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Micro Processors & Interfacing

16CS307

Unit- 4

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Micro Processor & Interfacing

Syllabus Overview

UNIT 1 - Introduction to 8086microprocessor

UNIT 2 - Hardware features of 8086

UNIT 3 - Advanced Processors

UNIT 4-Introduction to 8051Microcontroller

UNIT 5 - 8051 Microcontroller Hardware :

UNIT 4

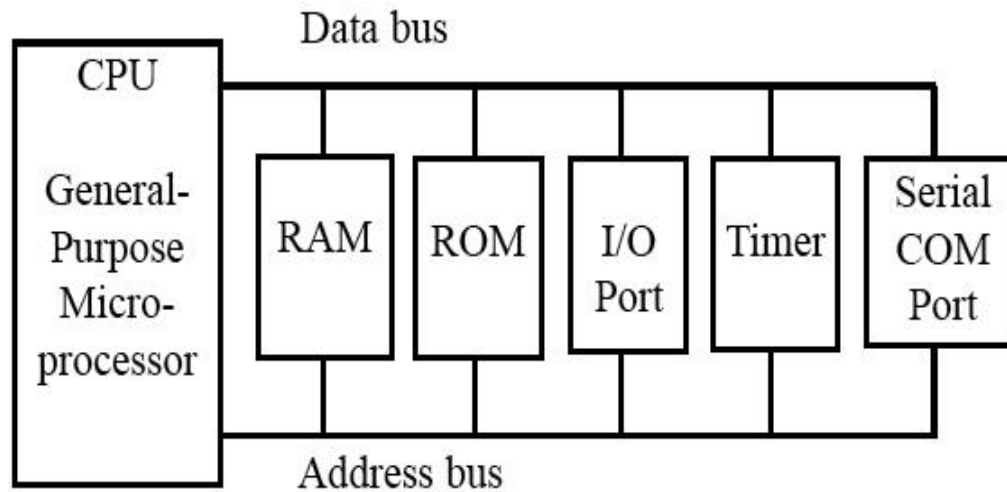
Introduction to 8051 Microcontroller

Unit-4 : Introduction to 8051 Microcontroller

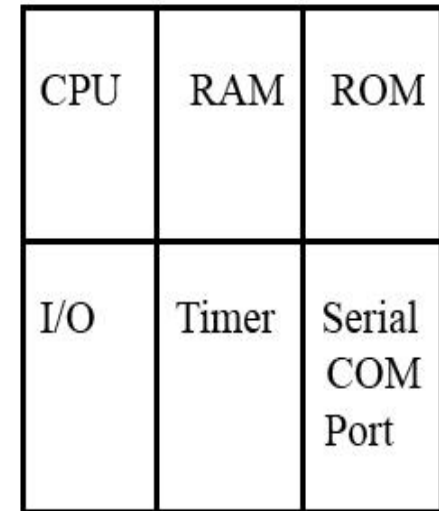
Syllabus Overview

- **Comparing microprocessors and microcontrollers**
- **8051 Micro controller Architecture**
- **Signal Description of 8051**
- **Memory organization**
- **Addressing modes of 8051**
- **Instruction set**
- **Assembly language program examples in 8051.**

Microcontroller versus general-purpose Microprocessor



(a) General-Purpose Microprocessor System



(b) Microcontroller

Figure 4–1 Microprocessor System Contrasted With Microcontroller System

- The **microprocessor with integrated peripherals** is the Micro controller.
- on chip Computer.

Microcontrollers for Embedded Systems

Home

Appliances
Intercom
Telephones
Security systems
Garage door openers
Answering machines
Fax machines
Home computers
TVs
Cable TV tuner
VCR
Camcorder
Remote controls
Video games
Cellular phones
Musical instruments
Sewing machines
Lighting control
Paging
Camera
Pinball machines
Toys
Exercise equipment

Office

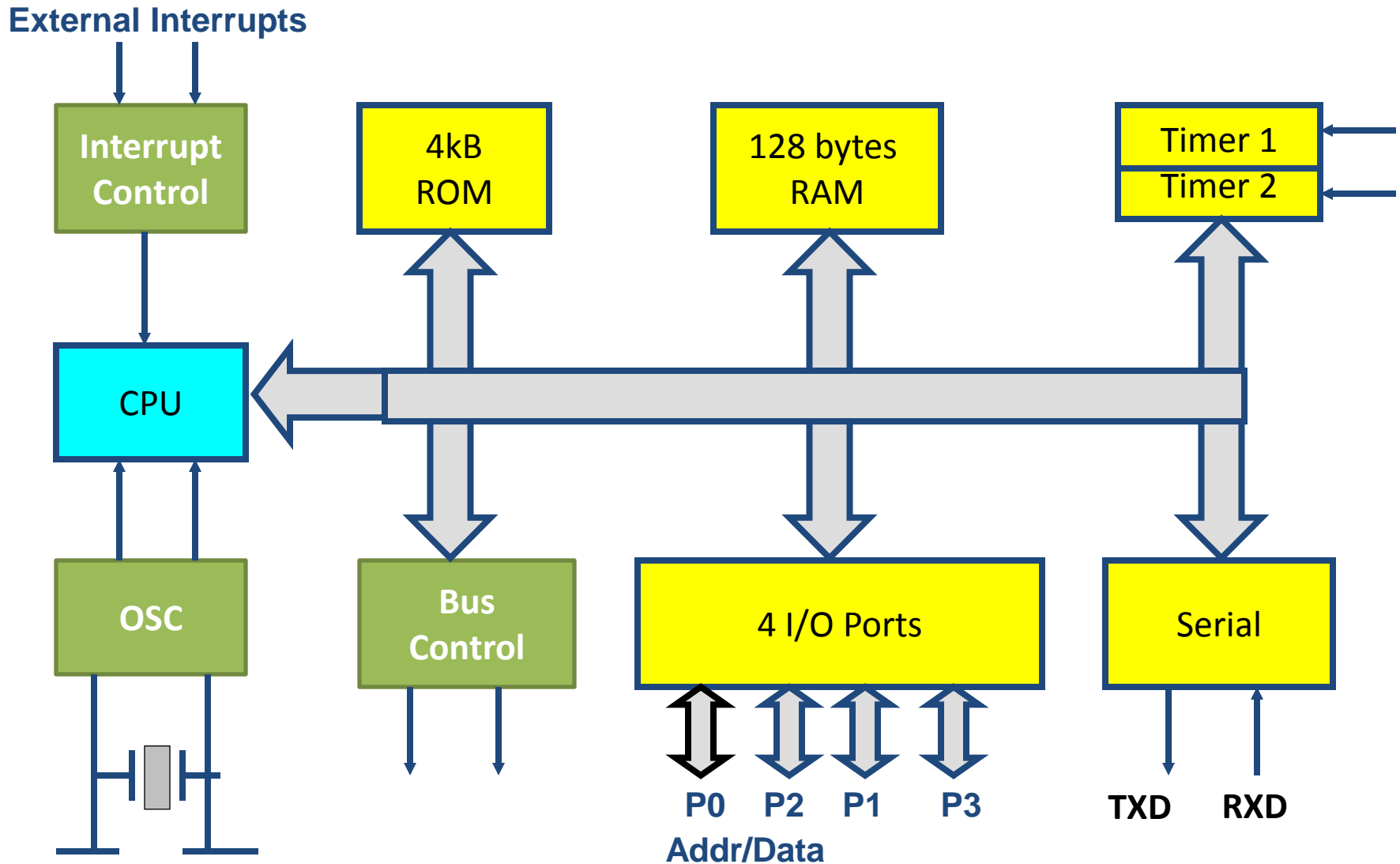
Telephones
Computers
Security systems
Fax machine
Microwave
Copier
Laser printer
Color printer
Paging

Auto

Trip computer
Engine control
Air bag
ABS
Instrumentation
Security system
Transmission control
Entertainment
Climate control
Cellular phone
Keyless entry

Table 1–1 Some Embedded Products using Microcontrollers

Block Diagram 8051 μC



Microcontrollers and Embedded Processors

- Choosing a microcontroller

Company	Web Site
Intel	www.intel.com/design/mcs51
Atmel	www.atmel.com
Philips/Signetics	www.semiconductors.philips.com
Infineon	www.infineon.com
Dallas Semi/Maxim	www.maxim-ic.com

Microcontrollers and Embedded Processors

- Criteria for choosing a microcontroller

Feature	Quantity
ROM	4K bytes
RAM	128 bytes
Timer	2
I/O pins	32
Serial port	1
Interrupt sources	6

Note: ROM amount indicates on-chip program space.

Table 1–3 Features of the 8051

Microcontrollers and Embedded Processors

Feature	8051	8052	8031
ROM (on-chip program space in bytes)	4K	8K	0K
RAM (bytes)	128	256	128
Timers	2	3	2
I/O pins	32	32	32
Serial port	1	1	1
Interrupt sources	6	8	6

Intel 8051 Family

<i>Microcontroller</i>	<i>On-chip Code Memory</i>	<i>On-chip Data Memory</i>	<i>Timers</i>
8051	4K ROM	128 bytes	2
8031	0	128 bytes	2
8751	4K EPROM	128 bytes	2
8052	8K ROM	256 bytes	3
8032	0	256 bytes	3
8752	8K EPROM	256 bytes	3

Table 1–4 Comparison of 8051 Family Members

Microcontrollers and Embedded Processors

Part Number	ROM	RAM	I/O pins	Timer	Interrupt	V _{CC}	Packaging
AT89C51	4K	128	32	2	6	5V	40
AT89LV51	4K	128	32	2	6	3V	40
AT89C1051	1K	64	15	1	3	3V	20
AT89C2051	2K	128	15	2	6	3V	20
AT89C52	8K	128	32	3	8	5V	40
AT89LV52	8K	128	32	3	8	3V	40

Note: “C” in the part number indicates CMOS.

Table 1–6 Versions of 8051 From Atmel (All ROM Flash)

Microcontrollers and Embedded Processors

Part Number	Speed	Pins	Packaging	Use
AT89C51-12PC	12 MHz	40	DIP plastic	commercial
AT89C51-16PC	16 MHz	40	DIP plastic	commercial
AT89C51-20PC	20 MHz	40	DIP plastic	commercial

Table 1–7 Various Speeds of 8051 From Atmel

Comparison of microprocessors and microcontrollers

S.No	Microprocessor	Micro Controller
1	Microprocessor is heart of Computer system.	Micro Controller is a heart of Embedded System.
2	Memory and I/O components have to be connected externally	Micro controller has internal processor along with internal memory and I/O components
3	Memory and I/O has to be connected externally, the circuit becomes large.	Memory and I/O are present internally, the circuit is small.
4	Cannot be used in compact systems and hence inefficient	Can be used in compact systems and hence it is an efficient technique
5	Cost of the entire system high	Cost of the entire system is low
6	Due to external components, the entire power consumption is high. Hence it is not suitable to use 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.

S.No	Microprocessor	Micro Controller
7	Most of the microprocessors do not have power saving features.	Most of the micro controllers have power saving modes like idle mode and power saving mode. This helps to reduce power consumption even further.
8	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 by internal instructions, hence speed is fast.
9	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.
10	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.
11	Mainly used in personal computers	Used mainly in washing machine, MP3 players etc.,

Features of 8051 Micro Controller:

1. It is 8 bit Micro Controller (8 bit data bus,16 bit address bus).
2. It has **on chip** oscillator and CLK generator ckt with operating freq.**12MHz**.
3. It has **on chip 4KB ROM** which can be expanded up to 64 KB.
4. It has **128 Bytes** of **on chip RAM**.
5. It has **4 Register Banks**: **bank 0, bank 1, bank 2 and bank 3**.

Each register bank consists of **8** registers.

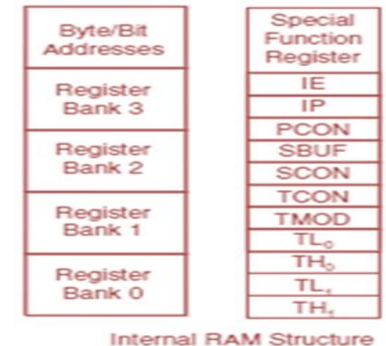
6. The data memory can be expanded up to 64kB.
7. It has 4 parallel I/O port: port0, port1, port2, port3.

Each port is 8-bit bidirectional I/O port. Each port is bit/byte addressable.

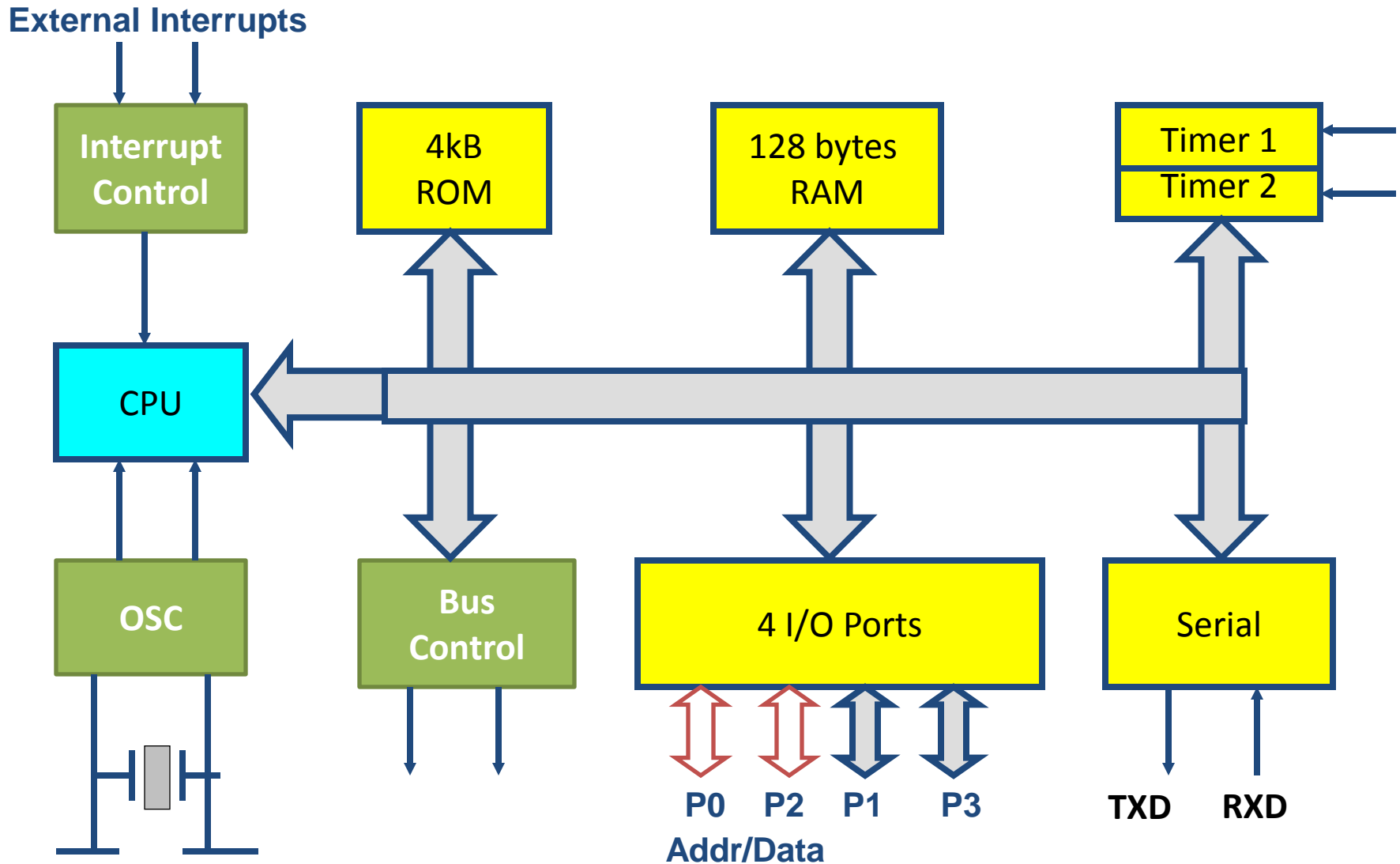
8. It has two 16 bit multi mode programmable timer/counter.

Features of 8051 Micro Controller: cont'd...

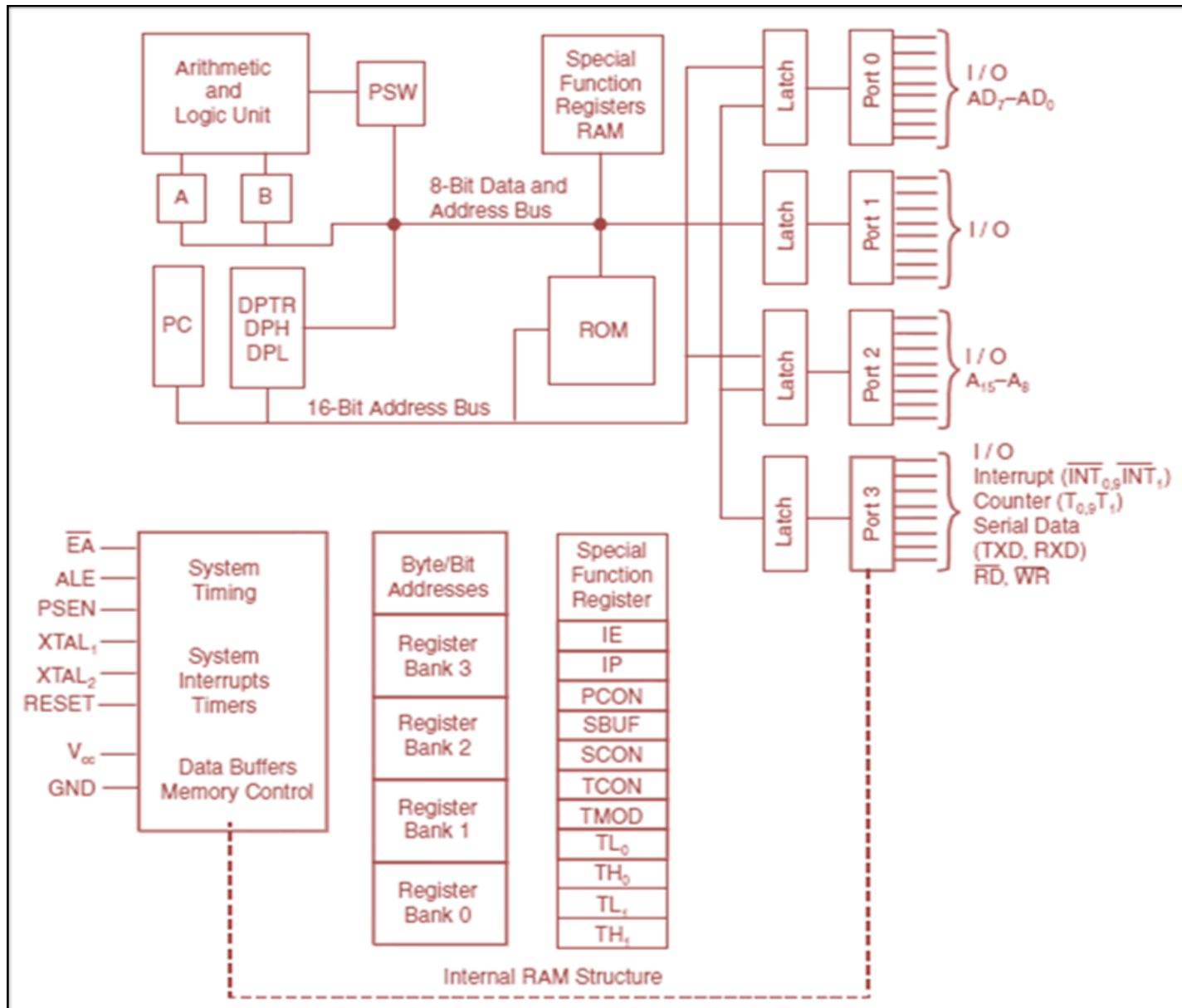
9. It has multi mode high speed programmable full duplex serial port.
10. It has **5** Hardware interrupts:
internal interrupts: **3** and
external interrupts: **2**
11. All 5 interrupt are operated in two priority level.
12. It has **on chip power saving circuit** operated in two modes:
1. Idle mode 2. Power down mode.
13. It has **11** special function register & **34** General purpose registers.
14. It has 111 instructions, 64 instructions are single cycle.
15. It has on chip Boolean processor for single bit manipulation.



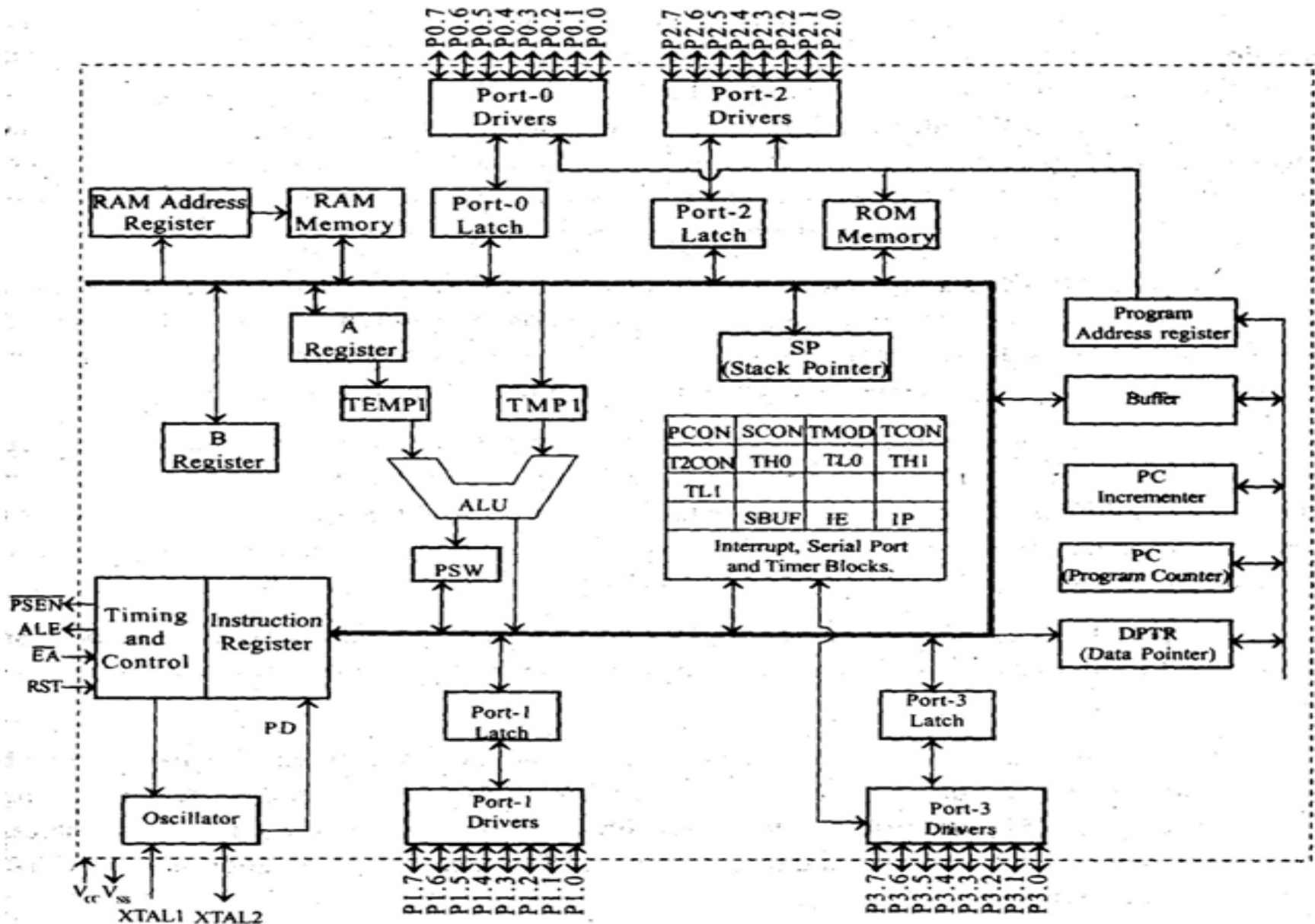
Block Diagram 8051 μC



8051- Architecture



8051- Architecture

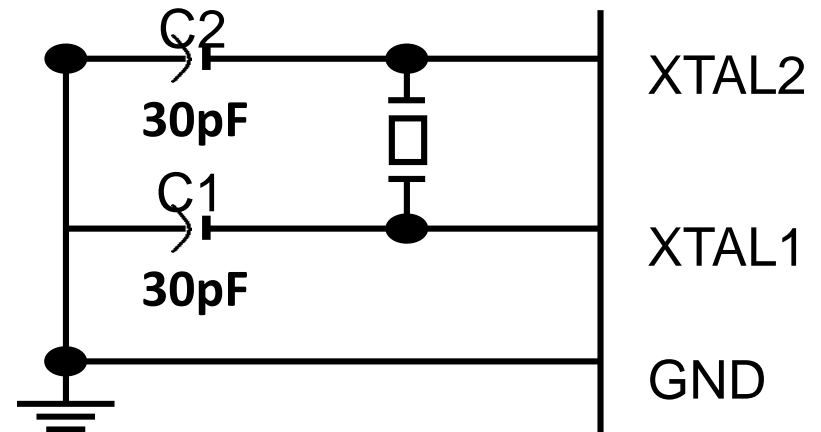
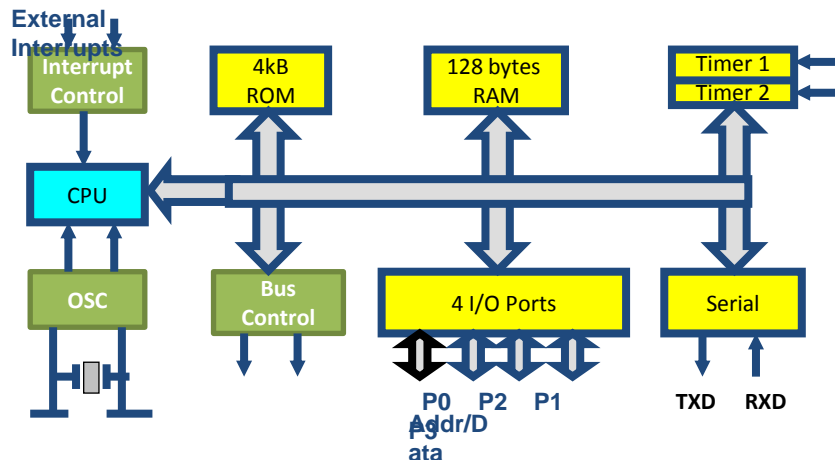


8051- Architecture

cont'd...

Oscillator and clock generator:

- All operations in a microcontroller are synchronized by an oscillator clock.
- A resonant network connected through pins XTAL1 and XTAL2 forms up an **oscillator**.
- For this purpose a **quartz crystal** and **capacitors** are employed.
- The crystal run at specified maximum and minimum frequencies typically at 1 MHz to 16 MHz



ALU:

- It is 8 bit unit .
- It performs arithmetic operation as addition, subtraction, multiplication, division, increment and decrement.
- It performs logical operations like AND, OR and EX-OR.
- It manipulates 8 bit and 16 bit data.
- It calculates address of jump locations in relative branch instruction.
- It performs compare, rotate and compliment operations.
- It consists of Boolean processor which performs bit, set, test and clear.
- **8051 micro controller contains 34 general purpose registers or working registers.**
- **2** of them are called **math registers A & B** and **32** are **bank of registers.**
- **Total Registers:** Bank Registers:32 Math: 2 SFR: 11 & PC,SP,DPTR,PSW

8051- Architecture

cont'd...

A Register (Accumulator): -

- The A (accumulator) register is the most versatile of the two CPU registers.
- It is used for **many operations**, including addition, subtraction, integer multiplication and division and Boolean bit manipulations.
- The A register is also used for all data transfers between the 8051 and any external memory.

B Register: -

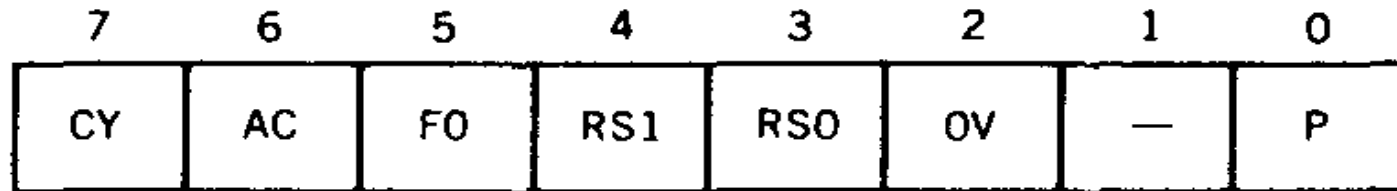
- The B register is used with the A register **for multiplication and division** operations and **has no other function** other than as a location where data may be stored.

8051- Architecture

cont'd...

Program Status Word Register (PSW): -

It contains several status bits that reflect **the current state** of the CPU.



- This register contains **four mathematical** flags
 1. **Carry** flag,
 2. **Auxiliary Carry**,
 3. **Overflow** flag,
 4. **Parity** bit
- **two register bank select** bits (**RS1 & RS0**),
- **one user-definable** status flag (**FO**) and
- one bit is **not defined**.

PSW: PROGRAM STATUS WORD. BIT ADDRESSABLE.

CY	AC	F0	RS1	RS0	OV	—	P
----	----	----	-----	-----	----	---	---

CY	PSW.7	Carry Flag.
AC	PSW.6	Auxiliary Carry Flag.
F0	PSW.5	Flag 0 available to the user for general purpose.
RS1	PSW.4	Register Bank selector bit 1 (SEE NOTE 1).
RS0	PSW.3	Register Bank selector bit 0 (SEE NOTE 1).
OV	PSW.2	Overflow Flag.
—	PSW.1	User definable flag.
P	PSW.0	Parity flag. Set/cleared by hardware each instruction cycle to indicate an odd/even number of '1' bits in the accumulator.

NOTE:

1. The value presented by RS0 and RS1 selects the corresponding register bank.

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

8051- Architecture

cont'd...

Program Status Word Register (PSW): -

P - Parity bit: -

odd parity-set

even parity-reset

- If a number stored in the accumulator A contains odd no. of 1's then this bit will be automatically set (1), otherwise it will be cleared (0).
- It is mainly used during data transmit and receive via serial communication.

OV - Overflow: -

- Overflow occurs when the result of an arithmetical operation is larger than 255 and cannot be stored in one register.
- Overflow condition causes the OV bit to be set (1) , otherwise, it will be cleared (0).

8051- Architecture

cont'd...

Program Status Word Register (PSW): -

RS0, RS1 - Register bank select bits.

- These two bits are used to select one of four register banks of RAM.
- By setting and clearing these bits, registers R0-R7 are stored in one of four banks of RAM.

RS1	RS0	Space in RAM
0	0	Bank0 (00H-07H)
0	1	Bank1 (08H-0FH)
1	0	Bank2 (10H-17H)
1	1	Bank3 (18H-1FH)

F0 – User Flag 0.

This is a general-purpose user defined flag the use of this flag is decided by the user.

8051- Architecture

cont'd...

Program Status Word Register (PSW): -

AC - Auxiliary Carry Flag: -

- It is used for BCD operations only.
- This flag is set to '1' when in the addition operation the carry is generated at bit position D3 or in subtraction operation borrow is needed at the bit position D3.

CY - Carry Flag: -

- This flag is set to '1' when in the addition operation the final carry is generated or in subtraction operation the Minuend is less than the Subtrahend.

Program counter(PC):

- 8051 has two 16- bit Registers. : **PC, DPTR**
- **PC is the only register that doesn't has any internal address.**
- The Program Counter (PC) is a 2-byte address register which tells the 8051 where the **next instruction** to execute is found in memory.
- It is used to hold 16 bit address of **Internal RAM , External RAM or External ROM** locations.
- When the 8051 is initialized, PC always starts at **0000h** and is **incremented** each time an instruction is executed.
- It is important to note that PC is always incremented by one and **never decremented.**

Data pointer register (DPTR):

- It is a 16 bit register **used to hold address of** external or internal **RAM** where data is stored or result is to be stored.
- It is used to store 16 bit data.
- It is divided into **two 8-bit** registers,
 DPH-data pointer higher order (83H) and
 DPL -data pointer lower order(82H).
- Each register can be used as general purpose register to store 8 bit data and can also be used as memory location.
- DPTR does not have single internal address.
- It functions as Base register in base relative addressing mode and indirect jump.

Stack pointer(SP):

- It is 8-bit register. It is byte addressable. Its address is 81H.
- It is **used to hold the internal RAM memory location address** , which are used as stack memory.
- When the data is to be placed on stack by **push** instruction, the content of **SP is incremented by 1**.
- When data is retrieved (**POP**) from stack, content of **SP is decremented by 1**.

Special function Registers(SFR): 11

1. **Timer/Counter register** : Timer-reg- $T_0 \rightarrow TL_0, TH_0$
Timer/counter Reg- $T_1 \rightarrow TL_1, TH_1$
Timer control register : **TMOD** and **TCON** .
TMOD: Timer Mode
TCON: Timer Control
2. **Serial data register**:
Serial **BU**ffer register (**SBUF**)
Serial **CON**trol register (**SCON**)
3. **Interrupt register**:
Interrupt **P**riority register (**IP**)
Interrupt **E**nable register (**IE**)
4. **Power control register** (**PCON**)

Memory Organization:

Internal Memory:

The 8051 μ C has internal program memory (ROM-4kB) and internal data memory (RAM-128bytes).

Internal RAM: -

- The 8051 microcontroller has 128 bytes of internal RAM.
- Its address range from **00H to 07FH**.
- From **80H to 0FFH** address space are assigned to **SFRs** (Special Function Registers).
- The internal **RAM** 128Bytes can **divide into three parts**. Those are
 1. Register Banks – **32 Bytes** (**00H – 1FH**)
 2. Bit/Byte addressable memory – **16 Bytes** (**20H – 2FH**)
 3. User memory or General purpose memory—**80 Bytes** (**30H – 7FH**)

8051- Architecture

cont'd...

Internal RAM organization:

BANK 3	1FH	R7
	1EH	R6
	1DH	R5
	1CH	R4
	1BH	R3
	1AH	R2
	19H	R1
	18H	R0
BANK 2	17H	R7
	16H	R6
	15H	R5
	14H	R4
	13H	R3
	12H	R2
	11H	R1
	10H	R0
BANK 1	0FH	R7
	0EH	R6
	0DH	R5
	0CH	R4
	0BH	R3
	0AH	R2
	09H	R1
	08H	R0
BANK 0	07H	R7
	06H	R6
	05H	R5
	04H	R4
	03H	R3
	02H	R2
	01H	R1
	00H	R0

Register Banks Memory

Byte Address	Bit Address	
2FH	7FH	78H
2EH	77H	70H
2DH	6FH	68H
2CH	67H	60H
2BH	5FH	58H
2AH	57H	50H
29H	4FH	48H
28H	47H	40H
27H	3FH	38H
26H	37H	30H
25H	2FH	28H
24H	27H	20H
23H	1FH	18H
22H	17H	10H
21H	0FH	08H
20H	07H	00H

Bit / Byte Addressable Memory

7FH	
7EH	
7DH	
	•
	•
	•
	•
	•
	•
	•
	•
	•
33H	
32H	
31H	
30H	

General Purpose Memory

FIG: INTERNAL RAM ORGANISATION

Bit Addressable Registers

Bit Addressable Registers means

to these registers : a byte address is allotted for the entire register and each and every individual bit also have their own address.

We can call these **register bits individually** by their bit addresses as well as register byte addresses.

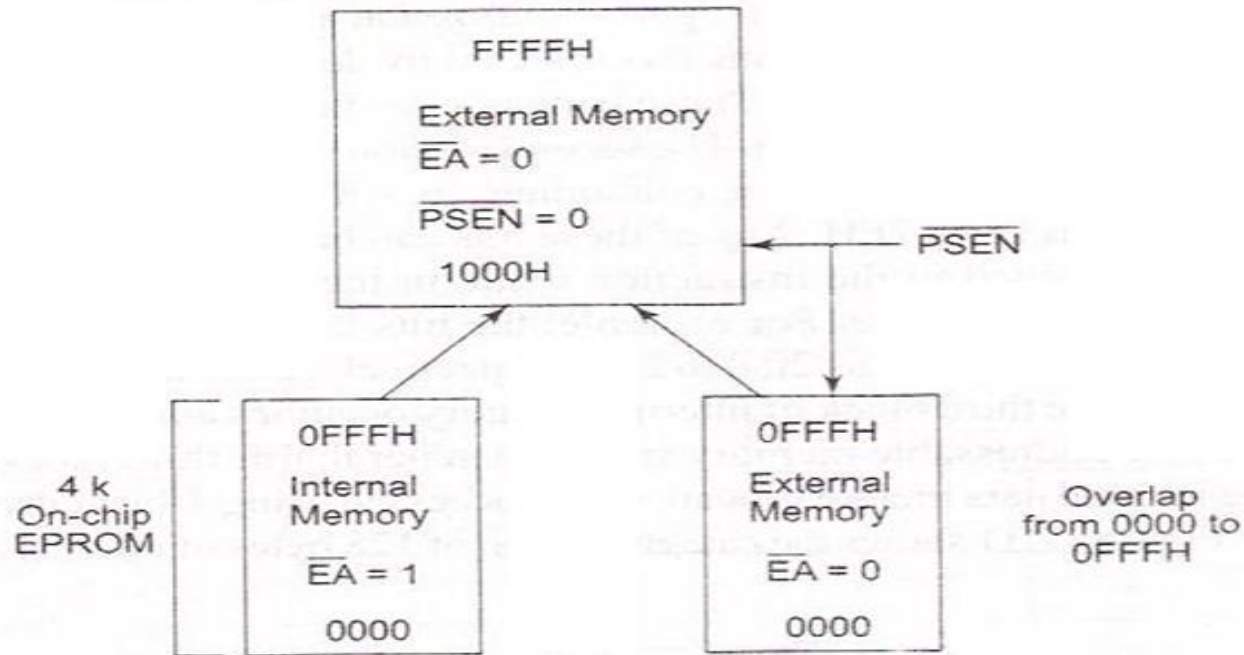
Internal ROM: -

- ✓ The 8051 microcontroller has an internal ROM of 4Kbytes
- ✓ its addresses from 0000H to 0FFFH.
- ✓ This is used to store the system files or system code information.
- ✓ The program addresses higher than the 0FFFH, which exceeds the internal ROM capacity, will cause the 8051 to automatically fetch the Program codes from external program memory.
- ✓ Code bytes can also be fetched exclusively from the **external** program memory addresses from 0000H to FFFFH (**64kB**), by connecting the **EA** (**External Active or External Enable**) pin to the ground.

8051- Architecture

cont'd...

ROM Organization: -

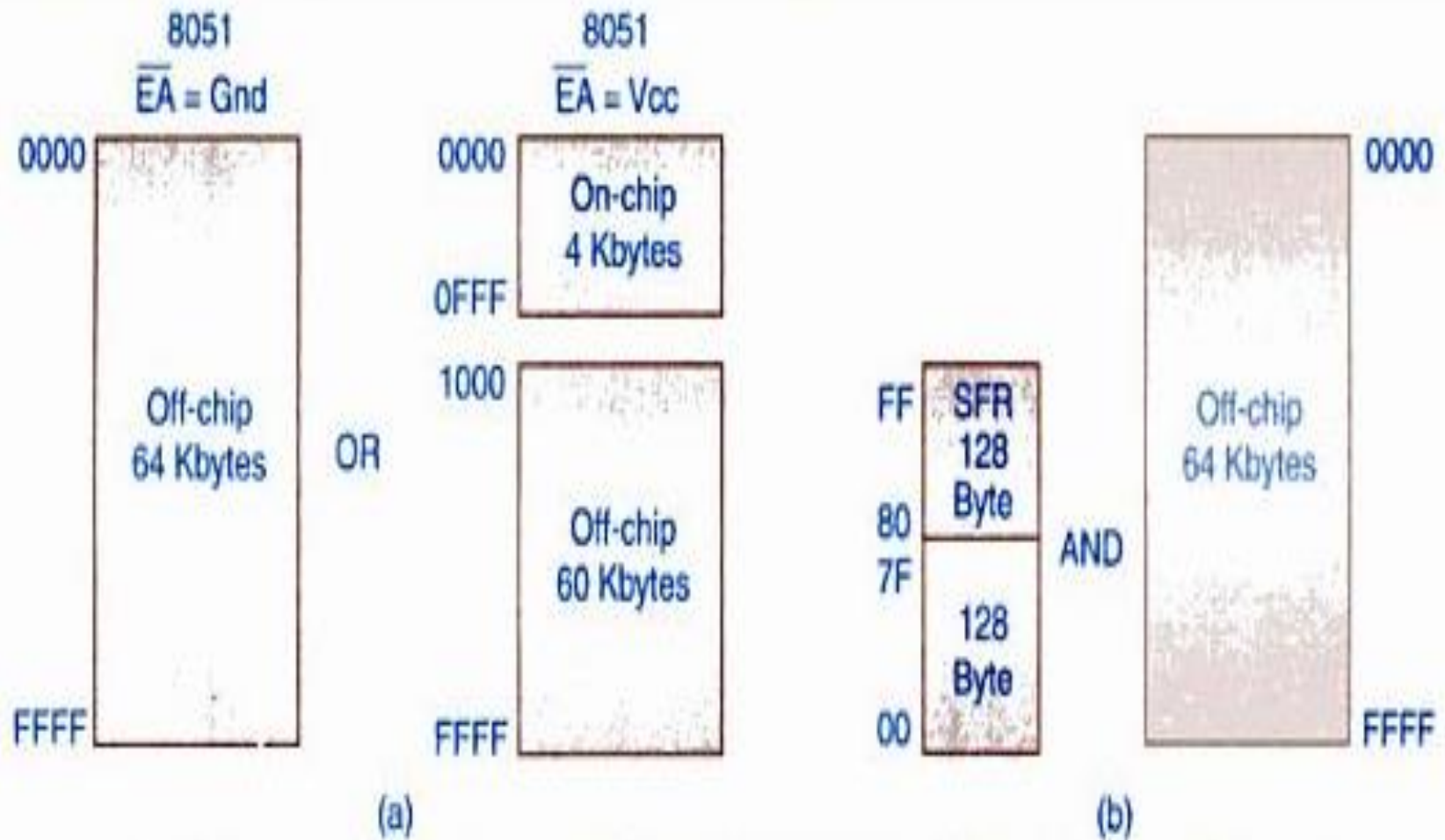


Program Memory Map of an 8051 System

- **DPTR** is used to access external data memory (**External RAM**)
- \overline{PSEN} is used to access external program memory (**External ROM**)

SFRs
80H to
0FFH

Register Name	Function	Internal Address in Hex
A	Accumulator *	0E0H
B	Arithmetic *	0F0H
DPL	Data Pointer Lower	82H
DPH	Data Pointer Higher	83H
SP	Stack Pointer	81H
TCON	Timer Control Register *	88H
TMOD	Timer Mode Register	89H
SCON	Serial Control Register *	98H
SBUF	Serial Buffer Register	99H
PCON	Power Control Register	87H
IP	Interrupt Priority Register *	0A8H
IE	Interrupt Enable Register *	0B8H
PORT 0	Input/output Port Latch – 0 *	80H
PORT 1	Input/output Port Latch – 1 *	90H
PORT 2	Input/output Port Latch – 2 *	0A0H
PORT 3	Input/output Port Latch – 3 *	0B0H
TL0	Timer - 0 Lower	8AH
TH0	Timer - 0 Higher	8CH
TL1	Timer - 1 Lower	8BH
TH0	Timer - 1 Higher	8DH
PSW	Program Status Word *	0D0H

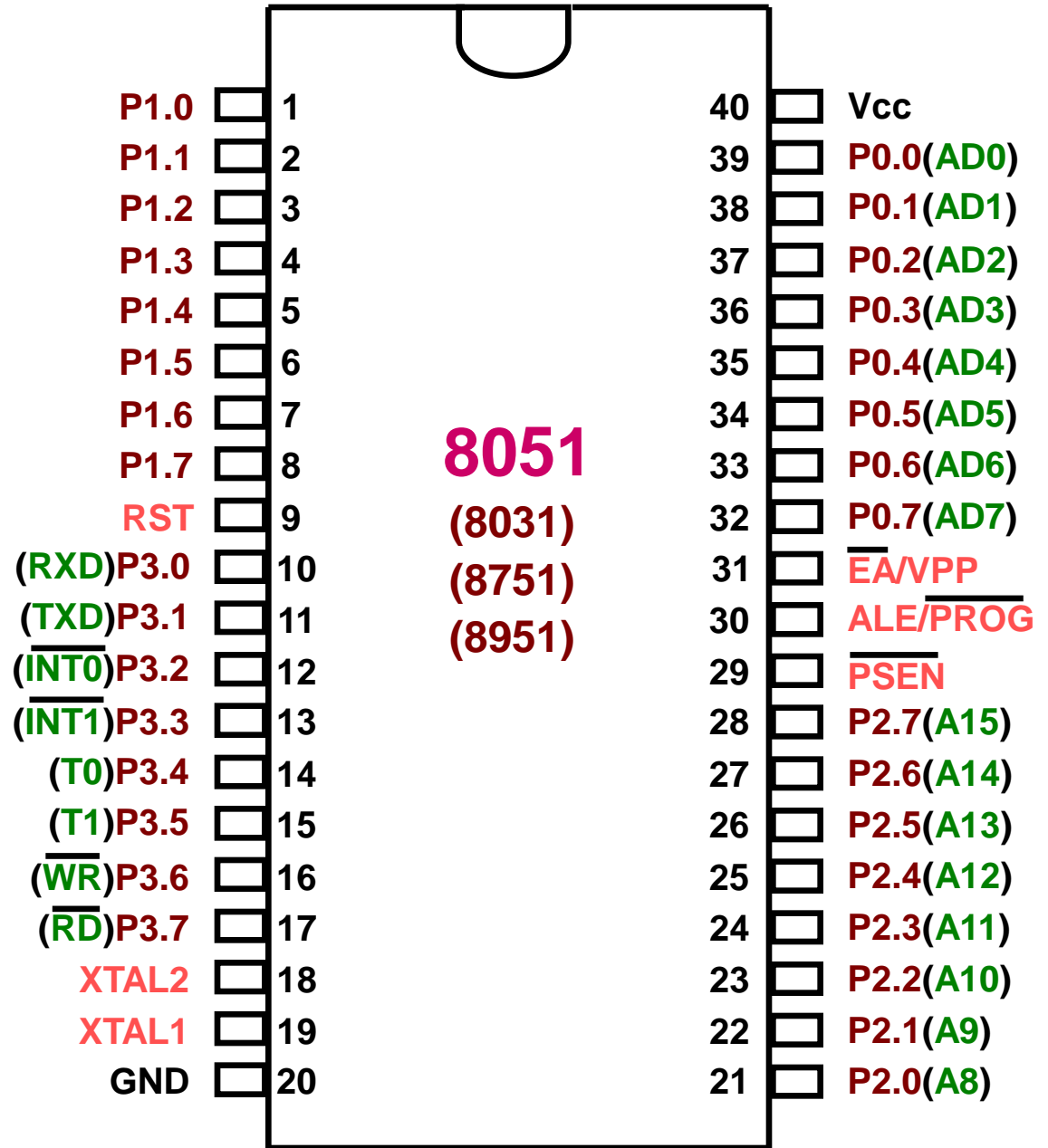


(a) On-chip and off-chip program Rom,

(b) On-chip and off-chip data memory

8051 Pin Diagram

S I T W R



PINS of 8051 (IO Ports)

- One of the most useful features of the 8051 is that it contains **four I/O ports (P0 - P3)**
- Port 0 (pins 32-39) : P0 (**P0.0~P0.7**)
 - 8-bit R/W - General Purpose I/O
 - Or acts as a multiplexed low byte **address** and **data** bus for **external** memory design
- Port 1 (pins 1-8) : P1 (**P1.0~P1.7**)
 - Only 8-bit R/W - General Purpose I/O
- Port 2 (pins 21-28) : P2 (**P2.0~P2.7**)
 - 8-bit R/W - General Purpose I/O
 - Or **high** byte of the **address** bus for external memory design
- Port 3 (pins 10-17) : P3 (**P3.0~P3.7**)
 - General Purpose I/O
 - if not using any of the internal peripherals (timers) or external interrupts.
- **Each port can be used as input or output (bi-directional)**

Port 3 Alternate Functions

Port Pin	Alternate Function
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{\text{INT0}}$ (external interrupt 0)
P3.3	$\overline{\text{INT1}}$ (external interrupt 1)
P3.4	T0 (Timer 0 external input)
P3.5	T1 (Timer 1 external input)
P3.6	$\overline{\text{WR}}$ (external data memory write strobe)
P3.7	$\overline{\text{RD}}$ (external data memory read strobe)

S I T W R

Pins of 8051

cont'd...

- **PSEN** (out): **P**rogram **S**tore **E**nable, the read signal for external program memory (active low).
- **ALE** (out): **A**ddress **L**atch **E**nable, to latch address outputs at Port0 and Port2
- **EA** (in): **E**xternal **A**ccess Enable, active low to access external program memory locations 0 to 4K
- **RXD, TXD**: UART pins for serial I/O on Port 3
- **XTAL1** & **XTAL2**: Crystal inputs for internal oscillator.

Pins of 8051

cont'd...

- **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.
 - Way 1 : using a quartz crystal oscillator
 - Way 2 : using a TTL oscillator

Pins of 8051

cont'd...

- RST (pin 9) : reset
 - input pin and active high (normally low) .
 - The high pulse must be high at least 2 machine cycles.
 - power-on reset.
 - Upon applying a high pulse to RST, the microcontroller will reset and all values in registers will be lost.
 - Reset values of some 8051 registers

RESET Value of Some 8051 Registers:

Register	Reset Value
PC	0000
ACC	0000
B	0000
PSW	0000
SP	0007
DPTR	0000
RAM are all zero	