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MICROCONTROLLER 8051 ARCHITECTURE

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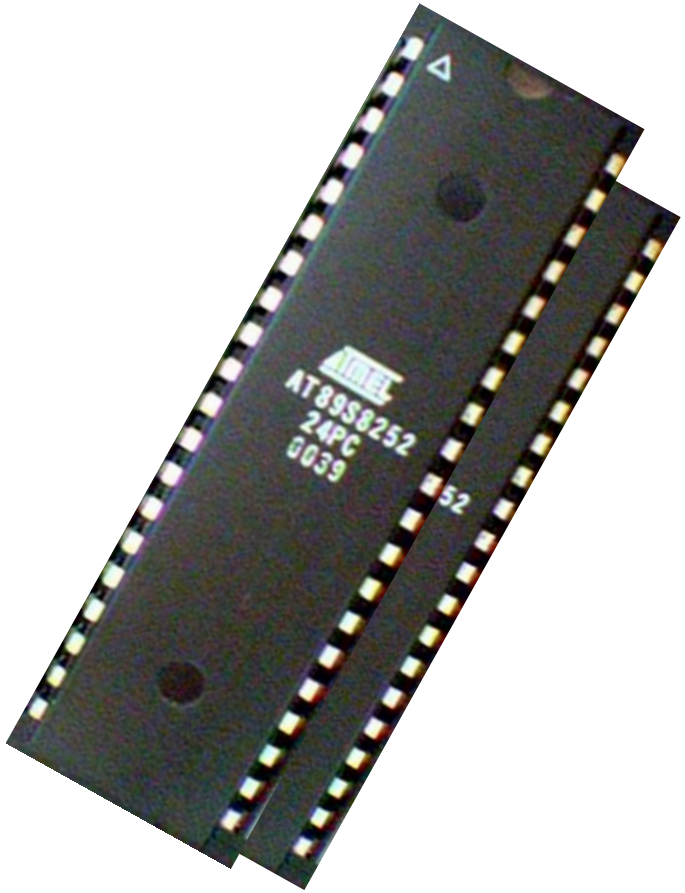
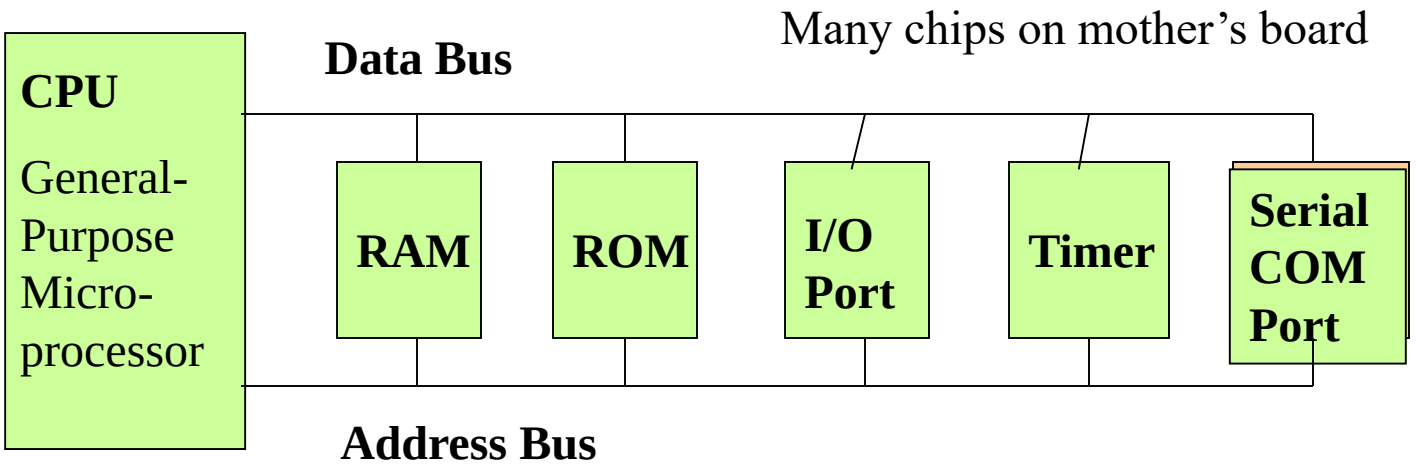
- Block Diagram of the 8051
- Pin Description of the 8051
- Register Bank



Topic covered in last lecture:

Microprocessor Vs Microcontroller

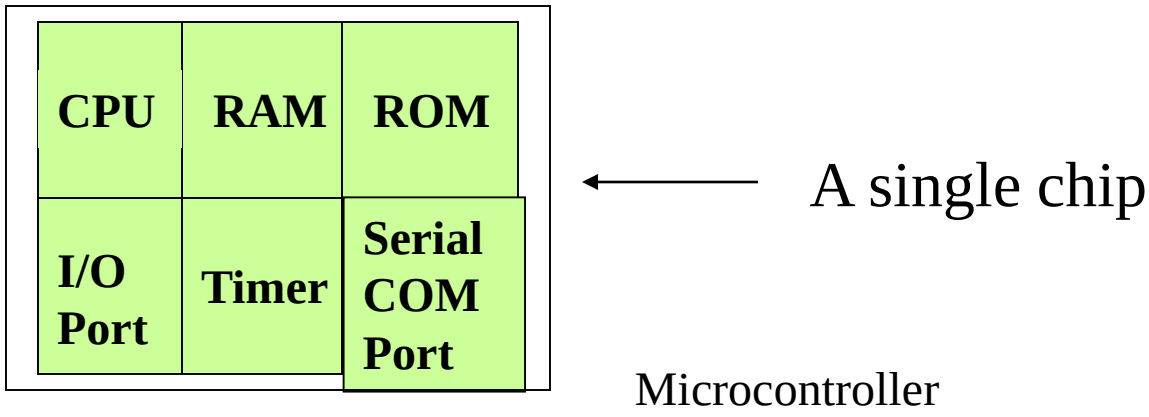
- CPU for Computers
- No RAM, ROM, I/O on CPU chip itself
- Example：Intel’s x86



General-Purpose Microprocessor System

Microcontroller :

- A smaller computer
- On-chip RAM, ROM, I/O ports...
- Example：Motorola’s 6811, Intel’s 8051, Zilog’s Z8 and PIC 16X



Microprocessor vs. Microcontroller

Microprocessor

- CPU is stand-alone, RAM, ROM, I/O, timer are separate
- designer can decide on the amount of ROM, RAM and I/O ports.
- versatility
- general-purpose

Microcontroller

- CPU, RAM, ROM, I/O and timer are all on a single chip
- fix amount of on-chip ROM, RAM, I/O ports
- for applications in which cost, power and space are critical
- single-purpose

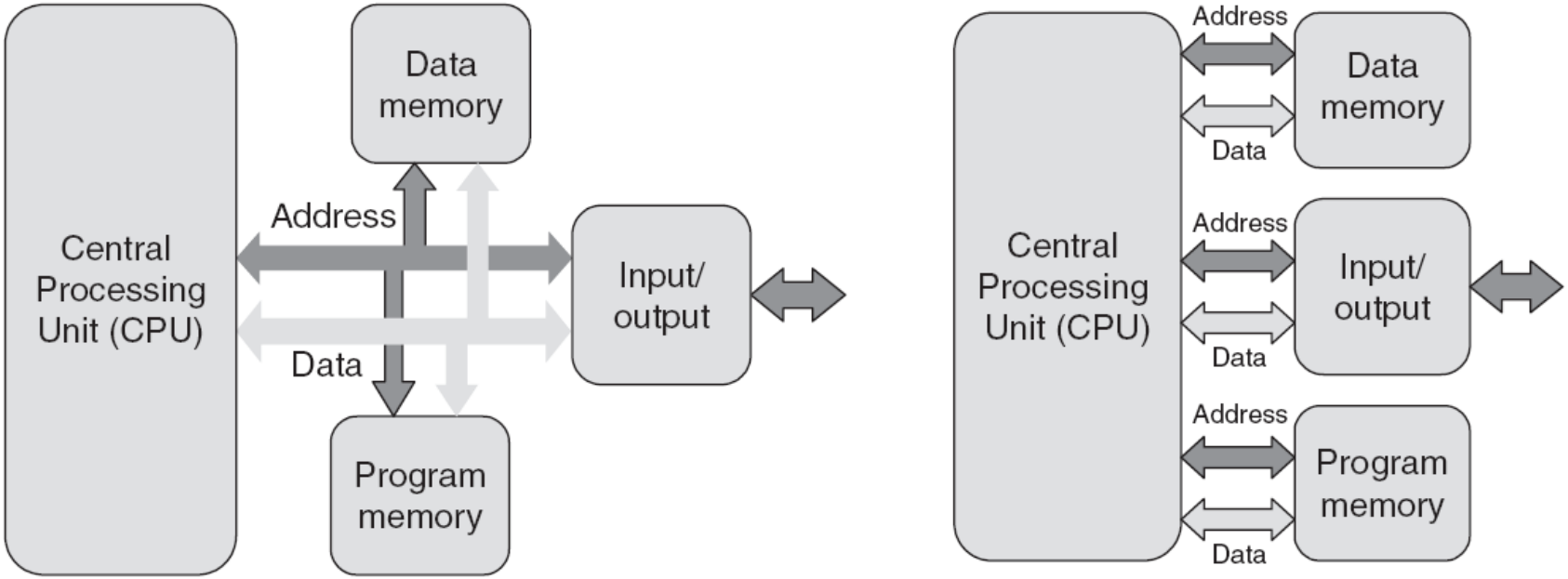
Topic covered in today's lecture:

8051 Microcontroller Architecture

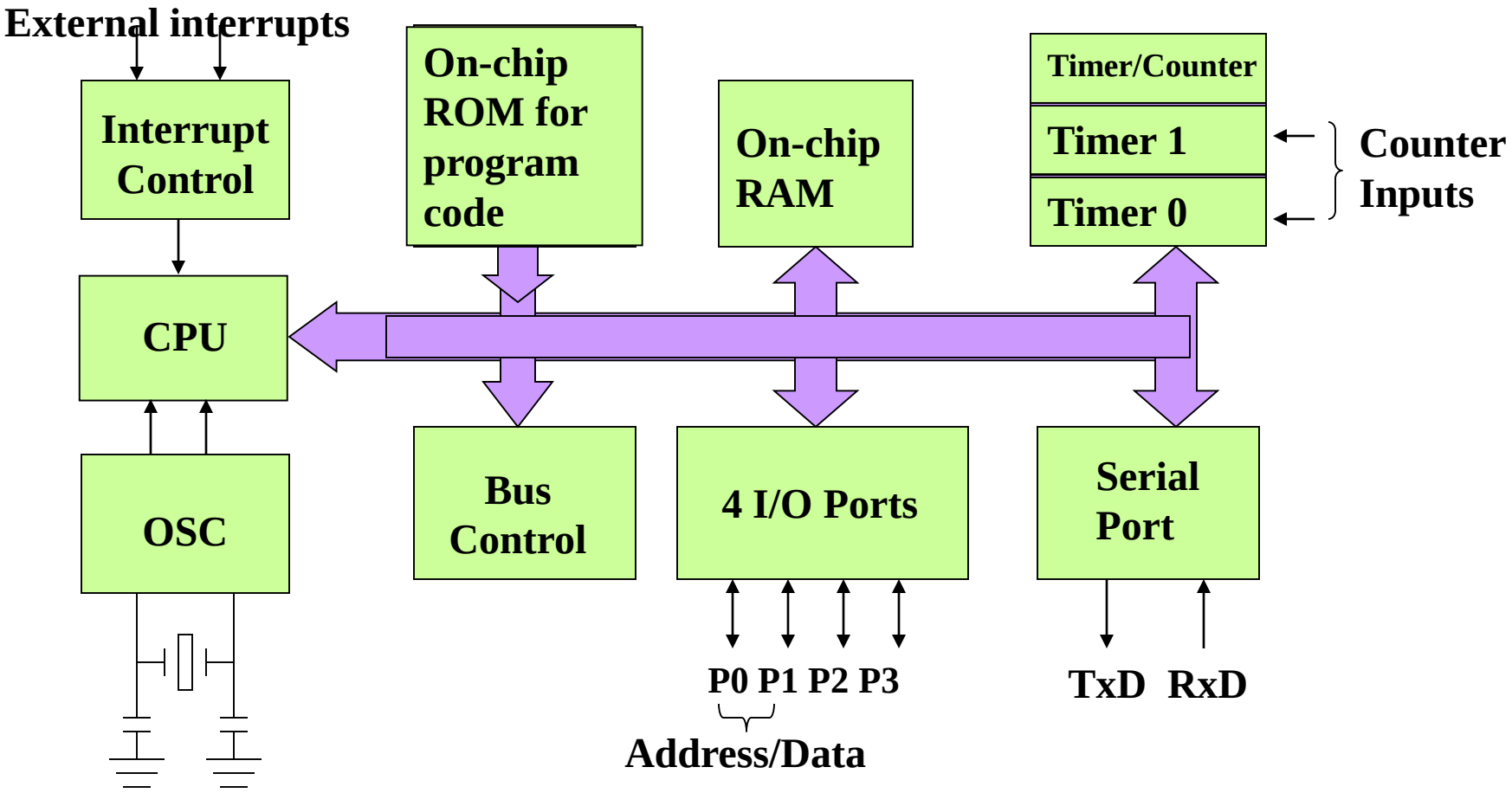
Mapped with CO2 – (Understand the working of different building blocks of 8051 Microcontroller)

- A Harvard architecture (separate instruction/data memories)
- single chip microcontroller (µC)
- developed by Intel in 1980 for use in embedded systems.
- today largely superseded by a vast range of faster and/or functionally enhanced 8051-compatible devices manufactured by more than 20 independent manufacturers

Von Neumann and Harvard Computers

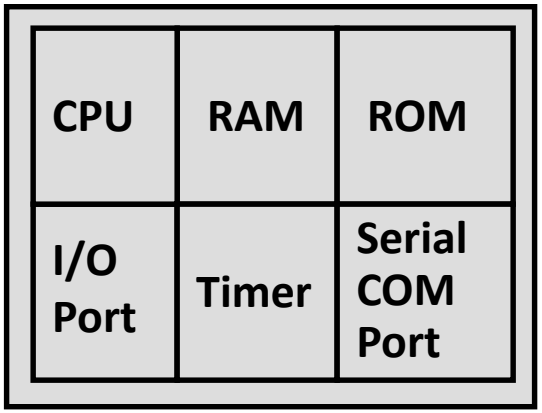


Block Diagram of 8051 Microcontroller



8051 Basic Components

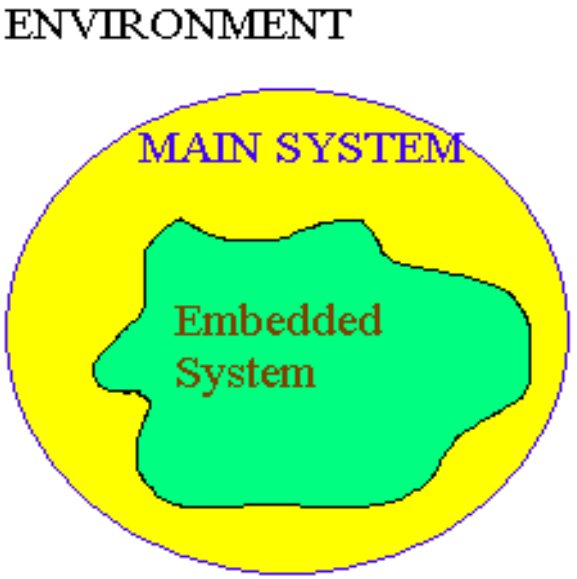
- 4K bytes internal ROM
- 128 bytes internal RAM
- Four 8-bit I/O ports (P0 - P3).
- Two 16-bit timers/counters
- One serial interface



A single chip Microcontroller

Embedded System (8051 Application)

- What is Embedded System?
  - An embedded system is closely integrated with the main system
  - It may not interact directly with the environment
  - For example – A microcomputer in a car ignition control

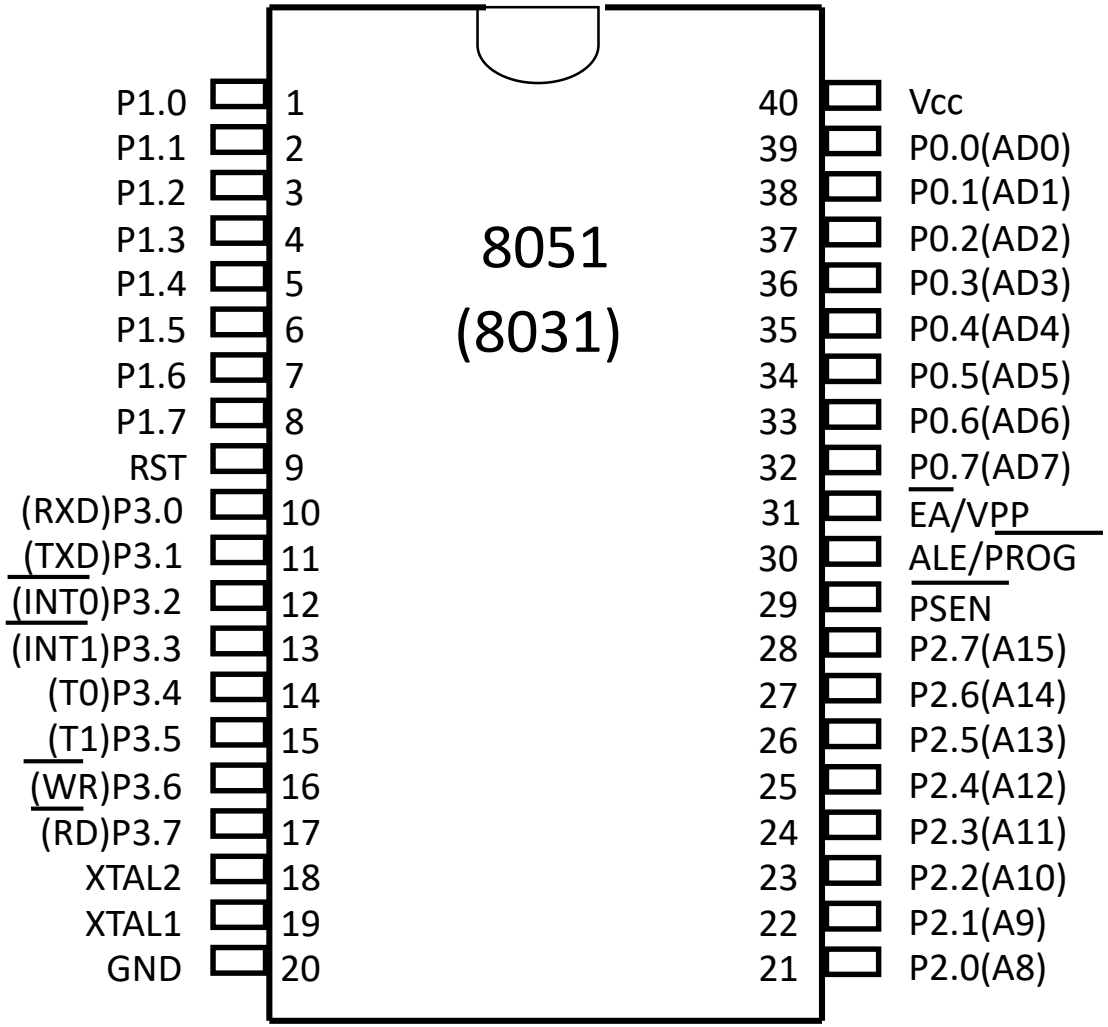


- An embedded product uses a microprocessor or microcontroller to do one task only
- There is only one application software that is typically burned into ROM

Examples of Embedded Systems

- Keyboard
- Printer
- video game player
- MP3 music players
- Embedded memories to keep configuration information
- Mobile phone units
- Domestic (home) appliances
- Data switches
- Automotive controls

Pin Description of the 8051



IMPORTANT PINS (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-direction)**

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)

IMPORTANT PINS

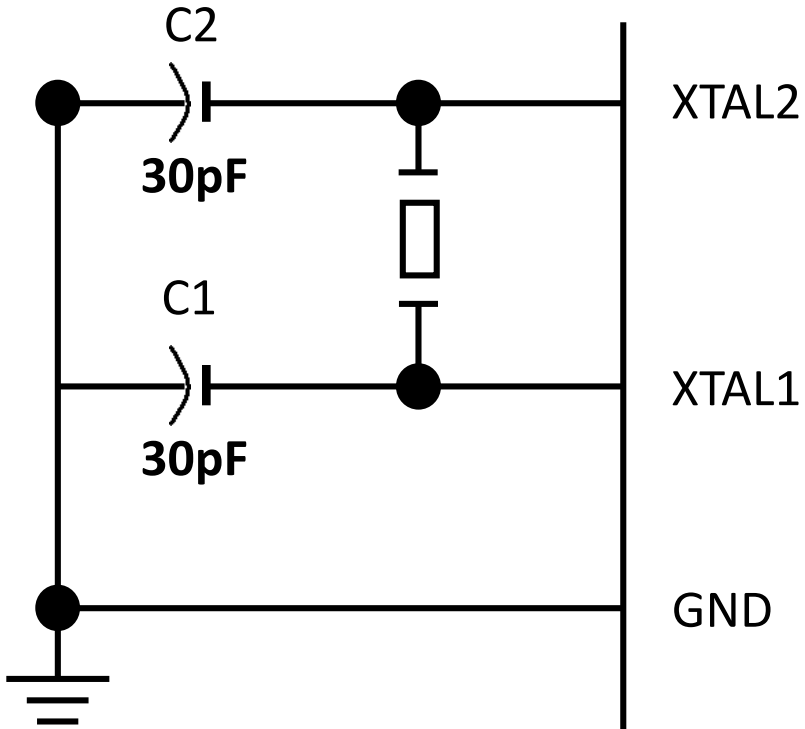
- **PSEN** (out): Program Store Enable, the read signal for external program memory (active low).
- **ALE** (out): Address Latch Enable, to latch address outputs at Port0 and Port2
- **EA** (in): External Access Enable, active low to access external program memory locations 0 to 4K
- **RXD**,**TXD**: UART pins for serial I/O on Port 3
- **XTAL1** & **XTAL2**: Crystal inputs for internal oscillator.

Pins of 8051

- 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

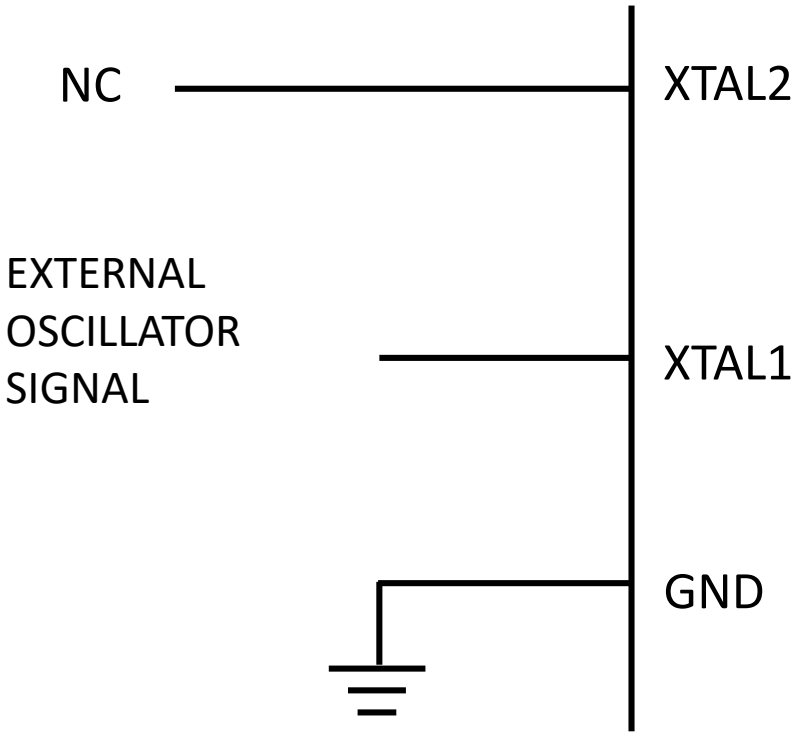
XTAL Connection to 8051

- Using a quartz crystal oscillator
- We can observe the frequency on the XTAL2 pin.



XTAL Connection to an External Clock Source

- Using a TTL oscillator
- XTAL2 is unconnected.



Pins of 8051（3/4）

- /EA（pin 31）：external access
  - There is no on-chip ROM in 8031 and 8032 .
  - The /EA pin is connected to GND to indicate the code is stored externally.
  - /PSEN ＆ ALE are used for external ROM.
  - 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

- 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
  - power-on reset circuit

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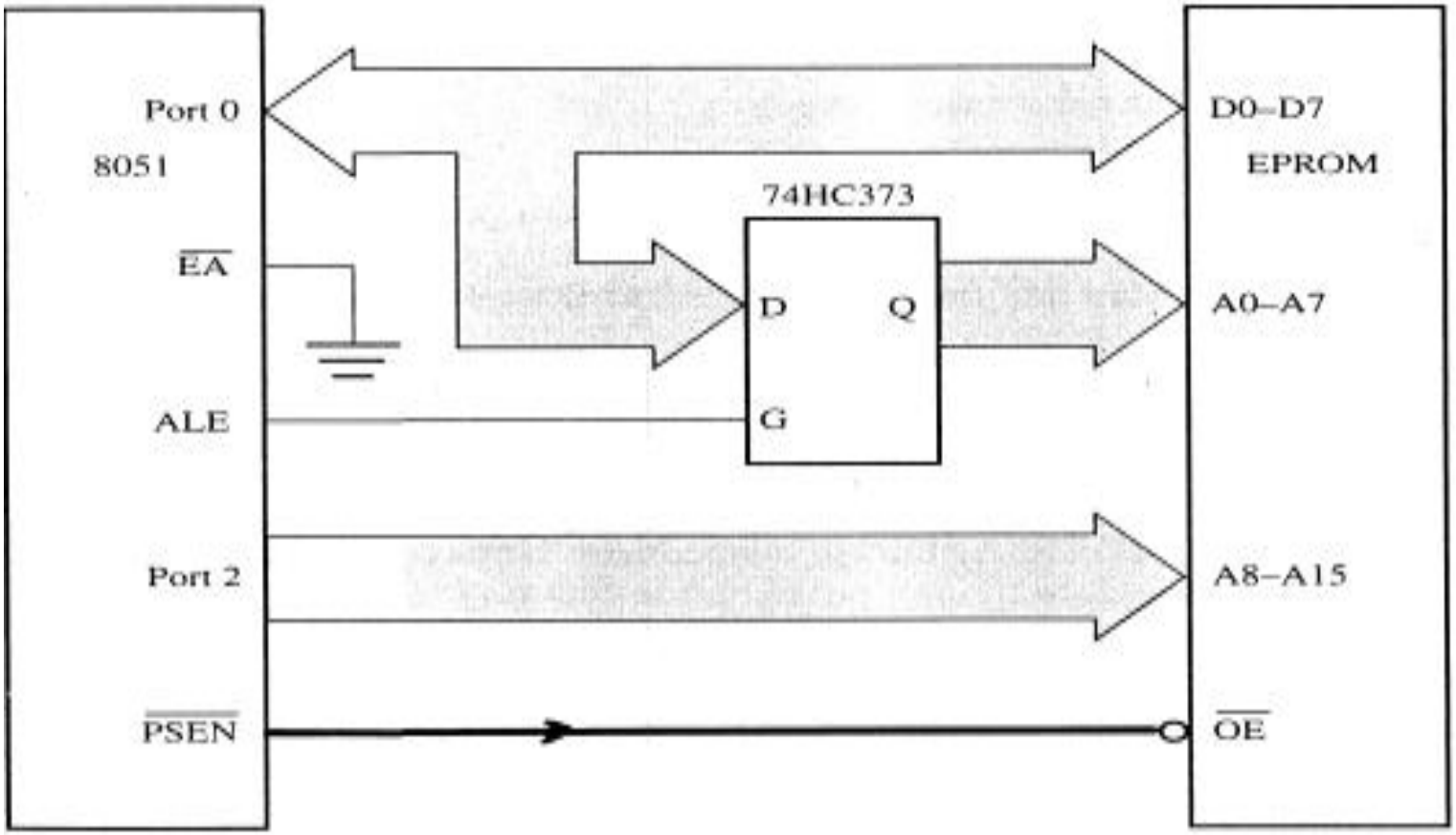
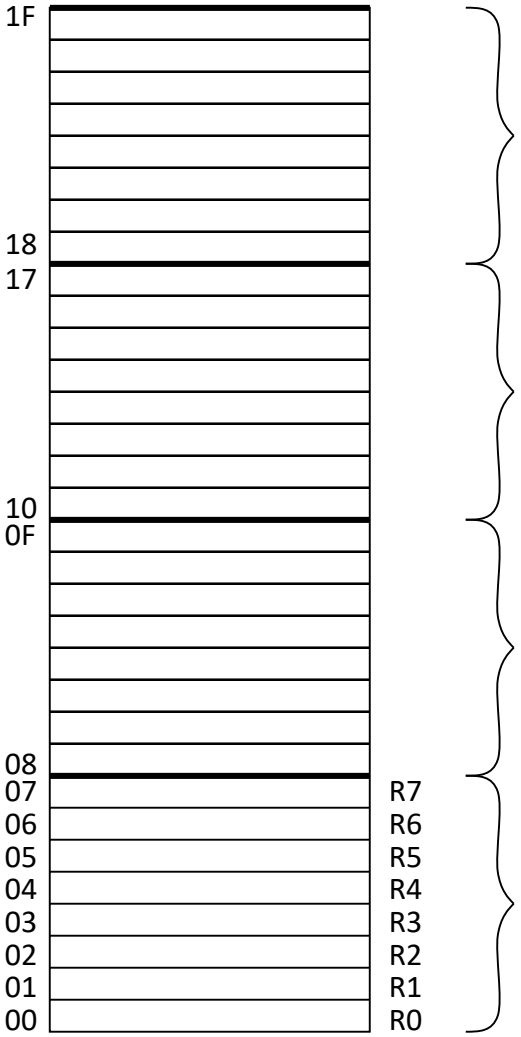
Address Multiplexing for External Memory

Figure 2-8

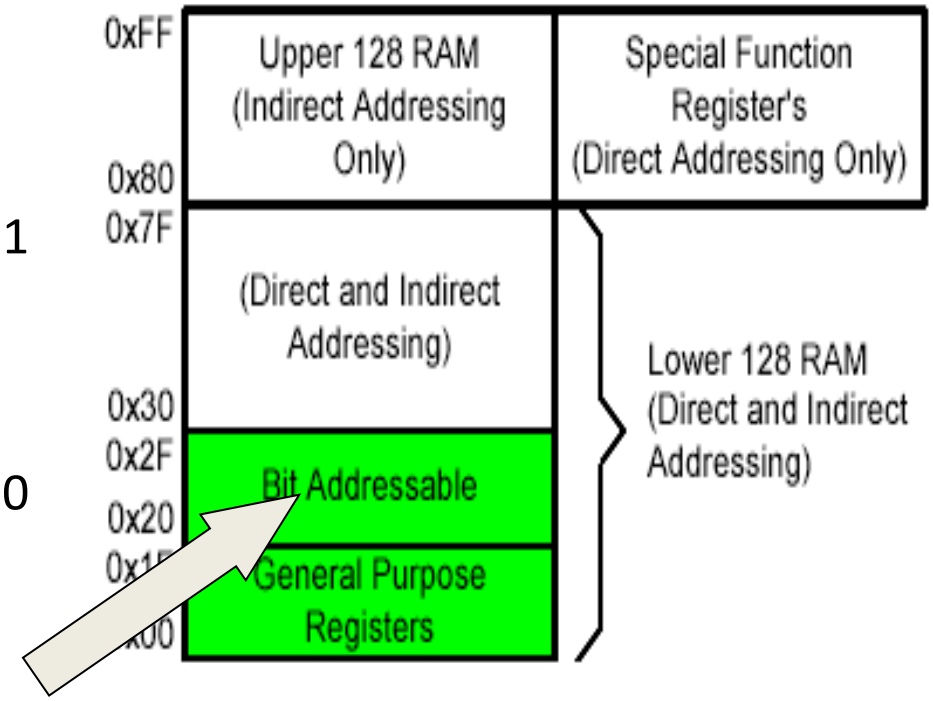
Accessing external code memory



Registers



Four Register Banks
Each bank has R0-R7
Selectable by psw.2,3



Bit Addressable Memory

2F	7F							78
2E								
2D								
2C								
2B								
2A								
29								
28								
27								
26								
25								
24						1A		
23								10
22	0F							08
21	07	06	05	04	03	02	01	00
20								

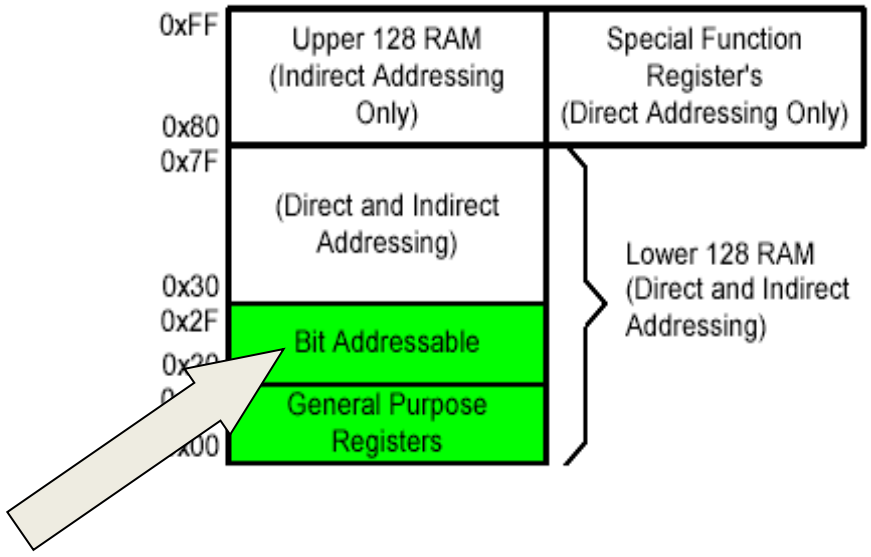
20h – 2Fh (16 locations X 8-bits = 128 bits)

Bit addressing:

mov C, 1Ah

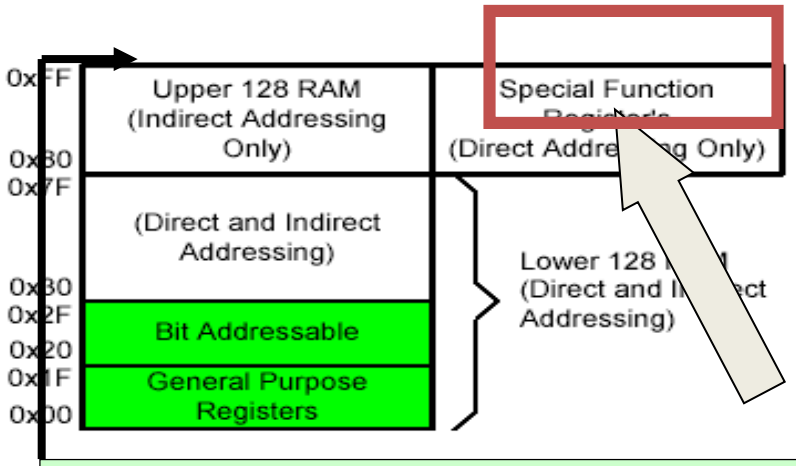
or

mov C, 23h.2



Special Function Registers

- DATA registers
- CONTROL registers
  - Timers
  - Serial ports
  - Interrupt system
  - Analog to Digital converter
  - Digital to Analog converter
  - Etc.



Addresses 80h – FFh

Direct Addressing used to access SPRs

SFR MEMORY MAP

8 Bytes

F8								FF
F0	B							F7
E8								EF
E0	ACC							E7
D8								DF
D0	PSW							D7
C8	T2CON		RCAP2L	RCAP2H	TL2	TH2		CF
C0								C7
B8	IP							BF
B0	P3							B7
A8	IE							AF
A0	P2							A7
98	SCON	SBUF						9F
90	P1							97
88	TCON	TMOD	TL0	TL1	TH0	TH1		8F
80	P0	SP	DPL	DPH				PCON 87

↑
Bit
Addressable

Figure 5

Register Banks

- Active bank selected by PSW [**RS1**,**RS0**] bit
- Permits fast "context switching" in interrupt service routines (ISR).

PSW: PROGRAM STATUS WORD. BIT ADDRESSABLE.

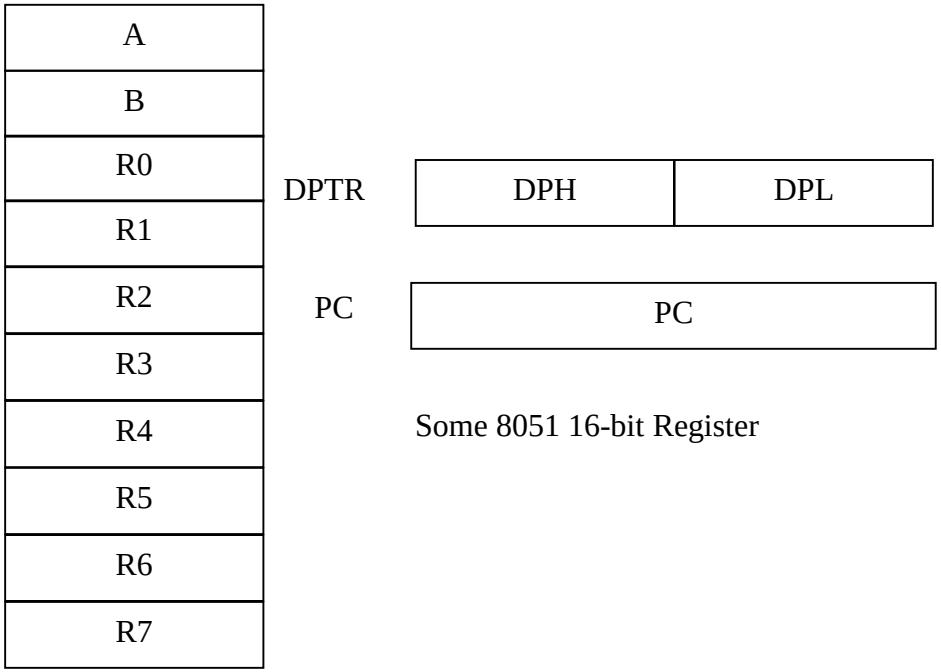
CY	AC	F0	RS1	RS0	OV	—	P

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

Registers



Some 8-bitt Registers of the 8051

Some 8051 16-bit Register

Topic to be covered in next lecture:

8051 Interrupts, Timer Programming