Lab4: Subroutine & Macro

複習PIC18 memory organization

Program Memory & Data Memory

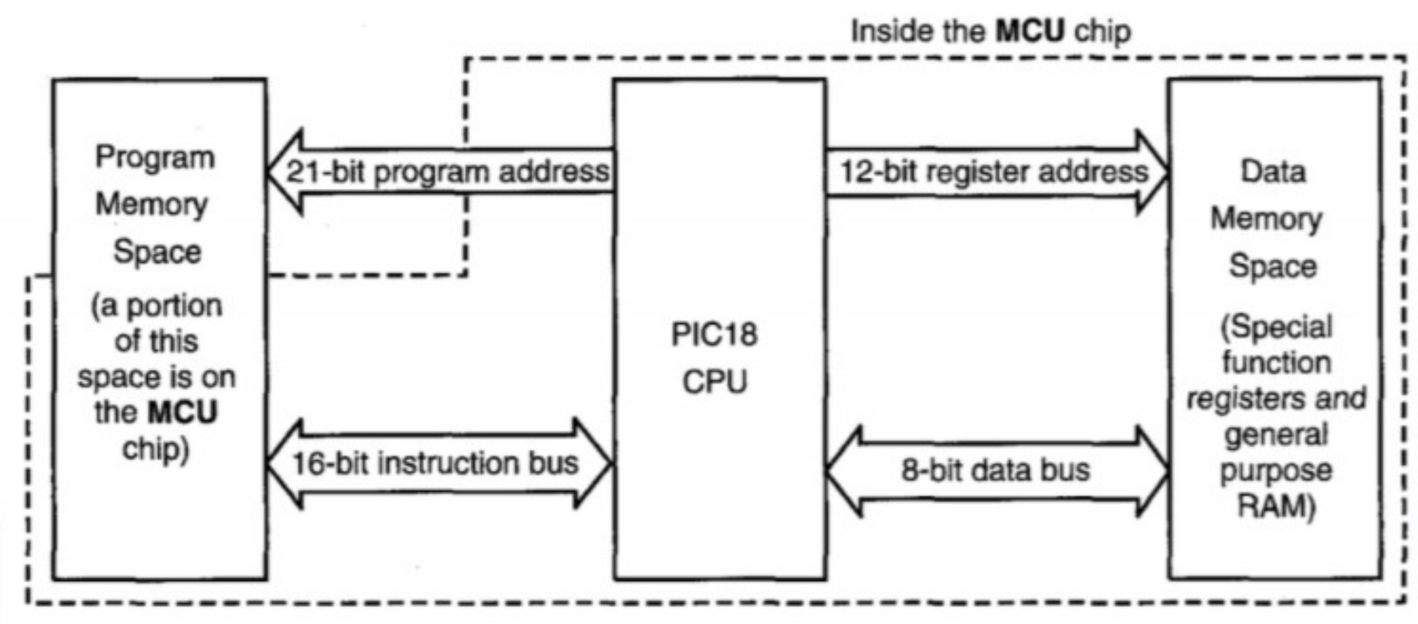


Figure 1.3 ■ The PIC18 memory spaces

放資料的抽屜分成兩類

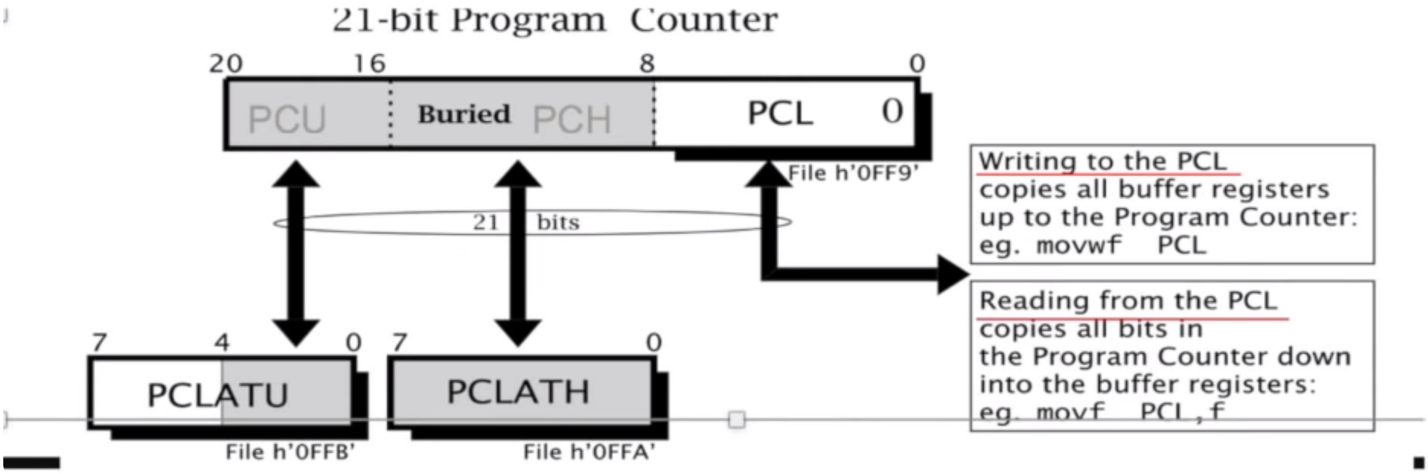
- 一種是用來存放Data的 (例：File register、SFR等等)
- 一種是用來放Program的 (例：你撰寫的程式碼)
- **Program Memory**
    - 每個抽屜號碼 **(Program Address)** 為 **21-bit** (最多可以有2^21個抽屜)
    - 每個抽屜只能放**8-bit**的資料，但**PIC18的每個指令會用掉16bit的大小**

    - 因此執行一個指令**會用掉2個抽屜**

- Data Memory
    - 抽屜號碼(Data Address)為12-bit
      也就是說共有2^12(4096)個抽屜
    - 裡面可以放8-bit大小的資料

介紹相關SFR（PCL、STKPTR、TOS)

21-bit program counter



- 是用來存放下一個要執行之指令的位置
- 由三個reg組合而成: PCU、PCH、PCL
    - 我們只能直接更改PCL的值
    - PCU和PCH需透過latch來做更改
        - PCU透過PCLATU來更改
        - PCH透過PCLATH來更改
- 可以利用改PCL的值來去指定的地方或拿來寫loop,不一定要用goto
- label那行不算進去

為甚麼裡面的值都是二的倍數?

- 因為一個指令大小就是16bit
  而PIC18的資料基本單位是8bit
  所以放一個指令需要兩個register~
  (不懂的話可看上面的複習資料)

Stack(STKPTR、TOS)

- STKPTR: 存stack目前有幾個東西
- TOS: rcall時會儲存下一道指令的位置，Return時會跳過去執行。

Subroutine

類似於在程式中呼叫一個function

使用方法

1. 寫好你要的label
2. 使用rcall label，開始執行subroutine
3. 結束時使用Return，會返回到當時rcall的下一行指令，繼續執行

範例

```
initial:
    MOVLW 0x03
    MOVWF 0x00
    CLRF WREG
    rcall func1
    goto finish
func1:
    ADDWF 0x00, W
    DECFSZ 0x00
    GOTO func1
    MOVWF 0x01
    RETURN

finish:
    end
```

Macro

定義新的指令,可以**給定參數**

```
macro_name macro p1,p2,p3,p4
    ;your macro code
    endm
```

Macro vs Subroutine

macro	subroutine
可直接傳參數	需在呼叫前,把參數的值放入register file
碰到macro,compiler會直接複製那段code上去	重複使用那段code
適合較短的code	適合較長但須常用的code,才不會佔空間

Multiply

- **unsigned**
  把值都當成正的,不會有負的

MULWF	**Multiply W with f**
Syntax:	MULWF f {,a}
Operands:	$0 \le f \le 255$ $a \in [0,1]$
Operation:	(W) x (f) → PRODH:PRODL
Status Affected:	None
Encoding:	`0000` `001a` `ffff` `ffff`
Description:	An unsigned multiplication is carried out between the contents of W and the register file location ‘f’. The 16-bit result is stored in the PRODH:PRODL register pair. PRODH contains the high byte. Both W and ‘f’ are unchanged. None of the Status flags are affected. Note that neither Overflow nor Carry is possible in this operation. A zero result is possible but not detected. If ‘a’ is ‘0’, the Access Bank is selected. If ‘a’ is ‘1’, the BSR is used to select the GPR bank (default). If ‘a’ is ‘0’ and the extended instruction set is enabled, this instruction operates in Indexed Literal Offset Addressing mode whenever

- **signed**

重點: 檢查MSB，並且做出負號的調整

公式推導

Signed 8-bit Multiplication

- The multiplication of signed numbers requires the programmer to consider the signs of the multiplier and the multiplicand. Let *M* and *N* represent the magnitudes of two numbers. There are four possible situations:
- Case 1: Both operands are positive (**opl** = *M*, **op2** = *N*). The product of these two operands can be computed by using either the **mulwf f, A** or the **mullw k** instruction.

- Case 2: The first operand is negative (**opl**= -*M*) whereas the second operand is positive (**op2**= *N*). The first operand **opl** will be represented in two's complement of *M* (2^8- *M*) in the PIC18. The product of -*M* and *N*:

$$-M \times N = (2^8 - M) \times N = (2^8 \times N) - M \times N = \underbrace{2^{16} - M \times N}_{①} + \underbrace{2^8 \times N}_{②}$$

- The value 2^{16} is added to this expression. Since in this case the PIC18 is performing a modulo-2^{16} arithmetic (PIC18uses PRODH and PRODL to hold the product), adding the value of 2^{16} makes no difference to the result

$$-M \times N$$

- Case 3: The first operand is positive (**opl**= *M*), but the second operand is negative (**op2**=-*N*). Similar to Case 2, the product of *M* and -*N*:

$$M \times (-N) = M \times (2^8 - N) = (2^8 \times M) - M \times N = \underbrace{2^{16} - M \times N}_{①} + \underbrace{2^8 \times M}_{②}$$

- The first term is the correct product, which is represented as the two's complement of $-M \times N$. The second term of this product is an extra term and can be eliminated by subtracting **opl** from the upper byte of the product of *M* and -*N*.

- Case 4: Both operands are negative (**opl**= -*M*, **op2** = -*N*). The product of -*M* and -*N*:

$$\begin{aligned}(-M) \times (-N) &= (2^8 - M) \times (2^8 - N) = 2^{16} - 2^8 \times M - 2^8 \times N + M \times N \\ &= M \times N + 2^{16} - 2^8 \times M + 2^{16} - 2^8 \times N \\ &= \underbrace{M \times N}_{①} + \underbrace{2^8 \times (2^8 - M)}_{②} + \underbrace{2^8 \times (2^8 - N)}_{③}\end{aligned}$$

- The first term is the product of -*M* and -*N*. The second term and the third term are extra terms and must be eliminated. The second term can be eliminated by subtracting **opl** from the upper byte of the product, whereas the third term can be eliminated by subtracting **op2** from the upper byte of the product.

實際步驟

- The signed 8-bitmultiplication can be implemented by the algorithm

Step 1
Multiply two operands (i.e., compute **op1** × **op2**) disregarding their signs.

Step 2
If **op1** is negative, then subtract **op2** from the upper byte of the product.

Step 3
If **op2** is negative, then subtract **op1** from the upper byte of the product.