Application Note 520
Using a Watchdog Timekeeping RAM with a Microcontroller

INTRODUCTION

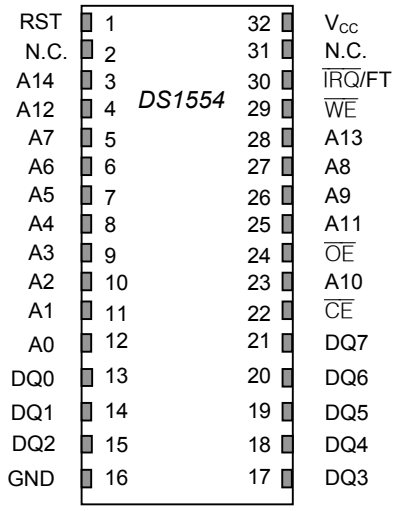
The nonvolatile (NV) Y2K-compliant timekeeping family of real-time clocks (RTCs) provides battery-backed NV static RAM (SRAM), time, and date as well as a watchdog timer. The clock registers are accessed identically to the SRAM. The DS155_ family is available in an encapsulated DIP or surface-mountable PowerCap® package. Table 1 shows a list of products in the nonvolatile timekeeping family.

In this example, a DS1553P, DS1554P, or DS1556P (PowerCap) is connected to a DS87C320. The DS87C320 high-speed microcontroller is compatible with the industry-standard 8051 architecture. For related application notes, please see the QuickView data sheets for the DS87C320 and DS1554. Other NV RAM densities could be supported with appropriate changes to the circuit. The DS155_ PowerCap is placed in the socket labeled DS1646 PWR_CAP. The PowerCap footprint is common to all PowerCap products. The software in this example does not support the DS1557.

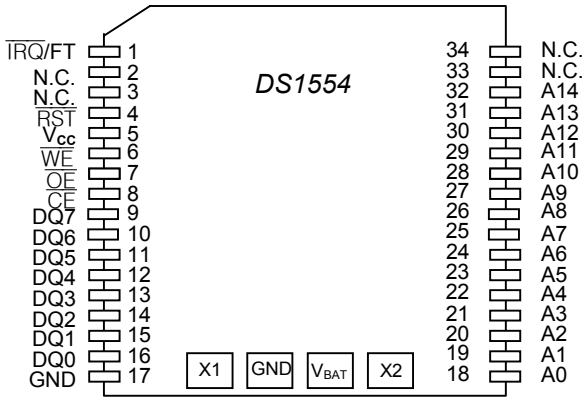
Table 1. Nonvolatile Timekeeping Products

PART	RAM DENSITY	V_{CC} (V)
DS1553	8k x 8	3.3 or 5
DS1554	32k x 8	3.3 or 5
DS1556	128k x 8	3.3 or 5
DS1557	512k x 8	3.3 or 5

PIN CONFIGURATION



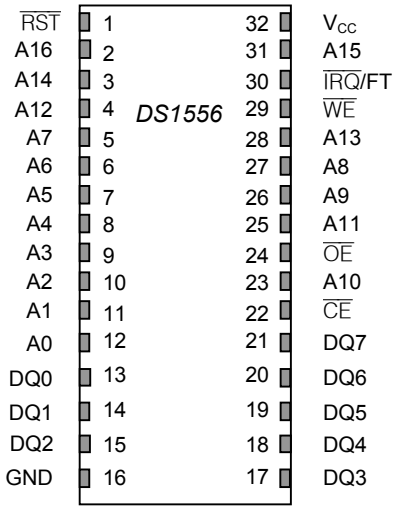
32-Pin Encapsulated DIP



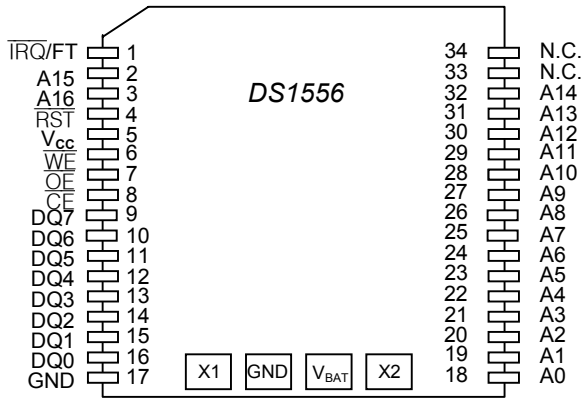
34-Pin PowerCap Module Board (Uses DS9034PCX PowerCap)

PowerCap is a registered trademark of Dallas Semiconductor.

PIN CONFIGURATION (CONTINUED)



32-Pin Encapsulated DIP



34-Pin PowerCap Module Board
(Uses DS9034PCX PowerCap)

EXAMPLE SOFTWARE

```
/*************************************************************************/
/* DS1556.c - access DS1553/4/6/7 using Ref RTC circuit                  */
/* This program if for example only and is not supported by Dallas       */
/* Semiconductor Maxim                                                   */
/*************************************************************************/
#pragma code symbols debug
#include <stdio.h>            /* Prototypes for I/O functions            */
#include <DS5000.h>           /* Register declarations for DS5000        */
#include <absacc.h>           /* needed to define xdata addresses */
#include <delay.c>
/************************* bit definitions ****************************/
/***************************** Defines ********************************/
/************************* Global Variables ***************************/
uchar int_flg = 0;
unsigned    MAXADD;

sbit  IRQb  = P3^2;
sbit  AD16  = P1^5;
sbit  AD17  = P1^6;
sbit  AD18  = P1^7;
/********************** Function Prototypes ***************************/
void  writereg();
void  init_rtc();
void  Disp_Clk_Regs();
void  ramread();
void  ramwrite();
void  wd1shot();
void  toggle_ft();
void  checkint();

void init_rtc()   /* ------------ set the time and date ----------------- */
/* Note: NO error checking is done on the user entries! */
```

```
{
uchar yr, mn, dt, dy, hr, min, sec, day;

      XBYTE[0xfff7] = 0;      /* disable watchdog */
      XBYTE[0xfff6] = 0;      /* disable alarms */

      printf("\nEnter the year (0-99): ");
      scanf("%bx", &yr);
      printf("Enter the month (1-12): ");
      scanf("%bx", &mn);
      printf("Enter the date (1-31): ");
      scanf("%bx", &dt);
      printf("Enter the day (1-7): ");
      scanf("%bx", &dy);
      printf("Enter the hour (1-23): ");
      scanf("%bx", &hr);
      printf("Enter the minute (0-59): ");
      scanf("%bx", &min);
      printf("Enter the second (0-59): ");
      scanf("%bx", &sec);

      AD16 = AD17 = AD18 = 1;
      XBYTE[0xfff8] = 0x80;   /* set write bit for write */
      XBYTE[0xfff9] = sec;
      XBYTE[0xfffa] = min;
      XBYTE[0xfffb] = hr;
      XBYTE[0xfffc] = dy;
      XBYTE[0xfffd] = dt;
      XBYTE[0xfffe] = mn;
      XBYTE[0xffff] = yr;
      XBYTE[0xfff8] = 0;      /* clear write bit to allow update */
}
void Disp_Clk_Regs()          /* ---------------------------------------- */
{
uchar msec, Sec, prv_sec = 99, Min, Hrs, Dte, Mon, Day, Yr;

      AD16 = AD17 = AD18 = 1;
      printf("\n    Yr Mn Dt Dy Hr:Mn:Sec AD AH:AM:AS");
      while(!RI)  /* Read & Display Clock Registers */
      {
            XBYTE[0xfff8] = 0x40;   /* set read bit to stop updates */
            Sec = XBYTE[0xfff9];
            Min = XBYTE[0xfffa];
            Hrs = XBYTE[0xfffb];
            Day = XBYTE[0xfffc];
            Dte = XBYTE[0xfffd];
            Mon = XBYTE[0xfffe];
            Yr  = XBYTE[0xffff];
            XBYTE[0xfff8] = 0;      /* clear read bit to resume updates */
            delay(3);               /* must allow time for transfer to occur */

            if(Sec != prv_sec)      /* display every time seconds change */
            {
                  printf("\nDUT %02.bX %02.bX %02.bX %02.bX", Yr, Mon, Dte, Day);
                  printf(" %02.bX:%02.bX:%02.bX", Hrs, Min, Sec);

                  printf(" %02.bX %02.bX:%02.bX.%02.bX", XBYTE[0xfff5],
                        XBYTE[0xfff4], XBYTE[0xfff3], XBYTE[0xfff2]);
            }
```

```
            prv_sec = Sec;
      }
      RI = 0;  /* Swallow keypress to exit loop */
}
void disp_clk_regs_int()            /* ----- display time using irq output ----- */
{
uchar msec, Sec, Min, Hrs, Dte, Mon, Day, Yr;

      XBYTE[0xfff5] = 0x80;   /* mask alarm date */
      XBYTE[0xfff4] = 0x80;   /* mask alarm hours */
      XBYTE[0xfff3] = 0x80;   /* mask alarm minutes */
      XBYTE[0xfff2] = 0x80;   /* mask alarm seconds */
      XBYTE[0xfff6] = 0x80;   /* enable alarm, configured for 1/sec */
      XBYTE[0xfff8] = 0;            /* clear read bit to enable updates */

      EX0 = 1;    /* enable interrupt 0 */
      IT0 = 1;    /* edge activated */
      PX0 = 0;    /* low priority */
      EX1 = 0;    /* disable interrupt 1 */
      EA = 1;     /* enable all interrupts */

      AD16 = AD17 = AD18 = 1;
      printf("\n    Yr Mn Dt Dy Hr:Mn:Sc WA AD AH:AM:AS FL");
      while(!RI)  /* Read & Display Clock Registers */
      {
            while(!int_flg);  /* wait for interrupt */

            /* in a real application, we'd service the interrupt once per second,
                  and let the micro do something else the rest of the time.  We
                  don't need to use the 'R' bit to disable transfers as long as
                  we take less than 1 second to service the interrupt */

            if(int_flg & 0x40)      /* only display if an alarm caused the interrupt
*/
            {
                  EX0 = EX1 = 0;    /* disable interrupts while updating the display
*/

                  Sec = XBYTE[0xfff9];
                  Min = XBYTE[0xfffa];
                  Hrs = XBYTE[0xfffb];
                  Day = XBYTE[0xfffc];
                  Dte = XBYTE[0xfffd];
                  Mon = XBYTE[0xfffe];
                  Yr  = XBYTE[0xffff];

                  printf("\nDUT %02.bX %02.bX %02.bX %02.bX", Yr, Mon, Dte, Day);
                  printf(" %02.bX:%02.bX:%02.bX", Hrs, Min, Sec);

                  printf("     %02.bX     %02.bX     %02.bX:%02.bX.%02.bX     %02.bX",
XBYTE[0xfff7],
                        XBYTE[0xfff5], XBYTE[0xfff4], XBYTE[0xfff3], XBYTE[0xfff2],
                        XBYTE[0xfff0]);

                  int_flg = 0;            /* for this example, we'll just clear all
interrupt sources */
                  EX0 = EX1 = 1;    /* re-enable interrupts */
            }
      }
```

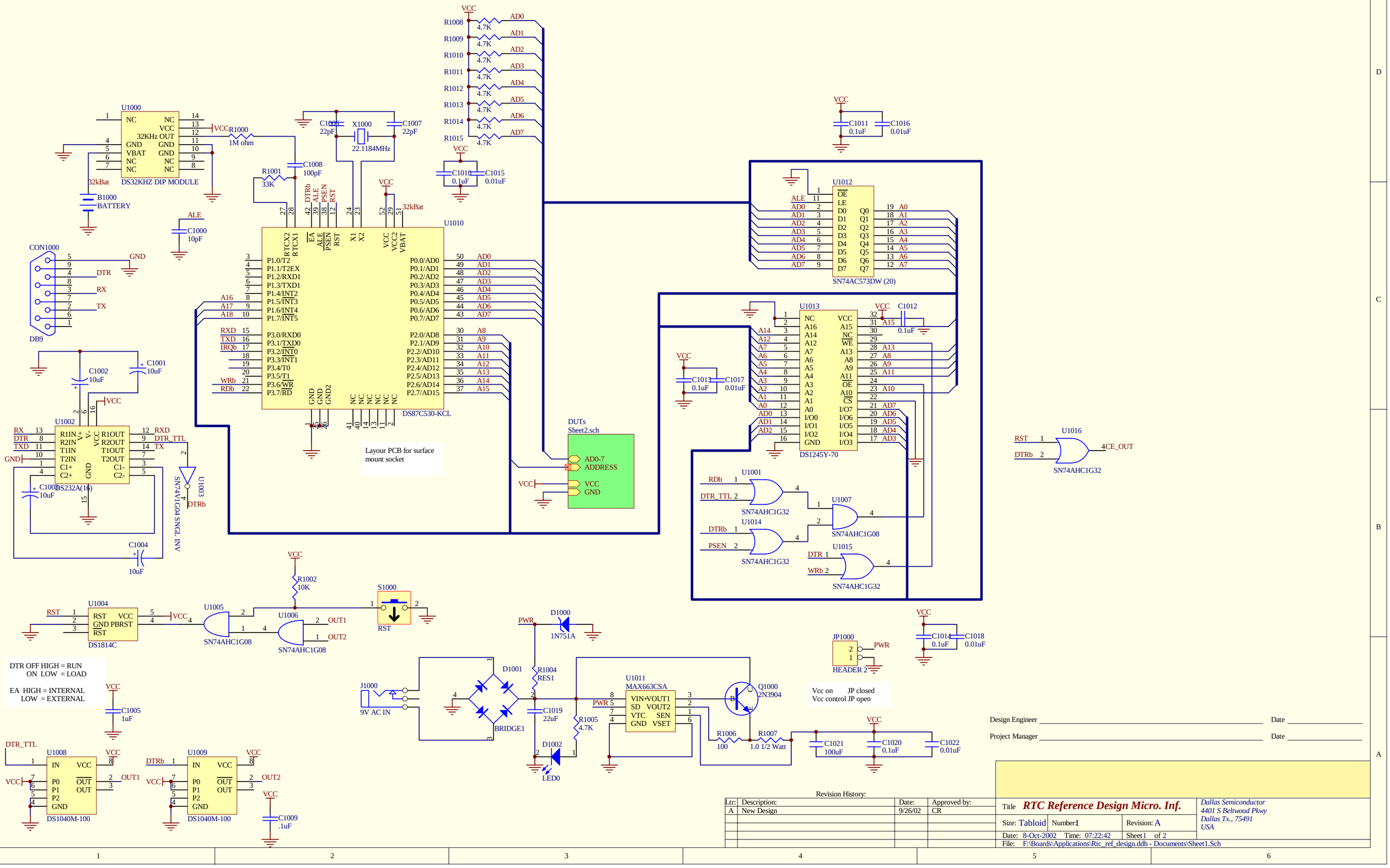
```
      EX0 = 0;          /* disable interrupt */
      XBYTE[0xfff6] = 0;      /* disable alarm */
      RI = 0;           /* Swallow keypress to exit loop */
}
void ramread()          /* ---------------------------------------- */
{
unsigned int j;

      AD16 = AD17 = AD18 = 0;

      for (j = 0; j <= MAXADD; j++)
      {
            if(j != 0 && !(j % 256) )
            {
                  printf("\nPress a key or Esc to exit ");
                  if( _getkey() == 0x1b)
                        return;
            }
            if(!(j % 16)) printf("\n%bx%04x ", (uchar) AD16, j);
            printf("%02.bx ", (uchar) XBYTE[j]);

            if (j == 0xffff)  break;
      }
      if(MAXADD == 0xffff)
      {
            printf("\nPress a key or Esc to exit ");
            if( _getkey() == 0x1b)
                  return;

            AD16 = 1;
            for (j = 0; j <= MAXADD; j++)
            {
                  if(j != 0 && !(j % 256) )
                  {
                        printf("\nPress a key or Esc to exit ");
                        if( _getkey() == 0x1b)
                              break;
                  }
                  if(!(j % 16)) printf("\n%bx%04x ", (uchar) AD16, j);
                  printf("%02.bx ", (uchar) XBYTE[j]);

                  if (j == 0xffff)  break;
            }
      }
}
void ramwrite()   /* ------------- write with incrementing data ------------- */
{
unsigned int j;
uchar offset = 0;

      if(MAXADD == 0xFFFF)
      {
            AD16 = AD17 = AD18 = 0;
            for (j = 0; j <= MAXADD; j++)
            {
                  XBYTE[j] = (uchar) ( (j & 0xff) + offset);
                  if( (j & 0xff) == 0xff) offset++;
                  if(j == 0xffff)   break;
            }
```

```
      }

      AD16 = 1;
      offset = 0;
      for (j = 0; j < (MAXADD - 16); j++)
      {
            XBYTE[j] = (uchar) ( (j & 0xff) + offset);
            if( (j & 0xff) == 0xff) offset++;
      }
}
void ramfill(uchar dat) /* ------------- fill with fixed data ------------- */
{
unsigned int j;

      if(MAXADD == 0xFFFF)
      {
            AD16 = AD17 = AD18 = 0;
            for (j = 0; j <= MAXADD; j++)
            {
                  if(j & 0x100)
                        XBYTE[j] = dat;
                  else
                        XBYTE[j] = dat ^ 0xff;
                  if(j == 0xffff)   break;
            }
      }
      AD16 = 1;
      for (j = 0; j < (MAXADD - 16); j++)
      {
                  if(j & 0x100)
                        XBYTE[j] = dat;
                  else
                        XBYTE[j] = dat ^ 0xff;
      }
}
void  toggle_ft() /* -------- toggle the Frequency Test bit --------- */
{
uchar creg;

      AD16=1;
      creg = XBYTE[0xfffc];
      if( (creg & 0x40) )                       /* check FT bit */
      {
            XBYTE[0xfff8] = 0x80;         /* set write bit for write */
            XBYTE[0xfffc] = (creg & 0xbf);      /* clear FT bit */
            XBYTE[0xfff8] = 0;                  /* clear write bit */
      }
      else
      {
            XBYTE[0xfff8] = 0x80;         /* set write bit for write */
            XBYTE[0xfffc] = (creg | 0x40);      /* set FT bit */
            XBYTE[0xfff8] = 0;                  /* clear write bit */
      }
}

void  checkint()        /* ------------------------------------------- */
{
      AD16=1;
      XBYTE[0xfff7] = 0x80;   /* set watchdog register */
```

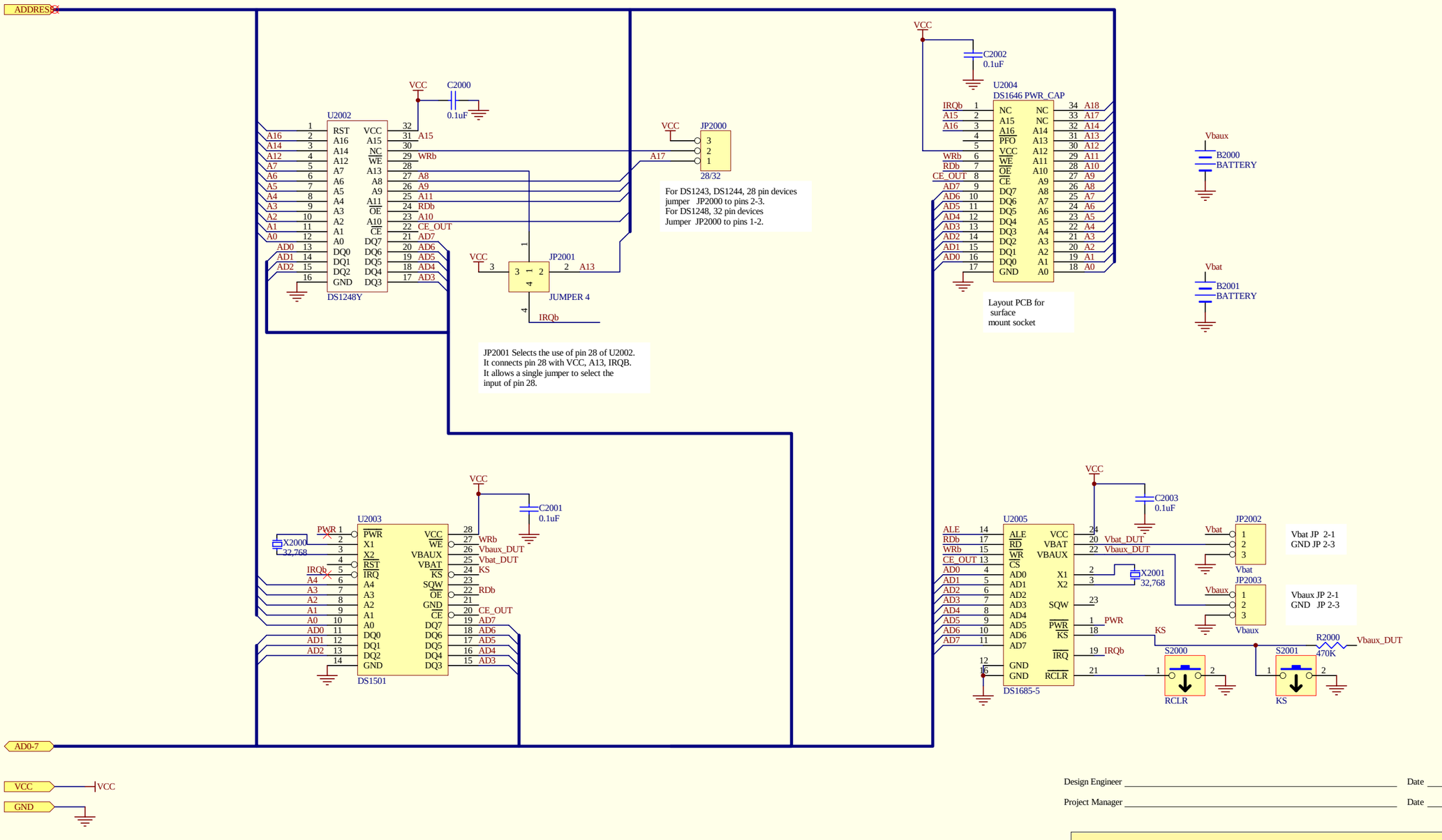
```
      XBYTE[0xfff6] = 0x80;   /* set the interrupt register */

      XBYTE[0xfff5] = 0x80;   /* mask date alarm */
      XBYTE[0xfff4] = 0x80;   /* mask hour alarm */
      XBYTE[0xfff3] = 0x80;   /* mask minute alarm */
      XBYTE[0xfff2] = 0;            /* minute alarm */

      while(1)
      {
            if( XBYTE[0xfff9] == 0x01 )
                  XBYTE[0xfff0];          /* clear the alarm */
      }
}
void  wd_irq_tst()      /* ---- test wd to IRQb function (repeat) ---- */
{
uchar tmp;

      AD16=1;

      IRQb = 1;               /* drive /IRQ high using port i/o */
      XBYTE[0xfff0] = 0;            /* clear interrupt flags */
      XBYTE[0xfff7] = 0x08;   /* enable watchdog, timeout = 2 * 1/16 = 125ms */
      XBYTE[0xfff6] = 0;            /* disable alarm */
      printf("\nPress a key to exit ");
      while(!RI)
      {
            while(IRQb);            /*  wait  for  IRQb  to  go  active  from  watchdog
timeout */
            tmp = XBYTE[0xfff0];    /* clear IRQ */
            tmp = XBYTE[0xfff7];    /* restart timer */
      }
      RI = 0;
}
void  wd_rst_tst()      /* ---- test wd to RSTb function (one shot) ---- */
{
uchar tmp;

      AD16=1;

      XBYTE[0xfff6] = 0;            /* disable alarm */
      XBYTE[0xfff0] = 0;            /* clear interrupt flags */
      XBYTE[0xfff7] = 0x90;   /* enable watchdog, timeout = 4 * 1/16 = 250ms */
      XBYTE[0xfff6] = 0;            /* disable alarm */
}
void  external0_int(void) interrupt 0     /* --- display time/date on interrupt from
RTC --- */
{
      EX0 = EX1 = 0;          /* disable interrupt */
      int_flg = XBYTE[0xfff0];      /* clear the interrupt source, save the info */
      EX0 = EX1 = 1;          /* re-enable interrupt */
}
main (void)       /* ------------------------------------------------------ */
{
uchar i, M, M1;

      IRQb = 1;

      printf("\n1) DS1553 2) DS1554 or 3)DS1556? ");
      i = _getkey();
```

```
MAXADD = 0xffff;  /* default */
if (i == '1')     MAXADD = 0x1fff;
if (i == '2')     MAXADD = 0x7fff;
printf("%x", MAXADD);
while (1)
{
printf("\nDS1553/4/6 build 106\n");
printf("CI Init clock CC Check Int\n");
printf("CR Read Time  CN Rd CLK w/int\n");
printf("RW Write RAM  RR Read RAM\n");
printf("W  Wtchdg tst T  Toggle FT\n");
printf("Enter Menu Selection:");

M = _getkey();

switch(M)
{
      case 'C':
      case 'c':
      printf("\rEnter Clock Routine to run: C");
      M1 = _getkey();

      switch(M1)
      {
            case 'C':
            case 'c':   checkint(); break;

            case 'I':
            case 'i':   init_rtc(); break;

            case 'N':
            case 'n':   disp_clk_regs_int();    break;

            case 'R':
            case 'r':   Disp_Clk_Regs();  break;
      }
      break;

      case 'R':
      case 'r':
      printf("\rFill RAM A)a, 5)5, I)nc data or R)ead: ");
      M1 = _getkey();
      switch(M1)
      {
            case '5':   ramfill(0x55);    break;

            case 'A':
            case 'a':   ramfill(0xaa);    break;

            case 'R':
            case 'r':   ramread();  break;

            case 'I':
            case 'i':   ramwrite(); break;
      }
      break;

      case 'T':
      case 't':   toggle_ft();      break;
```

```
            case 'W':
            case 'w':
            printf("\rEnter wd test I)rq: R)st");
            M1 = _getkey();
            switch(M1)
            {
                  case 'I':
                  case 'i':   wd_irq_tst();     break;

                  case 'R':
                  case 'r':   wd_rst_tst();     break;
            }
            break;
      }
   }
}
```


U1000
DS32KHZ DIP MODULE
32kBat
B1000
BATTERY
R1000
1M ohm
VCC
ALE
C1000
10pF
C1008
100pF
R1001
33K
C1006
22pF
X1000
22.1184MHz
C1007
22pF
R1008
R1009
R1010
R1011
R1012
R1013
R1014
R1015
4.7K
AD0
AD1
AD2
AD3
AD4
AD5
AD6
AD7
C1010
0.1uF
C1015
0.01uF
U1010
DS87C530-KCL
CON1000
DB9
GND
DTR
RX
TX
C1002
10uF
C1001
10uF
U1002
DS232A(16)
C1003
10uF
C1004
10uF
SN74AHC1G04 SNGL INV
DTRb
RXD
DTR_TTL
TX
Layour PCB for surface mount socket
DUTs
Sheet2.sch
AD0-7
ADDRESS
VCC
GND
U1011
MAX663CSA
C1019
22uF
R1004
RES1
R1005
4.7K
D1000
1N751A
D1001
BRIDGE1
D1002
LED0
J1000
9V AC IN
PWR
Q1000
2N3904
R1006
100
R1007
1.0 1/2 Watt
C1021
100uF
C1020
0.1uF
C1022
0.01uF
JP1000
HEADER 2
Vcc on JP closed
Vcc control JP open
U1012
SN74AC573DW (20)
C1011
0.1uF
C1016
0.01uF
U1013
DS1245Y-70
C1013
0.1uF
C1017
0.01uF
C1012
0.1uF
C1014
0.1uF
C1018
0.01uF
U1001
SN74AHC1G32
U1007
SN74AHC1G08
U1014
SN74AHC1G32
U1015
SN74AHC1G32
U1016
SN74AHC1G32
CE_OUT
U1004
DS1814C
U1005
SN74AHC1G08
U1006
SN74AHC1G08
R1002
10K
S1000
RST
OUT1
OUT2
C1005
1uF
U1008
DS1040M-100
U1009
DS1040M-100
C1009
.1uF
DTR OFF HIGH = RUN
ON LOW = LOAD
EA HIGH = INTERNAL
LOW = EXTERNAL
Design Engineer
Project Manager
Date
Revision History:
Ltr: A
Description: New Design
Date: 9/26/02
Approved by: CR
Title RTC Reference Design Micro. Inf.
Size: Tabloid
Number 1
Revision: A
Date: 8-Oct-2002 Time: 07:22:42
Sheet 1 of 2
File: F:\Boards\Applications\Rtc_ref_design.ddb - Documents\Sheet1.Sch
Dallas Semiconductor
4401 S Beltwood Pkwy
Dallas Tx., 75491
USA

Note: Populate U2002, U2003, U2004 or U2005 as needed.



Design Engineer _____ Date _____

Project Manager _____ Date _____

Revision History:

Ltr:	Description:	Date:	Approved by:
A	New Design	9/26/02	CR

Title **RTC Reference Design - R.T.C. Inf.**

Size: Tabloid | Number 1 | Revision: A

Date: 8-Oct-2002 Time: 07:22:44 | Sheet 2 of 2

File: F:\Boards\Applications\Rtc_ref_design.ddb - Documents\Sheet2.sch

Dallas Semiconductor
4401 S Beltwood Pkwy
Dallas Tx., 75491
USA