8051 Assembly Language Programming [Part-2]

Bilal Habib

DCSE, UET

8051 DATA TYPES AND DIRECTIVES

Assembler Directives (cont')

ORG (origin)

- The ORG directive is used to indicate the beginning of the address
- ➤ The number that comes after ORG can be either in hex and decimal
 - If the number is not followed by H, it is decimal and the assembler will convert it to hex

END

- This indicates to the assembler the end of the source (asm) file
- ➤ The END directive is the last line of an 8051 program
 - Mean that in the code anything after the END directive is ignored by the assembler

8051 DATA TYPES AND DIRECTIVES

Assembler directives (cont')

□ EQU (equate)

- This is used to define a constant without occupying a memory location
- ➤ The EQU directive does not set aside storage for a data item but associates a constant value with a data label
 - When the label appears in the program, its constant value will be substituted for the label

8051 DATA TYPES AND DIRECTIVES

Assembler directives (cont')

- EQU (equate) (cont')
 - Assume that there is a constant used in many different places in the program, and the programmer wants to change its value throughout
 - By the use of EQU, one can change it once and the assembler will change all of its occurrences

```
COUNT EQU 25
....
MOV R3, #COUNT

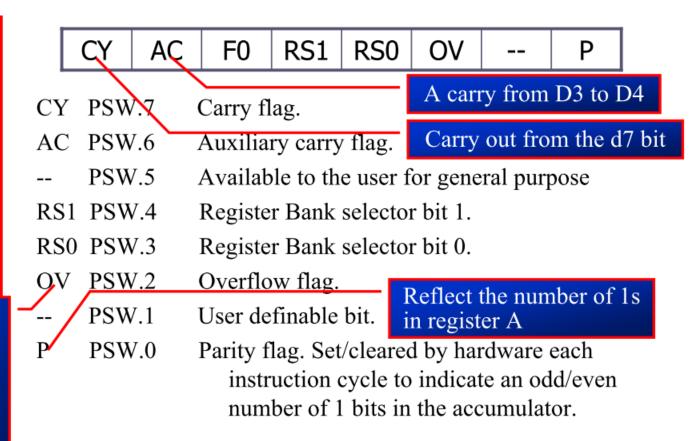
The constant is used to load the R3 register
```

Program Status Word

- The program status word (PSW)
 register, also referred to as the *flag*register, is an 8 bit register
 - Only 6 bits are used
 - These four are CY (carry), AC (auxiliary carry), P (parity), and OV (overflow)
 - They are called *conditional flags*, meaning that they indicate some conditions that resulted after an instruction was executed
 - The PSW3 and PSW4 are designed as RS0 and RS1, and are used to change the bank
 - The two unused bits are user-definable

Program Status Word (cont')

The result of signed number operation is too large, causing the high-order bit to overflow into the sign bit



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		

ADD Instruction And PSW (cont')

The flag bits affected by the ADD instruction are CY, P, AC, and OV

Example 2-2

Show the status of the CY, AC and P flag after the addition of 38H and 2FH in the following instructions.

```
MOV A, #38H
ADD A, #2FH ;after the addition A=67H, CY=0
```

Solution:

```
38 00111000
+ 2F 00101111
```

ADD Instruction And PSW (cont')

The flag bits affected by the ADD instruction are CY, P, AC, and OV

Example 2-2

Show the status of the CY, AC and P flag after the addition of 38H and 2FH in the following instructions.

ADD A, #2FH; after the addition A=67H, CY=0

Solution:

CY = 0 since there is no carry beyond the D7 bit

AC = 1 since there is a carry from the D3 to the D4 bi

P = 1 since the accumulator has an odd number of 1s (it has five 1s)

ADD
Instruction And
PSW
(cont')

Example 2-3

Show the status of the CY, AC and P flag after the addition of 9CH and 64H in the following instructions.

Solution:

ADD
Instruction And
PSW
(cont')

Example 2-3

Show the status of the CY, AC and P flag after the addition of 9CH and 64H in the following instructions.

MOV A,
$$\#9CH$$
 ADD A, $\#64H$;after the addition A=00H, CY=1

Solution:

CY = 1 since there is a carry beyond the D7 bit

AC = 1 since there is a carry from the D3 to the D4 bi

P = 0 since the accumulator has an even number of 1s (it has zero 1s)

ADD
Instruction And
PSW
(cont')

Example 2-4

Show the status of the CY, AC and P flag after the addition of 88H and 93H in the following instructions.

Solution:

ADD Instruction And PSW (cont')

Example 2-4

Show the status of the CY, AC and P flag after the addition of 88H and 93H in the following instructions.

Solution:

CY = 1 since there is a carry beyond the D7 bit

AC = 0 since there is no carry from the D3 to the D4 bi

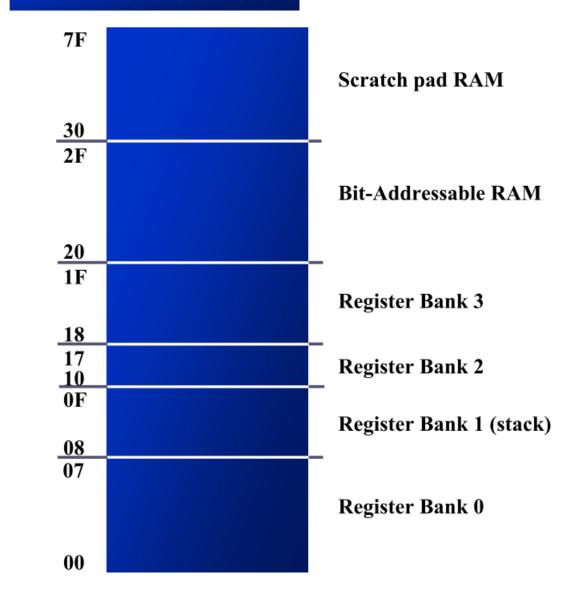
P = 0 since the accumulator has an even number of 1s (it has four 1s)

RAM Memory Space Allocation

- There are 128 bytes of RAM in the 8051
 - Assigned addresses 00 to 7FH
- The 128 bytes are divided into three different groups as follows:
 - 1) A total of 32 bytes from locations 00 to 1F hex are set aside for register banks and the stack
 - 2) A total of 16 bytes from locations 20H to 2FH are set aside for bit-addressable read/write memory
 - 3) A total of 80 bytes from locations 30H to 7FH are used for read and write storage, called *scratch pad*

RAM Memory Space Allocation (cont')

RAM Allocation in 8051



Register Banks

- These 32 bytes are divided into 4 banks of registers in which each bank has 8 registers, R0-R7
 - RAM location from 0 to 7 are set aside for bank 0 of R0-R7 where R0 is RAM location 0, R1 is RAM location 1, R2 is RAM location 2, and so on, until memory location 7 which belongs to R7 of bank 0
 - ➤ It is much easier to refer to these RAM locations with names such as R0, R1, and so on, than by their memory locations
- Register bank 0 is the default when 8051 is powered up

Register Banks (cont')

Register banks and their RAM address

	Bank 0		Bank 1		Bank 2		Bank 3
7	R 7	F	R7	17	R7	1 F	R7
6	R6	${f E}$	R6	16	R6	1E	R6
5	R5	D	R5	15	R5	1 D	R5
4	R4	\mathbf{C}	R4	14	R4	1 C	R4
3	R3	В	R3	13	R3	1B	R3
2	R2	\mathbf{A}	R2	12	R2	1A	R2
1	R1	9	R1	11	R1	19	R1
0	R0	8	R0	10	R0	18	R0

Register Banks (cont')

- We can switch to other banks by use of the PSW register
 - Bits D4 and D3 of the PSW are used to select the desired register bank
 - Use the bit-addressable instructions SETB and CLR to access PSW.4 and PSW.3

PSW bank selection		
	RS1(PSW.4)	RS0(PSW.3)
Bank 0	0	0
Bank 1	0	1
Bank 2	1	0
Bank 3	1	1

Micro-Processor Based System Design

Datatypes, Loops and masking

Bilal Habib

DCSE, UET Peshawar

Slides are adapted from Chung-Ping Young lectures

The unsigned int is a 16-bit data type

- ➤ Takes a value in the range of 0 to 65535 (0000 FFFFH)
- Define 16-bit variables such as memory addresses
- > Set counter values of more than 256
- Since registers and memory accesses are in 8-bit chunks, the misuse of int variables will result in a larger hex file

Signed int is a 16-bit data type

- ▶ Use the MSB D15 to represent or +
- ▶ We have 15 bits for the magnitude of the number from –32768 to +32767

Write an 8051 C program to toggle bit D0 of the port P1 (P1.0) 50,000 times.

Solution:

```
#include <reg51.h>
sbit MYBIT=P1^0;
void main (void)
    unsigned int z;
    for (z=0; z \le 50000; z++)
         MYBIT=0;
         MYBIT=1;
```

sbit keyword allows access to the single bits of the SFR registers

DATA TYPES

Bit and sfr

- The bit data type allows access to single bits of bit-addressable memory spaces 20 – 2FH
- To access the byte-size SFR registers,
 we use the sfr data type

Data Type	Size in Bits	Data Range/Usage
unsigned char	8-bit	0 to 255
(signed) char	8-bit	-128 to +127
unsigned int	16-bit	0 to 65535
(signed) int	16-bit	-32768 to +32767
sbit	1-bit	SFR bit-addressable only
bit	1-bit	RAM bit-addressable only
sfr	8-bit	RAM addresses 80 – FFH only

Delay using Loops

Write an 8051 C program to toggle bits of P1 continuously forever with some delay. **Solution:** //Toggle P1 forever with some delay in between //"on" and "off" #include <reg51.h> We must use the oscilloscope to void main(void) measure the exact duration unsigned int/x; for (;;) //repeat forever p1=0x55;for (x=0; x<40000; x++); //delay size//unknown p1=0xAA;for (x=0; x<40000; x++);22

Millisecond delay

```
Digital Oscilloscope
                                  50 50 mS
                                                  100,00 mS
```

```
#include <reg51.h>
#include <stdio.h>
void MS delay(unsigned int);
void main(void)
        while (1)
            P1 = 0x01; // 0000 0001...ON
            MS delay(50);
            P1 = 0x00; // 0000 0000...Off
            MS delay(100);
void MS delay(unsigned int itime)
    unsigned int i,j;
    for (i=0;i<itime;i++)</pre>
        for (j=0; j<125; j++);
                                            23
```

LOGIC OPERATIONS

Bit-wise Operators in C

Logical operators

- ➤ AND (&&), OR (||), and NOT (!)
- Bit-wise operators
 - ➤ AND (&), OR (|), EX-OR (^), Inverter (~), Shift Right (>>), and Shift Left (<<)
 - These operators are widely used in software engineering for embedded systems and control

Bit-wise Logic Operators for C

		AND	OR	EX-OR	Inverter
Α	В	A&B	A B	A^B	~B
0	0	0	0	0	1
0	1	0	1	1	0
1	0	0	1	1	
1	1	1	1	0	

LOGIC OPERATIONS

Bit-wise
Operators in C
(cont')

Run the following program on your simulator and examine the results.

Solution:

LOGIC OPERATIONS

Bit-wise
Operators in C
(cont')

Write an 8051 C program to get bit P1.0 and send it to P2.7 after inverting it.

Solution:

```
#include <reg51.h>
sbit inbit=P1^0;
sbit outbit=P2^7;
bit membit;
void main(void)
    while (1)
        membit=inbit; //get a bit from P1.0
        outbit=~membit; //invert it and send
                         //it to P2.7
```