Microcontroller 8051

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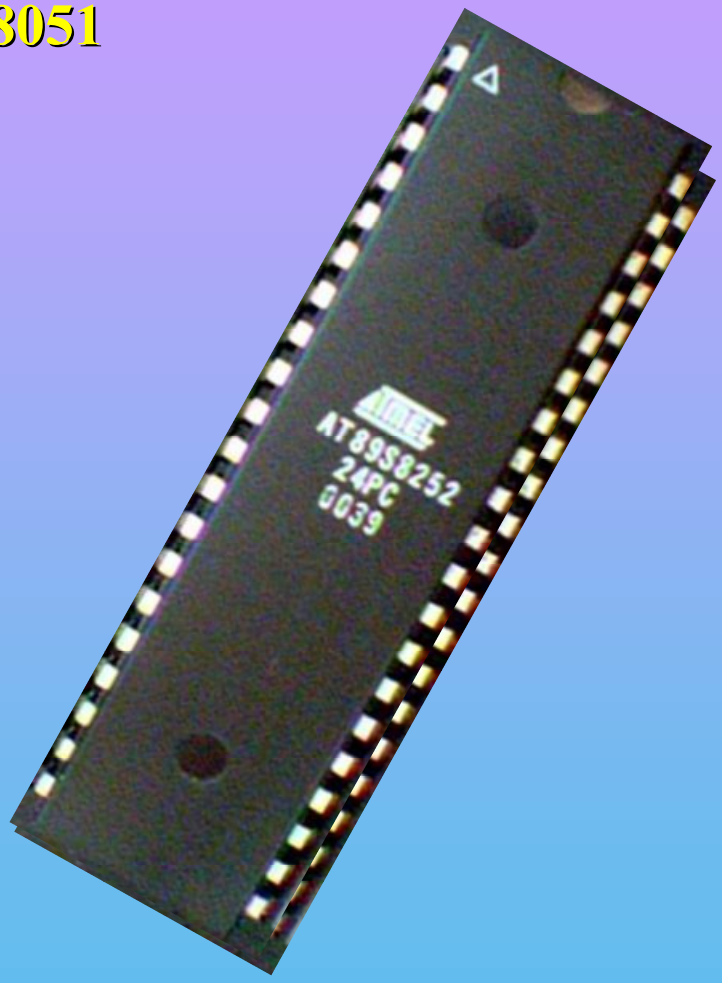


Why do we need to learn Microprocessors/controllers?

- The microprocessor is the core of computer systems.
- Nowadays many communication, digital entertainment, portable devices, are controlled by them.
- A designer should know what types of components he needs, ways to reduce production costs and product reliable.

Different aspects of a microprocessor/controller

- Hardware :Interface to the real world
- Software :order how to deal with inputs

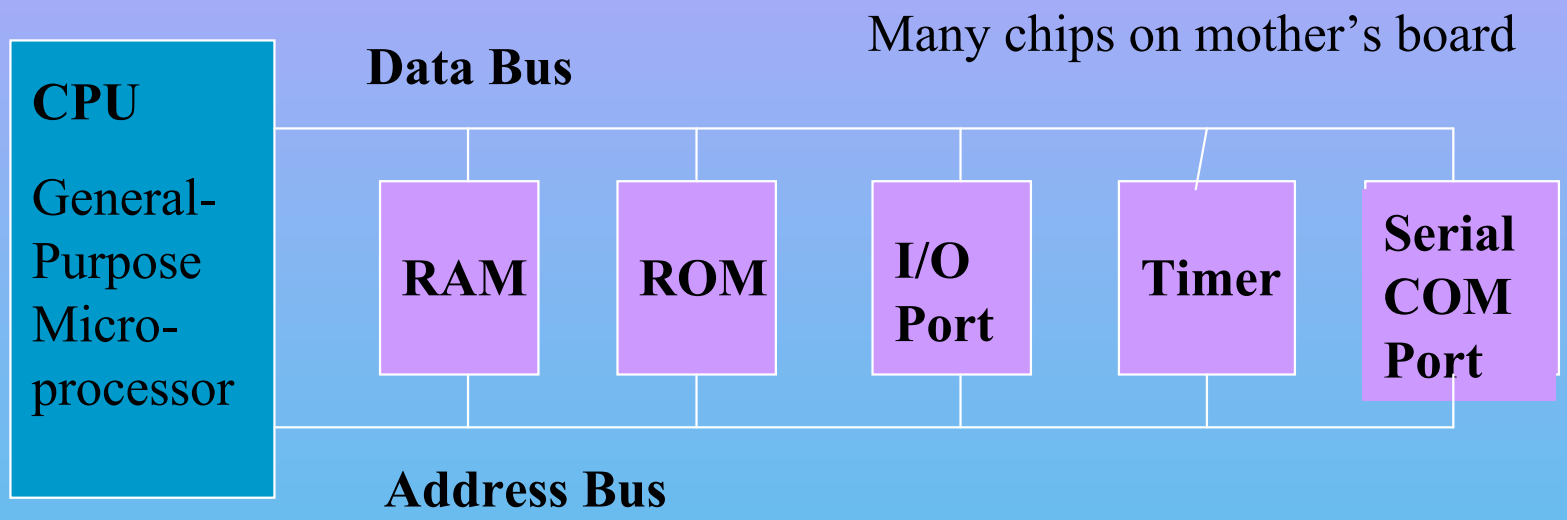
The necessary tools for a microprocessor/controller

- CPU: Central Processing Unit
- I/O: Input /Output
- Bus: Address bus & Data bus
- Memory: RAM & ROM
- Timer
- Interrupt
- Serial Port
- Parallel Port

Microprocessors:

General-purpose microprocessor

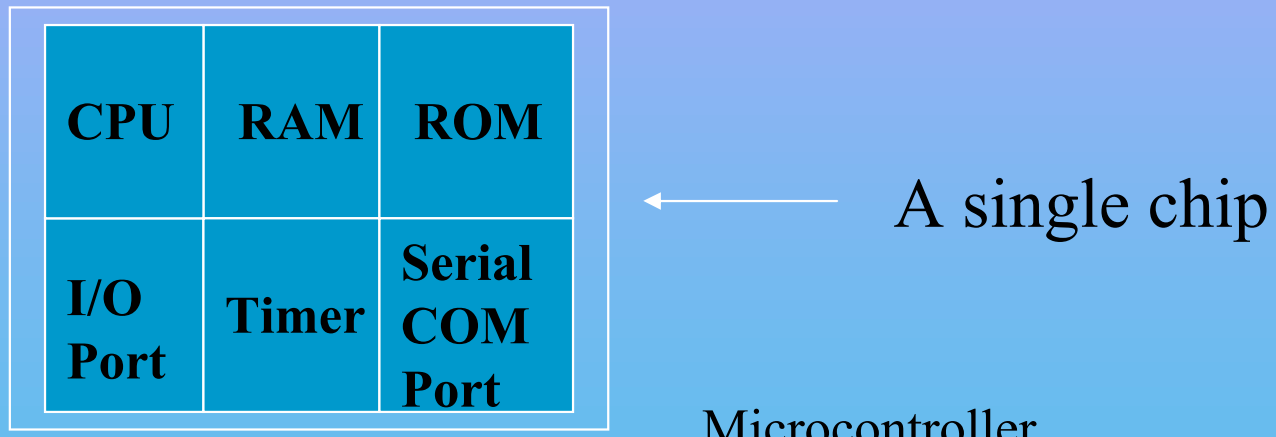
- CPU for Computers
- No RAM, ROM, I/O on CPU chip itself
- Example：Intel’s x86, Motorola’s 680x0



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.
- expansive
- 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

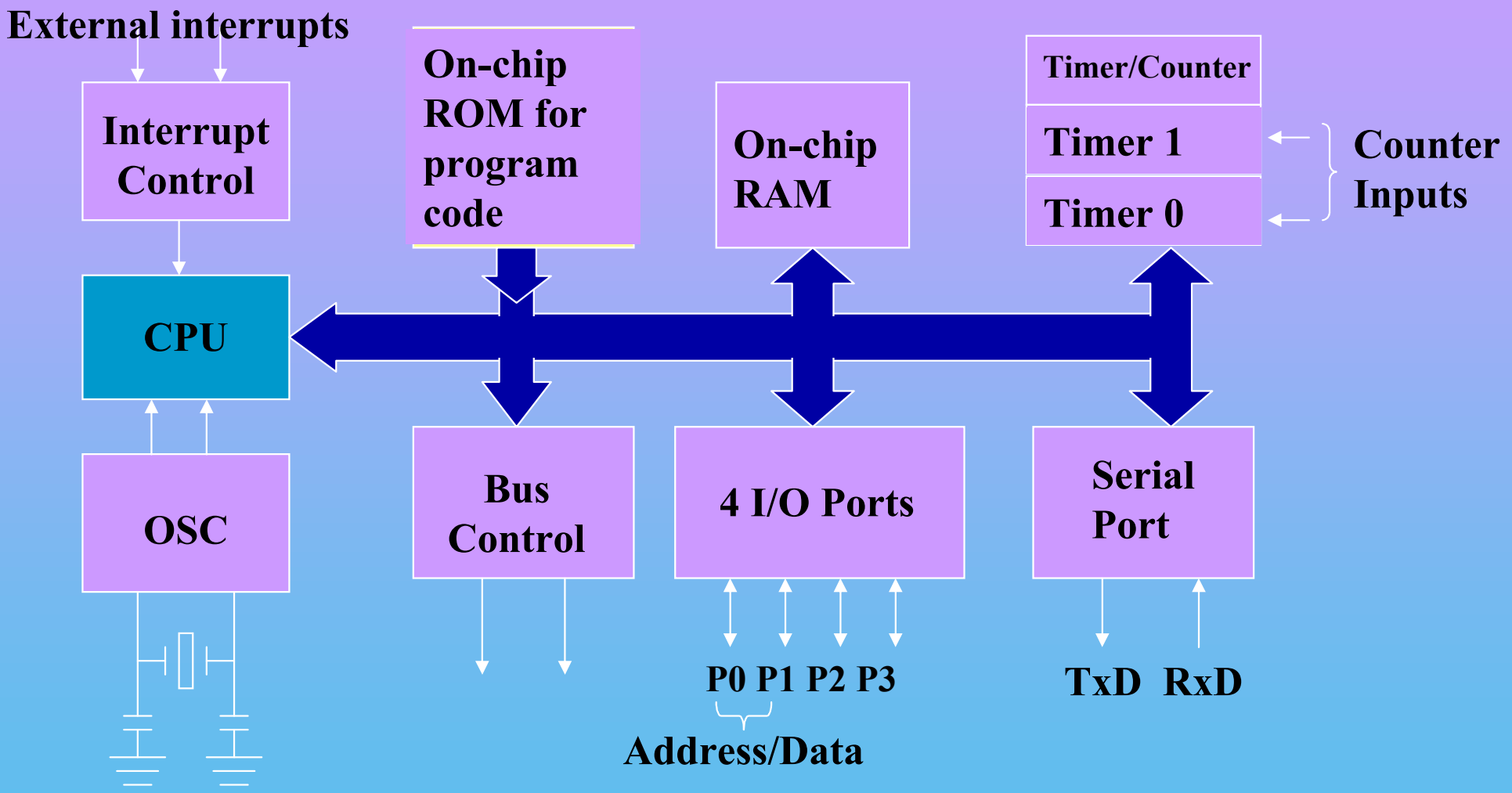
Embedded System

- Embedded system means the processor is embedded into that application.
- An embedded product uses a microprocessor or microcontroller to do one task only.
- In an embedded system, there is only one application software that is typically burned into ROM.
- Example：printer, keyboard, video game player

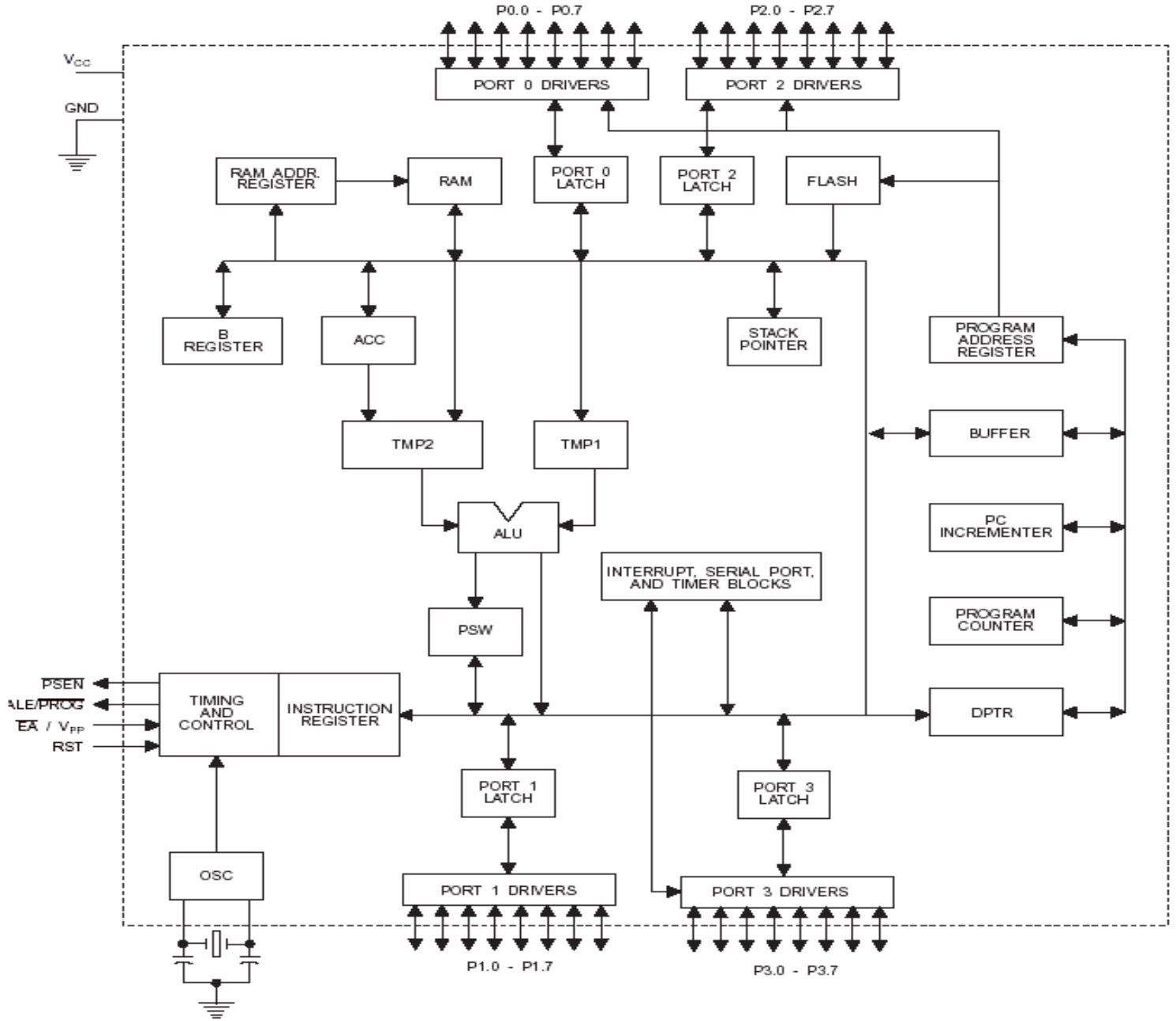
Three criteria in Choosing a Microcontroller

1. meeting the computing needs of the task efficiently and cost effectively
   - speed, the amount of ROM and RAM, the number of I/O ports and timers, size, packaging, power consumption
   - easy to upgrade
   - cost per unit
2. availability of software development tools
   - assemblers, debuggers, C compilers, emulator, simulator, technical support
3. wide availability and reliable sources of the microcontrollers.

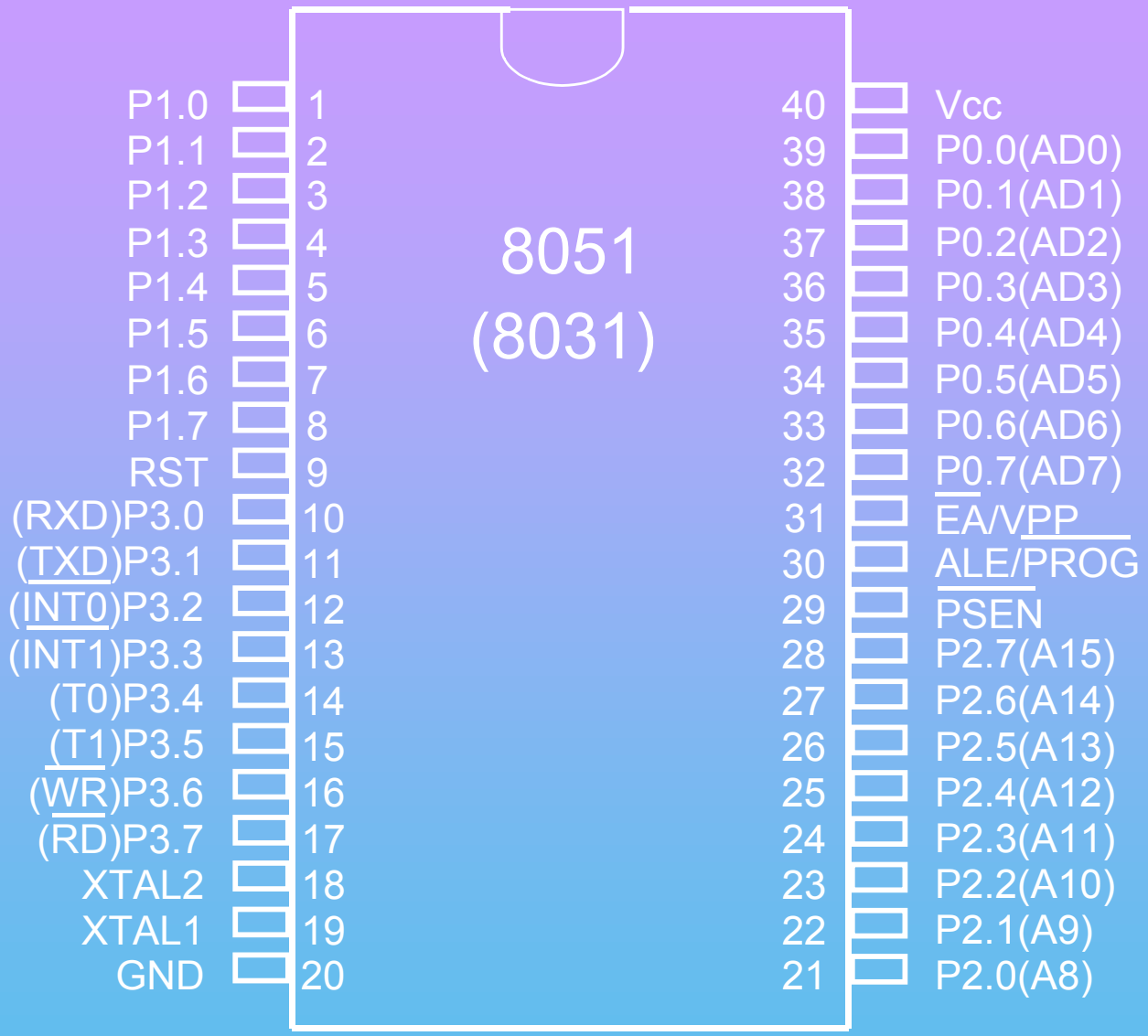
Block Diagram



Block Diagram



Pin Description of the 8051

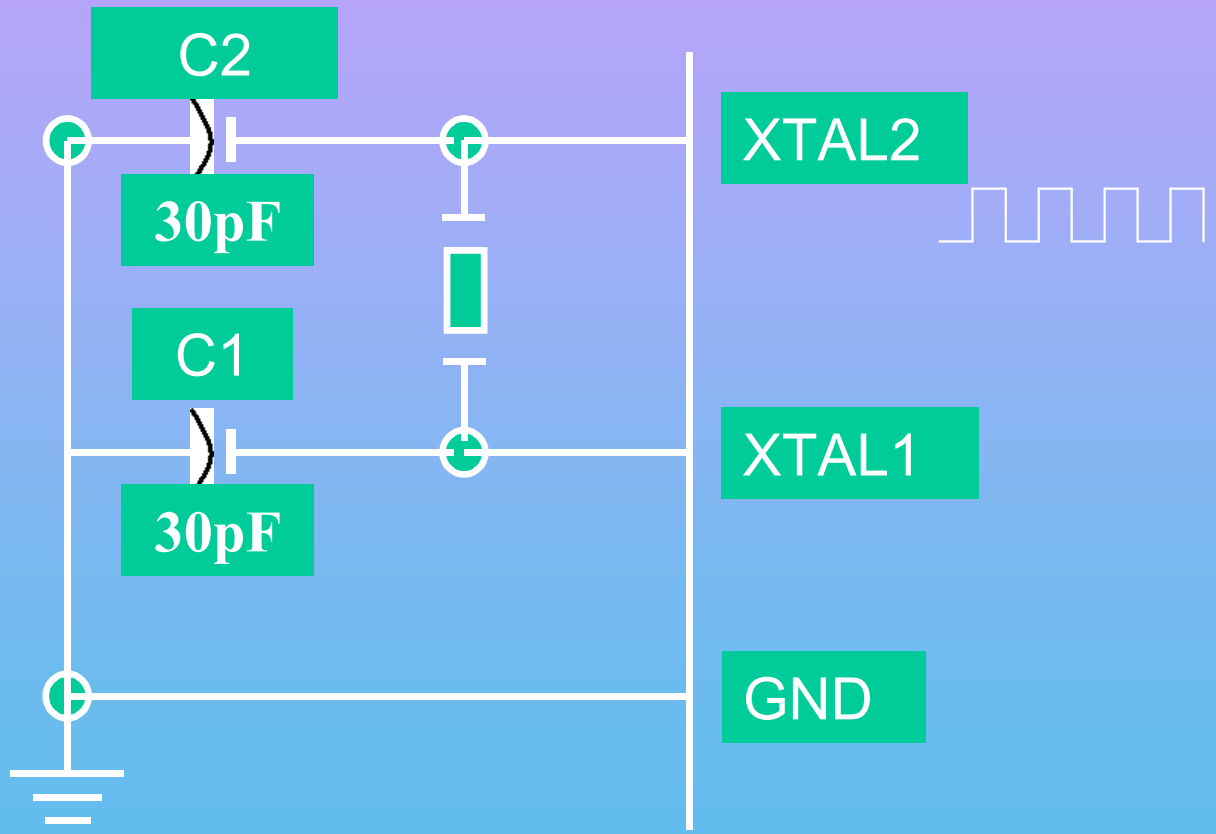


Pins of 8051（1/4）

- 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）

Figure (a). XTAL Connection to 8051

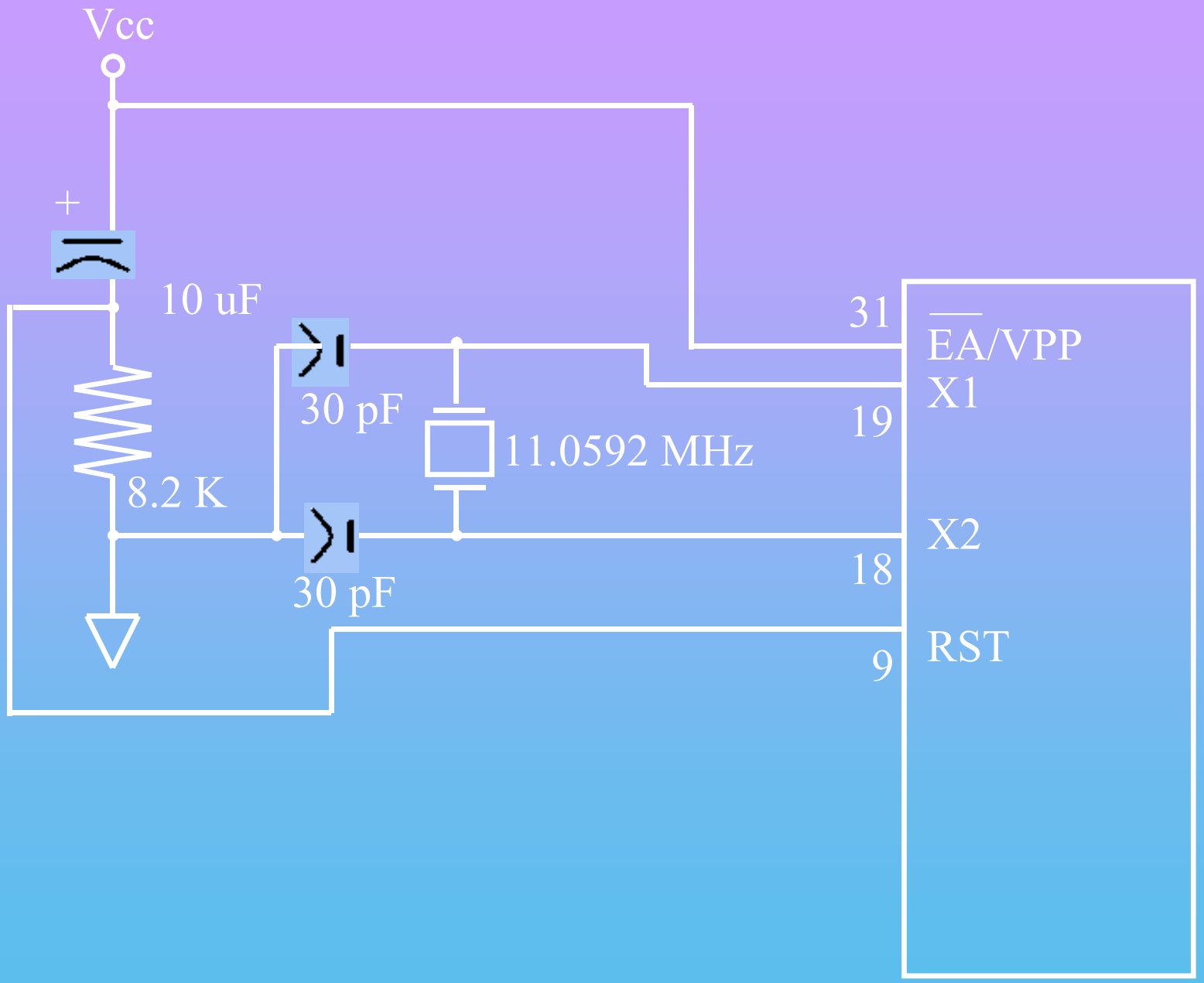
- Using a quartz crystal oscillator
- We can observe the frequency on the XTAL2 pin.



Pins of 8051（2/4）

- RST（pin 9）：reset
  - It is an input pin and is active high（normally low）.
    - The high pulse must be high at least 2 machine cycles.
  - It is a 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 

Figure (b). Power-On RESET Circuit



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（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.

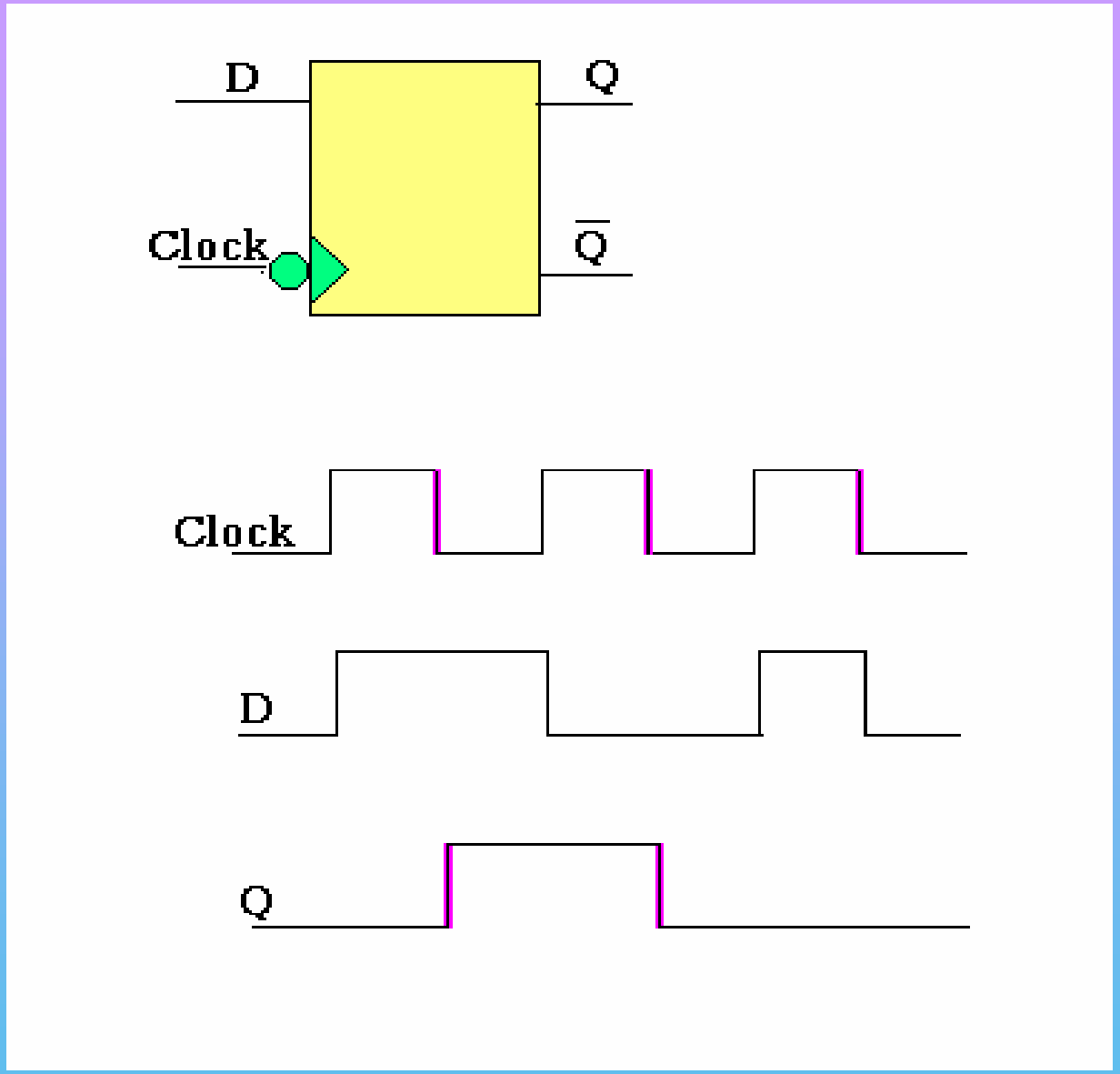
Pins of I/O Port

- 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).

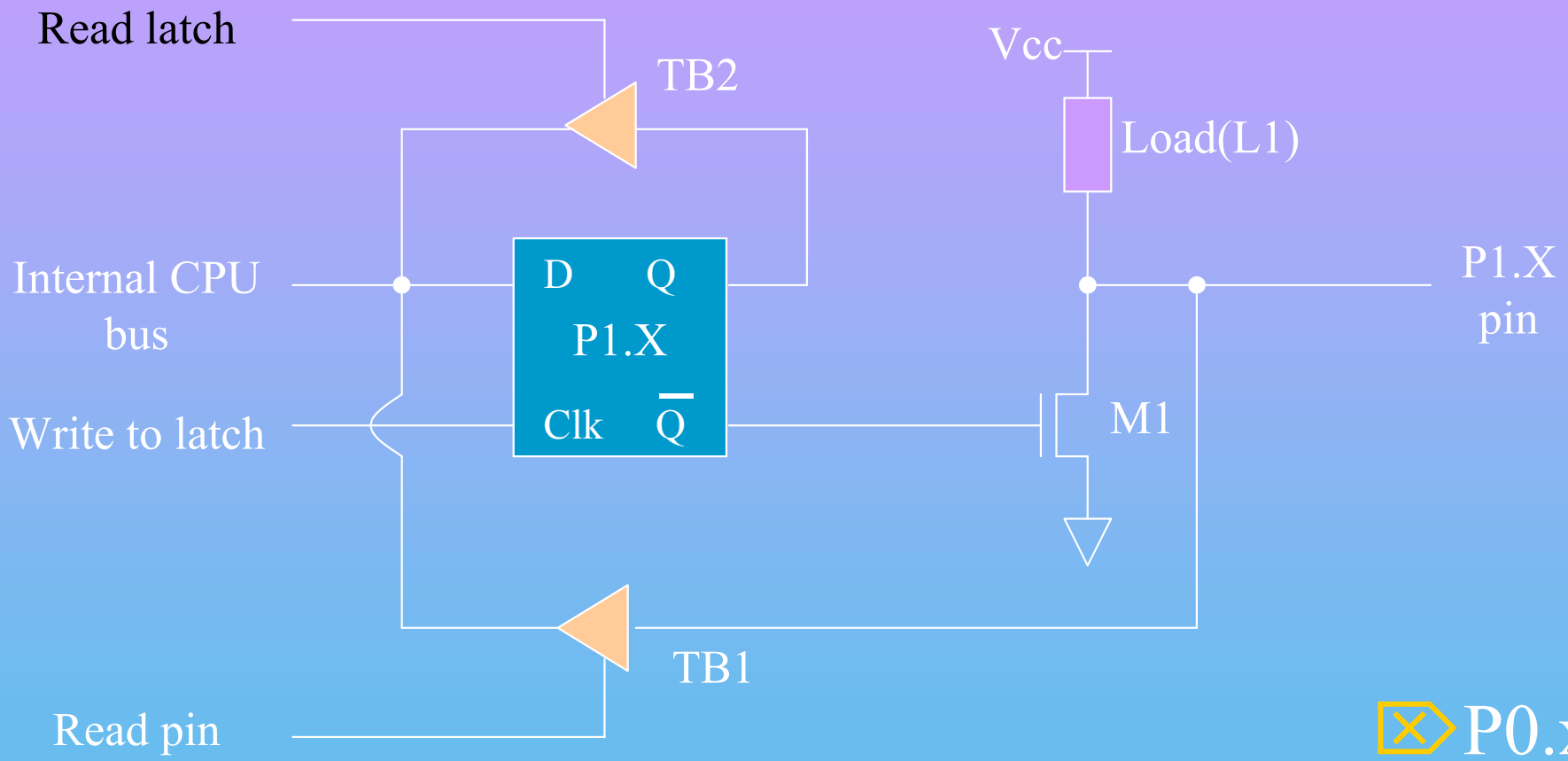
Hardware Structure of I/O Pin

- Each pin of I/O ports
  - Internal CPU bus：communicate with CPU
  - A D latch store the value of this pin
    - D latch is controlled by “Write to latch”
      - Write to latch = 1：write data into the D latch
  - 2 Tri-state buffer：
    - TB1: controlled by “Read pin”
      - Read pin = 1：really read the data present at the pin
    - TB2: controlled by “Read latch”
      - Read latch = 1：read value from internal latch
  - A transistor M1 gate
    - Gate=0: open
    - Gate=1: close

D Latch:



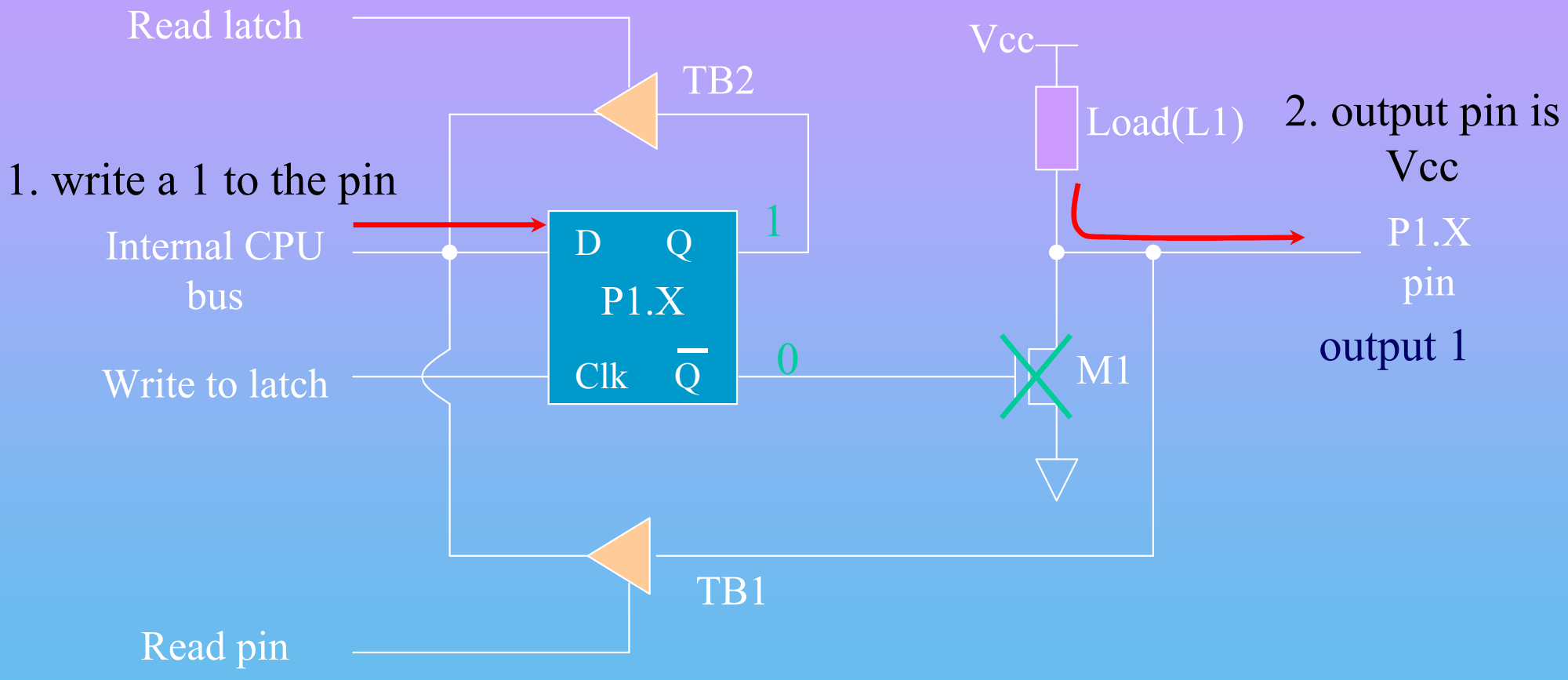
A Pin of Port 1



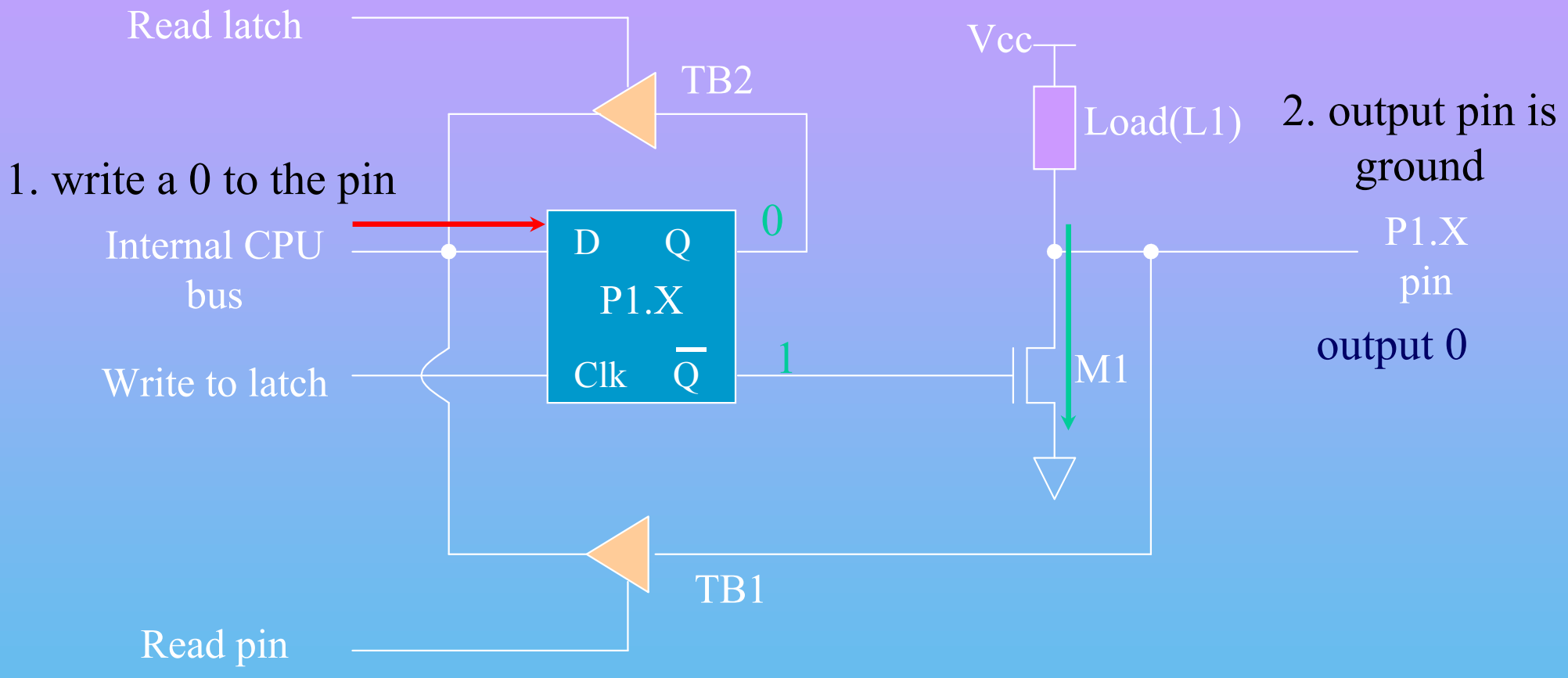
P0.x

8051 IC

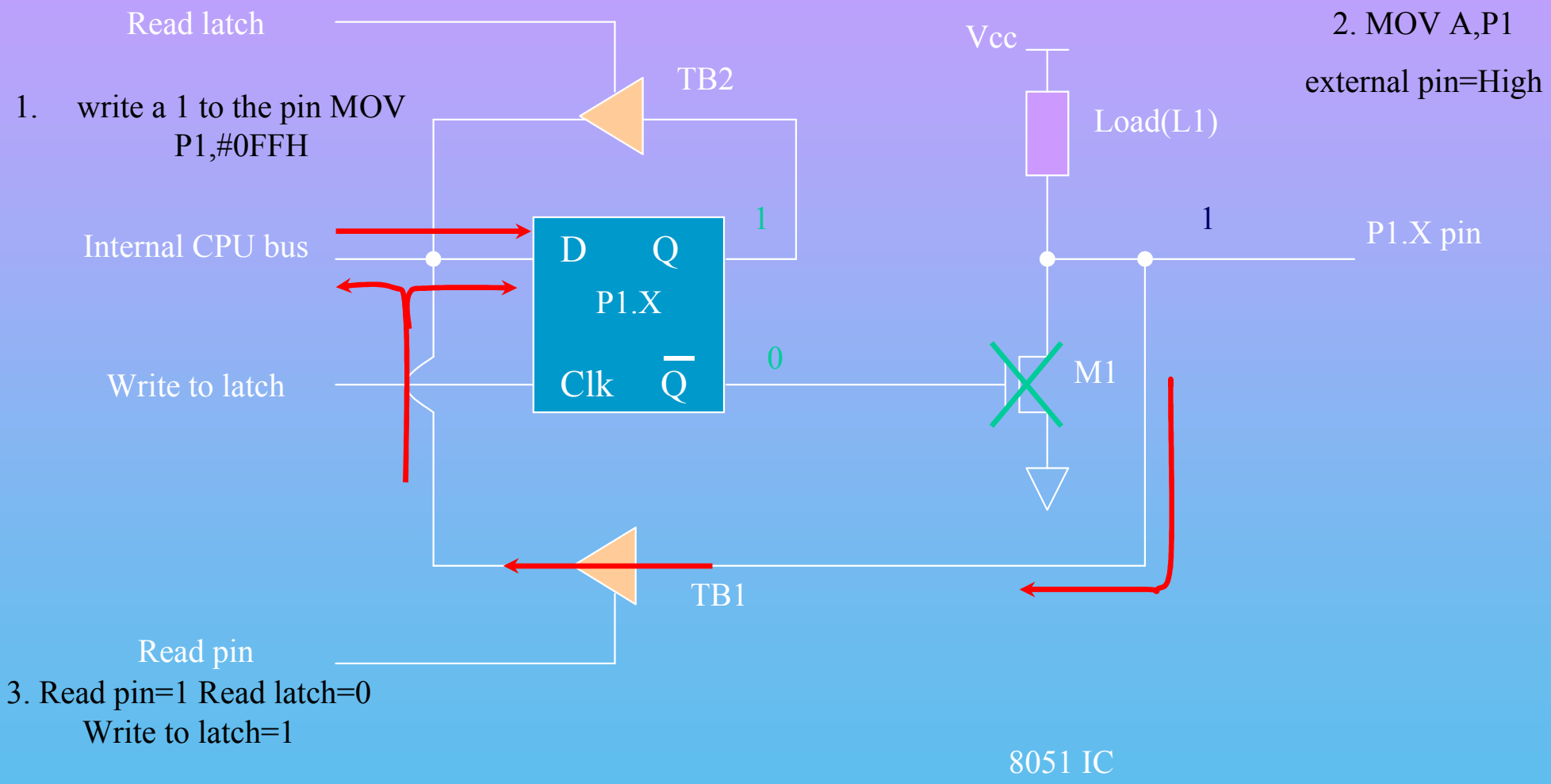
Writing “1” to Output Pin P1.X



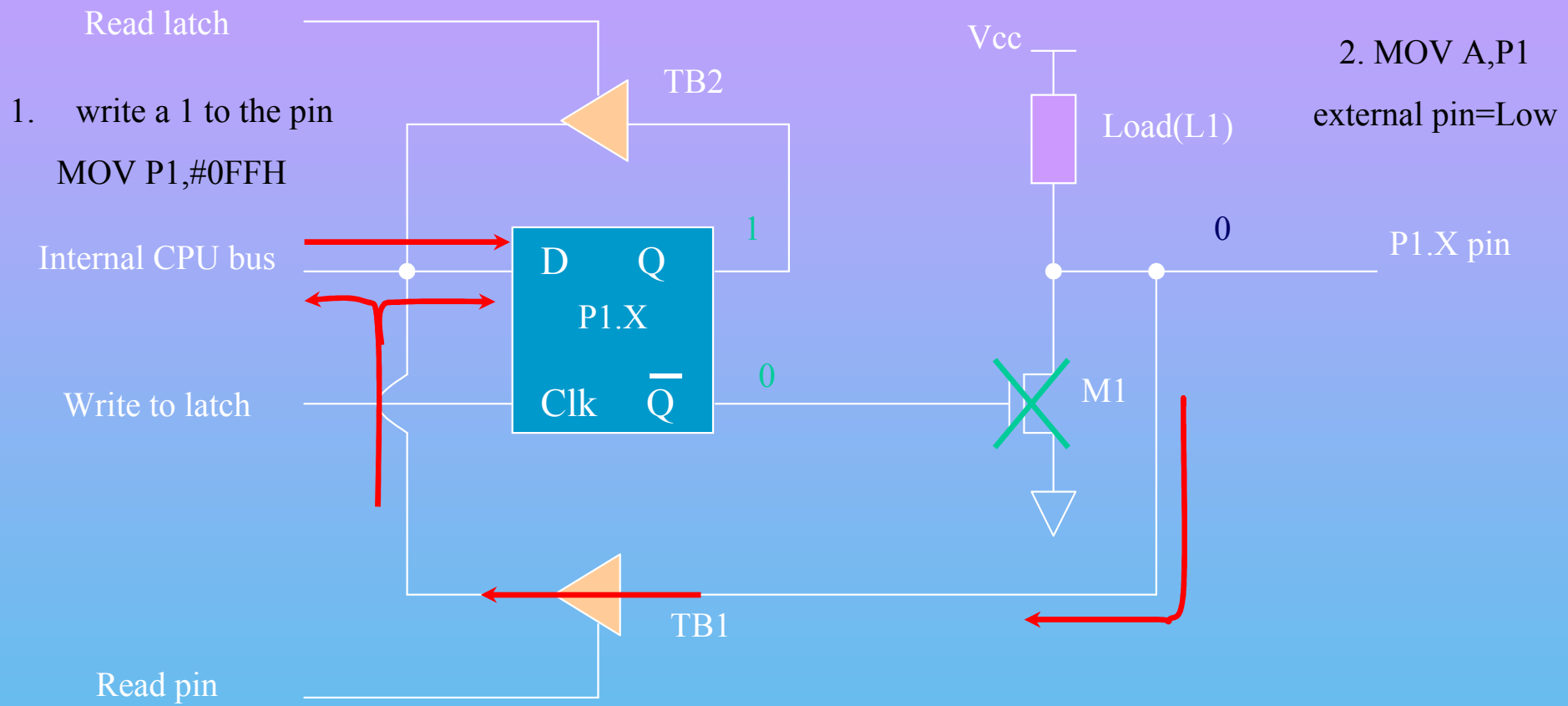
Writing “0” to Output Pin P1.X



Reading “High” at Input Pin



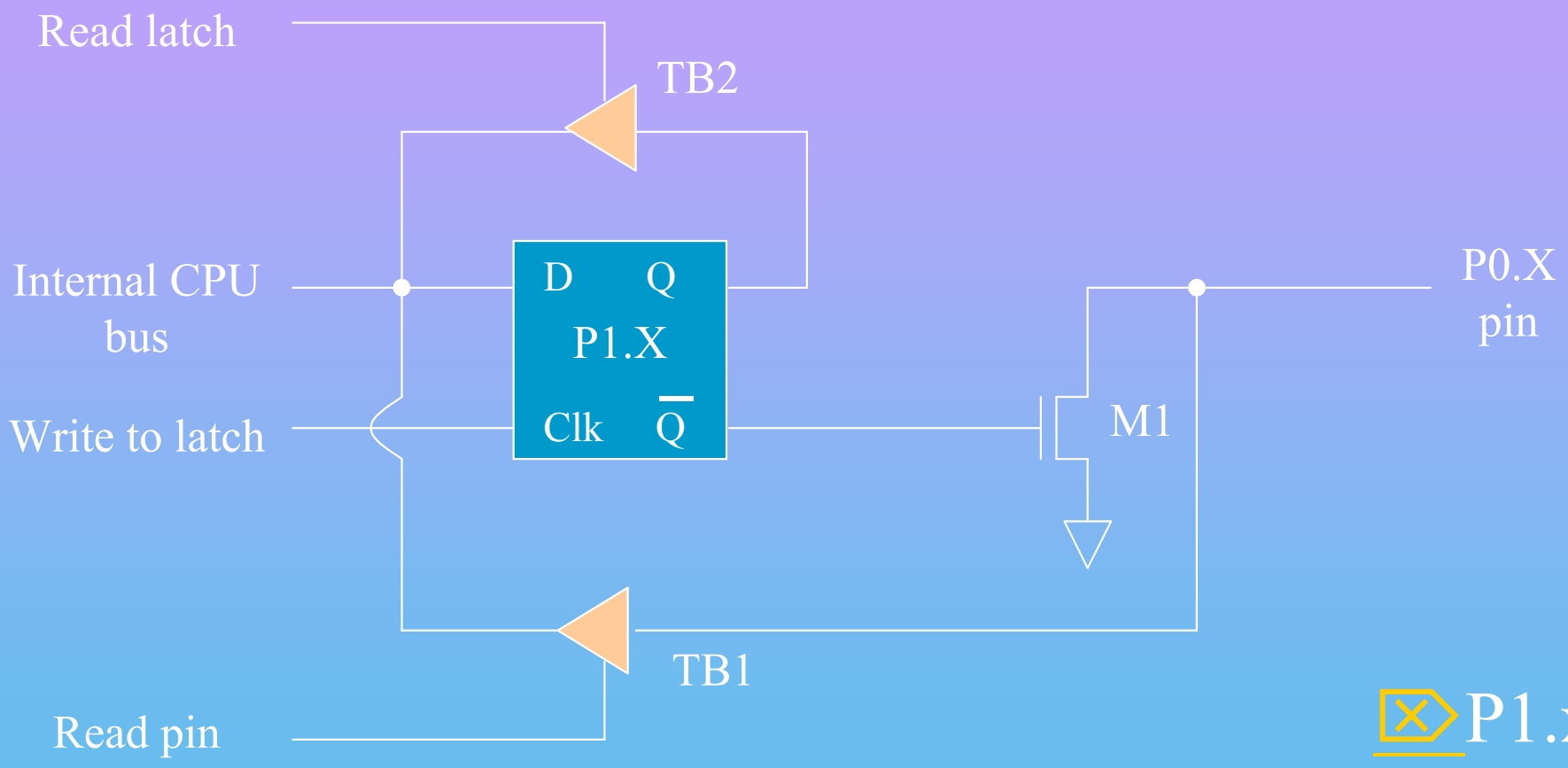
Reading “Low” at Input Pin



Other Pins

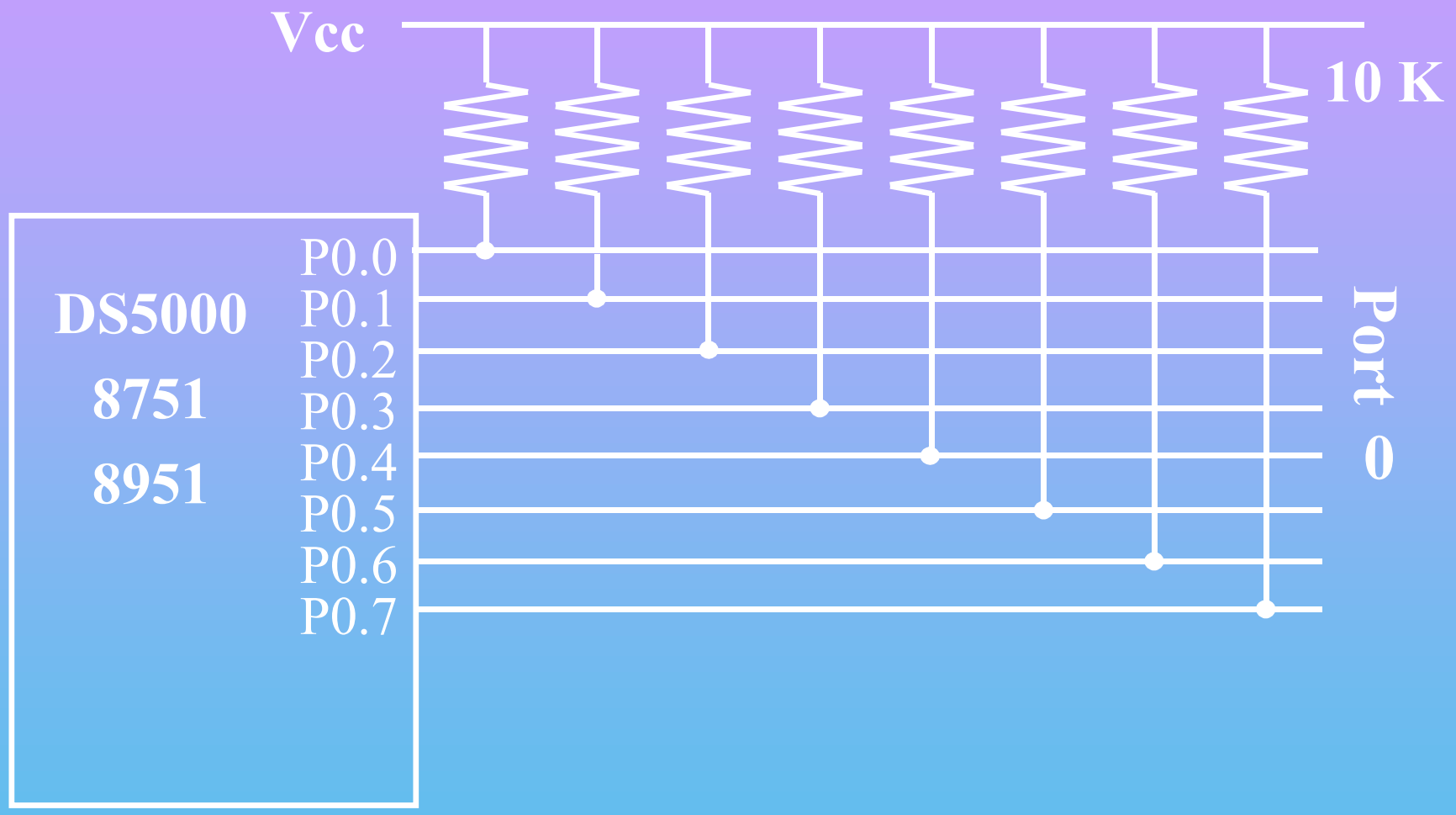
- P1, P2, and P3 have internal pull-up resisters.
  - P1, P2, and P3 are not open drain.
- P0 has no internal pull-up resistors and does not connects to Vcc inside the 8051.
  - P0 is open drain.
  - Compare the figures of P1.X and P0.X. 
- However, for a programmer, it is the same to program P0, P1, P2 and P3.
- All the ports upon RESET are configured as output.

A Pin of Port 0



8051 IC

Port 0 with Pull-Up Resistors



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

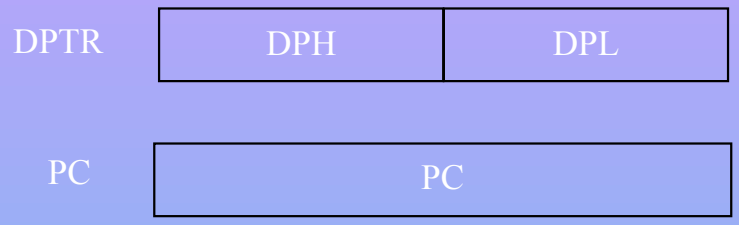
RESET Value of Some 8051 Registers:

Register	Reset Value
PC	0000
ACC	0000
B	0000
PSW	0000
SP	0007
DPTR	0000

RAM are all zero.

Registers

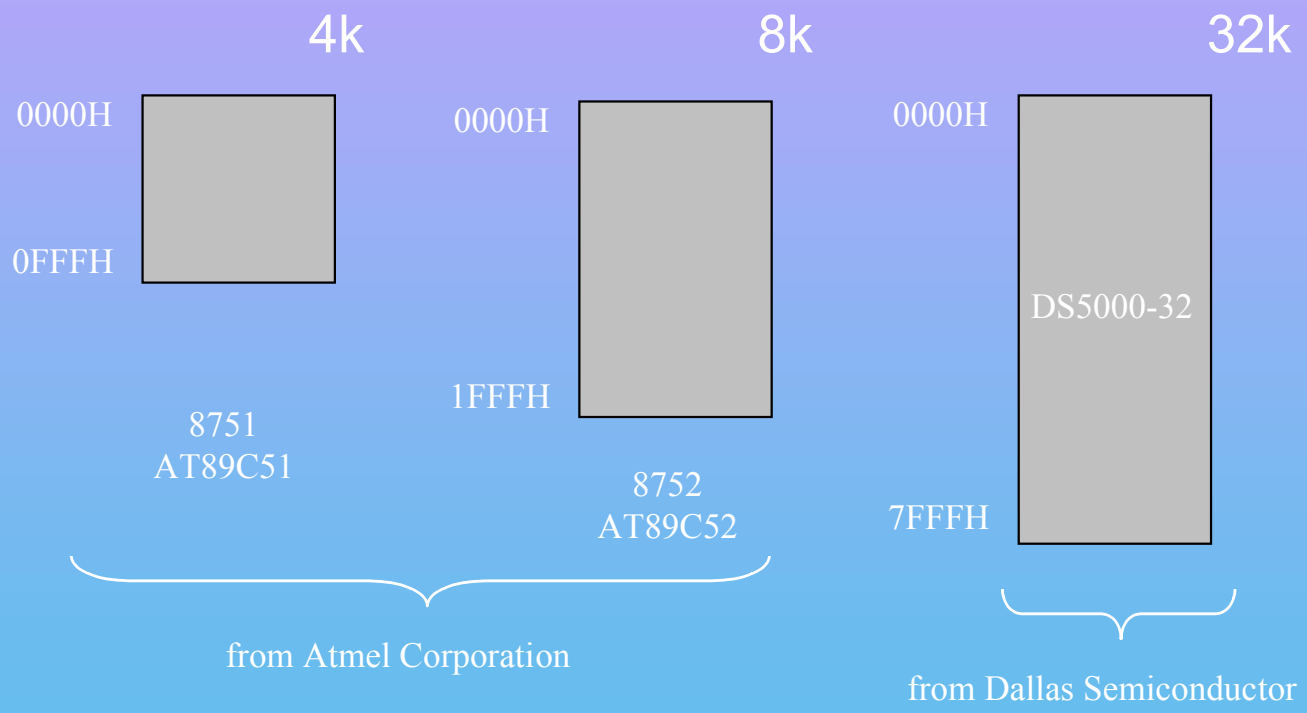
Some 8-bitt Registers of the 8051



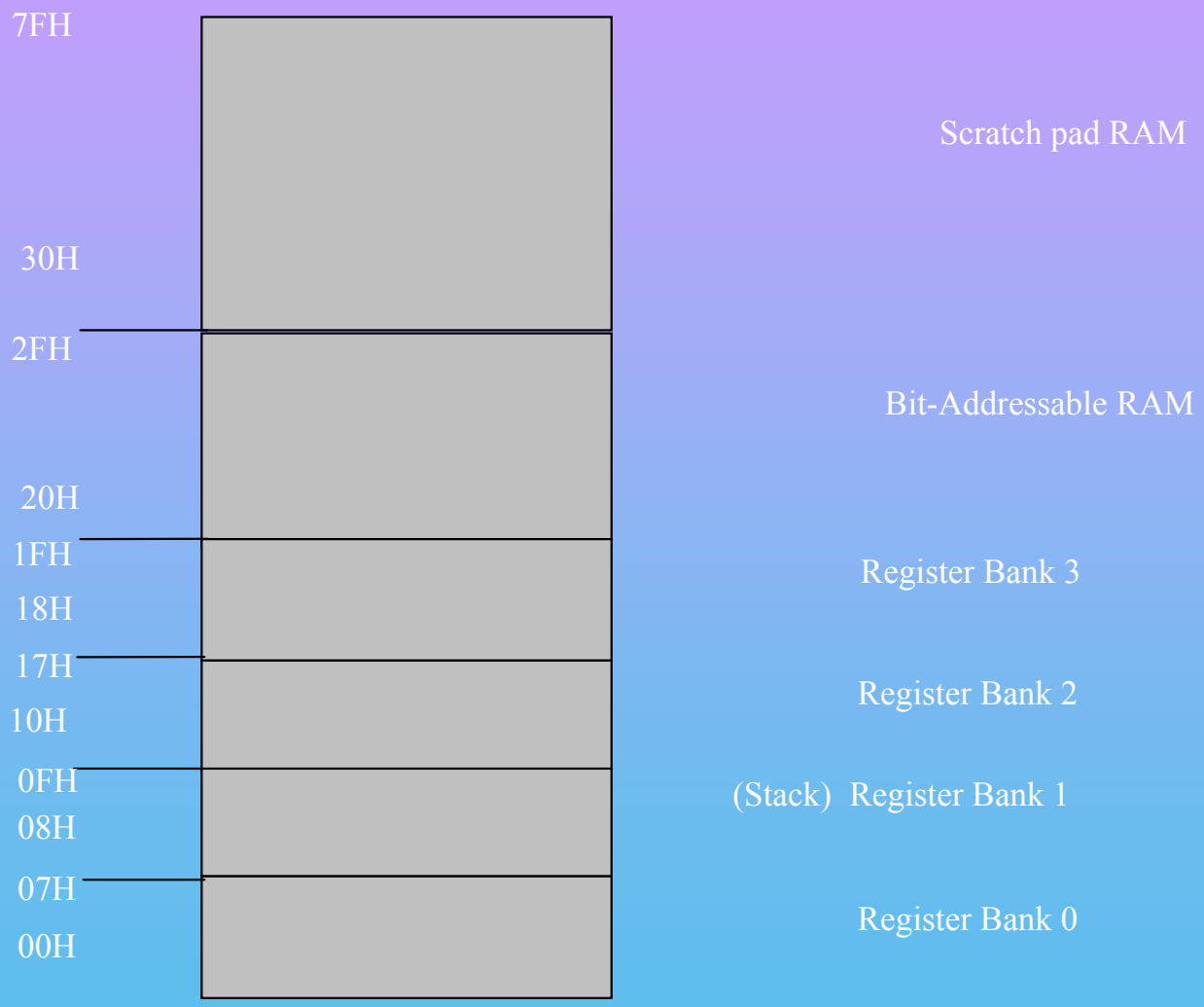
Some 8051 16-bit Register

Memory mapping in 8051

- **ROM memory map in 8051 family**



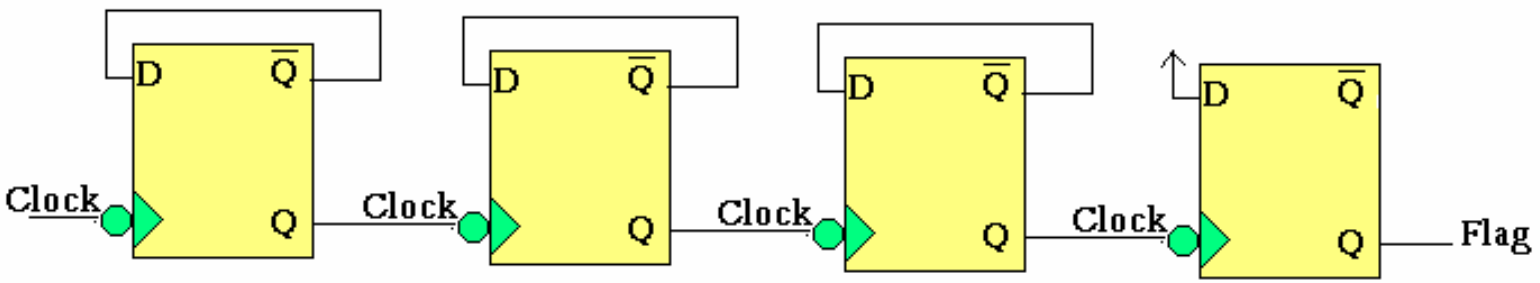
- **RAM memory space allocation in the 8051**

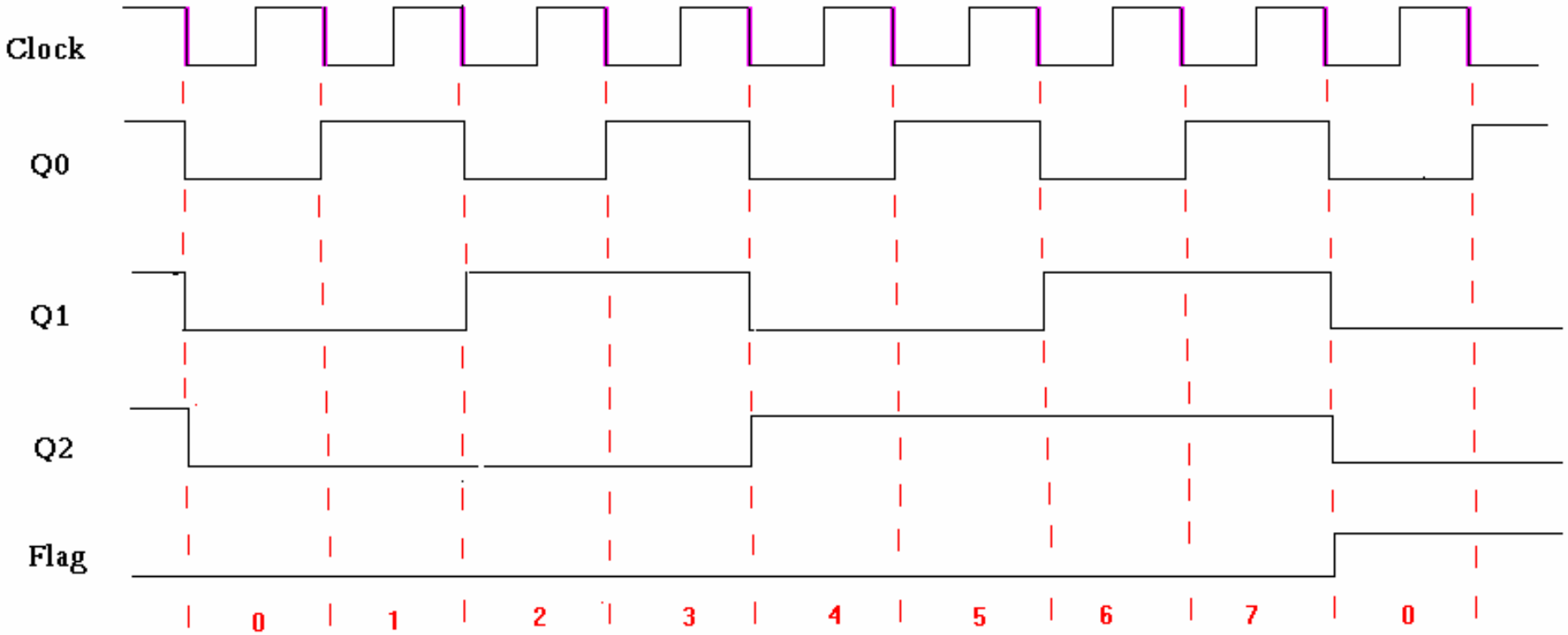


Stack in the 8051

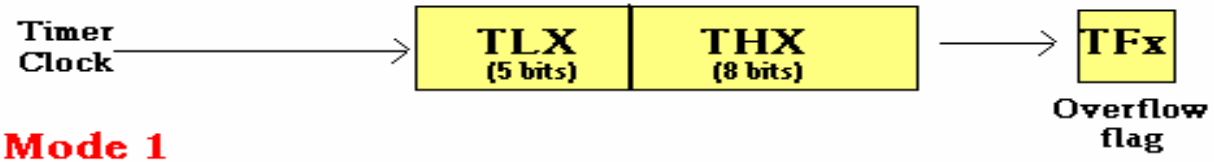
- The register used to access the stack is called **SP** (stack pointer) register.
- The stack pointer in the 8051 is only 8 bits wide, which means that it can take value 00 to FFH. When 8051 powered up, the SP register contains value 07.

Timer :

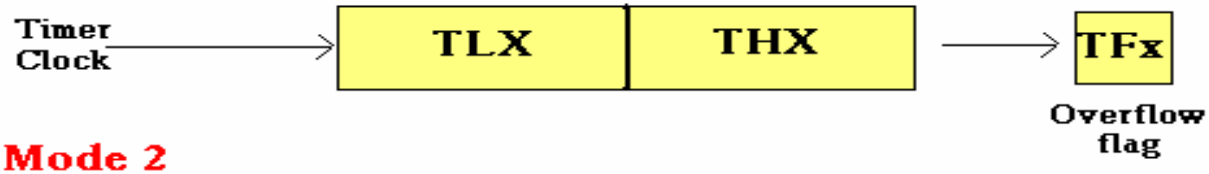




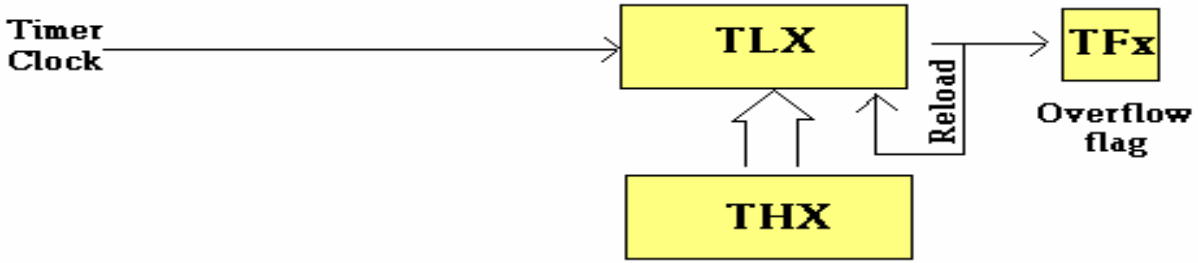
Mode 0



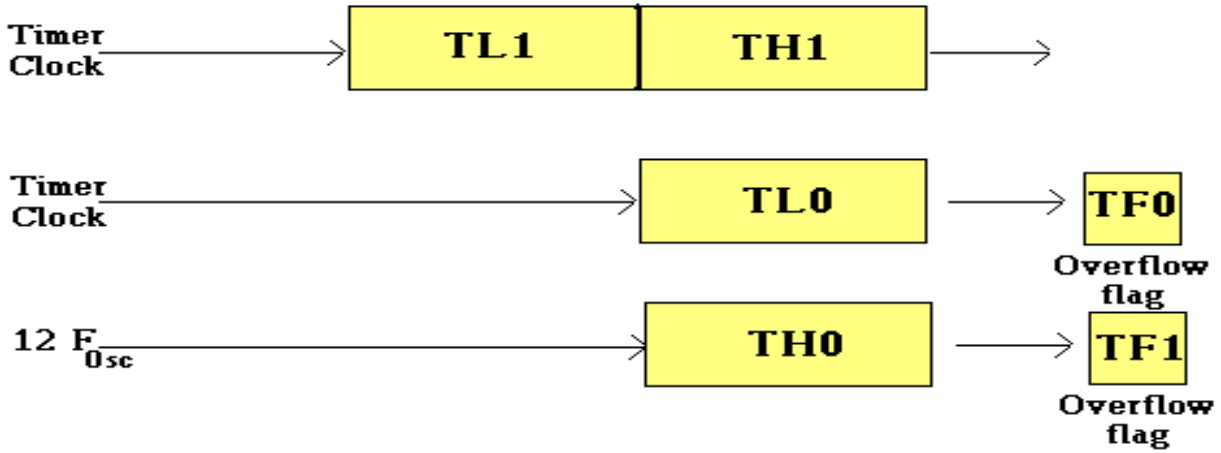
Mode 1



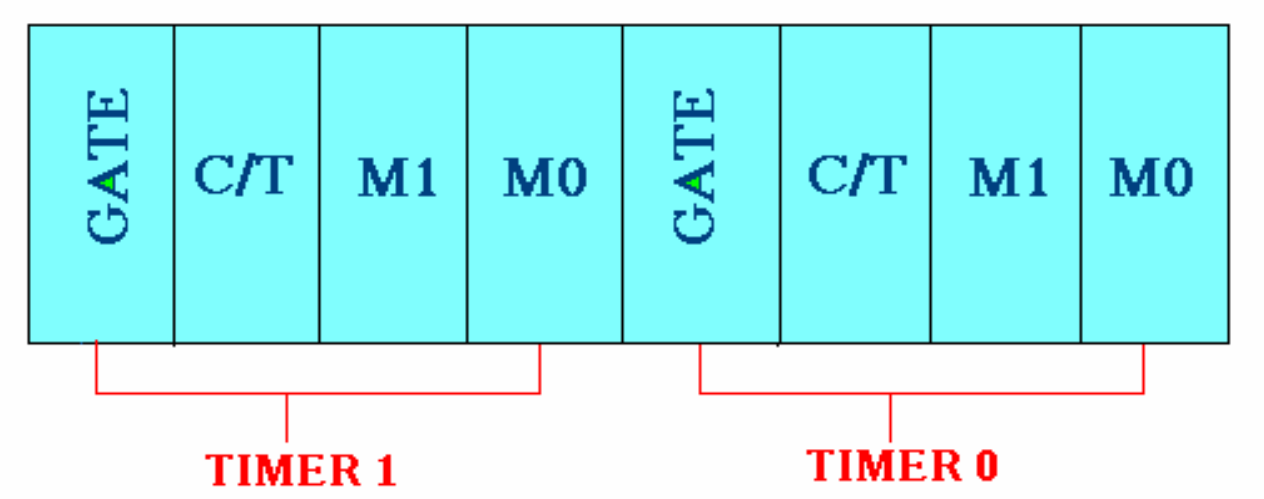
Mode 2



Mode 3



TMOD Register:



- Gate：When set, timer only runs while INT(0,1) is high.
- C/T：Counter/Timer select bit.
- M1：Mode bit 1.
- M0：Mode bit 0.

M1	M0	MODE
0	0	13-bit timer mode
0	1	16-bit timer mode
1	0	8-bit auto-reload mode
1	1	split mode

TCON Register:

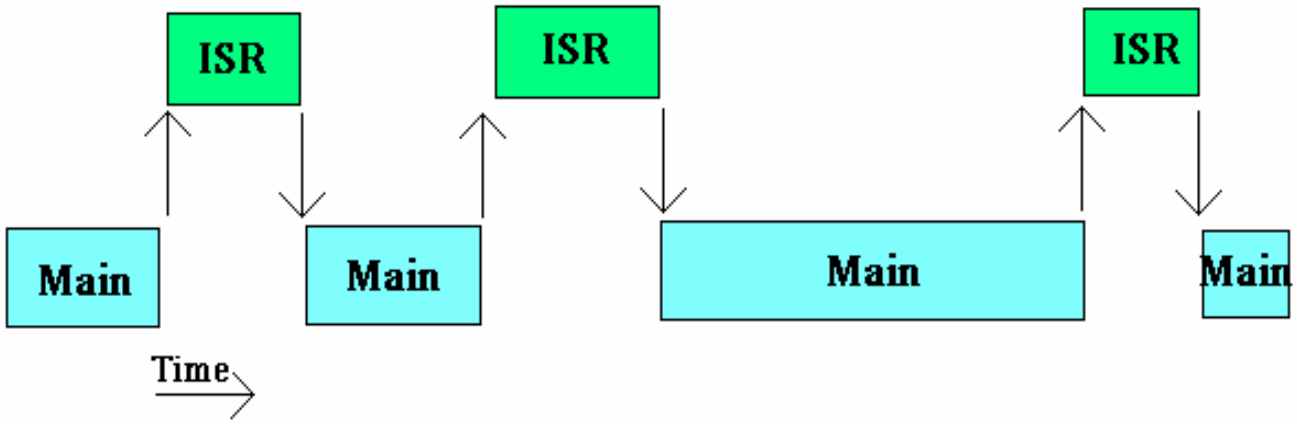
TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0

- TF1: Timer 1 overflow flag.
- TR1: Timer 1 run control bit.
- TF0: Timer 0 overflag.
- TR0: Timer 0 run control bit.
- IE1: External interrupt 1 edge flag.
- IT1: External interrupt 1 type flag.
- IE0: External interrupt 0 edge flag.
- IT0: External interrupt 0 type flag.

Interrupt :

Program execution without intrrupts :

Program execution with intrrupts :



ISR : Intrrupt Service Routin

Interrupt Enable Register :

EA	—	ET2	ES	ET1	EX1	ET0	EX0

- EA : **Global enable/disable**.
- **---** : **Undefined**.
- ET2 :Enable Timer 2 interrupt.
- ES :Enable Serial port interrupt.
- ET1 :Enable Timer 1 interrupt.
- EX1 :Enable External 1 interrupt.
- ET0 : Enable Timer 0 interrupt.
- EX0 : Enable External 0 interrupt.