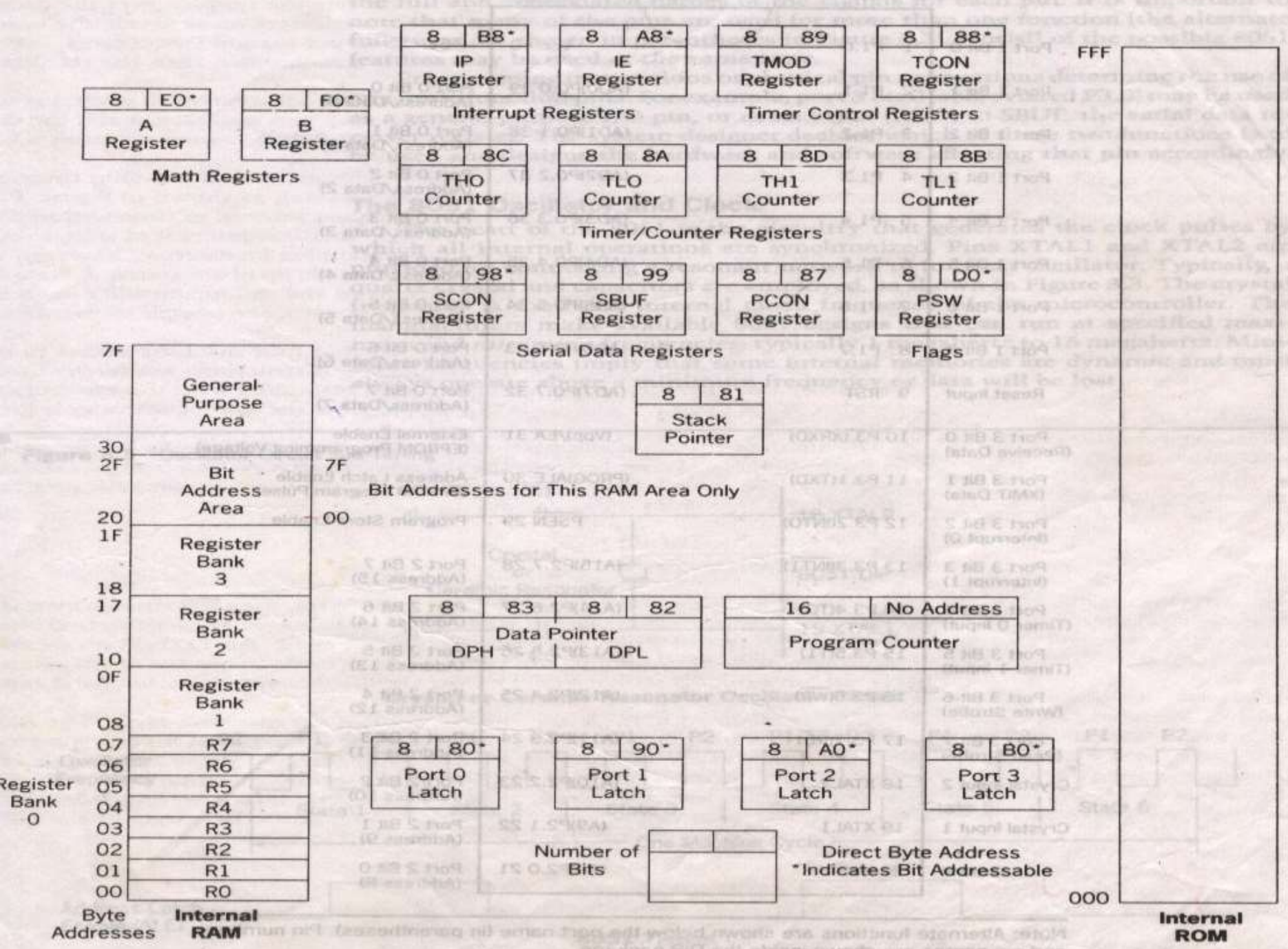
- ALE（pin 30）：address latch enable
  - It is an output pin and is active high.
  - 8051 port 0 provides both address and data.
  - The ALE pin is used for de-multiplexing the address and data by connecting to the G pin of the 74LS373 latch.
- I/O port pins
  - The four ports P0, P1, P2, and P3.
  - Each port uses 8 pins.
  - All I/O pins are bi-directional.

Figure 3.1a 8051 Block Diagram



- *Internal ROM and RAM*
- *I/O Ports with programmable Pins*
- *ALU*
- *Working Registers*
- *Clock Circuits*
- *Timers and Counters*
- *Serial Data Communication.*

Figure 3.1b 8051 Programming Model



Specific Features

- 8 bit cpu with registers A and B
- 16 bit PC and DPTR(data pointer).
- 8 bit program status word(PSW)
- 8 bit Stack Pointer
- 4K Internal ROM
- 128bytes Internal RAM
  - →4 register banks each having 8 registers
    →16 bytes,which may be addressed at the bit level.
    →80 bytes of general purpose data memory

Specific Features

- 32 i/o pins arranged as 4 8 bit ports:P0 to P3
- Two 16 bit timer/counters:T0 and T1
- Full duplex serial data receiver/transmitter
- Control registers:TCON,TMOD,SCON,PCON,IP and IE
- Two external and Three internal interrupt sources.
- Oscillator and Clock Circuits.

Pins of I/O Port

- The 8051 has four I/O ports
  - Port 0 （pins 32-39）：P0（P0.0～P0.7）
  - Port 1（pins 1-8）　：P1（P1.0～P1.7）
  - Port 2（pins 21-28）：P2（P2.0～P2.7）
  - Port 3（pins 10-17）：P3（P3.0～P3.7）
  - Each port has 8 pins.
    - Named P0.X （X=0,1,...,7）, P1.X, P2.X, P3.X
    - Ex：P0.0 is the bit 0（LSB）of P0
    - Ex：P0.7 is the bit 7（MSB）of P0
    - These 8 bits form a byte.
- Each port can be used as input or output (bi-direction).

Program Counter & Data Pointer

- *They are both 16 bit registers.*
- *Each is to hold the address of a byte in memory*
- *PC contains the address of the next instruction to be executed.*
- *DPTR is made up of two 8 bit register DPH and DPL;*
- *DPTR contains the address of internal & external code and data that has to be accessed.*

A and B CPU registers

- Totally 34 general purpose registers or working registers.
- Two of these A and B hold results of many instructions, particularly math and logical operations of 8051 cpu.
- The other 32 are in four banks,B0 – B3 of eight registers each.
- A(accumulator) is used for addition,subtraction,mul,div,boolean bit manipulation and for data transfers.
- But B register can only be used for mul and div operations.

8051 Flag bits and the PSW register

- PSW Register

CY	AC	F0	RS1	RS0	OV	--	P

Carry flag	PSW.7	**CY**
Auxiliary carry flag	PSW.6	**AC**
Available to the user for general purpose	PSW.5	**--**
Register Bank selector bit 1	PSW.4	**RS1**
Register Bank selector bit 0	PSW.3	**RS0**
Overflow flag	PSW.2	**OV**
User define bit	PSW.1	**--**
Parity flag Set/Reset odd/even parity	PSW.0	**P**

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

- *Two flag bits are stored in PCON(Power control) registers also.*

- *They are the GF1 (3^{RD}) and GF0(2^{nd}) bits*

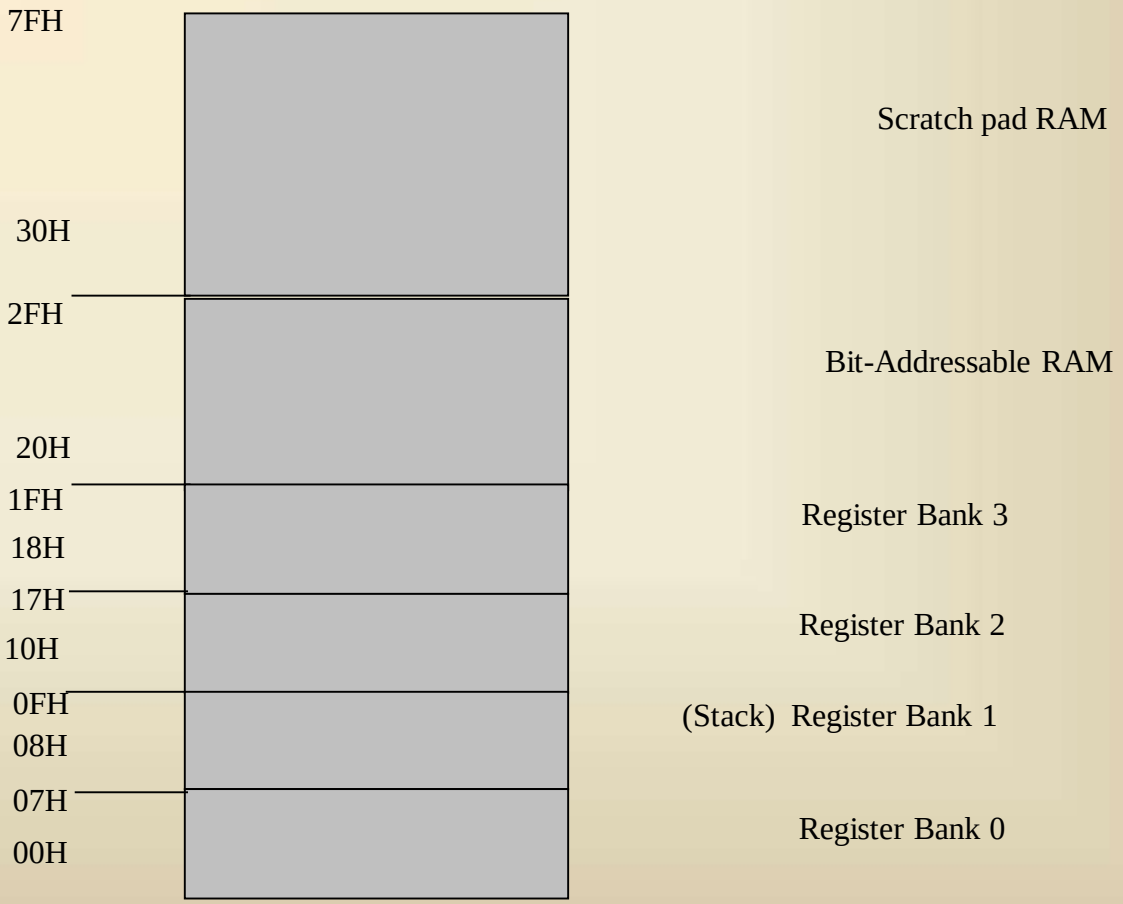
- *They are general purpose user flag bit 1 and 0 respectively*

- *They can be set or cleared by the program*

- *For more details of PCON, refer fig 3.13 in text book.*

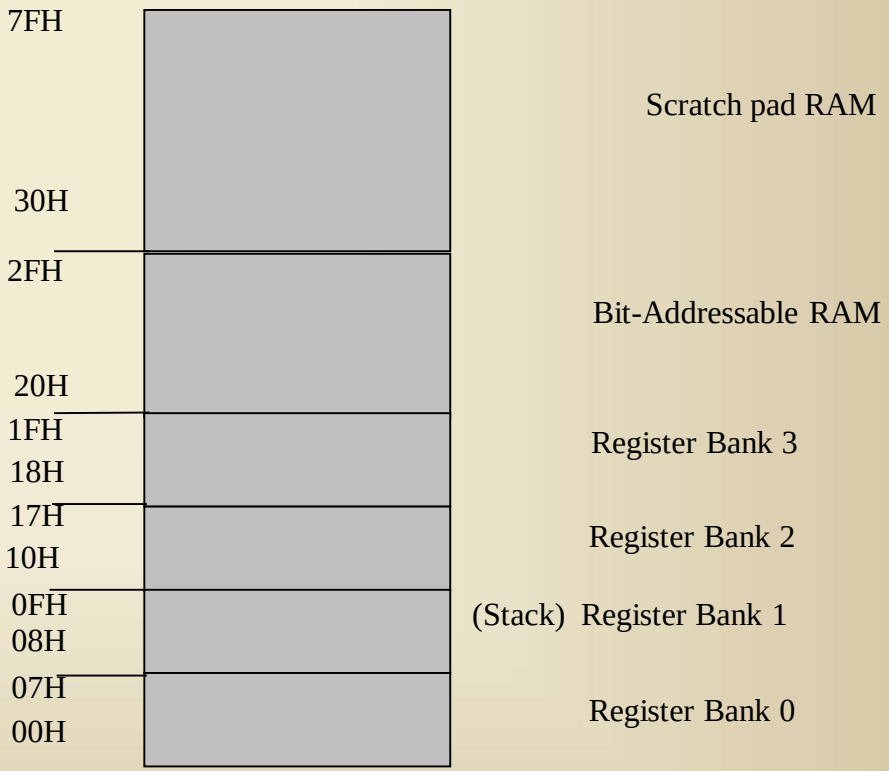
Memory Organization

- **RAM memory space allocation in the 8051**



Stack in the 8051

- The register used to access the stack is called **SP** (stack pointer) register.
- The stack pointer in the 8051 is only 8 bits wide, which means that it can take value 00 to FFH. When 8051 powered up, the SP register contains value 07.



Special Function Registers

Name	Function	Name	Function
A	Accumulator	SBUF	Serial Port data buffer
B	Arithmetic	SP	Stack Pointer
DPH	Addressing Ext Memory	TMOD	Timer/Counter mode cntrl
DPL	Addressing Ext Memory	TCON	Timer/Counter cntrl
IE	Interrupt enable	TL0	Timer0 lower byte
IP	Interrupt Priority	TH0	Timer0 higher byte
P0	I/O Port Latch	TL1	Timer1 lower byte
P1	I/O Port Latch	TH1	Timer1 higher byte
P2	I/O Port Latch		
P3	I/O Port Latch		
PCON	Power Control		
PSW	Pgm Status Word		
SCON	Serial PortCntrl		

I/O Port Programming

Port 0（pins 32-39）

- *When connecting an 8051 to an external memory, the 8051 uses ports to send addresses and read instructions.*
  - *16-bit address：P0 provides both address A0-A7, P2 provides address A8-A15.*
  - *Also, P0 provides data lines D0-D7.*
- *When P0 is used for address/data multiplexing, it is connected to the 74LS373 to latch the address.*

Port 1（pins 1-8）

- Port 1 is denoted by P1.
  - P1.0 ~ P1.7
  - P1 as an output port (i.e., write CPU data to the external pin)
  - P1 as an input port (i.e., read pin data into CPU bus)

ALE Pin

- The ALE pin is used for de-multiplexing the address and data by connecting to the G pin of the 74LS373 latch.
  - When ALE=0, P0 provides data D0-D7.
  - When ALE=1, P0 provides address A0-A7.
  - The reason is to allow P0 to multiplex address and data.

Port 3（pins 10-17）

- Although port 3 is configured as an output port upon reset, this is not the way it is most commonly used.
- Port 3 has the additional function of providing signals.
  - Serial communications signal：RxD, TxD
  - External interrupt：/INT0, /INT1
  - Timer/counter：T0, T1
  - External memory accesses ：/WR, /RD

Port 3 Alternate Functions

P3 Bit	Function	Pin
P3.0	RxD	10
P3.1	TxD	11
P3.2	$\overline{\text{INT0}}$	12
P3.3	$\overline{\text{INT1}}$	13
P3.4	T0	14
P3.5	T1	15
P3.6	$\overline{\text{WR}}$	16
P3.7	$\overline{\text{RD}}$	17

Addressing Modes

The way in which the instruction is specified.

- Immediate
- Register
- Direct
- Register Indirect
- Indexed

Immediate Addressing Mode

- Immediate Data is specified in the instruction itself

- Egs:

```
MOV     A,#65H
MOV     A,#’A’
MOV     R6,#65H
MOV     DPTR,#2343H
MOV     P1,#65H
```

Register Addressing Mode

```
MOV     Rn, A          ;n=0,..,7
ADD     A, Rn
MOV     DPL, R6

MOV     DPTR, A
MOV     Rn, Rn
```

Direct Addressing Mode

Although the entire of 128 bytes of RAM can be accessed using direct addressing mode, it is most often used to access RAM loc. 30 – 7FH.

```
MOV     R0, 40H
MOV     56H, A
MOV     A, 4          ; ≡ MOV A, R4
MOV     6, 2          ; copy R2 to R6
                      ; MOV  R6,R2 is invalid !
```

Register Indirect Addressing Mode

- In this mode, register is used as a pointer to the data.

MOV A,@Ri

; move content of RAM loc. Where address is held by Ri into A

(i=0 or 1)

MOV @R1,B

In other word, the content of register R0 or R1 is sources or target in MOV, ADD and SUBB insructions.

⌦ jump

Indexed Addressing Mode And On-Chip ROM Access

- This mode is widely used in accessing data elements of look-up table entries located in the program (code) space ROM at the 8051

MOVC A,@A+DPTR

A= content of address A +DPTR from ROM

Note:

Because the data elements are stored in the program (code) space ROM of the 8051, it uses the instruction MOVC instead of MOV. The “C” means code.