

Microprocessor

Ch.7 Programming In C

OUTLINE

- **Data types and time delay**
- **I/O programming and Logic operations**
- **Data conversion programs**
- **Accessing code ROM space**

DATA TYPE: C V.S. ASSEMBLY

- **C V.S. Assembly language**

- Advantage of C

- It's easier to program in C compared to assembly.
 - C code can be easily ported to other microcontroller, while assembly language can usually be used for 1 type of microcontroller
 - There are lots of function libraries written in C

- Advantage of assembly language

- The hex file generated by assembly is usually smaller
 - Code efficiency is higher (faster)

- **C programming**

- C has become the standard for embedded system programming

- Object oriented language (C++, Java, C#) are usually not as efficient as C
 - C is flexible

- One of the main concerns in C programming for embedded system is to generate a hex file that is small in size

- We need to pay attention to the size of variables during programming

DATA TYPE

- **Data types**

- unsigned char, signed char, unsigned int, signed int, sbit, bit and sfr

- **unsigned char**

- 8-bit. Most popular data type, matches most registers. Represent ASCII code or integers in the range of 0 ~ 255.

- Example: write a C program to send the ASCII code of 0, 1, 2, A, B, C to port 1 (demo)

```
#include <reg51.h>           // the definition of registers
void main (void)
{
    unsigned char mynum[] = "012ABC";
    unsigned char z;
    for (z = 0; z <=5; z++)
        P1 = mynum[z];    //port 1 is denoted as P1
}
```

- Example: write a C program to toggle all bits of P2 continuously

```
#include <reg51.h>
void main(void)
{
    for ( ; ; )                // infinite loop
    {
        P1 = 0x55;              // hex number: 0x55
        P1 = 0xAA;
    }
}
```

DATA TYPE

- **signed char**

- an 8-bit number with the most significant bit representing sign (+ or -)
 - Range: -128 ~ 127 (range of unsigned char: 0 ~ 255)
- Example: write a C program to send -3 to 3 to port 1

```
#include <reg51.h>
void main(void)
{
    char mynum[] = {-3,-2,-1,0,1,2,3};           // signed char
    unsigned char z;
    for (z = 0; z<=6; z++)
        P1 = mynum[z];
}
```

- **unsigned int**

- 16-bit (needs to registers), range: 0 ~ 65535 (FFFFH)
- E.g.: unsigned int a;

- **signed int**

- 16-bit, MSB represents sign. Range: -32768 ~ 32767
- E.g.: int a;
- Since int requires twice as many memory space as char, use unsigned or signed int only when the number cannot be represented with unsigned or signed char.

DATA TYPE

- **sbit**

- Single bit, used to access single-bit addressable registers
- Example: write a C program to toggle bit D0 of P1 50,000 times

```
#include <reg51.h>
sbit MYBIT = P1^0;
void main(void)
{
    unsigned int z;; 50000 times, cannot use char
    for (z=0; z<=50000;z++)
    {
        MYBIT = 0;
        MYBIT = 1;
    }
}
```

- **bit**

- Used to access single bit of bit-addressable RAM (20H – 2FH)
- Example: bit mybit = 0; // the compiler will assign a RAM space to a //automatically

- **sfr**

- Used to access special function registers
- example: sfr ACC = 0xE0; // the address of reg. A

DATA TYPE: TIME DELAY

- **Time delay**

- Two methods to achieve time delay:
 - Timer (Ch. 9)
 - Loop
- When using loops in C, it's difficult to determine the exact time delay by means of calculation
 - For the same C code, different compilers usually will generate different assembly codes
 - Thus the same C codes with different compilers might generate different delays
 - The only way to know the exact delay is through oscilloscope.

```
#include <reg51.h>
void main(void)
{
    unsigned int x;
    while(1)
    {
        P1 = 0x55;
        for (x=0;x<40000;x++); //delay
        P1=0xAA;
        for (x=0;x<40000;x++); //delay
    }
}
```

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I/O PROGRAMMING

- **Byte size I/O**

- Example: write a program to get a byte of data from P0. If it's less than 100, send it to P1; otherwise send it to P2

```
#include <reg51.h>
void main(void)
{
    unsigned char mybyte;
    P0=0xFF;           //make P0 an input port
    while(1)
    {
        mybyte=P0;     //get a byte from P0
        if(mybyte<100)
            P1=mybyte;  //send it to P1 if less than 100
        else
            P2=mybyte;  //send it to P2 if more than 100
    }
}
```

- **Self study: examples 7-9, 7-10**

I/O PROGRAMMING

- **Bit-addressable I/O Programming**

- Example: write a program to monitor bit P1.5. If it is high, send 55H to P0; otherwise send AAH to P2

```
#include <reg51.h>
sbit mybit = P1^5;    //notice the way single bit is declared
void main(void)
{
    mybit=1;           //make mybit an input
    while(1)
    {
        if(mybit==1)
            P0=0x55;
        else
            P2=0xAA;
    }
}
```

I/O PROGRAMMING: SFR REGISTERS

- Access SFR register

- Use sfr or sbit
- Example: read P0, send the result to P1; read in the value of P2.6

```
sfr regA = 0xE0;
sfr P0 = 0x80;
sfr P1 = 0x90;
sbit inbit = 0xA6;    // bit address for P2^6
bit mybit;            // compiler will automatically allocate memory to mybit
void main(void)
{
    unsigned int z;
    P0 = 0xff;    // input mode
    inbit = 1; //input mode
    for (z = 0; z<50000; z++)
    {
        regA = P0;
        P1 = regA;
        mybit = inbit;    //read P2^6 to mybit
    }
}
```

LOGIC

- **logic operators in C**

- && (and), || (or), ! (not)
- Example: `if (var1 < 3 && var2 == 1)`
`if (!(var > 5))`

- **Bit-wise logic operators**

- Bit-by-bit logical operations: & (and), | (or), ^ (xor), ~ (not)
- Shifting: << (shift to left) >> (shift to right): **NOT cyclic shift!**
- Example

```
#include <reg51.h>
void main(void)
{
    P0=0x35 & 0x0F;
    P1=0x04 | 0x68;
    P2=0x04 ^ 0x78;
    P3=~0x55;
    P0 = 0x35 << 3;
}
```

LOGIC: DATA SERIALIZATION

- **Data serialization**

- 1. using serial port (Ch. 10)
- 2. using shifting operators
- Example: write a C program to bring in a byte of data serially one bit at a time via P1.0. LSB should come first

```
#include <reg51.h>
sbit P1b0 = P1^0;
sbin ACCMSB = ACC^7;
void main(void)
{
    unsigned char x;
    for (x=0; x<8; x++)
    {
        ACCMSB = P1B0;
        ACC = ACC >> 1;
    }
}
```

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~~DATA CONVERSION: PACKED BCD TO ASCII~~

- **Packed BCD to ASCII**

- Recall: packed BCD → unpacked BCD → ASCII
- Example: Write a C program to convert packed BCD 0x29 to ASCII, send the result to P1 and P2

```
#include <reg51.h>
void main(void)
{
    unsigned char x, y, z;
    unsigned char packedBCD = 0x29;
    x = packedBCD & 0x0F;    // extract low nibble
    P1 = x | 0x30;           // unpacked BCD → ASCII
    x = packedBCD & 0xF0;    // extract high nibble
    y = x >> 4;              // shift it to low nibble
    P2 = y | 0x30;           // unpacked BCD → ASCII
}
```

~~DATA CONVERSION: ASCII TO BCD~~

- **ASCII to packed BCD**
 - ASCII → unpacked BCD → packed BCD
 - Example: Write C program to convert “47” to packed BCD

DATA CONVERSION: BINARY TO ASCII

- **Binary (or decimal) to ASCII**

- iteratively divided by 10 and keep the remainder
- Example: convert 0xFD = 1111 1101 = 253D to ASCII: '2', '5', '3'

```
#include <reg51.h>
```

```
void main(void)
```

```
{
```

```
    unsigned char quotient, remainder, binbyte;
```

```
    binbyte = 0xFD;    //0xFD=253
```

```
    quotient = binbyte/10;    // quotient = 25
```

```
    remainder = binbyte % 10;    // remainder = 3
```

```
    P0 = remainder | 0x30;    // P0 = '3'
```

```
    binbyte = quotient;    // binbyte = 25;
```

```
    quotient = binbyte/10;    // quotient = 2
```

```
    remainder = binbyte%10;    // remainder = 5
```

```
    P1 = remainder | 0x30;    // P1 = '5'
```

```
    P2 = quotient | 0x30;    // P1 = '2'
```

```
}
```

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RAM AND ROM

- In 8051, data can be stored in
 - RAM (e.g. MOV)
 - ROM (e.g. MOVC)
 - External ROM (e.g. MOVX)
- RAM
 - Compiler will automatically allocate RAM space for declared variables (demo)
 - R0 – R7: bank 0 (00H – 07H)
 - Variables (including array): address 08 and beyond
 - stack: address right after variables.

RAM AND ROM

- **Accessing ROM in C**

- To require the compiler store data in ROM, use the “code” keyword
 - Without code keyword, all the data will be stored in RAM
- The compiler will automatically allocate ROM space for the variables.
- Example

```
#include <reg51.h>
void main(void)
{
    code unsigned char mynum[] = “ABCDEF”;
    unsigned char z;
    for (z = 0; z<=6; z++)
        P1 = mynum[z];
}
```