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H8/300L

Writing a printf function to LCD and a serial port (Bprintf)

Introduction

This application note demonstrated how to write a printf function. Either calling from the library function or custom coded. It also shows the ways to direct its output messages. i.e. either to the SIM IO window, LCD or serial port.

Unlike the PC, which has a standard input (keyboard) and output (console) device, developers have to define the input source and output destination for embedded system.

One such example is the printf function. Embedded developers have to define the output destination for this function. Commonly used outputs are LCD panel, and hyper terminal of PC (through the device serial port).

In this application note, five HEW 2.1 project files are provided, to demonstrate five different scenarios targeting at the SLP H8/38024F. The demonstration is done on the SLP CPU Board (or ALE300L) and the application board.

1. Simulated I/O
2. Printf to LCD panel (using standard library function)
3. Printf to Serial Port (using standard library function)
4. Basic Printf to LCD panel (using custom written code)
5. Basic Printf to Serial Port (using custom written code)

Target Device

H8/300L Super Low Power (SLP) series – H8/38024

Contents

1. Usage of Printf function

Printf is a commonly used function by embedded developer, to provide information to the outside world.

Two main usages are:

i. Providing a user interface (e.g. Blood pressure reading on the LCD panel of a blood pressure product).

ii. Provide a mean for debugging (e.g. sending of raw ADC reading to the PC hyper terminal through the serial port)

Note:

The following examples are build on HEW2.1 (H8 TINY / Super Low Power Tool chain). Previous version of HEW will not be able to access the project files. A simple mean is to create a new project based on user HEW version, and replace the essential C code and header file into the newly generated project directory.

2. Simulated I/O

Developers can start work on the HEW simulator, before the hardware is ready. In order to provide a more efficient debugging environment, Simulated I/O was introduced in the HEW simulator. Simulated I/O provides a mean for the developers to output their results (debugging information) to a debug (SIM IO) window within HEW. i.e. the printf function will direct its messages to be displayed in this window.

The setup of SIM I/O function is created by the HEW project generator. [For this example, the project is built on H8S, H8/300 standard Tool chain. The free H8 TINY / Super Low Power Tool chain do not have the simulator function.

A quick and simple guide to observe the effect of the simulated I/O is listed as follow

i. At step 3 of the project generation, select the option **Use I/O Library,** and **Use heap memory** and leave the number of I/O streams to be **3.**

ii. This will generate/ modify the following files

   a. Lowsrc.c (contain the low level standard I/O function)

   b. Lowlev.src (contain the charget and charput destination – to the PC SIM IO window)

   c. Resetprg.c (addition of the calling functions, _INIT_IOLIB() and _CLOSEALL() to initialized the standard I/O)

   d. Sbrk.c (allocation of heap memory)

iii. Add a printf() in the main routine (remember to add - #include <stdio.h>)

iv. Change the default debug session from ”Debug” to “SimDebug_H8-300L”

v. **Build** the project (F7)

vi. Goto Option/**Debug Setting** window, and set the session to “SimSessionH8-300L” and the following will be automatically set.

a. Setup the target as “H8/300L Simulator”

b. Setup the default Debug Format as “Elf/Dwarf2”

c. Add the download modules as the compiled file in step v.

vii. Change the session to “SimSession H8-300L”

viii. Goto Option/ simulator/ **Simulator Memory Resources**

Add memory available in the memory map as read/write. The allocated resources will be display in the system memory resources. [Automatically set by HEW]

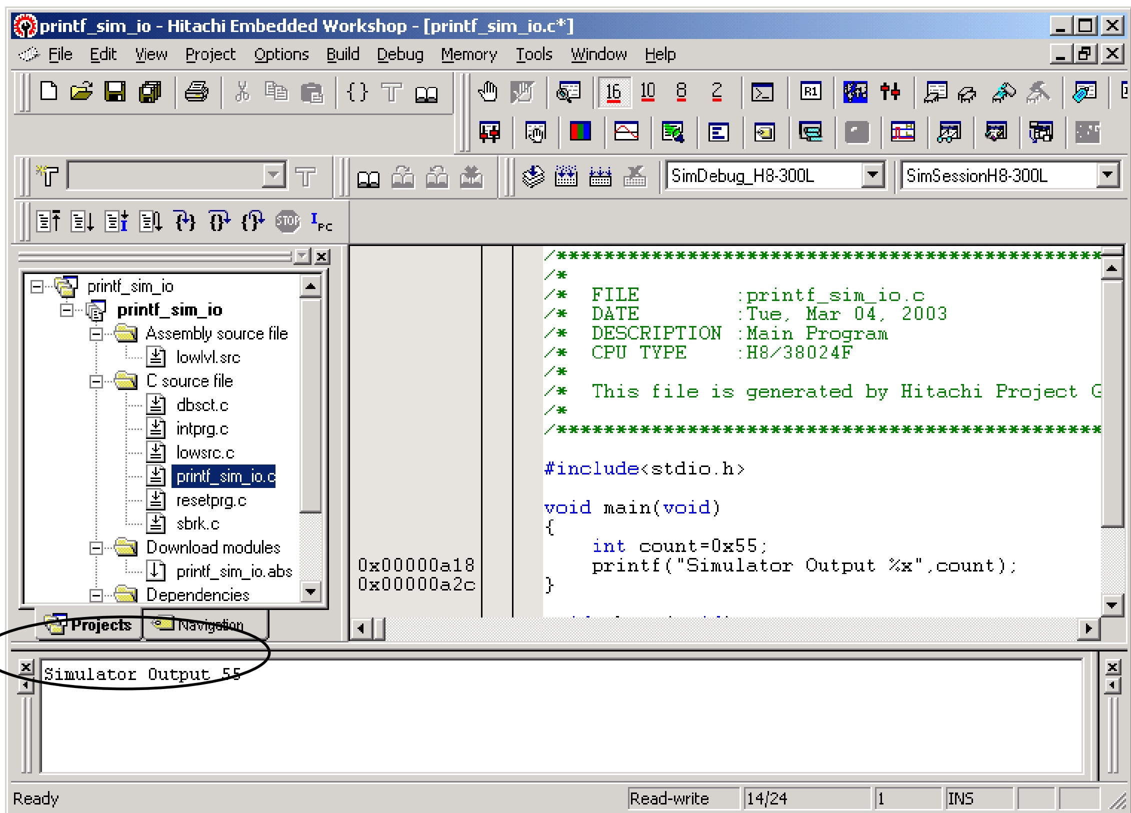
ix. Goto Option/ simulator/ **Simulator System** -> to enable system call address [Automatically set by HEW]

x. Goto Debug/**Download Modules** -> to load the files [Previously set in Debug setting]

xi. Goto View/ **Simulated IO**

xii. Goto Debug/**Reset Go**

xiii. Observe the message in the simulated I/O window



A detailed steps-by steps guide is provided in the HEW on-line user manual.

The following is the HEW-generated reset routine.

```
__entry(vect=0) void PowerON_Reset(void)
{
    set_imask_ccr(1);
   _INITSCT();
// _CALL_INIT();     // Remove the comment when you use global class object
   _INIT_IOLIB();    // Use SIM I/O
// errno=0;          // Remove the comment when you use errno
// srand(1);         // Remove the comment when you use rand()
// _s1ptr=NULL;      // Remove the comment when you use strtok()
// HardwareSetup();  // Remove the comment when you use Hardware Setup
   set_imask_ccr(0);

   main();

   _CLOSEALL();      // Use SIM I/O
// _CALL_END();      // Remove the comment when you use global class object
   sleep();
}
```

The following is HEW-generated Lowlev.src, to send character to SIM IO

```
         .EXPORT    _charput
         .EXPORT    _charget
SIM_IO:  .EQU       H'0000
         .SECTION   P,CODE,ALIGN=2
;------------------------------------------------------------------------
;  _charput:
;------------------------------------------------------------------------
_charput:
         MOV.B      R0L,@IO_BUF
         MOV.W      #H'0102,R0
         MOV.W      #IO_BUF,R1
         MOV.W      R1,@PARM
         MOV.W      #PARM,R1
         JSR        @SIM_IO
         RTS
;------------------------------------------------------------------------
;  _charget:
;------------------------------------------------------------------------
_charget:
         MOV.W      #H'0101,R0
         MOV.W      #IO_BUF,R1
         MOV.W      R1,@PARM
         MOV.W      #PARM,R1
         JSR        @SIM_IO
         MOV.B      @IO_BUF,R0L
         RTS
;------------------------------------------------------------------------
;  I/O Buffer
;------------------------------------------------------------------------
         .SECTION   B,DATA,ALIGN=2
PARM:    .RES.W     1
IO_BUF:  .RES.B     1
         .END
```

3. Modification of Charput and Charget functions

From the above examples, we can observe that the HEW function generator has generated all the necessary functions for the printf(), to output its message to the SIM IO window. If programmers have the intention to output the messages to other means, such as serial port and LCD, the charput function in lowsrc.src file can be modified. Programmers may write these two functions in C and placed in another .c file.

The following shows two examples of output mean:

i. Serial port

ii. LCD

3.1 Printf to Serial port

3.1.1 Coding Description

This demonstration makes use of the Serial Port 3 (SCI-3) in the SLP application board.

The main routine will initialize the general IO and the SCI-3. Next the printf function will output a series of characters through the charput function. The charput function will send the data out through the serial port.

The “no_float.h” must be declared before “stdio.h“, this is to reduce the printf function code size (if programmers are not going use the floating point formatter).

```
#include <no_float.h>
#include <stdio.h>
#include "iodefine.h"
#include <machine.h>

static const char string[] = {"\n\n\rCan putstr too!"};

void main(void)
{
   int count=0;

   init_io();
   init_sci();

   printf("\n\n\n\rDemonstration of printf function");
   printf("\n\rCounting = ");

   for (count=0;count<10;count++)
      printf(" %d",count);

   PutStr((char *)string);
}
```

The following elaborate the three functions that main function called;

i. void init_io(void); //general initialization routine

```
void init_io(void)
{
   P_IO.PCR3.BYTE = 0x00;    //P37..P31 : inputs
   P_IO.PUCR3.BYTE = 0x00;   //Turn off the MOS pull-up

   //PMR3 : |AEVL|AEVH|---|---|---|TMOFH|TMOFL|---|
   P_IO.PMR3.BYTE = 0x00;

   P_IO.PCR4.BYTE = 0xF8;    //P40 is connected to keypad 0

   //PMR2 : |---|---|POF1|---|---|---|---|IRQ0| : |1|1|0|1|1|0|0|1|
   P_IO.PMR2.BYTE = 0xD9;

   //PMR9 : |---|---|---|---|PIOFF|---|PWM2|PWM1|
   P_IO.PMR9.BYTE = 0xF0;

   //PMRB : |---|---|---|---|IRQ1|---|---|---|
   P_IO.PMRB.BYTE = 0xF7;

#if ALE300L_38024||ALE300L_3802
   init_sci();
#endif

   //IEGR : |---|---|---|---|---|---|IEG1|IEG0| : |1|1|1|0|0|0|0|0|
   P_SYSCR.IEGR.BYTE = 0xE0;

   //IENR1 : |IENTA|---|IENWP|---|---|IENEC2|IEN1|IEN0| : |0|0|0|0|0|
   P_SYSCR.IENR1.BYTE = 0x01;
   P_SYSCR.IENR2.BYTE = 0x10;

   set_imask_ccr(0);
}
```

ii. void init_sci(void); // initialization of SCI-3 to 2400bps, 8 bit, 1 stop bit, no parity

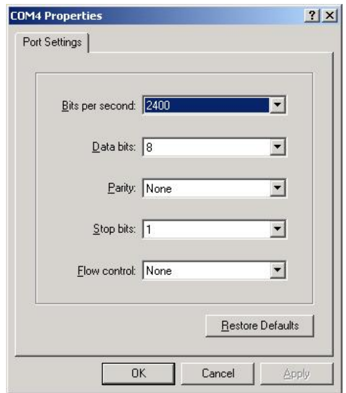
```
void init_sci(void)
{  unsigned char  temp = 0;

   //SCR3 : |TIE|RIE|TE|RE|MPIE|TEIE|CKE1|CKE0|
   //asynchronous mode, internal clock source, SCK32 functions as I/O port
   P_SCI3.SCR3.BYTE = 0x30;

   //SMR : |COM|CHR|PE|PM|STOP|MP|CKS1|CKS0| : |0|0|0|0|0|0|0|0|
   P_SCI3.SMR.BYTE = 0x00;

   //Bit rate = 19200 bps, n = 0, N = 64 // MODIFY TO 2400bps
   P_SCI3.BRR = 64;

   //SPCR : |---|---|SPC32|---|SCINV3|SCINV2|---|---| : |1|1|1|0|0|0|0|0|
   P_SCI3.SPCR.BYTE = 0xE0;

   //SSR  : |TDRE|RDRF|OER|FER|PER|TEND|MPBR|MPBT|
   P_SCI3.SSR.BYTE = 0x84;                //Initialise upon reset to 0x84
}
```

iii. void charput(char outputchar) // send data out to serial port 3

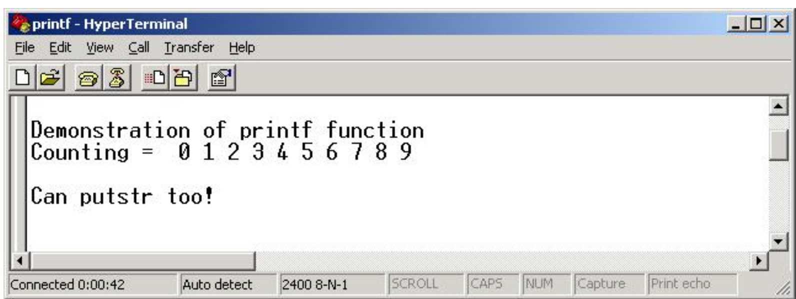
```
void charput(char OutputChar)              //Serial Port
{
   while ((P_SCI3.SSR.BIT.TDRE) == 0);

   P_SCI3.TDR = OutputChar;
   P_SCI3.SSR.BIT.TDRE = 0;
}
```

3.1.2 Hardware Setup

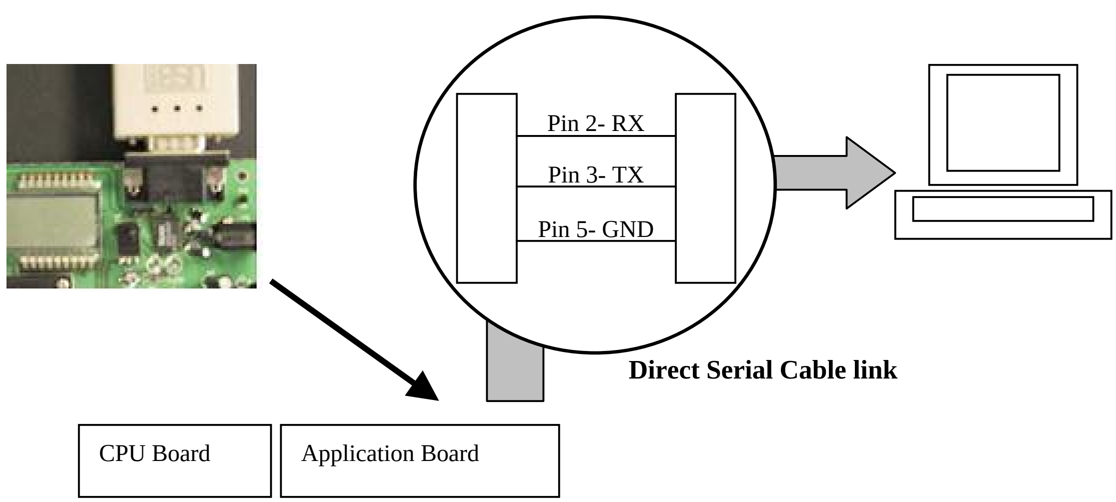
The PC window hyper terminal can be set up to view this message. A serial cable (direct pin to pin type) must be used to link the application board to the PC serial port. A snapshot of the hyper terminal setup is as shown.



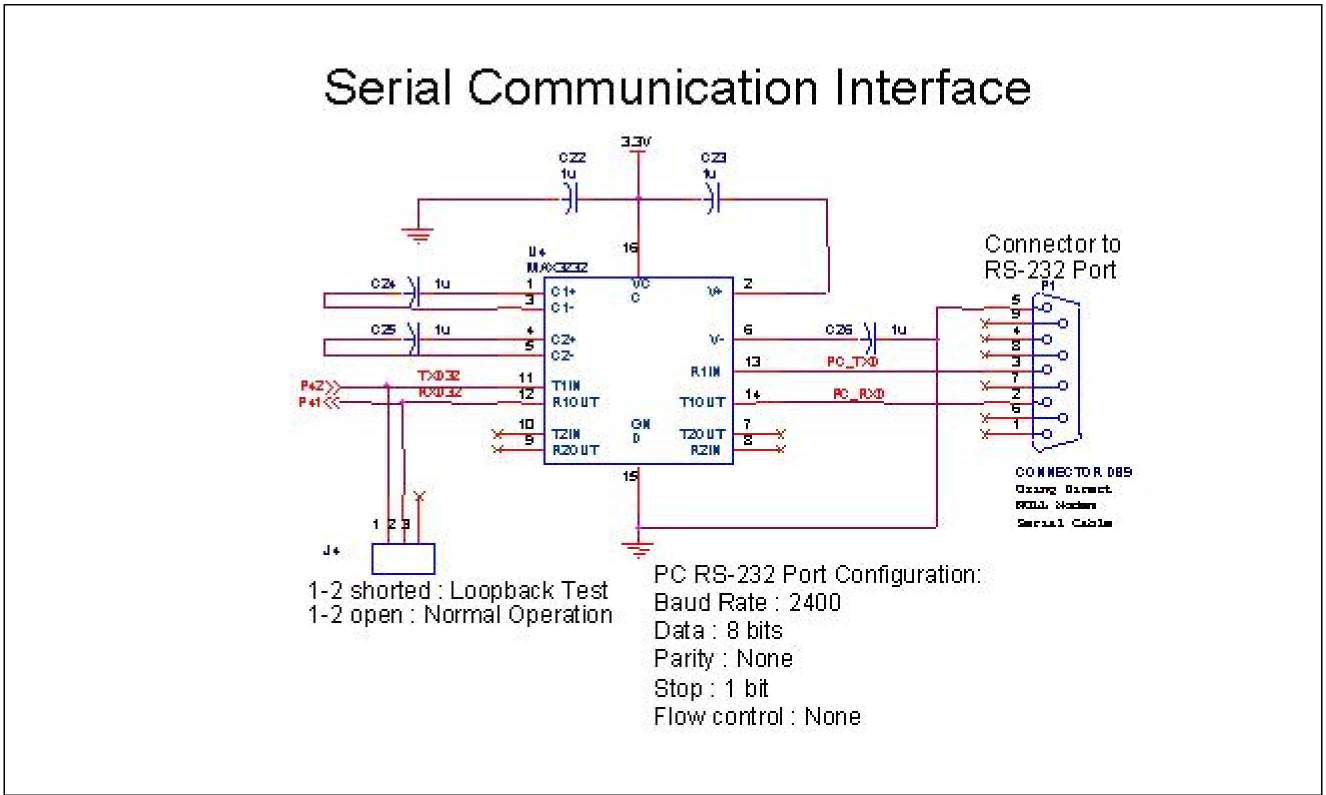
Another snap shot of the output message.



The physical setup:



A RS232 driver, which is built on the application board, is required to interface the MCU to the PC.



3.2 Printf to LCD

3.2.1 Coding Description

This demonstration makes use of the LCD in the SLP application board.

After the main routine initialized the general I/O and LCD, the standard library Printf function can be called. At this time, the charput function directs its output to the LCD (1 row x 7 characters). The global variable, *position*, determines the position of the character to be displayed on the LCD.

```
#include <no_float.h>
#include <stdio.h>

#include "iodefine.h"
#include "printf_lcd.h"
#include <machine.h>

unsigned int position=7;

void main(void)
{
  char temp1 ='e';
  int  temp2 =15; //0xF

  init_io();
  init_lcd();

  printf("HI %c %x", (BYTE)temp1, (DWORD)temp2);
 }
```

The sample code contains four main functions;

i. void init_io(void); //general initialization routine (identical as section 3.1)

ii. void init_lcd(void) // initialization of LCD

```
void init_lcd(void)
{
   unsigned char  temp_a;
   unsigned char  *dest;

   //clear LCD RAM
   dest = (unsigned char *)0xF740;
   for (temp_a = 0 ; temp_a < 16 ; temp_a++)
   {
      *dest++ = 0;
   }

   //LPCR : |DTS1|DTS0|CMX|---|SGS3|SGS2|SGS1|SGS0| : |1|1|0|0|0|1|1|0|
   //|DTS1|DTS0| = |1|1| : 1/4 duty
   //|CMX | = 0
   //Bit 4 is reserved; only 0 can be written to this bit
   //|SGS3|SGS2|SGS1|SGS0| = |1|0|0|0| : Use SEG1 to SEG32
   P_LCD.LPCR.BYTE = 0xC8;   //1/4 duty cycle

   //LCR : |---|PSW|ACT|DISP|CKS3|CKS2|CKS1|CKS0| : |1|1|1|1|1|1|1|1|
   //Bit 7 is reserved; always read as 1 and cannot be modified
   //PSW = 1 : LCD drive power supply on
   //ACT = 1 : LCD controller/driver operates
   //DISP = 1 : LCD RAM data is displayed
   P_LCD.LCR.BYTE = 0xFF;    //display is faint

   //LCR2 : |LCDAB|---|---|---|---|---|---|---|
   //LCDAB : 0 : drive using A waveform
   //Bits 6 and 5 are reserved; always read as 1 and cannot be modified
   //Bits 4 to 0 are reserved; only 0 can be written to these bits
   P_LCD.LCR2.BYTE = 0x60;
}
```

iii. void Display_number(…) // display the 'number' in the LCD, which can only displays 7 characters

```
void display_number(unsigned char digit, unsigned char number, unsigned char
decimal_point)
{
   unsigned short *dest;

   switch(digit)
   {
      case 0:     dest = (unsigned short *)0xF740;
               break;
      case 1:     dest = (unsigned short *)0xF742;
               break;
      case 2:     dest = (unsigned short *)0xF744;
               break;
      case 3:     dest = (unsigned short *)0xF746;
               break;
      case 4:     dest = (unsigned short *)0xF748;
               break;
      case 5:     dest = (unsigned short *)0xF74A;
               break;
      case 6:     dest = (unsigned short *)0xF74C;
               break;
      case 7:     dest = (unsigned short *)0xF74E;
               break;
      default:    break;
   }

   if (decimal_point)
      *dest = (unsigned short)(lcd_number_data[number] | 0x0800);
   else
      *dest = lcd_number_data[number];
}
```

iv. void charput(char outputchar) // call display_number() to display characters.

```
void charput(char OutputChar)
{
    display_number(position, OutputChar, 0);
    position--;
}
```

v. Printf_lcd.h // look up table to convert character to be display in LCD

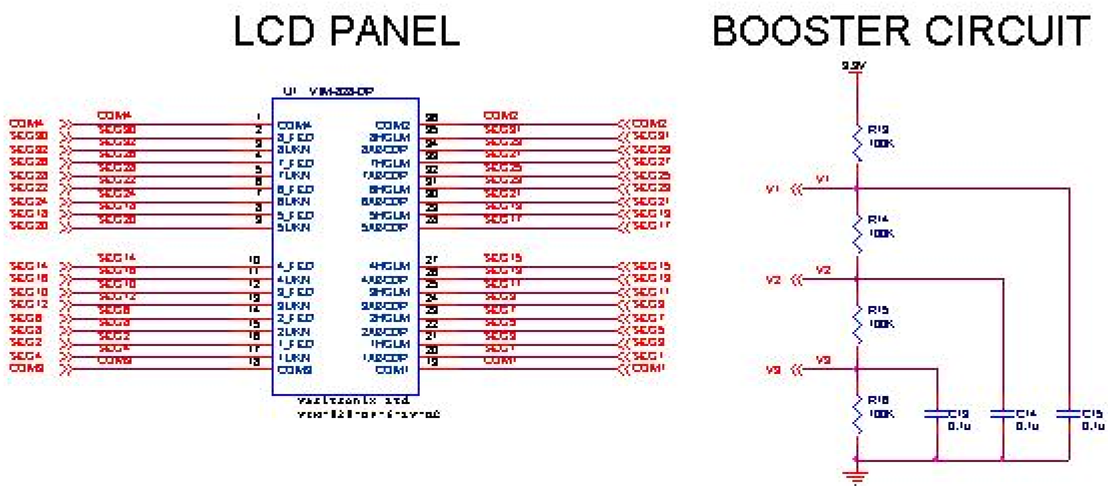
```
//for 1/4 duty cycle
const unsigned short lcd_number_data[128]
= {                   //ASCII
                      0x0039, //  00.   'NUL'     :Display
                      0x0039, //  01.   'SOH'     :Display
                      0x0039, //  02.   'STX'     :Display
                      0x0039, //  03.   'ETX'     :Display
                      0x0039, //  04.   'EOT'     :Display
                      0x0039, //  05.   'ENQ'     :Display
                      0x0039, //  06.   'ACK'     :Display
                      0x0039, //  07.   'BEL'     :Display
                      0x0039, //  08.   'BS'      :Display
                      0x0039, //  09.   'HT'      :Display
                      0x0039, //  0A.   'LF'      :Display
                      0x0039, //  0B    'VT'      :Display
                      0x0039, //  0C.   'FF'      :Display
                      0x0039, //  0D.   'CR'      :Display
                      0x0039, //  0E.   'SO'      :Display
                      0x0039, //  0F.   'SI'      :Display
                      0x0039, //  10.   'DLE'     :Display
                      0x0039, //  11.   'DC1'     :Display
                      0x0039, //  12.   'DC2'     :Display
                      0x0039, //  13.   'DC3'     :Display
                      0x0039, //  14.   'DC4'     :Display
                      0x0039, //  15.   'NAK'     :Display
                      0x0039, //  16.   'SYN'     :Display
                      0x0039, //  17.   'ETB'     :Display
                      0x0039, //  18.   'CAN'     :Display
                      0x0039, //  19.   'EM'      :Display
                      0x0039, //  1A.   'SUB'     :Display
                      0x0039, //  1B.   'ESC'     :Display
                      0x0039, //  1C.   'FS'      :Display
                      0x0039, //  1D.   'GS'      :Display
                      0x0039, //  1E.   'RS'      :Display
                      0x0039, //  1F.   'US'      :Display
                      0x0000, //  20.   'SP'      :Space, all segment off
                      0x0039, //  21.   '!'       :Display
                      0x2200, //  22.   '"'       :"
                      0x0039, //  23.   '#'       :Display
                      0xA55A, //  24.   '$'       :$
                      0x0039, //  25.   '%'       :Display
                      0x0039, //  26.   '&'       :Display
                      0x0010, //  27.   '''       :'
                      0x0039, //  28.   '('       :Display
                      0x0039, //  29.   ')'       :Display
                      0x00E7, //  2A.   '*'       :*
                      0x005A, //  2B.   '+'       :+
```

```
0x0039, //  2C.   ','       :Display
0x0042, //  2D.   '-'       :-
0x0800, //  2E.   '.'       :.
0x0024, //  2F.   '/'       :/
0xE724, //  30.   '0'       :0
0x0600, //  31.   '1'       :1
0xC342, //  32.   '2'       :2
0x8742, //  33.   '3'       :3
0x2642, //  34.   '4'       :4
0xA542, //  35.   '5'       :5
0xE542, //  36.   '6'       :6
0x0700, //  37.   '7'       :7
0xE742, //  38.   '8'       :8
0x2742, //  39.   '9'       :9
0x0039, //  3A.   ':'       :Display
0x0039, //  3B.   ';'       :Display
0x00A0, //  3C.   '<'       :<
0x8100, //  3D.   '='       :=
0x0005, //  3E.   '>'       :>
0x0039, //  3F.   '?'       :Display
0x0039, //  40.   '@'       :Display
0x6742, //  41.   'A'       :A
0xE442, //  42    'B'       :b
0xE100, //  43.   'C'       :C
0xC642, //  44.   'D'       :D
0xE142, //  45.   'E'       :E
0x6142, //  46.   'F'       :F
0xE540, //  47.   'G'       :G
0x6642, //  48.   'H'       :H
0x8118, //  49.   'I'       :I
0xC600, //  4A.   'J'       :J
0x60A2, //  4B.   'K'       :K
0xE000, //  4C.   'L'       :L
0x6621, //  4D.   'M'       :M
0x6681, //  4E.   'N'       :N
0xE700, //  4F.   'O'       :O
0x6342, //  50.   'P'       :P
0xE780, //  51.   'Q'       :Q
0x63C2, //  52.   'R'       :R
0xA542, //  53.   'S'       :S
0x0118, //  54.   'T'       :T
0xE600, //  55.   'U'       :U
0x0681, //  56.   'V'       :V
0x6684, //  57.   'W'       :W
0x00A5, //  58.   'X'       :x
0x0029, //  59.   'Y'       :Y
0x8124, //  5A.   'Z'       :Z
0xE100, //  5B.   '['       :[
0x0081, /*  5C.   '\'       :\       */
0x8700, //  5D    ']'       :]
0x0084, //  5E.   '^'       :^
0x0000,  //  5F.   ' '       :
0x0001, //  60.   '`'       :`
0xC742, //  61.   'a'       :a
```

```
                    0xE442, //  62     'b'        :b
                    0xC042, //  63.    'c'        :c
                    0xC642, //  64.    'd'        :d
                    0xE142, //  65.    'e'        :E
                    0x6142, //  66.    'f'        :F
                    0xE540, //  67.    'g'        :G
                    0x6442, //  68.    'h'        :h
                    0x8118, //  69.    'i'        :I
                    0xC600, //  6A.    'j'        :J
                    0x60A2, //  6B.    'k'        :K
                    0xE000, //  6C.    'l'        :L
                    0x444A, //  6D.    'm'        :m
                    0x4442, //  6E.    'n'        :n
                    0xC442, //  6F.    'o'        :o
                    0x6342, //  70.    'p'        :P
                    0xE780, //  71.    'q'        :Q
                    0x63C2, //  72.    'r'        :R
                    0xA542, //  73.    's'        :S
                    0x0118, //  74.    't'        :T
                    0xE600, //  75.    'u'        :U
                    0x0681, //  76.    'v'        :V
                    0x6684, //  77.    'w'        :W
                    0x00A5, //  78.    'x'        :x
                    0x0025, //  79.    'y'        :Y
                    0x8124, //  7A.    'z'        :Z
                    0x0039, //  7B.    '{'        :Display
                    0x0018, //  7C.    '|'        :|
                    0x0039, //  7D.    '}'        :Display
                    0x0039, //  7E.    '~'        :Display
                    0x0039, //  7F.    'DEL'      :Display
};
```

3.2.2 Hardware setup

The LCD glass is directly connected to the SLP MCU.



A snap shot of the application board's LCD display .

```
char k='e';
int j =15;

printf("Hi %c%x",(BYTE)k,(DWORD)j);
```

4. Disadvantages of printf() library function

The printf() is a easy to use but a very complex library function. (refers to the H8 compiler user manual for the detail function description) When used in SLP MCU, the function has the following disadvantages

4.1 ROM size

The printf() functions takes up a huge ROM space, as it has to deal with IO stream, heap and lots of arguments. (refer to section 6 for the detail comparison)

Note: SLP H8/38024 has a maximum of 32K Bytes ROM

4.2 RAM size

As printf() has to use the heap memory, a size of H’80 Bytes are reserved purely for printf (If the programmers are not going use the heap for other purposes).

Note: SLP H8/38024 has a maximum of 1K Bytes RAM.

5. Custom written Printf function – Bprintf()

The solution is to custom write a function. In this application note, a Basic Printf (Bprintf) function is generated. Programmers may like to further customize it to their application need.

As compared to the implementation stated in session 2-3, this Bprintf function does not need

i. Lowsrc.c

ii. Lowlev.src

iii. _INIT_IOLIB() and _CLOSEALL() functions call in Resetprg.c

iv. sbrk.c

In another word, it does not require the IO stream and heap memory. It is just a custom written function.

5.1 Function Usage

The Prototype

```
BYTE Bprintf(const char *fmt, BYTE arg1, DWORD arg2);
```

Generally, this function can be called just like normal printf function except that it is limited by

i. The no of display characters (20)

ii. There are only two arguments

iii. The first argument is a BYTE, whereas the second is a DWORD.

iv. The supported arguments are: %x, %c, & %u.

Example of usage:

i. Bprintf("Hello world",0,0);

ii. Bprntf("\n\rGet data = %x from address %x", (BYTE)data, (DWORD)address);

5.2 Functions Description

Unlike the library printf(), the Bprintf() is a simplify version of printf function. It is restricted by

i. MAXCHARS, which determine the string size. This is also the major components to determine the depth of stack used.

ii. The three cases statement, which restrict the use of argument to only %x, %c & %u

iii. The variable, num, which determine the number of arguments to two.

The Bprintf() function will called the charput function to output the message to the destination.

```
#define MAXCHARS       20
#define LEN 9

BYTE Bprintf(const char *fmt, BYTE arg1, DWORD arg2);
void itoab(char **buf, DWORD i, unsigned int base);


BYTE Bprintf(const char *fmt, BYTE arg1, DWORD arg2)
{
   DWORD u;
   BYTE num=0;               // argument index
   BYTE index=0;             // string index
   char buf[MAXCHARS];
   char *buf_ptr;

   buf_ptr = buf;

   // Rearranging output strings
   while (*fmt && index<(MAXCHARS-1))
   {  if (*fmt != '%')
            *buf_ptr++ = *fmt++;         // store string into buf
      else
      {   switch (*++fmt)                // if %, check what type
         {
              case 'x':                  // %x, hexadecimal unsigned number
               if (num == 0)
                  u = (DWORD)arg1;
               else if (num == 1)
                     u = (DWORD)arg2;
                  else
                     break;              //ignore > 2 arg
                  num++;
               *buf_ptr++ = '0';
               *buf_ptr++ = 'x';
                     b_itoab((char **)&buf_ptr, u, (unsigned int)16);
                     break;
```

```
               case 'u':                // %u, decimal unsigned number
               if (num == 0)
                  u = (DWORD)arg1;
               else if (num == 1)
                     u = (DWORD)arg2;
                  else
                     break;             //ignore > 2 arg
                  num++;
                     b_itoab((char **)&buf_ptr, u, (unsigned int)10);
                     break;

               case 'c':                // %c, a single character
               if (num==0)
                  *buf_ptr++ = (char)arg1;
               else if (num == 1)
                  *buf_ptr++ = (char)arg2;
                  else
                     break;             //ignore > 2 arg
                  num++;
                       break;

               default:
                       break;
            }// end switch
            fmt++;
         }// end else
   } //end while

   *buf_ptr = 0;                        // end of string indicator

   // Output rearranged string
   buf_ptr = buf;
      for (index = 0 ; *buf_ptr != (char)0 & index < MAXCHARS ; index++)
      charput(*buf_ptr++);              // output

      return(index);
}
```

The function b_itoab(), which perform conversion from integer to ASCII, has limited the integers to be based either 16 or 10.

```
void b_itoab(char **buf, DWORD i, unsigned int base)
{
      BYTE index=0;
      DWORD rem;
      char conv[LEN];

      if (i == 0)
      {
      (*buf)[0] = '0';
         ++(*buf);
      return;
   }
      conv[index++] = 0;
      while (i)
      {
      rem = i % base;
      if (base == 10)
         conv[index++] = rem + '0';
      else if (base == 16)
      {
         if (rem < 10)
               conv[index++] = rem + '0';
            else
               conv[index++] = rem + 'A'- 0xA;
       }
      i /= base;
      }
      while (conv[--index])
      {
      (*buf)[0] = conv[index];
         ++(*buf);
      }
}
```

The Bprintf() functions can be further customized to

i. Increase the string size

ii. Include other arguments: %f, %3d, %o…

iii. Increase the number of arguments

iv. Increase/ Decrease the argument size (BYTE, WORD, DWORD)

6. Comparison

In order to make a comparison of the code size, the map files for the following project is generated (under Option/ Link Library/List). To simplify the comparison, the size of section P is used to gauge the function's size. Both the debug & release(with optimization) setting are used.

	Debug	Release
Printf LCD (without include <no_float.h>)	20.4KBytes	14.9KBytes
Printf LCD (with include <no_float.h>)	7.4KBytes	5.6KBytes
Bprintf LCD.	1.1KBytes	0.8KBytes

The estimated code size for printf() with floating point formatters support is about 20.4Kbytes. When <no_float.h> is included, it can be reduced to about 7.4Kbytes. However if a customized function is written, the code size is further reduced by 7 times to 1.1K. Another reminder to the reader is that SLP maximum ROM size is just a mere 32K!

For RAM size, the custom Bprintf() function will used about 30 Bytes of stack (when MAXCHAR=20), whereas the library printf() function will reserved 128 (H'80) Bytes of heap memory.

7. Conclusion

As SLP has small ROM size, and most of its targeted application do not required the complication of IO streams. Thus the usage of the library printf() function is not efficient. Programmers are advised to customize their own printf() function.

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	Sep.03	—	First edition issued

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