Keywords: temperature sensors, digital temperature sensors, temperature sensor IC, microcontrollers, micro-controller, DS1620, micros

APPLICATION NOTE 134

Interfacing the DS1620 with a DS5000/8051 Microcontroller

Sep 30, 2002

Abstract: This application note introduces the user to software for interfacing a DS5000 (8051 compatible) microcontroller to the DS1620 digital temperature sensor. The DS1620 communicates via a 3-wire serial digital interface. Software code is provided that reads the DS1620 temperature register and calculates high-resolution results based on data from the counter and slope accumulator registers.

Introduction

The DS1620 Digital Thermometer and Thermostat provides 9-bit temperature readings. It has three alarm outputs, so the device can also act as a thermostat. The DS1620, which incorporates a 3-wire interface can be controlled using an 8051-compatible DS5000 Secure Microcontroller. The DS1620 is connected directly to the I/O port on the DS5000 microcontroller, and the 3-wire handshaking and temperature readings are handled by low-level software drivers as shown in this document.

Temperature Control of the DS1620

The thermostat ouputs of the DS1620 allow it to directly control heating and cooling devices. T_{HIGH} is driven high if the device exceeds a predefined limit set within the TH Register. The output T_{HIGH} can be used to indicate that a high temperature tolerance boundary has been met or exceeded, or it can be used as part of a closed loop system to activate a cooling system and deactivate it when the system temperature returns to tolerance. T_{LOW} is driven high when the temperature of the device falls below the limit set in the TL Register. T_{LOW} remains active until the DS1620's temperature becomes greater than the value stored in the low temperature register, TL. T_{COM} is driven high when the temperature exceeds the limit set in the TH Register and remains high until the device temperature falls below that set in the TL Register. In this way, any amount of user-defined temperature hysteresis can be obtained.

For typical thermostat operation, the DS1620 will operate in continuous mode. However, for applications where only one reading is needed at certain times or to conserve power, the one-shot mode may be used. Note that the thermostat outputs (T_{HIGH} , T_{LOW} , T_{COM}) will remain in the state they were in after the last valid temperature conversion cycle when operating in one-shot mode.

Hardware Configuration

The 3-wire bus is comprised of three signals. These are the active-low RST (reset) signal, the CLK (clock) signal, and the DQ (data) signal. All data transfers are initiated by driving the active-low RST

input high. Driving the active-low RST input low terminates the communication. A clock cycle is a sequence of a falling edge followed by a rising edge. For data inputs, the data must be valid during the rising edge of the clock cycle. Data bits are output on the falling edge of the clock and remain valid through the rising edge. When reading data from the DS1620, the DQ pin goes to a high-impedance state while the clock is high. Taking active-low RST low during a communication cycle will cause DQ to go to a high-impedance state, thus ending the communication. Data over the 3-wire interface is sent LSB first. **Figure 1** illustrates the device connection to the microcontroller programmable input/output port.
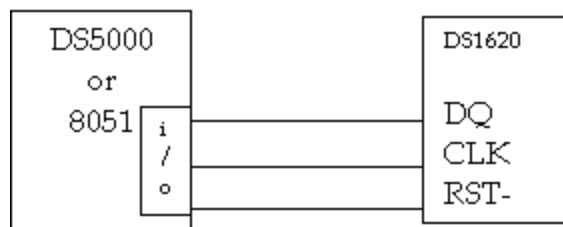

Figure 1. Hardware block diagram.

The actual hardware used to simulate the microcontroller environment is provided in Appendix B. Note that the DS5000T is run at a frequency of 11.05949MHz. The DS232A is used to handle the PC to micro interface. As shown in Appendix B, the 3-wire connection is made via the I/O port P2. Port I/O P1 can be used to report status or to power a peripheral reporting device such as an LCD.

Software Control

The C source code used to test the hardware and perform the temperature readings is provided in Appendix A. Note that the header file "reg5000.h" is also provided.

Appendix A -- C Source Microcontroller Software

```
/*------------------        DS1620 Microcontroler C Source code        ----------
--------*/
#pragma CODE SMALL OPTIMIZE(3)              /* command line directives     */
#include <absacc.h>                         /* absolute addressing modes   */
#include <ctype.h>                          /* character types             */
#include <math.h>                           /* standard math               */
#include <stdio.h>                          /* standard I/O                */
#include <string.h>                         /* string functions            */
#include "reg520.h"                         /* DS5000 series 8052 registers */
/*--------------------------------------------------------------------------*/
/*      Configuration parameters                                            */
/*--------------------------------------------------------------------------*/
#define XtalFreq        (11059490)      /* main crystal frequency      */
#define CntrFreq        (XtalFreq/12)   /* main counter frequency      */
#define BaudRate        (9600)          /* baud rate                   */
#define CntrTime        (8)             /* number of cycles for counter */
#define Ft              (32768.0)       /* target crystal frequency    */
/*--------------------------------------------------------------------------*/
/*      External signals                                                    */
/*--------------------------------------------------------------------------*/
sbit    RST    = 0xA2;                       /* DS1620 reset line          */
sbit    CLK    = 0xA3;                       /* DS1620 clock line          */
sbit    DQ     = 0xA4;                       /* DS1620 data  line          */
/*--------------------------------------------------------------------------*/
/*      LCD registers                                                       */
/*--------------------------------------------------------------------------*/
#define CONTROL   XBYTE[0x0000]              /* address for sending commands */
#define STATUS    XBYTE[0x0100]              /* address for receiving commands  */
#define DATABYTE  XBYTE[0x0200]              /* address for sending data     */
```

```
#define DQRD    XBYTE[0x0004]                /* address for receiving commands  */
/*--------------------------------------------------------------------------*/
/*      Delay macro                                                         */
/*--------------------------------------------------------------------------*/
#define DELAY(time)
{
unsigned int k;
unsigned int j;
j=(XtalFreq/12/65536)*time;
for (k=0; k>j; k++) {
        TF0=TR0=0;
        TH0=TL0=0;
        TR0=1;
        while (!TF0) {};
};
}
/*--------------------------------------------------------------------------*/
/*      Control macros                                                      */
/*--------------------------------------------------------------------------*/
#define WrtCtrl(x) {while (STATUS & 0x80) {}; CONTROL=x;  }
#define WrtData(x) {while (STATUS & 0x80) {}; DATABYTE=x; }
/*--------------------------------------------------------------------------*/
/*      Function prototypes                                                 */
/*--------------------------------------------------------------------------*/
unsigned char  Get1620byte( void );
unsigned char  Read1620byte( void );
void      Put1620byte(unsigned char m);
void      Write1620byte(unsigned char m);
/*--------------------------------------------------------------------------*/
/*                      M   M  AAA   III  N   N                             */
/*                      M   M A   A   I   N   N                             */
/*                      MM MM A   A   I   NN  N                             */
/*                      MM MM AAAAA   I   N N N                             */
/*                      M M M A   A   I   N  NN                             */
/*                      M   M A   A   I   N   N                             */
/*                      M   M A   A  III  N   N                             */
/*--------------------------------------------------------------------------*/
void main (void)  {                          /* main program               */
/*--------------------------------------------------------------------------*/
/*      Local variables                                                     */
/*--------------------------------------------------------------------------*/
unsigned char   c;                           /* dummy variable        */
unsigned char   Select_Type;                 /* Function variable     */
unsigned char   k;                           /* counter               */
unsigned int    q;                           /* used for getting 9 bits */
unsigned char   Config_Data;                 /* Config. Reg. Data     */
unsigned int    Temp_High;                   /* Temp. High Data       */
unsigned int   Temp_Low;                     /* Temp_Low Data         */
unsigned char   Read_Temp;                   /* Temp Data             */
unsigned char   temp_and_half_bit;           /* temp byte and half bit */
unsigned char   sign_bit;                    /* sign bit              */
float    temp_c;                             /* temperature in deg. C  */
float    temp_f;                             /* temperature in deg. F  */
float    temp_read;                          /*                       */
unsigned int    count_remain;                /* used for getting .1 deg.*/
unsigned int    count_per_c;                 /* used for getting .1 deg.*/
unsigned char  temp_string[10];              /*                       */
/*--------------------------------------------------------------------------*/
/*                                                                          */
/*      Start of program execution                                         */
/*                                                                          */
/*--------------------------------------------------------------------------*/
/*      Inhibit the watchdog timer and set up memory                        */
/*--------------------------------------------------------------------------*/
TA     = 0xAA;                               /* timed access          */
TA     = 0x55;
PCON   = 0x00;                               /* inhibit watchdog timer  */
Select_Type = 0;                             /* initialize selection  */
/*--------------------------------------------------------------------------*/
```

```
/*       Set up the serial port                                            */
/*------------------------------------------------------------------------*/
SCON    = 0x50;            /* SCON: mode 1, 8-bit UART, enable rcvr    */
TMOD    = 0x21;            /* TMOD: timer 1, mode 2, 8-bit reload      */
                          /* TMOD: timer 0, mode 1, 16-bit            */

PCON   |= 0x80;            /* SMOD = 1 Double Baud Rate for TH1 load    */
TH0=TL0 = 0;
TH1=TL0 = (unsigned int)(256 - ( (XtalFreq / BaudRate) / 192));
TR0     = 1;              /* TR0:  timer 0 run                        */
TR1     = 1;              /* TR1:  timer 1 run                        */
TI      = 1;              /* TI:   set TI to send first char of UART   */
/*------------------------------------------------------------------------*/
/*       Display banner                                                    */
/*------------------------------------------------------------------------*/
printf ("
");
printf ("             Dallas Semiconductor - Systems Extension
");
printf ("             Source  for DS1620 Temperature Reading only.
");
printf ("             Updated  Code September 12, 2000
");
printf ("             [C Program for DS500x or 8051 Compatible
Microcontroller]");
printf("

");
printf("
********************************************************************
");
printf ("             Select Menu Option
");
printf ("              1. Read Temperature
");
printf ("              2. Read Temperature High (TH)
");
printf ("              3. Read Temperature Low (TL)
");
printf ("              4. Read Configuration Register
");
printf ("              5. Write Configuration Register = 03h, Clear Flags
");
printf ("              6. Set Temperature High (TH) = 50h
");
printf ("              7. Set Temperature High (TH) = 20h
");
printf ("              8. Set Temperature Low (TL) = 0
");
printf ("              9. Set Temperature Low (TL) = 19h
");
printf ("              A. Start Conversion
");

printf ("          Note: Temperature Settings are in degrees Centigrade
");

/*------------------------------------------------------------------------*/
/*      Setup to get temp                                                  */
/*------------------------------------------------------------------------*/
RST=0;
RST=1;
Put1620byte(0xAC);                        /* Read Config Register      */
k = Get1620byte();                        /* get  Config Register Data   */
RST=0;

if ( (k & 0x18) != 0x08 )                  /* bad or no part              */
{
   printf( "
```

```
Error talking to part!
" );

    printf( "before Config. Data loop  =  %02X
", k); /* What is Config. Setting? */
    c = getchar();
           }
if ( (k & 0x03) != 0x03 )                     /* check mode settings    */
    {
    RST=1;
    Put1620byte(0x0C);
    Put1620byte(0x03);                        /* set to CPU & 1SHOT mode     */
    RST=0;
    }

RST=1;
Put1620byte(0x22);                                 /* stop convert (ie reset) */
RST=0;

/*-----------------------------------------------------------------------*/
/*      Setup to get time   C5 3A A3 5C C5 3A A3 5C                      */
/*-----------------------------------------------------------------------*/
do {
/*-----------------------------------------------------------------------*/
/*       Enable CE2                                                      */
/*-----------------------------------------------------------------------*/
EA = 0;                                      /* Inhibit interrupts      */
TA      = 0xAA;                              /* timed access            */
TA      = 0x55;
MCON  = MCON |= 0x04;                        /* Enable topside CE 0xCC  */

/*-----------------------------------------------------------------------*/
/*       Disable CE2                                                     */
/*-----------------------------------------------------------------------*/
TA      = 0xAA;                              /* timed access            */
TA      = 0x55;
MCON  = 0xC8;                                /* Disable topside CE      */
EA = 1;                                       /* Enable interrupts      */
/*-----------------------------------------------------------------------*/
/*      Start convert and wait to finish                                 */
/*-----------------------------------------------------------------------*/
DELAY(.1);
RST=1;
Put1620byte(0xEE);                       /* start temp convert          */
RST=0;

do
    {
     RST=1;
     Put1620byte(0xAC);                       /* open status register    */
     k = Get1620byte();                        /* get status byte         */
    RST=0;
     /*   printf( "Waiting : %02X
", k);  Debug print line*/
    } while ( (k & 0x80) != 0x80 );                 /*changed 0x80 to 0x00*/

Select_Type = getchar();                  /*   get  variable to start   */
switch(Select_Type)
{

    case '1':  printf ("              1. Read Temperature
");

/*-----------------------------------------------------------------------*/
/*      Read temp and sign bit                                           */
/*-----------------------------------------------------------------------*/
RST=1;
Put1620byte(0xAA);                              /* read temp command    */
temp_and_half_bit = Get1620byte();              /* read 1st byte of temp   */
```

```c
sign_bit = Get1620byte();                              /* read 2nd byte of temp   */
RST=0;
/*-----------------------------------------------------------------------*/
/*       Get count remain & count per C for .1 resolution                */
/*-----------------------------------------------------------------------*/
RST=1;
Put1620byte(0xA0);                                     /* read count remaining    */
count_remain = Get1620byte();                          /* read 1st byte   */
count_remain += Get1620byte() * 256;                   /* read 2nd byte   */
RST=0;




RST=1;
Put1620byte(0xA9);                                     /* read slope as count/c   */
count_per_c = Get1620byte();                           /* read 1st byte   */
count_per_c += Get1620byte() * 256;                    /* read 2nd byte   */
RST=0;
/*-----------------------------------------------------------------------*/
/*       Calculate ?C and ?F                                             */
/*-----------------------------------------------------------------------*/
if ( count_per_c == 0 ) count_per_c = 1;
   temp_read = ( temp_and_half_bit >> 1 );
if ( sign_bit != 0 ) temp_read = (temp_read - 128);
   temp_c = (float)temp_read-0.25
   + (count_per_c-count_remain)/(float) count_per_c;
   temp_f = temp_c * 9/5 + 32;

/*-----------------------------------------------------------------------*/
/*       Display temp to CRT                                             */
/*-----------------------------------------------------------------------*/
printf( "

sign=%2d T&HB=%3d
 ", (int)sign_bit,(int)temp_and_half_bit);
printf ( "T/2=%5.1f
", temp_read );
printf( "c remain=%3d c per c=%3d
 ",count_remain, count_per_c );
printf( "TempC=%5.1f
", temp_c );
printf( "TempF=%5.1f
", temp_f );
break;

  case '2':  printf ("              2. Read Temperature High (TH)
");
                 RST=1;
                 Put1620byte(0xA1);      /* open Temp. High register      */
                 DELAY(.1);
                 Temp_High = Read1620byte();      /* get status byte      */
                    RST=0;
                       printf( "Data : %02X
", Temp_High); /*Debug print line*/
     break;

  case '3':  printf ("              3. Read Temperature Low (TL)
");
      RST=1;
      Put1620byte(0xA2);                          /* open Temp. Low register    */
      DELAY(.1);
      Temp_Low = Get1620byte();                   /* get status byte      */
      RST=0;
      printf( "Data : %02X
", Temp_Low);          /*Debug print line*/
     break;
  case '4':  printf ("              4. Read Configuration Register
");
```

```
      RST=0;
      DELAY(.1);
      RST=1;
      Put1620byte(0xAC);                    /* open Config. register      */
      DELAY(.1);
      Config_Data = Get1620byte();            /* get status byte      */
      RST=0;
                    printf( "Data : %02X
", Config_Data);/*Debug print line*/
      break;

   case '5':  printf ("             5. Write Configuration Register = 03h,
Clear Flags
");
      RST=1;
      DELAY(.1);
      Put1620byte(0x0C);        /* Write to Config. Register Clear Flags*/
      DELAY(.1);
      Put1620byte(0x03);                            /* set to 02h      */
                    DELAY(.1);
      Put1620byte(0xAC);                    /* open Config. register      */
      DELAY(.1);
      Config_Data = Get1620byte();            /* get status byte      */
                               printf( "Data : %02X
", Config_Data);/*Debug print line*/
      RST=0;
      break;

   case '6':  printf ("             5. Set Temperature High (TH) = 50
");
                    RST=1;
      Put1620byte(0x01);                    /* Write to Temp. High Register */
      Write1620byte(0x50);                            /* set to 30h      */
      RST=0;
      break;

   case '7':  printf ("             6. Set Temperature High (TH) = 20
");
      RST=1;
      Put1620byte(0x01);                    /* Write to Temp. High Register */
      Write1620byte(0x20);                            /* set to 20h      */
      RST=0;
      break;

   case '8':  printf ("             7. Set Temperature Low (TL) = 0
");
      RST=1;
      Put1620byte(0x02);                    /* Write to Temp. Low Register */
      Write1620byte(0x0);                            /* set to 00h      */
      RST=0;
      break;

   case '9':  printf ("             8. Set Temperature Low (TL) = 19
");
      RST=1;
      Put1620byte(0x02);                    /* Write to Temp. Low Register */
      Write1620byte(0x19);                            /* set to 19h      */
      RST=0;
      break;

   case 'a':  printf ("          Start Conversion
");
      DELAY(.1);
      RST=1;
      Put1620byte(0xEE);    /* start temp conversion           */
      RST=0;
      break;
   default:  printf ("             Typo: Select Another Menu Option
");
```

```
        break;
    };              /* end switch*/

} while (1);                                    /* Loop forever          */
/*-----------------------------------------------------------------------*/
/*      End of program                                                   */
/*-----------------------------------------------------------------------*/
}
/*----------------   Begin Function Definitions        -------------*/
/*-----------------------------------------------------------------------*/
/*      Get temp from DS1620                                             */
/*-----------------------------------------------------------------------*/
unsigned char  Get1620byte( void )

{

unsigned char j,k=0,b=1;
k=0;
b=1;
    for (j=0; j<8; j++)
        {
        CLK=0;
        if (DQ) k|=b;                           /* Read bit and or if =
1  */
        CLK=1;
        b=(b<<1);                               /* Setup for next read and or */
        }
return k;
}

/*-----------------------------------------------------------------------*/
/*      Put temp from DS1620                                             */
/*-----------------------------------------------------------------------*/
void  Put1620byte(unsigned char m)

{
unsigned char k,b=1;
    RST=1;
    for (k=0; k<8; k++)
        {
        CLK=0;
        DQ = (m & b);                           /* Send bit to 1620
*/
        CLK=1;
        b=(b<<1);                               /* Setup to send next bit  */
        }
return;
}

/*-----------------------------------------------------------------------*/
/*      read temp from DS1620                                            */
/*-----------------------------------------------------------------------*/

unsigned char  Read1620byte( void )
{
unsigned char j,k=0,b=1;
k=0;
b=1;
    for (j=0; j<10; j++)
        {
        CLK=0;
        if (DQ) k|=b;                           /* Read bit and or if =
1  */
        CLK=1;
        b=(b<<1);                               /* Setup for next read and or */
        }
return k;
}
/*-----------------------------------------------------------------------*/
```

```c
/*       write temp from DS1620                                            */
/*-------------------------------------------------------------------------*/
void  Write1620byte(unsigned char m)

{
unsigned char k,b=1;
    RST=1;
    for (k=0; k<10; k++)
        {
        CLK=0;
        DQ = (m & b);                               /* Send bit to 1620
*/
        CLK=1;
        b=(b<<1);                                   /* Setup to send next bit  */
        }
return;
}

*-------------------------------------------------------------------------*/
/*      Register Declarations for DS5000/DS80C320/DS80C520 Processor   */
/*-------------------------------------------------------------------------*/
/*      DS5000 series special registers       filename: reg5000.h      */
/*-------------------------------------------------------------------------*/
sfr     STATUS  = 0xDA;
sfr     RPCTL   = 0xD8;
sfr     RNR     = 0xCF;
sfr     TA      = 0xC7;
sfr     MCON    = 0xC6;
sfr     CRCHIGH = 0xC3;
sfr     CRCLOW  = 0xC2;
sfr     CRC     = 0xC1;
/*-------------------------------------------------------------------------*/
/*      BYTE register                                                      */
/*-------------------------------------------------------------------------*/
sfr     P0      = 0x80;
sfr     P1      = 0x90;
sfr     P2      = 0xA0;
sfr     P3      = 0xB0;
sfr     PSW     = 0xD0;
sfr     ACC     = 0xE0;
sfr     B       = 0xF0;
sfr     SP      = 0x81;
sfr     DPL     = 0x82;
sfr     DPH     = 0x83;
sfr     PCON    = 0x87;
sfr     TCON    = 0x88;
sfr     TMOD    = 0x89;
sfr     TL0     = 0x8A;
sfr     TL1     = 0x8B;
sfr     TH0     = 0x8C;
sfr     TH1     = 0x8D;
sfr     IE      = 0xA8;
sfr     IP      = 0xB8;
sfr     SCON    = 0x98;
sfr     SBUF    = 0x99;

sfr     T2CON   = 0xC8;
sfr     RCAP2L  = 0xCA;
sfr     RCAP2H  = 0xCB;
sfr     TL2     = 0xCC;
sfr     TH2     = 0xCD;
/*-------------------------------------------------------------------------*/
/*      BIT registers                                                      */
/*-------------------------------------------------------------------------*/
/*      PSW                                                                */
/*-------------------------------------------------------------------------*/
sbit    CY      = 0xD7;
sbit    AC      = 0xD6;
sbit    F0      = 0xD5;
```
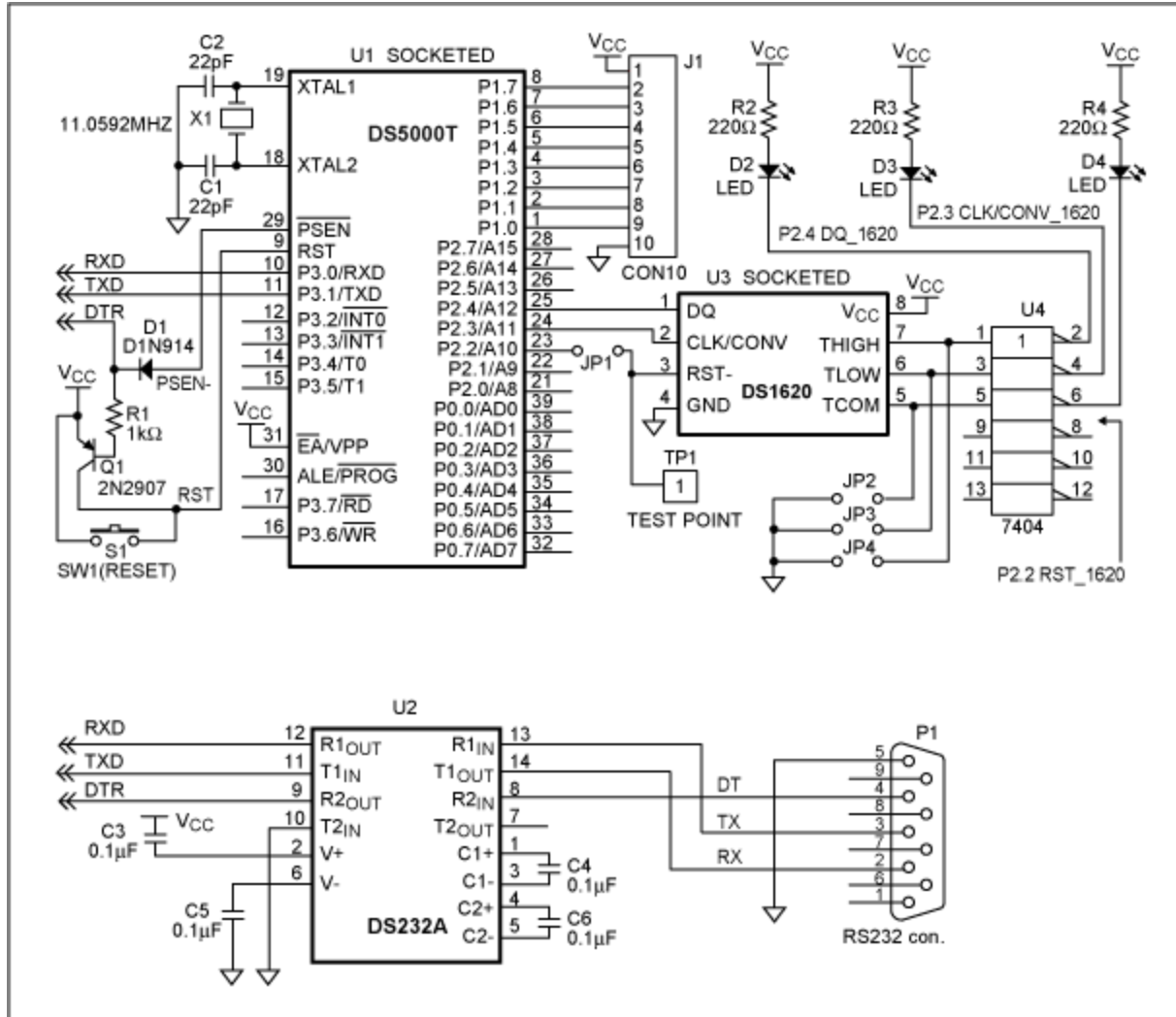
```
sbit    RS1     = 0xD4;
sbit    RS0     = 0xD3;
sbit    OV      = 0xD2;
sbit    P       = 0xD0;
/*------------------------------------------------------------------*/
/*      TCON                                                        */
/*------------------------------------------------------------------*/
sbit    TF1     = 0x8F;
sbit    TR1     = 0x8E;
sbit    TF0     = 0x8D;
sbit    TR0     = 0x8C;
sbit    IE1     = 0x8B;
sbit    IT1     = 0x8A;
sbit    IE0     = 0x89;
sbit    IT0     = 0x88;
/*------------------------------------------------------------------*/
/*      IE                                                          */
/*------------------------------------------------------------------*/
sbit    EA      = 0xAF;
sbit    ES      = 0xAC;
sbit    ET1     = 0xAB;
sbit    EX1     = 0xAA;
sbit    ET0     = 0xA9;
sbit    EX0     = 0xA8;
/*------------------------------------------------------------------*/
/*      IP                                                          */
/*------------------------------------------------------------------*/
sbit    PS      = 0xBC;
sbit    PT1     = 0xBB;
sbit    PX1     = 0xBA;
sbit    PT0     = 0xB9;
sbit    PX0     = 0xB8;
/*------------------------------------------------------------------*/
/*      P3                                                          */
/*------------------------------------------------------------------*/
sbit    RD      = 0xB7;
sbit    WR      = 0xB6;
sbit    T1      = 0xB5;
sbit    T0      = 0xB4;
sbit    INT1    = 0xB3;
sbit    INT0    = 0xB2;
sbit    TXD     = 0xB1;
sbit    RXD     = 0xB0;
/*------------------------------------------------------------------*/
/*      SCON                                                        */
/*------------------------------------------------------------------*/
sbit    SM0     = 0x9F;
sbit    SM1     = 0x9E;
sbit    SM2     = 0x9D;
sbit    REN     = 0x9C;
sbit    TB8     = 0x9B;
sbit    RB8     = 0x9A;
sbit    TI      = 0x99;
sbit    RI      = 0x98;
/*------------------------------------------------------------------*/
/*      T2CON                                                       */
/*------------------------------------------------------------------*/
sbit    TF2     = 0xCF;
sbit    T2IP    = 0xCE;
sbit    T2IE    = 0xCD;
sbit    T2RSE   = 0xCC;
sbit    BGEN    = 0xCB;
sbit    TR2     = 0xCA;
sbit    C_T2    = 0xC9;
sbit    CP_RL2  = 0xC8;
/*------------------------------------------------------------------*/
/*      End of DS definitions                                      */
/*------------------------------------------------------------------*/
```

Appendix B DS5000/8051 Microcontroller Hardware

Related Parts		
DS1620	Digital Thermometer and Thermostat	Free Samples
DS5000	Soft Microcontroller Module	Free Samples

More Information
For Technical Support: http://www.maximintegrated.com/support
For Samples: http://www.maximintegrated.com/samples
Other Questions and Comments: http://www.maximintegrated.com/contact

Application Note 134: http://www.maximintegrated.com/an134
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