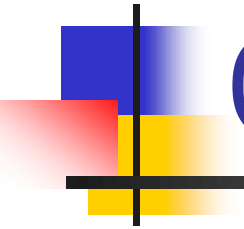
Lab 02

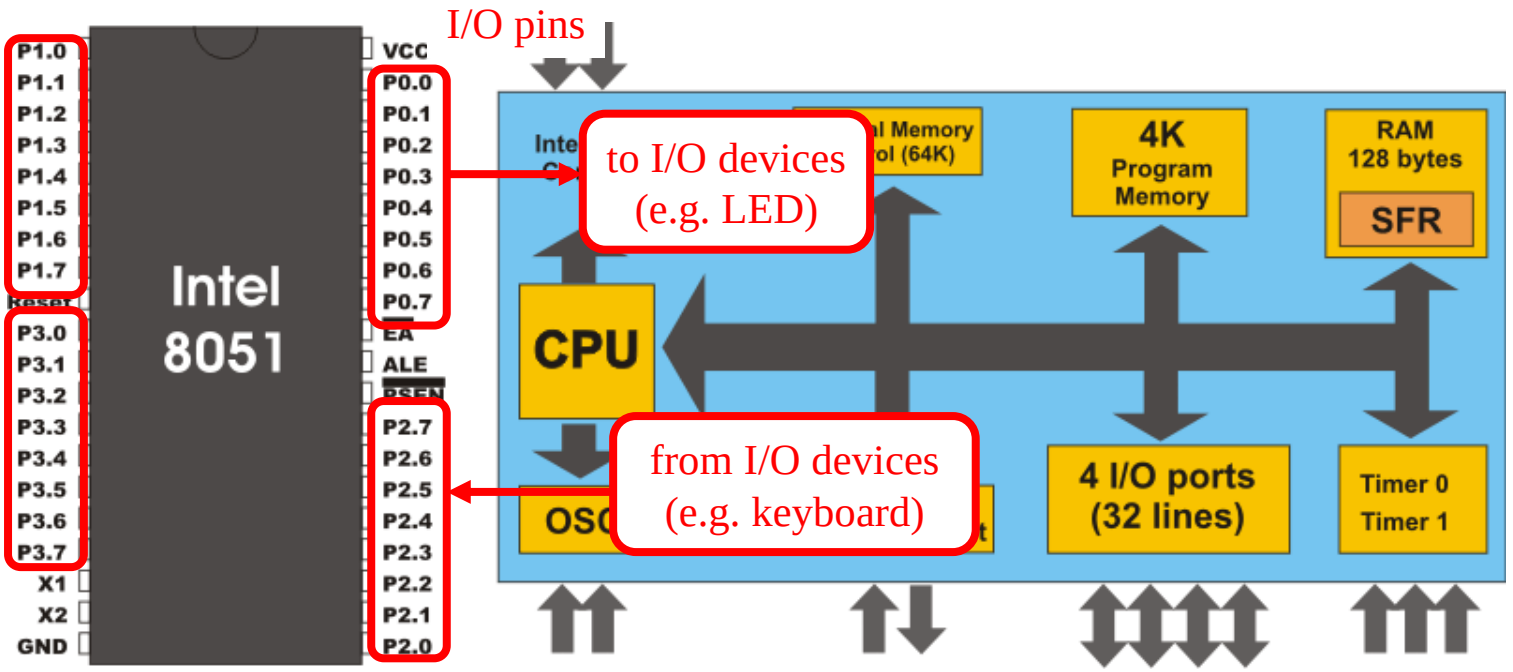
General Purpose Digital I/O (GPIO)



Objectives of this lab

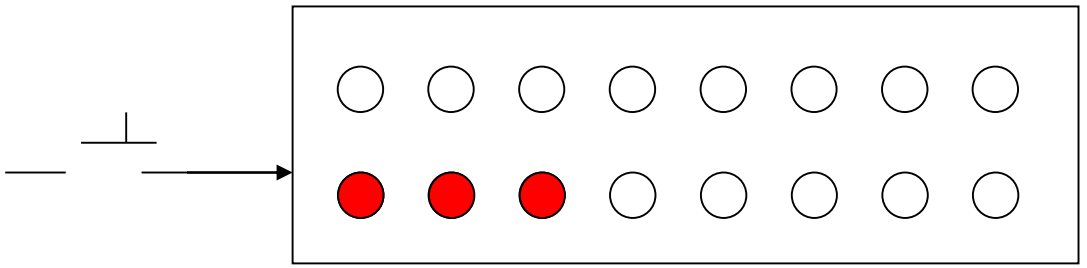
(1) to build up your imagination on how a program affects hardware signals

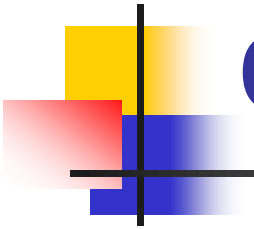
(2) to learn how to send/receive signals from an application processor to external devices through I/O pads



Your work today

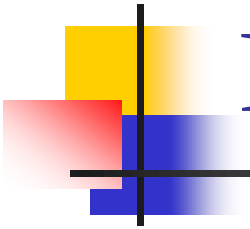
- design a LED box
  - initial: all LED off
  - the LED runs some pattern after some button pressed
    - you can design your own pattern





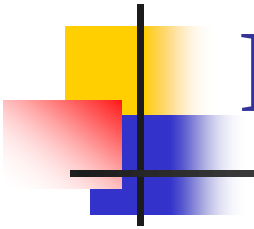
Outline

- Basic concepts of I/O control
- I/O model of legacy 8051 processor
- SiliconLab C8051F040 I/O control
- Simplified programming model



Preparations before the Lab

- Read the data sheet of SiliconLab C8051F040 SoC
  - Chap. 17
- Read the schematics of the Big8051 experiment board
  - On LEDs



Pre-Lab Report

- Q1: Explain what is watch-dog timer
  - Somewhere in your OS textbook
- Q2: Explain what is memory-mapped I/O
  - Check the textbooks of Computer Organization, Computer Architecture, or OS

Pre-Lab Report (cont'd)

- Q3:
  - Read Figure 17.1 of C8051F040 spec and the schematics of Big8051
  - List all control signal values to turn-on an LED at P0.0

Value of these Control signals

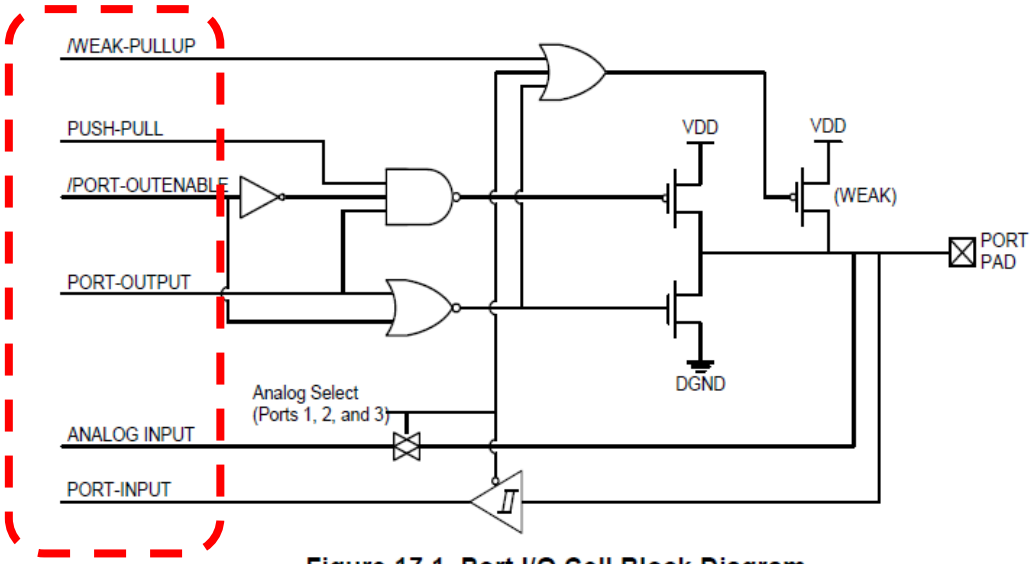


Figure 17.1. Port I/O Cell Block Diagram

Pre-Lab Report (cont'd)

- Q4:
  - Read Figure 17.2 of C8051F040 spec
  - List the values of all control registers to configure port P0 as a digital output port

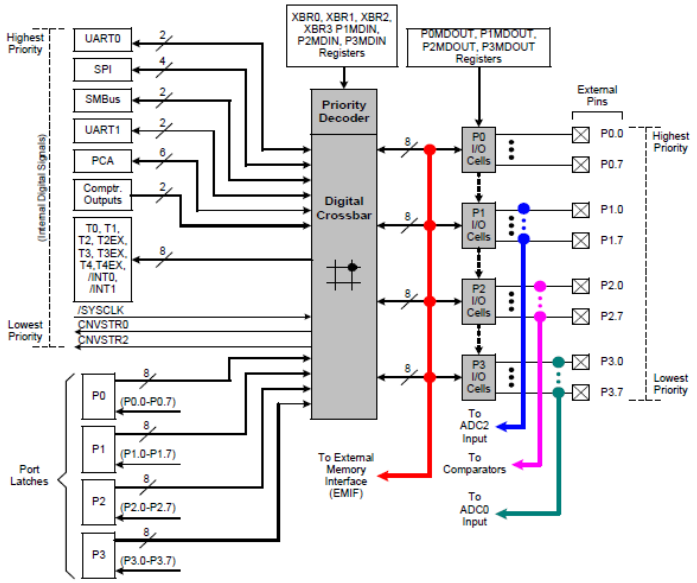
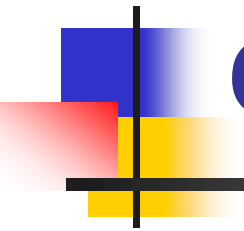


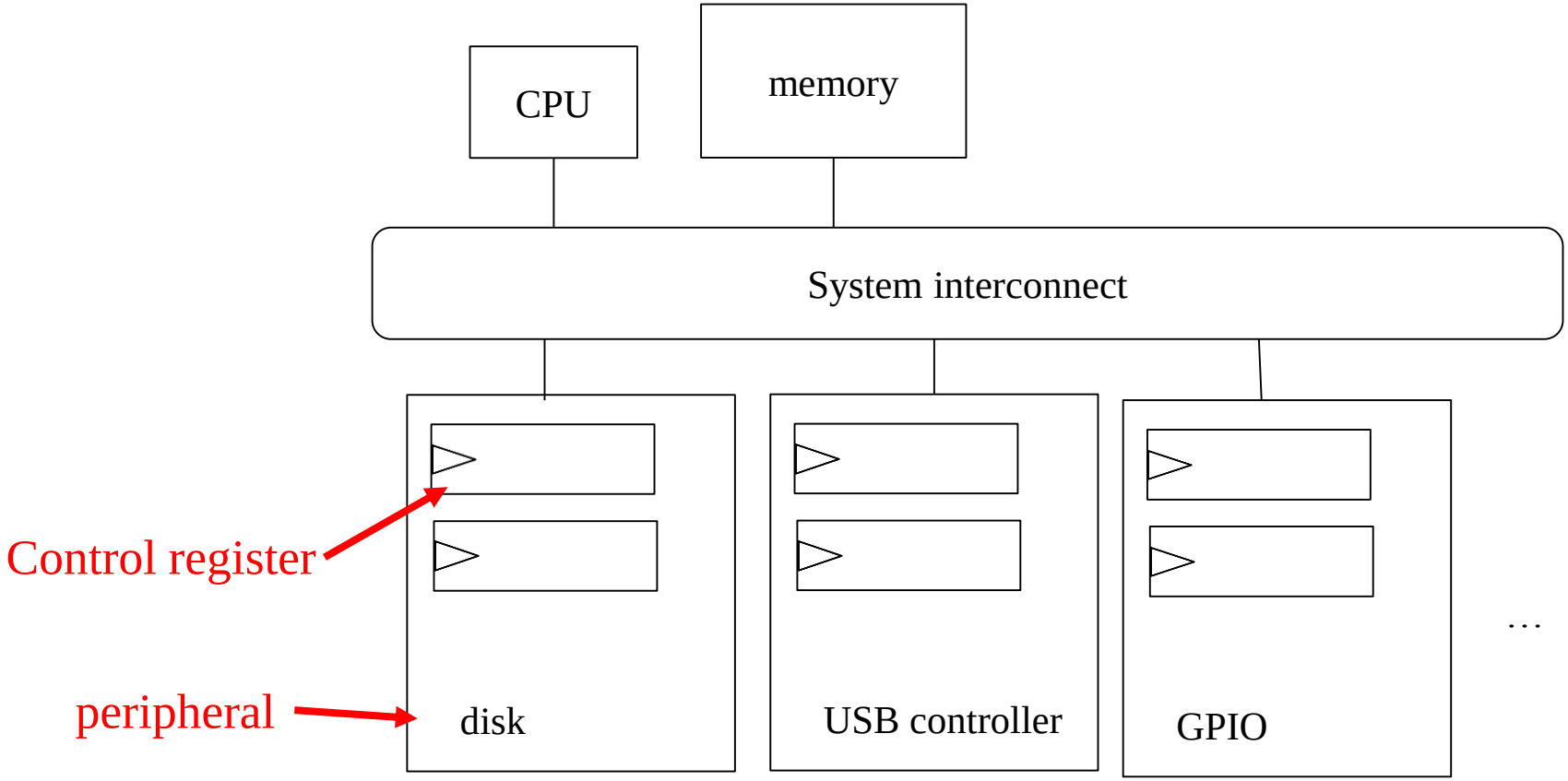
Figure 17.2. Port I/O Functional Block Diagram



General I/O Control Model

How a processor commands an I/O peripheral

- Through access control registers



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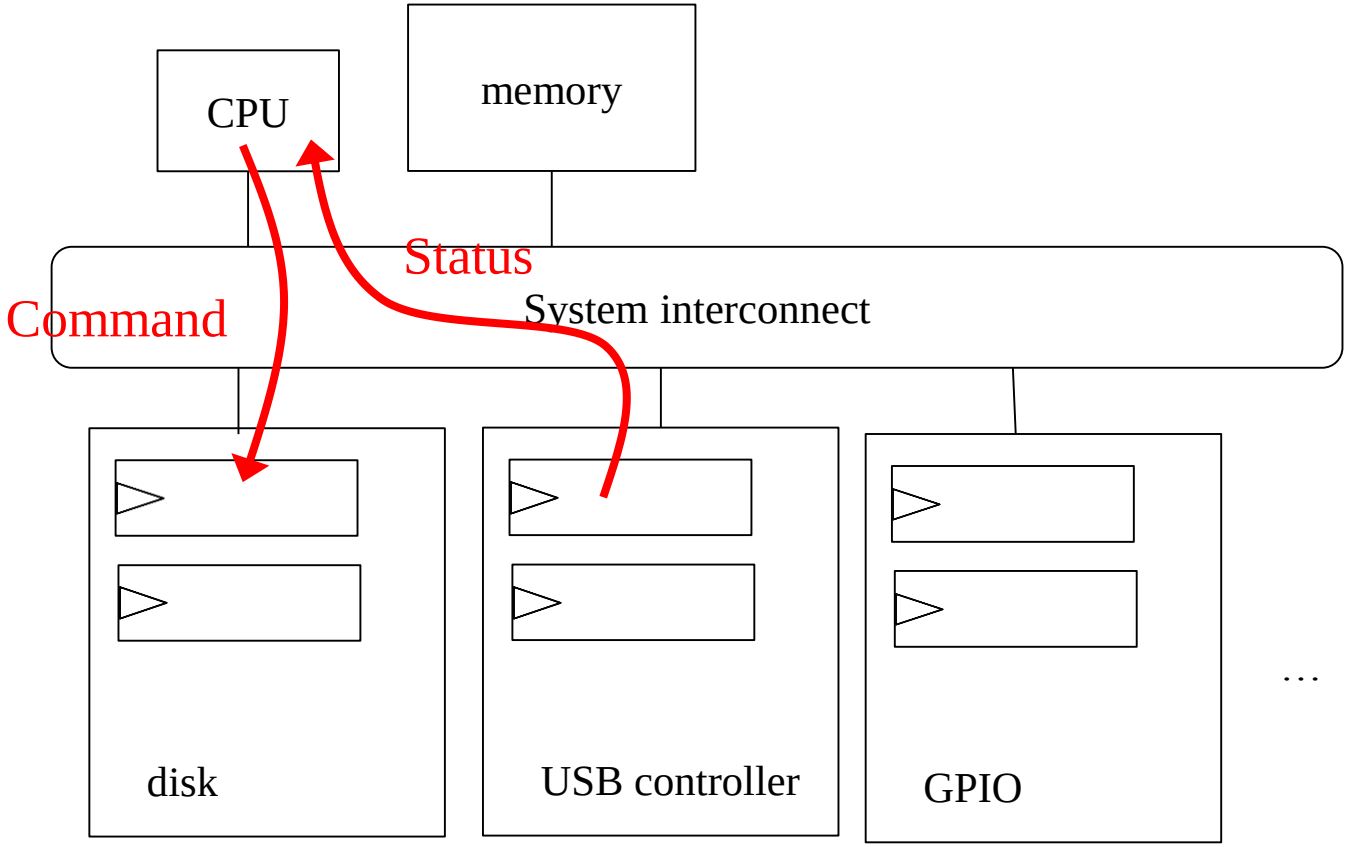


How to access control registers: the memory-mapped I/O

- Part of the addressing space is assigned to control registers
- Each control register is mapped to some memory address

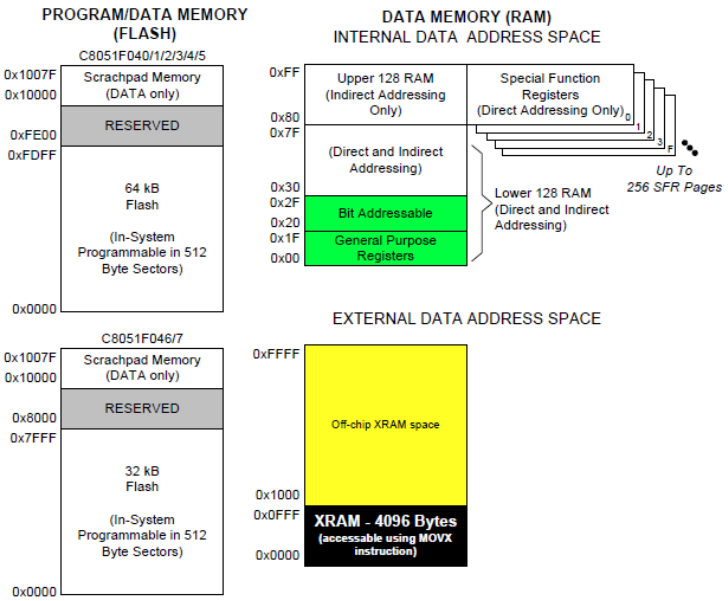
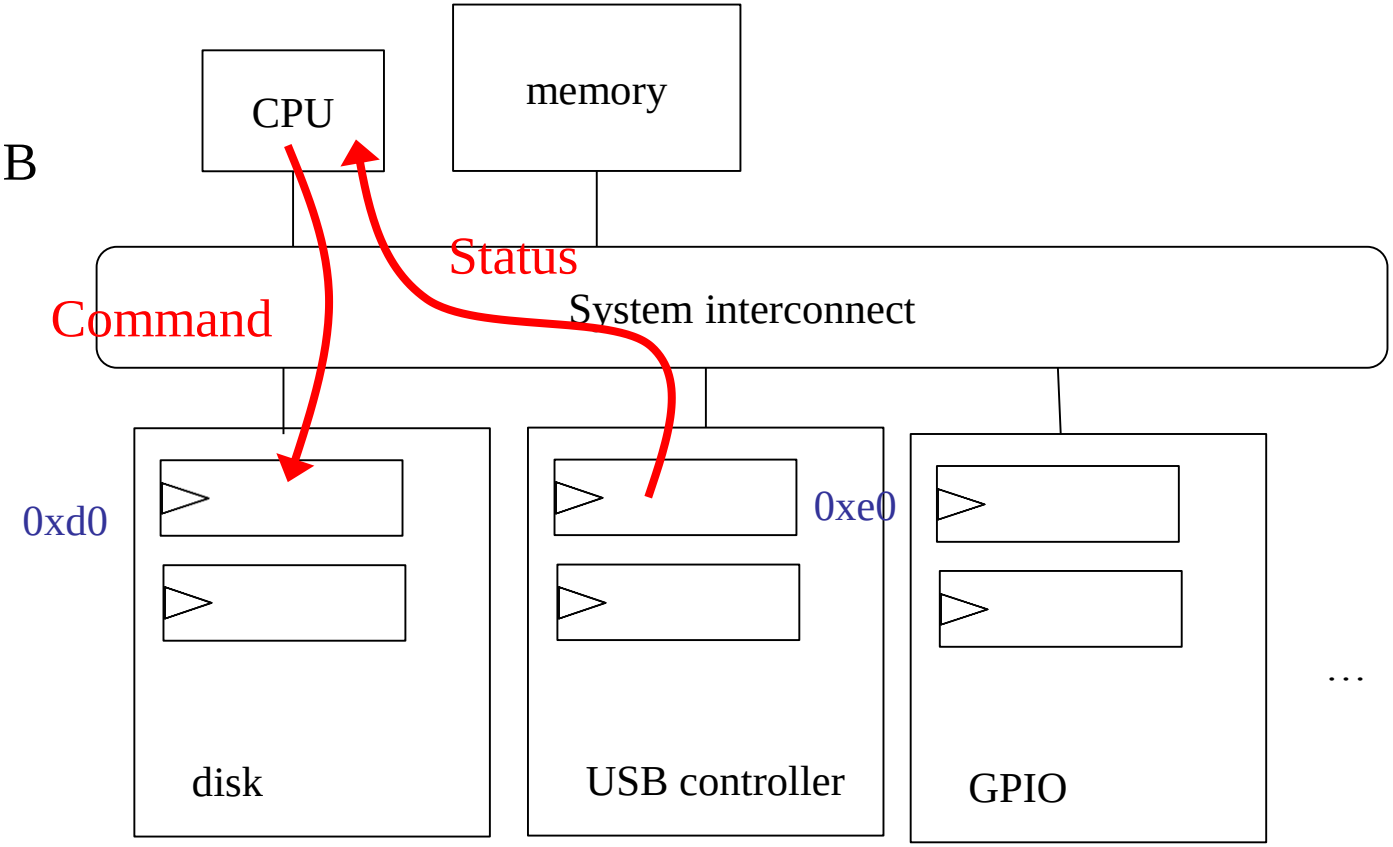


Figure 1.7. On-Chip Memory Map

How a processor commands an I/O peripheral

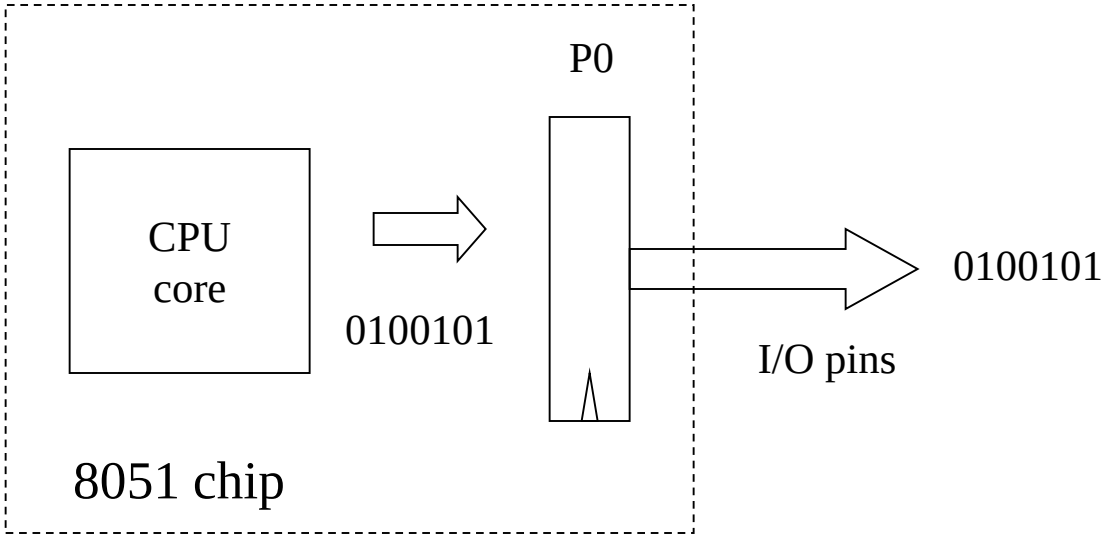
- Through access control registers

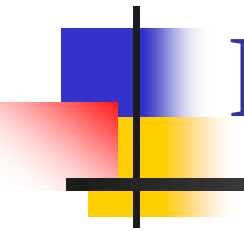
mov 0xd0, #0101B
mov R1, 0xe0



General Purpose Digital I/O

- the processor assigns/examines the logical status of some I/O pins directly





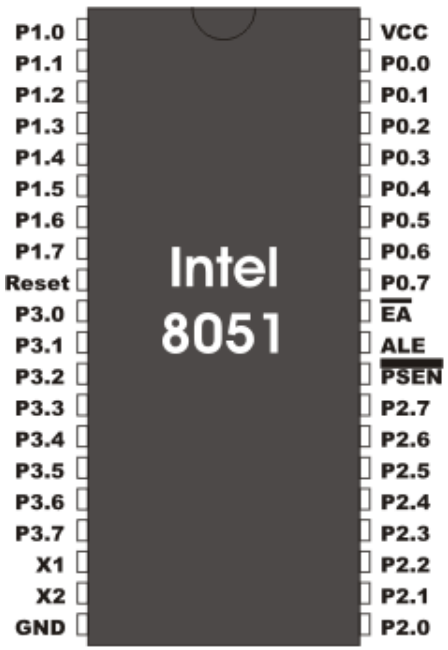
I/O Model of Legacy 8051 Processor

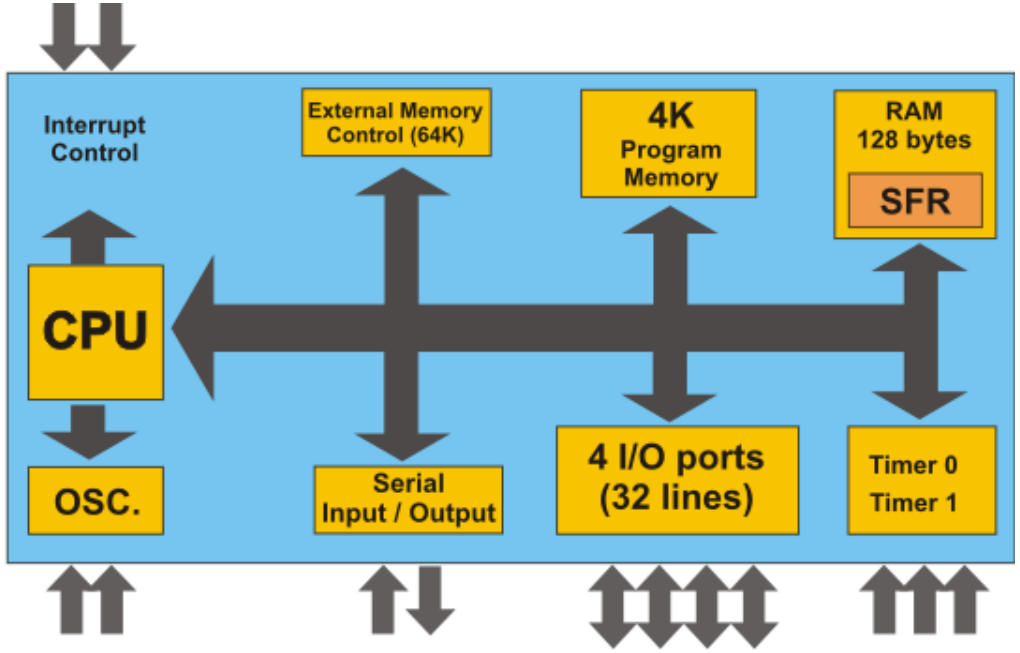
Features of 8051 I/O

(1) four 8-bit I/O ports P0-P3

(2) each pin is bidirectional

- sometimes input and sometimes output





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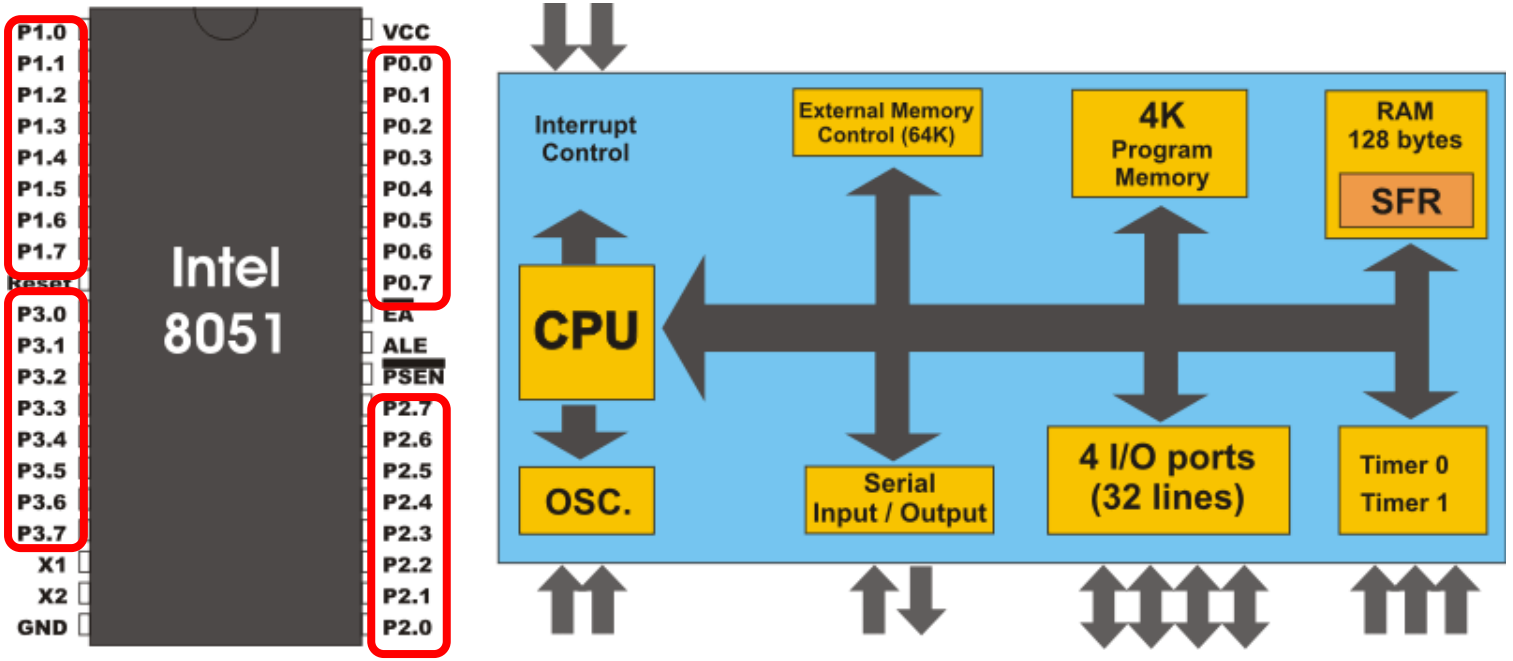

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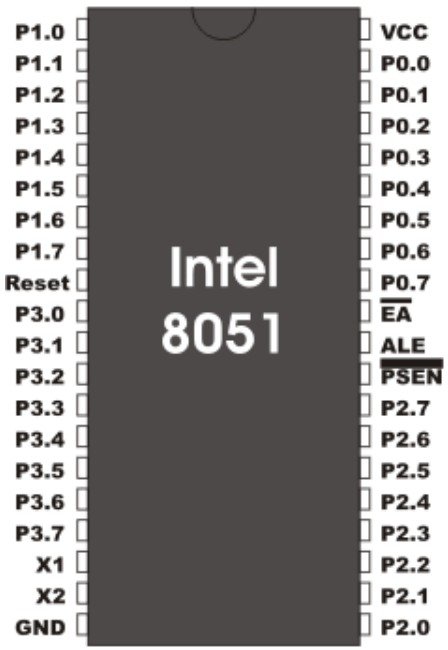

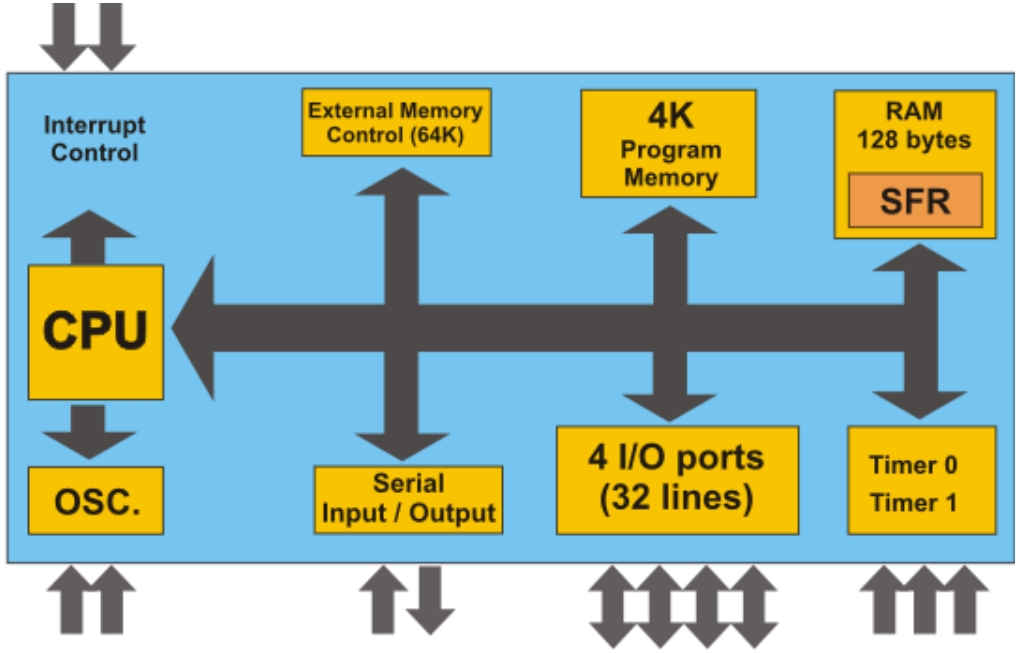

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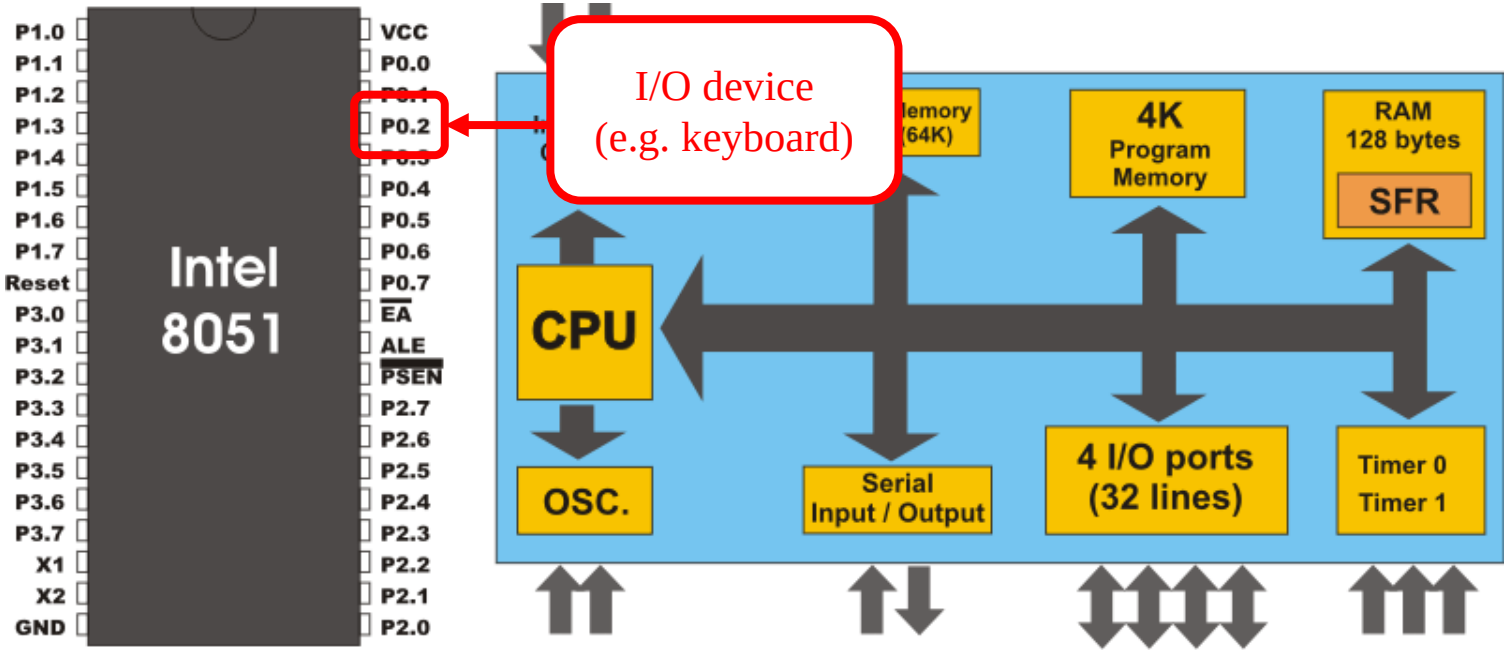

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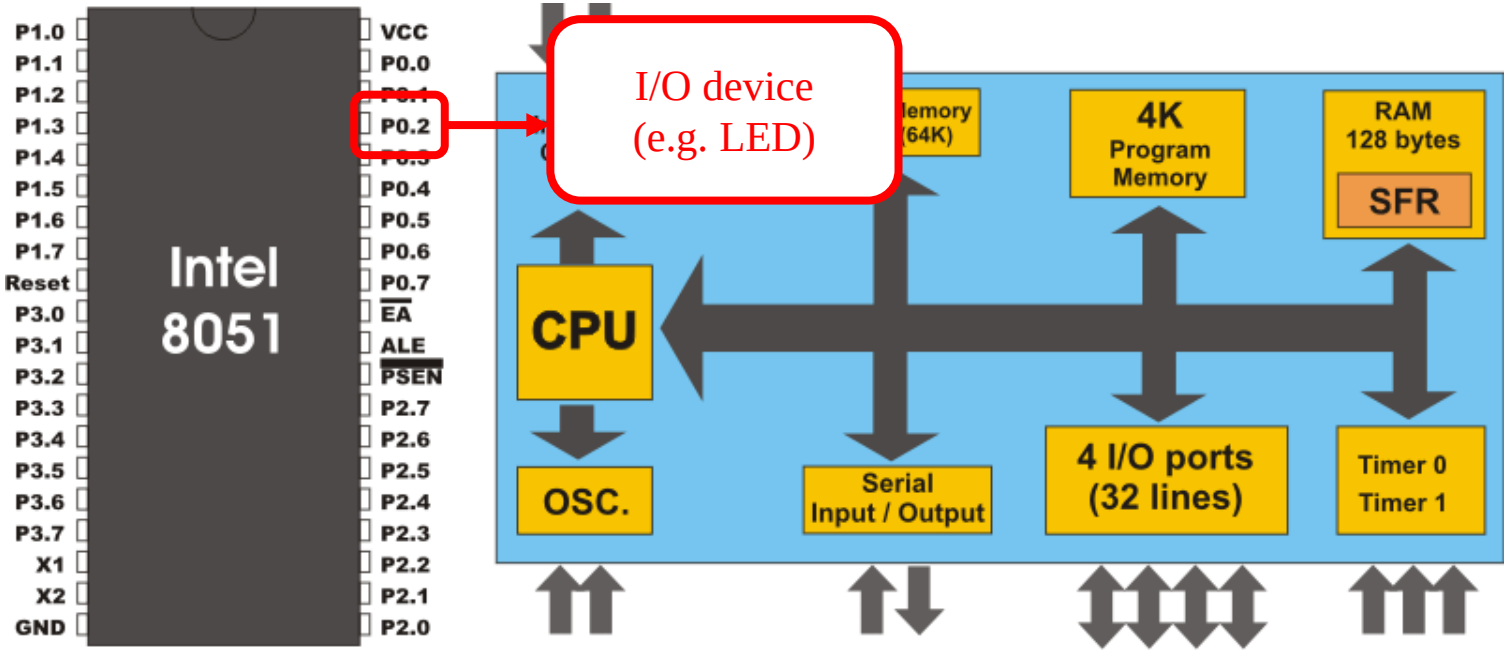
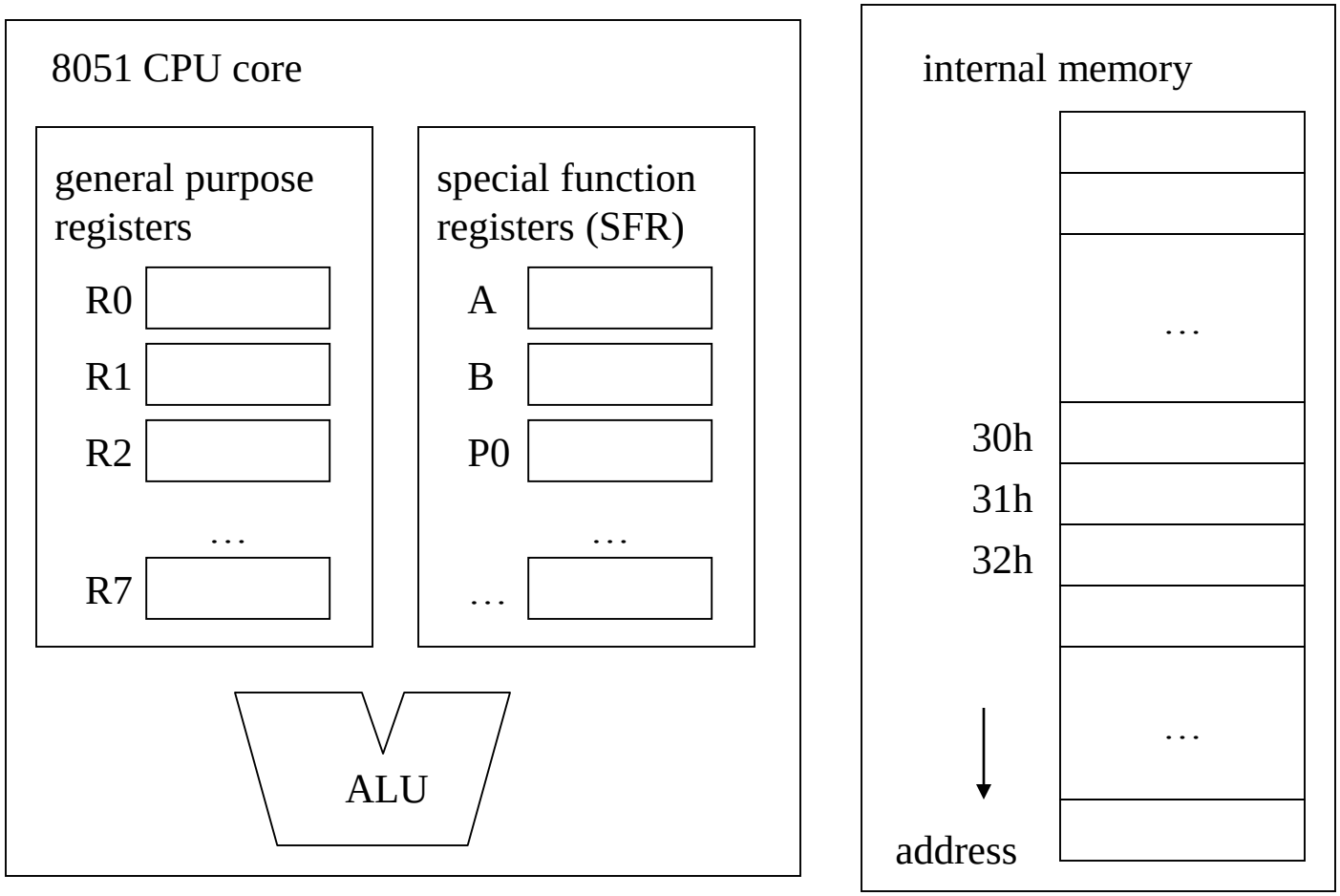


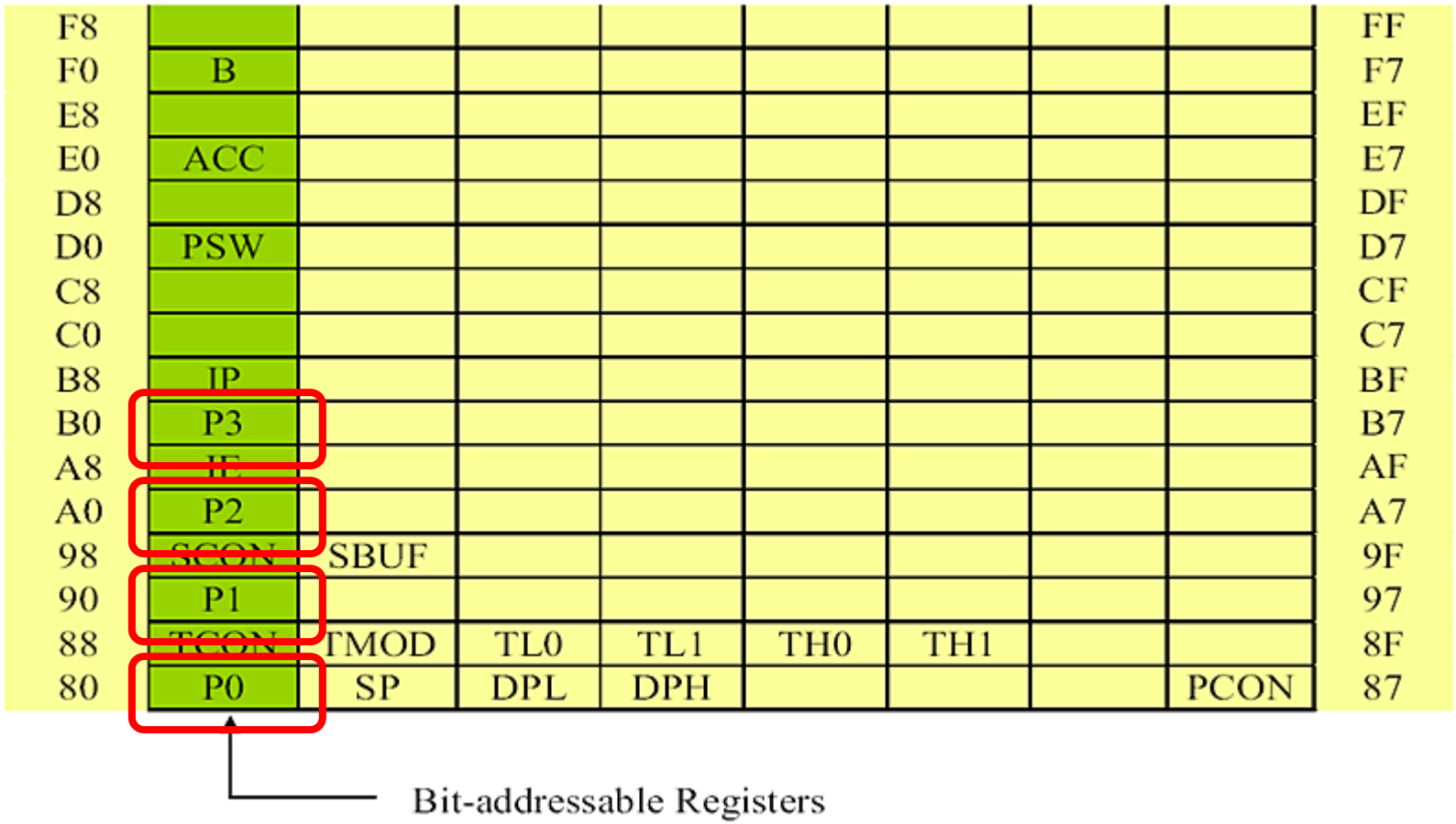
Imagination on 8051 architecture

- Imagine how data flow in the architecture!



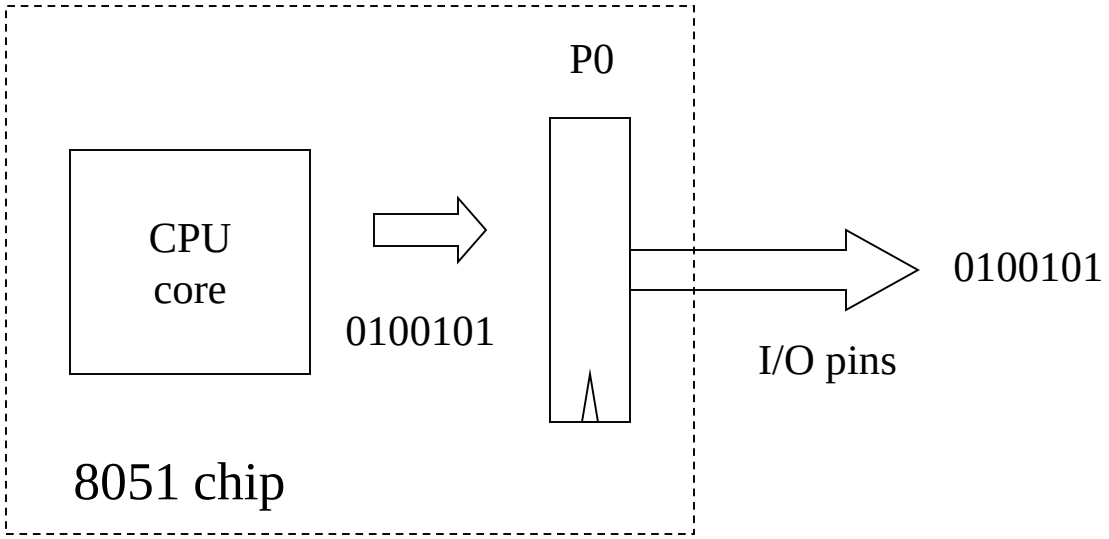
How to program I/O ports?

- through SFRs P0-P3



How 8051 send out dedicated control signals

```
MOV  R0, #01001101B
MOV  P0, R0
```



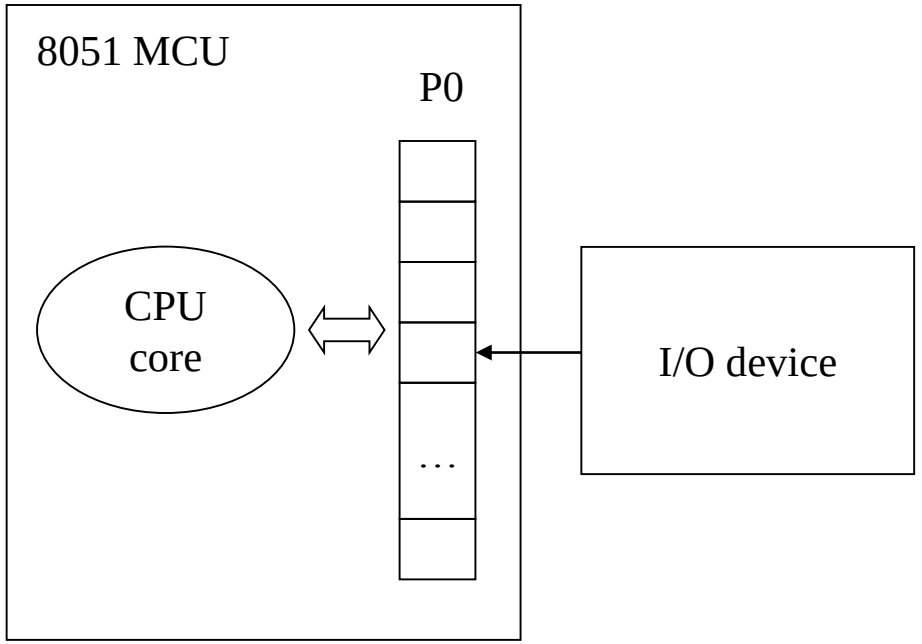
The case of input (receive)

- initial: set a bit (pin) with value 1
- receive (input): wait for the bit to be toggled to be 0

```
P0.3 = 1

//wait unit P0.3 been set to 0
while (P0.3==1);

//action for the I/O event
```



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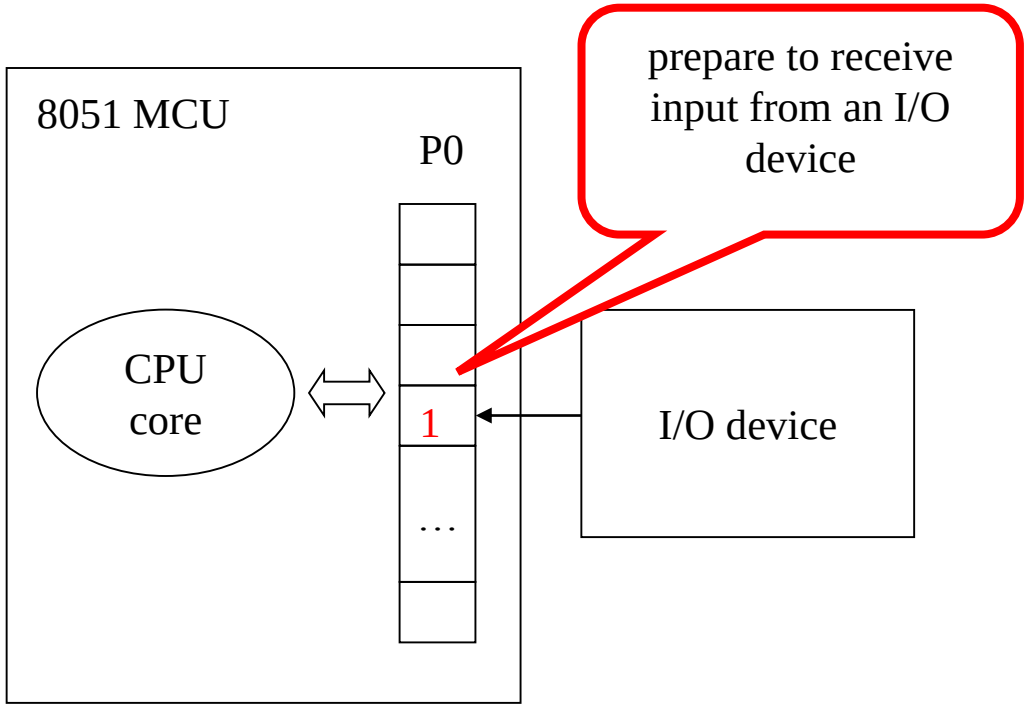

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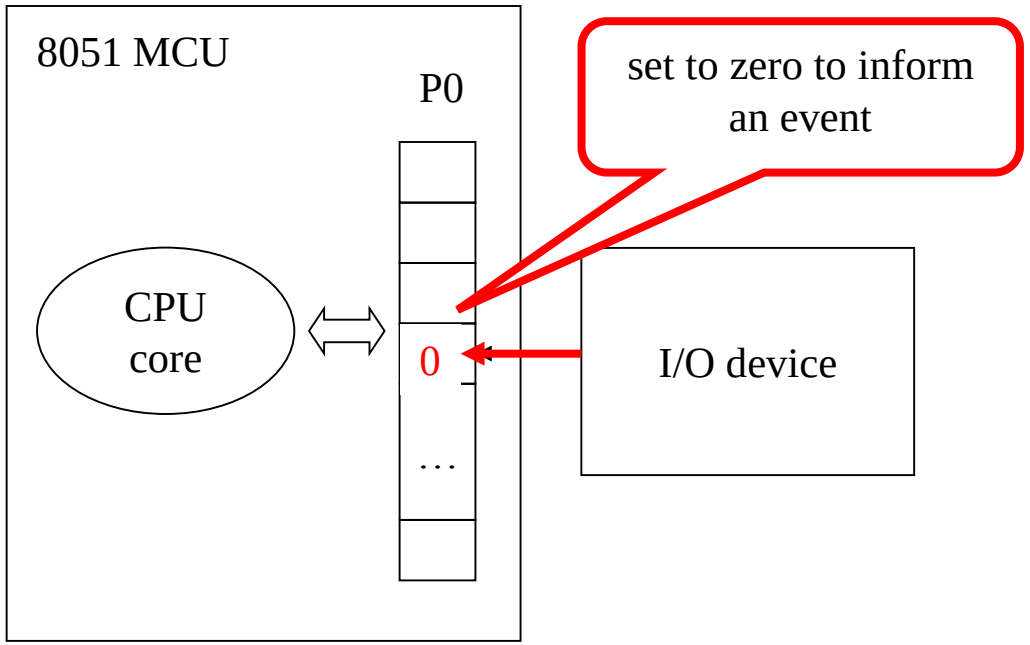
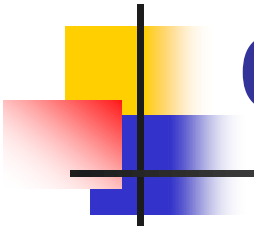


The GPIO of C8051F040 SoC

Overview of SFR



- Extension from legacy 8051
- Divided into 3 pages
- Page 145-149 of the C8051F040 data sheet

The port configuration

- Set XBR2, PxMDIN and PxMDOUT to set port Px as general purpose I/O

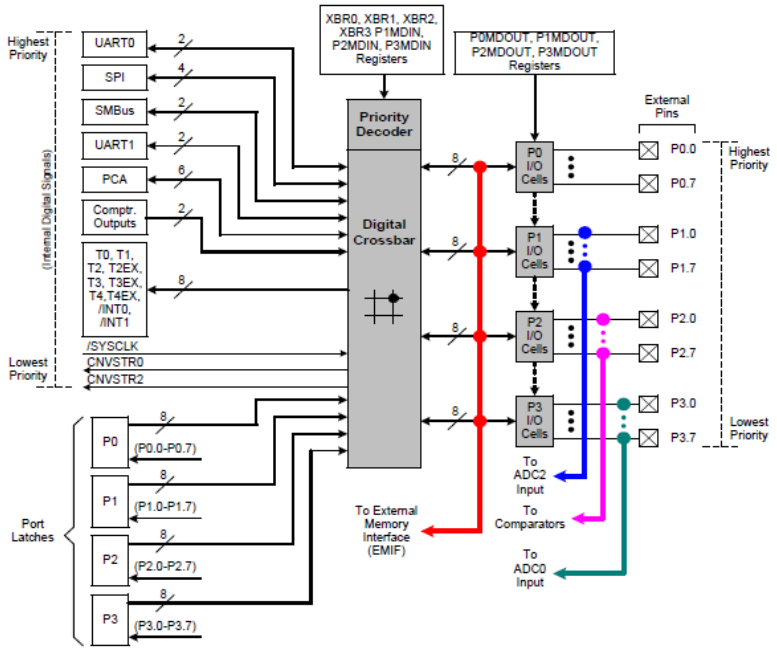


Figure 17.2. Port I/O Functional Block Diagram

The I/O pad

- To send output 1

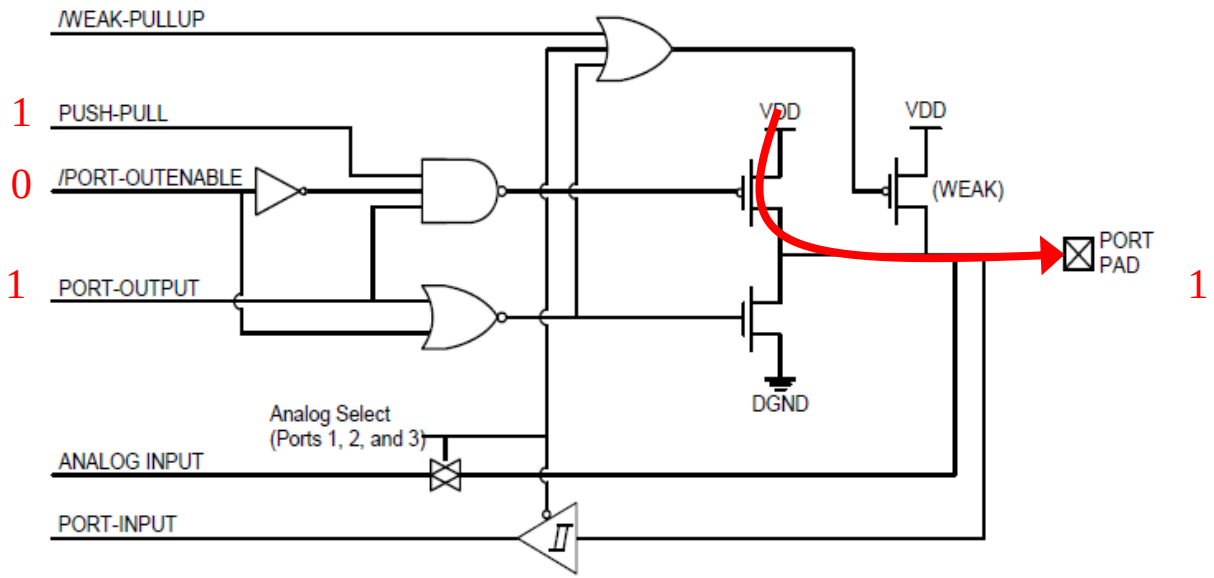


Figure 17.1. Port I/O Cell Block Diagram

The I/O pad

- To send output 0

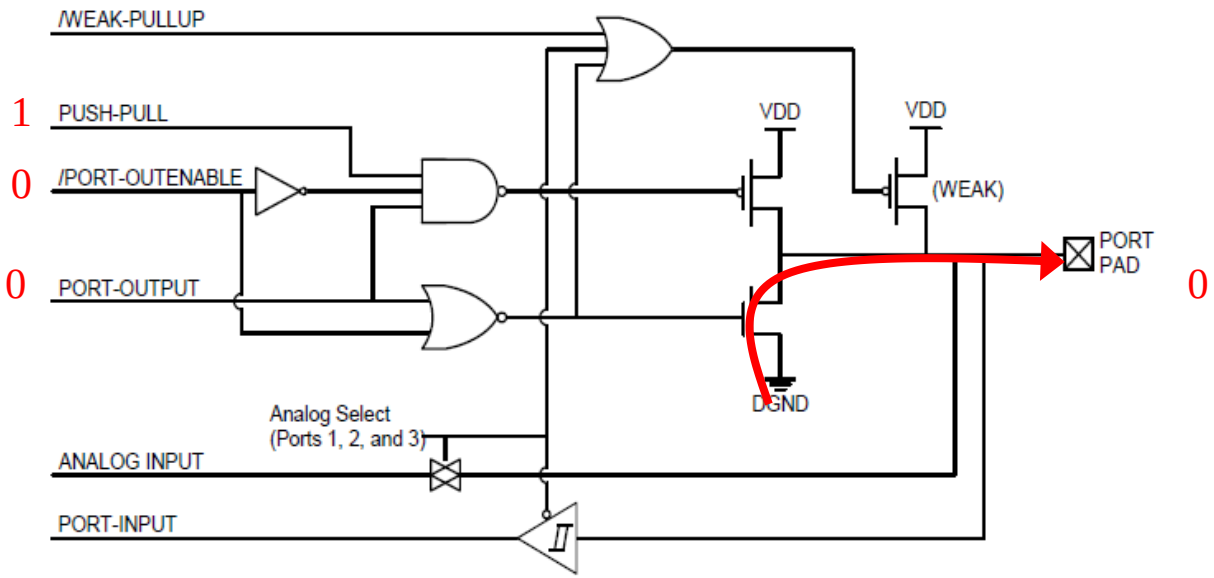
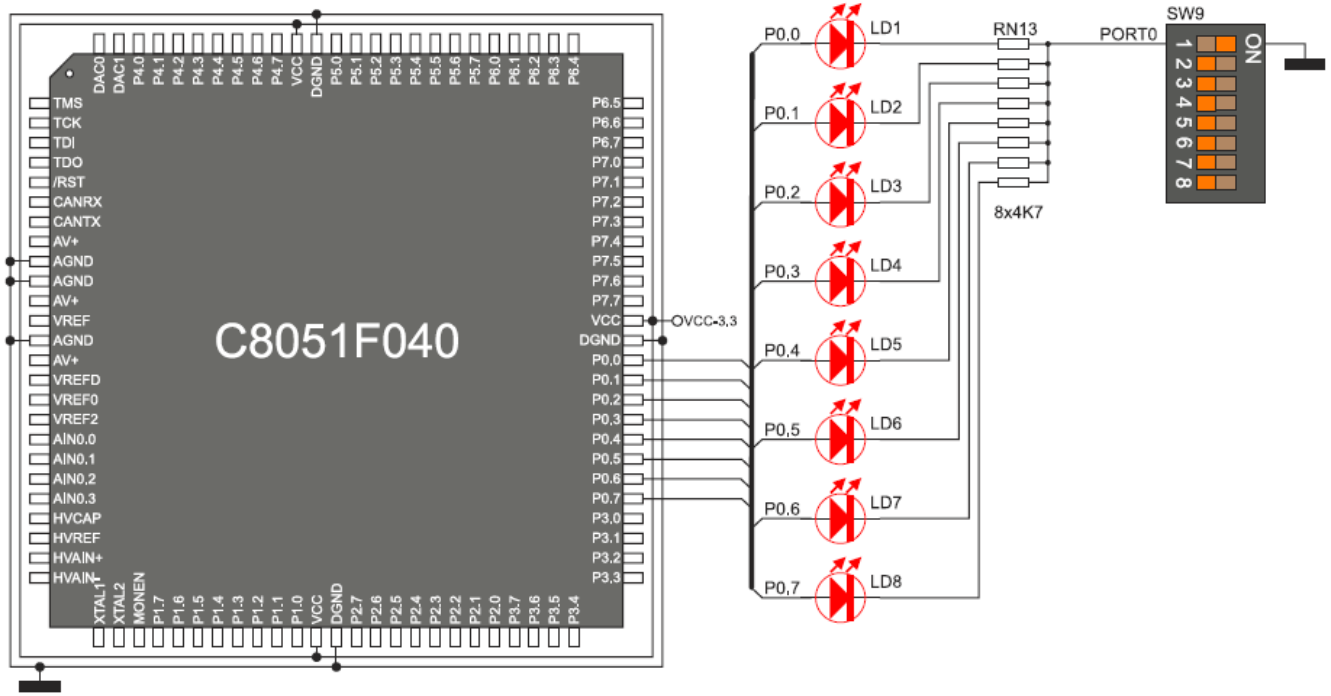
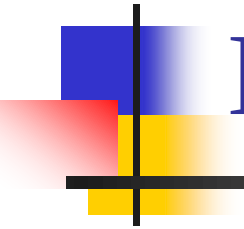


Figure 17.1. Port I/O Cell Block Diagram

Schematics of the LED

- mov P0, #10000000h to turn on LD8





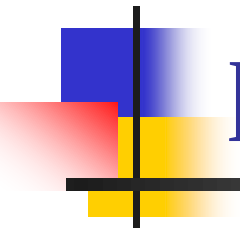
Example 1

Detect button press and display on LED

Example Code

```
;define control registers (with address)
XBR2            equ     0e3h
P1MDIN          equ     0adh
P2MDOUT         equ     0a6h
WDTCN           equ     0ffh
SFRPAGE         equ     084h
P1              equ     090h
P2              equ     0a0h

;define control words
CONFIG_PAGE     equ     0fh
LEGACY_PAGE     equ     00h

                ;turn-off the watch-dog timer
                mov     WDTCN, #0deh
                mov     WDTCN, #0adh

                ;setup port configuration
                mov     SFRPAGE, #CONFIG_PAGE
                mov     XBR2, #0c0h
                mov     P1MDIN, #0ffh
                mov     P2MDOUT, #0ffh
                mov     SFRPAGE, #LEGACY_PAGE

                mov     R0, #0

                ;detect button and display
Loop_Begin:
                mov     R0, P1
                mov     P2, R0
                sjmp    Loop_Begin

                end
```

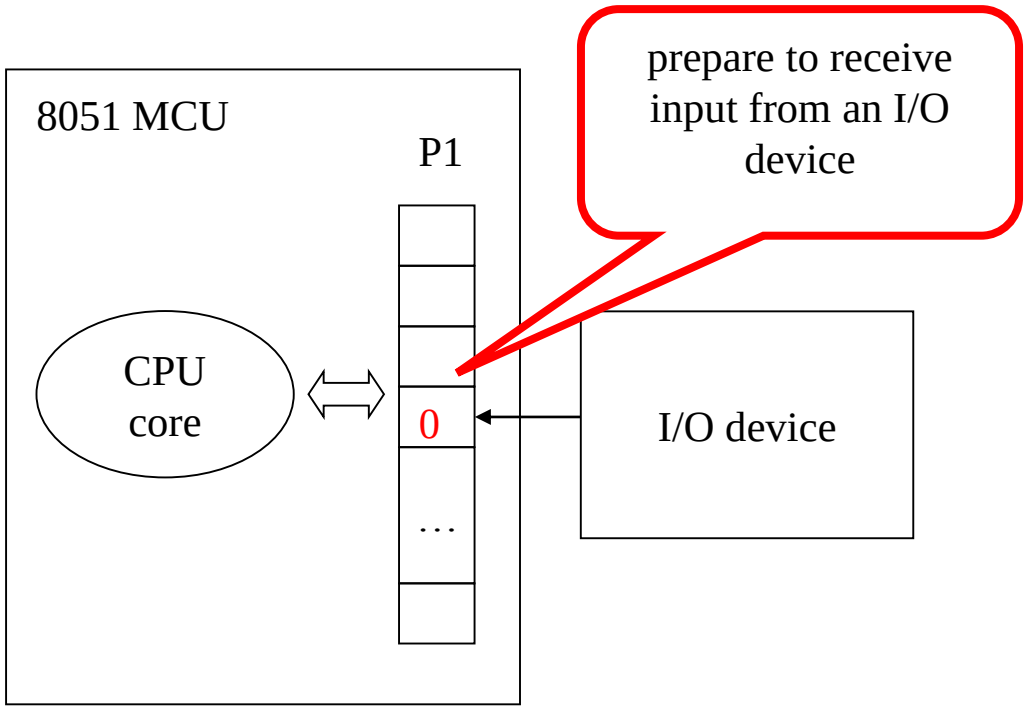
Example 2: wait for a button pressed



Demo: wait for a button pressed

```
wait:
        A  = P1;
        if (A==0) goto wait;

exit:
        //something after button pressed
```

```
wait:
        mov A, P1
        JZ wait

exit:
        //something after button pressed
```



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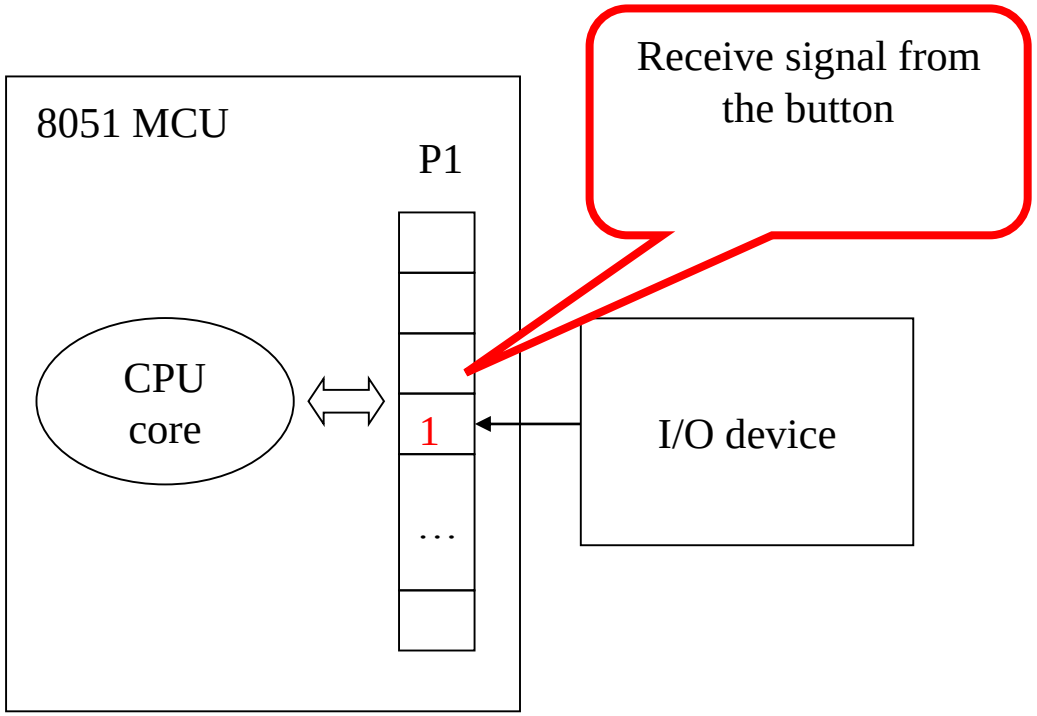
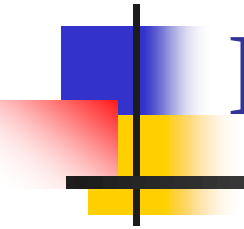




Example 3: make LED run

show how to output signal

Demo: rotate the LED light

```
MAIN:
        MOV A, #11111110B
        MOV PSW, #00H

Loop:
        MOV     P0, A
        LCALL   Delay
        RR      A
        LJMP    Loop

                MOV     R0, #50
Delay:  MOV     R1, #40
Delay1: MOV     R2, #249
Delay2: DJNZ    R2, Delay2
                DJNZ    R1, Delay1
                DJNZ    R0, Delay
                RET
```

Demo: rotate the LED light

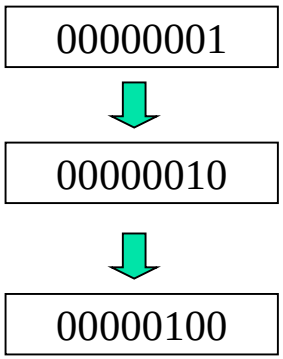
```
MAIN:
        MOV A, #00000001B
        MOV PSW, #00H

Loop:
        MOV     P0, A
        LCALL   Delay
        RR      A
        LJMP    Loop

                MOV     R0, #50
Delay:  MOV     R1, #40
Delay1: MOV     R2, #249
Delay2: DJNZ    R2, Delay2
                DJNZ    R1, Delay1
                DJNZ    R0, Delay
                RET
```

control the LED through content of A

Demo: rotate the LED light

```
MAIN:
        MOV A, #11111110B
        MOV PSW, #00H

Loop:
        MOV     P0, A
        LCALL   Delay
        RR      A
        LJMP    Loop

        MOV     R0, #50
Delay:  MOV     R1, #40
Delay1: MOV     R2, #249
Delay2: DJNZ    R2, Delay2
        DJNZ    R1, Delay1
        DJNZ    R0, Delay
        RET
```

- rotate right (RR) A



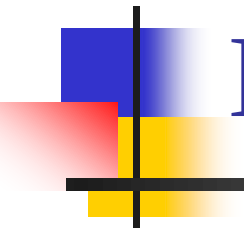
Demo: rotate the LED light

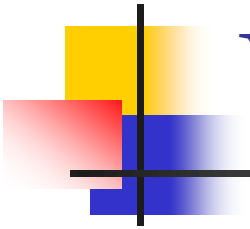
```
MAIN:
        MOV A, #11111110B
        MOV PSW, #00H

Loop:
        MOV     P0, A
        LCALL   Delay
        RR      A
        LJMP    Loop

        MOV     R0, #50
Delay:  MOV     R1, #40
Delay1: MOV     R2, #249
Delay2: DJNZ    R2, Delay2
        DJNZ    R1, Delay1
        DJNZ    R0, Delay
        RET
```

call a function at label "Delay"

a nested loop to delay some time

The Next Lab: Timer and Interrupt





Your Work at Lab 03

- make LED run but using the timer interrupt to trigger pattern change

Pre-Lab Report

- Q1: what is interrupt?
  - check Mano: logic and computer design fundamentals, Section 10-9
- Q2: how to setup an ISR on 8051
  - ISR: interrupt service routine