DALLAS SEMICONDUCTOR

Application Note 95
Interfacing the DS1307/1308 with an 8051–Compatible Microcontroller

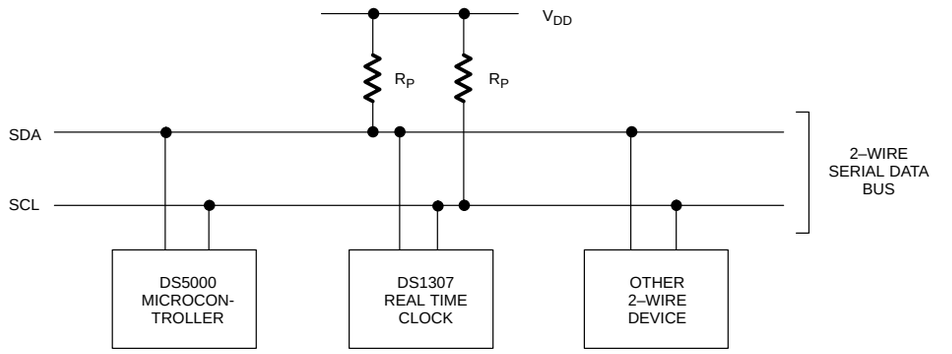
INTRODUCTION
The DS1307 Serial Real Time Clock, which incorporates a 2–wire serial interface, can be controlled using an 8051–compatible DS5000 Secure Microcontroller. The DS1307 is connected directly to two of the I/O ports on a DS5000 microcontroller and the 2–wire handshaking is handled by low–level drivers, which are discussed in this application note.

DS1307 DESCRIPTION
The DS1307 Serial Real Time Clock is a low–power, full BCD clock/calendar plus 56 bytes of nonvolatile SRAM. Address and data are transferred serially via the 2–wire bi–directional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with less than 31 days, including corrections for leap year. The clock operates in either the 24–hour or 12–hour format with AM/PM indicator. The DS1307 has a built–in power sense circuit which detects power failures and automatically switches to the battery supply.

DS1307 OPERATION
The DS1307 operates as a slave device on the serial bus. Access is obtained by implementing a START condition and providing a device identification code followed by a register address. Subsequent registers can be accessed sequentially until a STOP condition is executed. The START and STOP conditions are generated using the low level drives, SEND_START and SEND_STOP found in the attached DS5000 code. Also the subroutines SEND_BYTE and READ_BYTE provide the 2–wire handshaking required for writing and reading 8–bit words to and from the DS1307.

HARDWARE CONFIGURATION
The system is configured as shown in Figure 1. The DS1307 has the 2–wire bus connected to two I/O port pins of the DS5000: SCL – P1.0, SDA – P1.1. The V_{DD} voltage is 5V, R_P = 5KΩ and the DS5000 is using a 12 MHz crystal. The other peripheral device could be any other device that recognizes the 2–wire protocol, such as the DS1621 Digital Thermometer and Thermostat. The interface with the D5000 was accomplished using the DS5000T Kit hardware and software. This development kit allows the PC to be used as a dumb terminal using the DS5000's serial ports to communicate with the keyboard and monitor.

TYPICAL 2–WIRE BUS CONFIGURATION Figure 1



The following bus protocol has been defined (see Figure 2).

- During data transfer, the data line must remain stable whenever the clock line is high. Changes in the data line while the clock line is high will be interpreted as control signals.

Accordingly, the following bus conditions have been defined:

Start data transfer: A change in the state of the data line from high to low, while the clock line is high, defines a START condition.

Stop data transfer: A change in the state of the data line from low to high, while the clock line is high, defines the STOP condition.

Data valid: The state of the data line represents valid data when, after a START condition, the data line is stable for the duration of the high period of the clock signal. The data on the line must be changed during the low period of the clock signal. There is one clock pulse per bit of data.

Each data transfer is initiated with a START condition and terminated with a STOP condition. The number of data bytes transferred between the START and the STOP conditions is not limited, and is determined by the master device. The information is transferred byte–wise and each receiver acknowledges with a ninth bit.

Acknowledge: Each receiving device, when addressed, is obliged to generate an acknowledge after the reception of each byte. The master device must generate an extra clock pulse which is associated with this acknowledge bit.

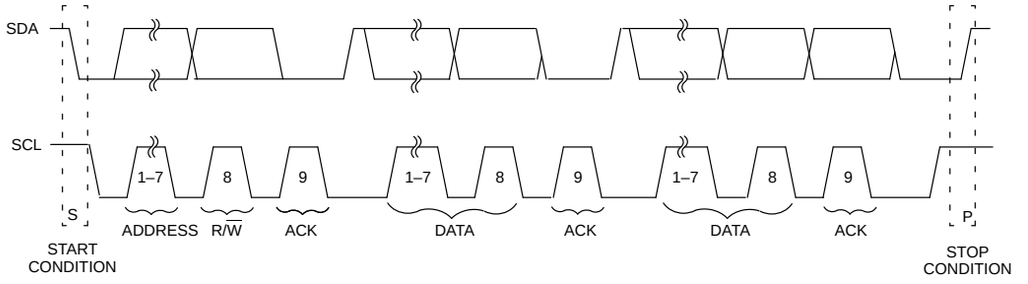
A device that acknowledges must pull down the SDA line during the acknowledge clock pulse in such a way that the SDA line is stable low during the high period of the acknowledge related clock pulse. Of course, setup and hold times must be taken into account. A master must signal an end of data to the slave by not generating an acknowledge bit on the last byte that has been clocked out of the slave. In this case, the slave must leave the data line high to enable the master to generate the STOP condition.

Figure 2 details how data transfer is accomplished on the 2–wire bus. Depending on the state of the R/$\overline{W}$ bit, two types of data transfer are possible:

1. **Data transfer from a master transmitter to a slave receiver.** The first byte transmitted by the master is the slave address. Next follows a number of data bytes. The slave returns an acknowledge bit after each received byte. Data is transferred with the most significant bit (MSB) first.

2. **Data transfer from a slave transmitter to a master receiver.** The first byte (the slave address) is transmitted by the master. The slave then returns an acknowledge bit. This is followed by the slave transmitting a number of data bytes. The master returns an acknowledge bit after all received bytes other than the last byte. At the end of the last received byte, a not acknowledge is returned.

DATA TRANSFER ON 2–WIRE SERIAL BUS Figure 2

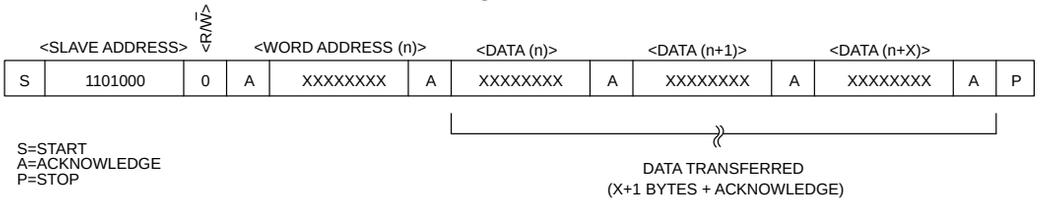


The master device generates all of the serial clock pulses and the START and STOP conditions. A transfer is ended with a STOP condition or with a repeated START condition. Since a repeated START condition is also the beginning of the next serial transfer, the bus will not be released. Data is transferred with the most significant bit (MSB) first.

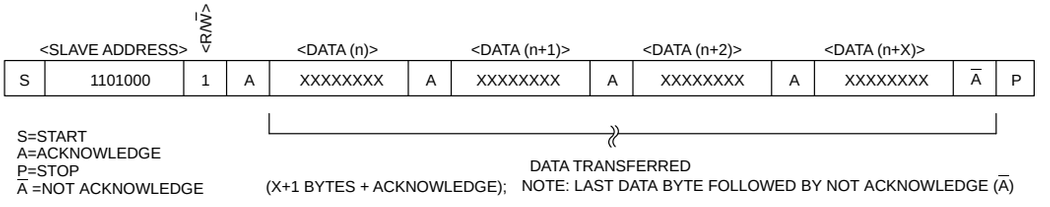
The DS1307 may operate in the following two modes:

1. **Slave receiver mode (DS1307 write mode):** Serial data and clock are received through SDA and SCL. After each byte is received, an acknowledge bit is transmitted. START and STOP conditions are recognized as the beginning and end of a serial transfer. Address recognition is performed by hardware after reception of the slave address and direction bit (see Figure 3). The address byte is the first byte received after the start condition is generated by the master. The address byte contains the 7–bit DS1307 address, which is 1101000, followed by the direction bit (R/$\overline{W}$) which for a write is a 0. After receiving and decoding the address byte, the DS1307 outputs an acknowledge on the SDA line. After the DS1307 acknowledges the slave address + write bit, the master transmits a register address to the DS1307. This will set the register pointer on the DS1307. The master will then begin transmitting each byte of data with the DS1307 acknowledging each byte received. The master will generate a stop condition to terminate the data write.
2. **Slave transmitter mode (DS1307 read mode):** The first byte is received and handled as in the slave receiver mode. However, in this mode, the direction bit will indicate that the transfer direction is reversed. Serial data is transmitted on SDA by the DS1307 while the serial clock is input on SCL. START and STOP conditions are recognized as the beginning and end of a serial transfer (See Figure 4). The address byte is the first byte received after the start condition is generated by the master. The address byte contains the 7–bit DS1307 address, which is 1101000, followed by the direction bit (R/$\overline{W}$) which for a read is a 1. After receiving and decoding the address byte, the DS1307 inputs an acknowledge on the SDA line. The DS1307 then begins to transmit data starting with the register address pointed to by the register pointer. If the register pointer is not written to before the initiation of a read mode, the first address that is read is the last one stored in the register pointer. The DS1307 must be sent a Not–Acknowledge bit by the master to terminate a read.

DATA WRITE – SLAVE RECEIVER MODE Figure 3



DATA READ – SLAVE TRANSMITTER MODE Figure 4



SOFTWARE OPERATION

DS5000 INTERFACE

The software presented in Appendix 1 is written to interface the DS5000 with the DS1307 over the 2–wire interface. The DS5000 was programmed using Dallas Semiconductor's DS5000T Evaluation Kit, which allows a PC to be used as a dumb terminal. The KIT5K software environment supplied with the DS5000T Evaluation Kit provides a high–level interface for loading application software to the DS5000 or for setting its configuration parameters via the Program command. The KIT5K software includes a dumb terminal emulator to allow users to run application software in the DS5000 which communicates with the user via a PC COM port.

DS1307 SOURCE CODE

The first section of the code found in the Appendix is used to configure the DS5000 for serial communication with the PC. Also at the beginning of the code is the MASTER_CONTROLLER subroutine which is used to control the demonstration software.

The subroutines that immediately follow the MASTER_CONTROLLER subroutine are the low level drivers for controlling the 2–wire interface. They are not specific to the DS1307 but can be used with any 2–wire compatible Slave–only device. These subroutines are:

SEND_START
: This subroutine is used to generate the Start condition on the 2–wire bus.

SEND_STOP
: This subroutine is used to generate the Stop condition on the 2–wire bus.

SEND_BYTE
: This subroutine sends an 8–bit word, MSB first, over the 2–wire bus with a 9th clock pulse for the Acknowledge pulse.

READ_BYTE
: This subroutine reads an 8–bit word over the 2–wire bus. It checks for the LASTREAD flag to be cleared indicating when the last read from the slave device is to occur. If it is not the last read, the DS5000 sends an Acknowledge pulse on the 9th clock and if it is the last read from the slave device, the DS5000 sends a Not–Acknowledge.

SCL_HIGH
: This subroutine transitions the SCL line low–to–high and ensures the SCL line is high before continuing.

DELAY and DELAY_4
: These two subroutines have been included to ensure that the 2–wire bus timing is maintained.

The rest of the code included in the appendix is specifically designed to demonstrate the functions of the DS1307. The functions that are demonstrated are:

Setting Time
: The time is read in from the keyboard and stored in the DS5000 scratchpad memory. It is then transferred, over the 2–wire interface, to the DS1307.

Set RAM
: A single hex byte is read in from the keyboard and written to the entire user RAM of the DS1307.

Read Date/Time
: The date and time are read, over the 2–wire bus, and stored in the DS5000 scratchpad memory. It is then written to the screen. This continues until a key is pressed on the keyboard.

Read RAM
: The entire user RAM of the DS1307 is read into the DS5000 scratchpad memory and then written to the PC monitor.

OSC On/ OSC Off
: The DS1307 clock oscillator can be turned on or off.

SQW/OUT On/ SQW/OUT Off
: The SQW/OUT can be turned on or off. It will toggle at 1 Hz.

AC ELECTRICAL CHARACTERISTICS Table 1

PARAMETER	SYMBOL	ACTUAL	UNITS
SCL Clock Frequency	f_{SCL}	59	kHz
Bus Free Time Between a STOP and START Condition	t_{BUF}	5.7	µs
Hold Time (repeated) START Condition	$t_{HD:STA}$	6.2	µs
LOW Period of SCL Clock	t_{LOW}	10.5	µs
HIGH Period of SCL Clock	t_{HIGH}	6.5	µs
Set–up Time for a Repeated START Condition	$t_{SU:STA}$	5.3	µs
Data Hold Time	$t_{HD:DAT}$	5.5	µs
Data Set–up Time	$t_{SU:DAT}$	3.1	µs
Rise Time of Both SDA and SCL Signals	t_R		ns
Fall Time of Both SDA and SCL Signals	t_F		ns
Set–up Time for STOP Condition	$t_{SU:STO}$	5.4	µs

CONCLUSION

It has been shown that it is very straight forward to interface the DS1307 or any other 2–wire slave device to an 8051–compatible microcontroller. The only concern must be that the 2–wire timing specification is not violated by the low level drivers on the microcontroller. The delay subroutines have been inserted into the code for this purpose. The values in Table 1 are the actual timing parameters observed in the hardware setup used to develop this application note.

APPENDIX

DS1307.ASM

```
; Program DS1307.ASM
;
;       This program responds to commands received over the serial
;       port to set the date/time as well as RAM data on the DS1307
;       using a DS5000 as a controller
;

CR              EQU             0DH
LF              EQU             0AH
MCON            EQU             0C6H
PCON            EQU             087H
TA              EQU             0C7H
SCL             BIT             P1.0
SDA             BIT             P1.1
TRIG            BIT             P1.2
DS1307W         EQU             0D0H
DS1307R         EQU             0D1H
FLAGS           DATA            20H
LASTREAD        BIT             FLAGS.0
_12_24  BIT     FLAGS.1
PM_AM   BIT     FLAGS.2
OSC             BIT     FLAGS.3
SQW             BIT     FLAGS.4
ACK             BIT     FLAGS.5
BUS_FAULT       BIT     FLAGS.6
_2W_BUSY        BIT     FLAGS.7
BITCOUNT        DATA    21H
BYTECOUNT       DATA    22H
BYTE            DATA    23H
                CSEG    AT      0
                AJMP    START
;
                CSEG    AT      30H
;*************************************************************
;
;*** RESET GOES HERE TO START PROGRAM ****
;
;*************************************************************
START:
                MOV             TA,#0AAH        ; Timed
                MOV             TA,#55H           ; access.
                MOV             PCON,#0           ; Reset watchdog timer.
                MOV             MCON,#0F8H      ; Turn off CE2 for
                                                  ; memory access.
                MOV             SP,#70H         ; Position stack above
                                                  ; buffer.
                MOV             IE,#0
```

```
                MOV             TMOD,#20H         ; Initialize the
                MOV             TH1,#0FAH      ; serial port
                MOV             TL1,#0FAH      ; for 9600
                ORL             PCON,#80H         ; baud.
                MOV             SCON,#52H
                MOV             TCON,#40H
                ;MOV            R0,#0
                ;MOV            R1,#0
                ;DJNZ   R0,$
                ;DJNZ   R1,$-2
                SETB            SDA                        ; ENSURE SDA HIGH
                LCALL   SCL_HIGH                        ; ENSURE SCL HIGH
                CLR             ACK                        ; CLEAR STATUS FLAGS
                CLR             BUS_FAULT
                CLR             _2W_BUSY
;-------------------------------------------------------------------------
; THIS IS THE MASTER CONTROLLER LOOP
;-------------------------------------------------------------------------
MASTER_CONTROLLER:
                MOV             BYTECOUNT,#10H
FORM_FEED:      MOV             A,#LF                   ; CLEAR SCREEN FOR MAIN
                                                           ; MENU
                LCALL   WRITE_DATA
                DJNZ            BYTECOUNT,FORM_FEED
                MOV             DPTR, #TEXT0            ; PUT MAIN MENU ON
                                                           ; SCREEN
                LCALL   WRITE_TEXT
                MOV             DPTR, #TEXT3
                LCALL           WRITE_TEXT
                LCALL   READ_DATA
                CLR             ACC.5                   ; CONVERT ACC TO UPPER
                                                           ; CASE
                CJNE            A,#'A',NOTA             ; CALL SET CLOCK
                                                           ; FUNCTION
                LCALL   SET_CLOCKM
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTA:
                CJNE            A,#'B',NOTB             ; CALL SET RAM FUNCTION
                                                           ; AND
                LCALL   SET_RAM                         ; CALL READ RAM FUNCTION
                LCALL   READ_RAM
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTB:
                CJNE            A,#'C',NOTC             ; CALL READ CLOCK
                                                           ; FUNCTION
                LCALL   READ_CLOCK
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTC:
                CJNE            A,#'D',NOTD             ; CALL READ RAM
                                                           ; FUNCTION
                LCALL   READ_RAM
```

```
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTD:   CJNE            A,#'E',NOTE             ; CALL OSC CONTROL
                                                        ; FUNCTION
                CLR             OSC                     ; CLR OSC FLAG – ON
                LCALL   OSC_CONTROL
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTE:   CJNE            A,#'F',NOTF                     ; CALL OSC CONTROL
                                                        ; FUNCTION
                SETB            OSC                     ; SET OSC FLAG – OFF
                LCALL   OSC_CONTROL
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTF:   CJNE            A,#'G',NOTG                     ; CALL SWQ CONTROL
                                                        ; FUNCTION
                CLR             SQW                     ; CLR SQW FLAG – ON
                LCALL   SQW_CONTROL_1HZ
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTG:   CJNE            A,#'G',NOTH                     ; CALL SWQ CONTROL
                                                        ; FUNCTION

                CLR             SQW                     ; CLR SQW FLAG – ON
                LCALL   SQW_CONTROL_1HZ
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTH:   CJNE            A,#'H',NOTI                     ; CALL SWQ CONTROL
                                                        ; FUNCTION
                CLR             SQW                     ; CLR SQW FLAG – ON
                LCALL   SQW_CONTROL_4KHZ
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTI:   CJNE            A,#'I',NOTJ                     ; CALL SWQ CONTROL
                                                        ; FUNCTION
                CLR             SQW                     ; CLR SQW FLAG – ON
                LCALL   SQW_CONTROL_8KHZ
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTJ:   CJNE            A,#'J',NOTK                     ; CALL SWQ CONTROL
                                                        ; FUNCTION
                CLR             SQW                     ; CLR SQW FLAG – ON
                LCALL   SQW_CONTROL_32KHZ
                JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
NOTK:   CJNE            A,#'K',NOTL             ; CALL SWQ CONTROL
                                                        ; FUNCTION
                SETB            SQW                     ; SET SQW FLAG – OFF
                LCALL   SQW_CONTROL_1HZ
                JMP             MASTER_CONTROLLER
NOTL:           CJNE            A,#'L',NOTM
                LCALL       SET_RAM_UNQ
                LCALL   READ_RAM
NOTM:   JMP             MASTER_CONTROLLER       ; RETURN TO MAIN MENU
 ;-------------------------------------------------------------------------
;
; THIS SUB SENDS THE START CONDITION
;
;-------------------------------------------------------------------------
```

```
SEND_START:                                    ;
               SETB           _2W_BUSY              ; INDICATE THAT 2WIRE
                                                    ; OPERATION IN PROGRESS
               CLR            ACK                   ; CLEAR STATUS FLAGS
               CLR            BUS_FAULT
               JNB            SCL,FAULT             ; CHECK FOR BUS CLEAR
               JNB            SDA,FAULT             ; BEGIN START CONDITION
               SETB           SDA                   ;
               LCALL   SCL_HIGH              ; SDA
               CLR            SDA
                                                    ;
               LCALL   DELAY          ; SCL ^START CONDITION
               CLR            SCL                   ;
               RET
FAULT:

               SETB           BUS_FAULT             ; SET FAULT STATUS
               RET                                  ; AND RETURN
;---------------------------------------------------------------------
;
; THIS SUB SENDS THE STOP CONDITION
;
 ;---------------------------------------------------------------------
SEND_STOP:                                          ;
               CLR            SDA                   ; SDA
               LCALL   SCL_HIGH              ;
               SETB           SDA                   ; SCL ^STOP CONDITION
               CLR            _2W_BUSY
               RET                                  ;
;---------------------------------------------------------------------
;
; THIS SUB SENDS ONE BYTE OF DATA TO THE DS1307
;
;---------------------------------------------------------------------
SEND_BYTE:
               MOV            BITCOUNT,#08H  ; SET COUNTER FOR 8 BITS
SB_LOOP:
               JNB            ACC.7,NOTONE   ; CHECK TO SEE IF BIT 7 OF
                                                    ; ACC IS A 1
               SETB           SDA                   ; SET SDA HIGH (1)

               JMP            ONE
NOTONE:
               CLR            SDA                   ; CLR SDA LOW (0)
ONE:
               LCALL   SCL_HIGH              ; TRANSITION SCL LOW-TO-HIGH
               RL             A                     ; ROTATE ACC LEFT ONE BIT
               CLR            SCL                   ; TRANSITION SCL HIGH-TO-LOW
               DJNZ           BITCOUNT,SB_LOOP      ; LOOP FOR 8 BITS
               SETB           SDA                   ; SET SDA HIGH TO LOOK
                                                    ; FOR ACKNOWLEDGE PULSE
```

```
                LCALL   SCL_HIGH                ; TRASITION SCL LOW-TO-HIGH
                CLR             ACK                     ; CLEAR ACKNOWLEDGE FLAG

                JNB             SDA,SB_EX               ; CHECK FOR ACK OR NOT ACK
                SETB            ACK                     ; SET ACKNOWLEDGE FLAG FOR
                                                        ; NOT ACK
SB_EX:
                LCALL           DELAY           ; DELAY FOR AN OPERATION
                CLR                     SCL                ; TRANSITION SCL
                                                        ; HIGH-TO-LOW
                LCALL           DELAY           ; DELAY FOR AN OPERATION
                RET
;---------------------------------------------------------------------
;
; THIS SUB READS ONE BYTE OF DATA FROM THE DS1307
;
 ;---------------------------------------------------------------------
READ_BYTE:
                MOV             BITCOUNT,#008H             ; SET COUNTER FOR 8 BITS OF

                                                        ; DATA
                MOV             A,#00H                  ;
                SETB            SDA                        ; SET SDA HIGH TO ENSURE
LINE
                                                        ; FREE
READ_BITS:
                LCALL   SCL_HIGH                ; TRANSITION SCL LOW-TO-HIGH
                MOV             C,SDA           ; MOVE DATA BIT INTO CARRY
                                                        ; BIT \
                RLC             A                       ; ROTATE CARRY BIT INTO ACC.0
                CLR             SCL                     ; TRANSITION SCL HIGH-TO-LOW
                DJNZ            BITCOUNT,READ_BITS      ; LOOP FOR 8 BITS
                JB              LASTREAD,ACKN           ; CHECK TO SEE IF THIS IS THE
                                                        ; LAST READ
                CLR             SDA                     ; IF NOT LAST READ SEND
                                                        ; ACKNOWLEDGE BIT
ACKN:
                LCALL   SCL_HIGH                ; PULSE SCL TO TRANSIMIT
                                                        ; ACKNOWLEDGE
                CLR             SCL                     ; OR NOT ACKNOWLEDGE BIT
                RET

;---------------------------------------------------------------------- ;
;
; THIS SUB SETS THE CLOCK LINE HIGH
;
;---------------------------------------------------------------------
SCL_HIGH:
                SETB            SCL                     ; SET SCL HIGH
                JNB             SCL,$           ; LOOP UNTIL STRONG 1 ON SCL
                RET
```

```
;------------------------------------------------------------------------ ;
;
; THIS SUB DELAY THE BUS
;
;------------------------------------------------------------------------
DELAY:
               NOP                                  ; DELAY FOR BUS TIMING
               RET
;------------------------------------------------------------------------
;
; THIS SUB DELAYS 4 CYCLES
;
;------------------------------------------------------------------------
DELAY_4:
               NOP                                  ; DELAY FOR BUS TIMING
               NOP
               NOP
               NOP
               RET

;------------------------------------------------------------------------
;
; THIS SUB SETS THE CLOCK (MANUAL)
;
;------------------------------------------------------------------------
SET_CLOCKM:
               MOV            R1,#2EH                 ; SET R1 TO SCRATCHPAD
MEMORY
                                                      ; FOR DATE/TIME
               MOV            DPTR, #YEAR             ; GET THE DATE/TIME
                                                      ; INFORMATION FROM THE

               LCALL   WRITE_TEXT                     ; USER. WRITE THE DATE/TIME
                                                      ; TO SCRATCHPAD
               LCALL   READ_BCD                       ; MEMORY
               MOV            @R1,A
               DEC            R1
               MOV            DPTR, #MONTH
               LCALL   WRITE_TEXT
               LCALL   READ_BCD
               MOV            @R1,A
               DEC            R1
               MOV            DPTR, #DAY
               LCALL   WRITE_TEXT
               LCALL   READ_BCD
               MOV            @R1,A
               DEC            R1
               MOV            DPTR, #DAYW
               LCALL   WRITE_TEXT
               LCALL   READ_BCD
               ANL            A, #7
```

```
                MOV             @R1,A
                DEC             R1
                MOV             DPTR, #HOUR
                LCALL   WRITE_TEXT
                LCALL   READ_BCD
                MOV             @R1,A
                DEC             R1
                MOV             DPTR, #MINUTE
                LCALL   WRITE_TEXT
                LCALL   READ_BCD
                MOV             @R1,A
                DEC             R1
                MOV             DPTR, #SECOND
                LCALL   WRITE_TEXT
                LCALL   READ_BCD
                MOV             @R1,A
                MOV             R1,#28H                 ; POINT TO BEGINNING OF CLOCK
                                                        ; DATA IN SCRATCHPAD MEMORY

                LCALL   SEND_START              ; SEND 2WIRE START CONDITION
                MOV             A,#DS1307W              ; SEND DS1307 WRITE COMMAND
                LCALL   SEND_BYTE
                MOV             A,#00H          ; SET DATA POINTER TO
                                                        ; REGISTER 00H ON
                LCALL   SEND_BYTE               ; THE DS1307
SEND_LOOP:
                MOV             A,@R1           ; MOVE THE FIRST BYTE OF DATA
                                                        ;TO ACC
                LCALL   SEND_BYTE               ; SEND DATA ON 2WIRE BUT
                INC             R1
                CJNE            R1,#2FH,SEND_LOOP ; LOOP UNTIL CLOCK DATA SENT
                                                        ; TO DS1307
                LCALL   SEND_STOP               ; SEND 2WIRE STOP CONDITION
                RET
;---------------------------------------------------------------------
;
; THIS SUB SETS THE DS1307 USER RAM TO THE VALUE IN 'BYTE'
;
;---------------------------------------------------------------------
SET_RAM:

                MOV             R1,#08H                    ; POINTER TO BEGINNING OF
                                                           ; DS1307 USER RAM
                MOV             DPTR, #TEXT5            ; MESSAGE TO ENTER DATA BYTE
                LCALL   WRITE_TEXT                      ;
                LCALL   READ_BCD                        ; READ BYTE FROM KEYBOARD
                MOV             BYTE,A                  ; AND STORE IN 'BYTE'

                LCALL   SEND_START                      ; SEND 2WIRE START CONDITION
                MOV             A,#DS1307W                 ; LOAD DS1307 WRITE COMMAND
```

```
                LCALL   SEND_BYTE                       ; SEND WRITE COMMAND
                MOV             A,#08H                  ; SET DS1307 DATA POINTER TO
                                                          ; BEGINNING
                LCALL   SEND_BYTE                       ; OF USER RAM – 08H
SEND_LOOP2:
                MOV             A,BYTE                  ; WRITE BYTE TO ENTIRE RAM
                                                          ; SPACE
                LCALL   SEND_BYTE                       ; WHICH IS 08H TO 37H
                INC             R1
                CJNE            R1,#040H,SEND_LOOP2     ; LOOP UNTIL RAM FILLED
                LCALL   SEND_STOP                       ; SEND 2WIRE STOP CONTION
                RET
;-----------------------------------------------------------------------
;
; THIS SUB SETS THE DS1307 USER RAM TO THE UNIQUE PATTERN
;
;-----------------------------------------------------------------------
SET_RAM_UNQ:
                MOV             R1,#08H                   ; POINTER TO BEGINNING OF
                                                          ; DS1307 USER RAM
                LCALL   SEND_START                      ; SEND 2WIRE START CONDITION
                MOV             A,#DS1307W                ; LOAD DS1307 WRITE COMMAND

                LCALL   SEND_BYTE                       ; SEND WRITE COMMAND
                MOV             A,#08H                  ; SET DS1307 DATA POINTER TO
                                                          ; BEGINNING
                LCALL   SEND_BYTE                       ; OF USER RAM – 08H

SEND_LOOP3:

                LCALL   SEND_BYTE                       ; WHICH IS 08H TO 37H
                INC             R1
                INC             A
                CJNE            R1,#040H,SEND_LOOP3     ; LOOP UNTIL RAM FILLED
                LCALL   SEND_STOP                       ; SEND 2WIRE STOP CONTION
                RET
;-----------------------------------------------------------------------
;
; THIS SUB READS THE DS1307 RAM AND WRITES IT TO THE SCRATCH PAD MEMORY
;
;-----------------------------------------------------------------------
READ_RAM:
                MOV             DPTR,#TEXT4     ; SEND KEY PRESS MSG
                LCALL   WRITE_TEXT
                MOV             R1,#30H                 ; START OF RAM REGS IN
                                                        ; SCRATCH PAD
                MOV             BYTECOUNT,#00H          ; COUNTER FOR 56 RAM BYTES
                CLR             LASTREAD                ; FLAG TO CHECK FOR LAST READ
                LCALL   SEND_START              ; SEND 2WIRE START CONDITION
                MOV             A,#DS1307W              ; SEND DS1307 WRITE COMMAND
                LCALL   SEND_BYTE
```

```
                MOV             A,#08H          ; SET POINTER TO REG 08H ON
                                                        ;DS1307
                LCALL   SEND_BYTE
                LCALL   SEND_STOP               ; SEND STOP CONDITION
                LCALL   SEND_START              ; SEND START CONDITION
                MOV             A,#DS1307R              ; SEND DS1307 READ COMMAND
                LCALL   SEND_BYTE
READ_LOOP2:
                MOV             A,BYTECOUNT     ; CHECK TO SEE OF DOING LAST
                                                        ;READ
                CJNE            A,#37H,NOT_LAST2
                SETB            LASTREAD                ; IF LAST READ SET LASTREAD
                                                        ;FLAG
NOT_LAST2:
                LCALL   READ_BYTE               ; READ A BYTE OF DATA
                MOV             @R1,A           ; MOVE DATA INTO SCRATCHPAD
                                                        ; MEMORY
                INC             R1                      ; INC POINTERS
                INC             BYTECOUNT
                MOV             A,BYTECOUNT
                CJNE            A,#38H,READ_LOOP2 ; LOOP FOR ENTIRE DS1307 RAM
                LCALL   SEND_STOP               ; SEND 2WIRE STOP CONDITION

                LCALL   DISP_RAM                ; DISPLAY DATA IN SCRATCHPAD


                                                        ;MEMORY
                JNB             RI,$                    ;WAIT UNTIL A KEY IS PRESSED

                CLR             RI
                RET
;---------------------------------------------------------------------
;
; THIS SUB DISPLAYS THE RAM DATA SAVED IN SCRATCHPAD MEMORY
;
;---------------------------------------------------------------------
DISP_RAM:
                MOV             R1,#30H                 ;START OF RAM IN SCRATCHPAD
                                                        ;MEMORY
                MOV             BITCOUNT,#00H
                MOV             DPTR,#TEXT6     ;DISPLAY TABLE HEADING
                LCALL   WRITE_TEXT
DISP_ADDR:
                LCALL   DISP_LOC                ; DISPLAY VALUE OF CURRENT
                                                        ; RAM LOCATION
DIS_LOOP:
                MOV             A,@R1           ; DISPLAY RAM DATA SAVED IN
                                                        ;SCRATCHPAD
                LCALL   WRITE_BCD               ; CONVERT TO BCD FORMAT AND
                                                        ; DISPLAY
                INC             R1
```

```
                INC             BITCOUNT
                MOV             A,#20H          ; SPACE BETWEEN DATA BYTES
                LCALL   WRITE_DATA
                MOV             A,BITCOUNT
                CJNE            A,#08H,DIS_LOOP         ; LINE FEED AFTER 8 BYTES OF
                                                        ; DATA
                MOV             BITCOUNT,#00H
                MOV             DPTR,#TEXT3     ; 'CR,LF'
                LCALL   WRITE_TEXT
                CJNE            R1,#68H,DISP_ADDR ; DISPLAY DATA FOR 56 BYTES
                                                        ; OF RAM
                RET
;-------------------------------------------------------------------- ;
;
; THIS SUB WRITES THE RAM LOCATION OF THE DATA
;
;--------------------------------------------------------------------

DISP_LOC:
                MOV             A,R1                    ; DISPLAY THE HEX VALUE FOR
                                                        ; THE DATA
ADD             A,#-28H                                 ; IN THE DS1307 RAM SPACE
                LCALL   WRITE_BCD               ; CONVERTS SCRATCHPAD ADDRESS
                MOV             A,#20H          ; INTO DS1307 RAM ADDRESS

                LCALL   WRITE_DATA
                MOV             A,#20H
                LCALL   WRITE_DATA
                MOV             A,#20H
                LCALL   WRITE_DATA
                RET
;--------------------------------------------------------------------
;
; THIS SUB READS THE CLOCK AND WRITES IT TO THE SCRATCH PAD MEMORY ;
;
;--------------------------------------------------------------------
READ_CLOCK:
                MOV             DPTR,#TEXT4     ; KEY PRESS MSG
                LCALL   WRITE_TEXT
READ_AGAIN:
                MOV             R1,#28H                 ; START OF CLOCK REG IN
                                                        ; SCRATCHPAD
                MOV             BYTECOUNT,#00H          ; COUNTER UP TO 8 BYTES FOR
                                                        ; CLOCK
                CLR             LASTREAD               ; FLAG TO CHECK FOR LAST READ
                LCALL   SEND_START              ; SEND START CONDITION
                MOV             A,#DS1307W              ; SET POINTER TO REG 00H ON
                                                        ; DS1307
                LCALL   SEND_BYTE
                MOV             A,#00H
                LCALL   SEND_BYTE
```

```
                LCALL   SEND_STOP               ; SEND STOP CONDITION
                LCALL   SEND_START              ; SEND START CONDITION
                MOV             A,#DS1307R              ; SEND READ COMMAND TO DS1307
                LCALL   SEND_BYTE
READ_LOOP:
                MOV             A,BYTECOUNT     ; CHECK TO SEE OF DOING LAST
                                                        ; READ
                CJNE            A,#07H,NOT_LAST
                SETB            LASTREAD                ; SET LASTREAD FLAG
NOT_LAST:
                LCALL   READ_BYTE               ; READ A BYTE OF DATA
                MOV             @R1,A           ; MOVE DATA IN SCRATCHPAD
                                                        ; MEMORY
                MOV             A,BYTECOUNT     ; CHECK TO SEE IF READING
                                                        ; SECONDS REG
                CJNE            A,#00H,NOT_FIRST
                CLR             OSC                     ; CLR OSC FLAG
                MOV             A,@R1           ; MOVE SECONDS REG INTO ACC
                JNB             ACC.7,NO_OSC    ; JUMP IF BIT 7 OF IS A 0
                SETB            OSC                     ; SET OSC FLAG, BIT 7 IS A 1
                CLR             ACC.7           ; CLEAR BIT 7 FOR DISPLAY
                                                        ; PURPOSES
                MOV             @R1,A           ; MOVE DATA BACK TO SCRATCHPAD
NO_OSC:
NOT_FIRST:
                INC             R1                      ; INC COUNTERS
                INC             BYTECOUNT
                MOV             A,BYTECOUNT
                CJNE            A,#08H,READ_LOOP        ; LOOP FOR ENTIRE CLOCK
                                                        ; REGISTERS
                LCALL   SEND_STOP               ; SEND 2WIRE STOP CONDITION
                LCALL   DISP_CLOCK              ; DISPLAY DATE/TIME FROM

                                                        ; SCRATCHPAD
                JNB             RI,READ_AGAIN   ; READ AND DISPLAY UNTIL A

                                                        ; KEY IS PRESSED
                CLR RI
                RET
;-------------------------------------------------------------------------
;
; THIS SUB DISPLAYS THE DATE AND TIME SAVED IN SCRATCHPAD MEMORY
;
;-------------------------------------------------------------------------
DISP_CLOCK:
                MOV             DPTR,#TEXT1             ; DATE:
                LCALL   WRITE_TEXT
                MOV             R1,#2DH                    ; MONTH
                MOV             A,@R1
                LCALL   WRITE_BCD
                MOV             A,#'/'
```

```
                LCALL   WRITE_DATA
                MOV             R1,#2CH                 ; DATE
                MOV             A,@R1
                LCALL   WRITE_BCD
                MOV             A,#'/'
                LCALL   WRITE_DATA
                MOV             R1,#2EH                 ; YEAR
                MOV             A,@R1
                LCALL   WRITE_BCD
                MOV             A,#09H                  ; TAB
                LCALL   WRITE_DATA
                MOV             DPTR,#TEXT2             ; TIME:
                LCALL   WRITE_TEXT
                MOV             R1,#2AH                 ; HOURS
                MOV             A,@R1
                LCALL   WRITE_BCD
                MOV             A,#3AH                  ; COLON
                LCALL   WRITE_DATA
                MOV             R1,#29H                 ; MINUTES
                MOV             A,@R1
                LCALL   WRITE_BCD
                MOV             A,#3AH                  ; COLON
                LCALL   WRITE_DATA
                MOV             R1,#28H                 ; SECONDS
                MOV             A,@R1
                LCALL   WRITE_BCD
                RET
;-------------------------------------------------------------------------
;
; THIS SUB SETS THE OSCILLATOR ACCORDING TO THE OSC BIT
;
;-------------------------------------------------------------------------
OSC_CONTROL:
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W          ; SET POINTER TO REG 00H ON
                                                            ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#00H
                LCALL           SEND_BYTE
                SETB                    LASTREAD            ; SET LAST READ FOR SINGLE
                                                            ; READ
                LCALL           SEND_STOP               ; SEND STOP CONDITION
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307R          ; SEND READ COMMAND TO
DS1307
                LCALL                   SEND_BYTE
                LCALL           READ_BYTE               ; READ SECONDS REGISTER
                CLR                     ACC.7               ; TURN OSC ON
                JNB                     OSC,OSC_SET
                SETB                    ACC.7               ; TURN OSC OFF IF OSC BIT IS
                                                            ; SET IN
```

```
OSC_SET:                                                ; SECONDS REGISTER
                PUSH                    ACC             ; SAVE SECONDS DATA ON
STACK
                LCALL           SEND_STOP               ; SEND STOP CONDITION
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W      ; SET POINTER TO REG 00H ON

                                                        ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#00H
                LCALL           SEND_BYTE
                POP                     ACC             ; SEND SECONDS REGISTER TO
                                                        ; CONTROL
                LCALL           SEND_BYTE               ; OSCILLATOR ON DS1307
                LCALL           SEND_STOP
                RET
;-------------------------------------------------------------------------
;
; THIS SUB CONTROLS THE SQW OUTPUT 1HZ
;
 ;-------------------------------------------------------------------------

SQW_CONTROL_1HZ:
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W      ; SET POINTER TO REG 07H ON
                                                        ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#07H
                LCALL           SEND_BYTE
                MOV                     A,#90H          ; SQW/OUT ON AT 1HZ
                JNB                     SQW,SQW_SET     ; JUMP IF SQW BIT IS ACTIVE
                MOV                     A,#80H          ; TURN SQW/OUT OFF – OFF HIGH

SQW_SET:
                LCALL           SEND_BYTE
                LCALL           SEND_STOP

                RET
;-------------------------------------------------------------------------
;
; THIS SUB CONTROLS THE SQW OUTPUT 4KHZ
;
 ;-------------------------------------------------------------------------
SQW_CONTROL_4KHZ:
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W      ; SET POINTER TO REG 07H ON
                                                        ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#07H
                LCALL           SEND_BYTE
                MOV                     A,#91H          ; SQW/OUT ON AT 1HZ
```

```
                JNB                     SQW,SQW_SET1    ; JUMP IF SQW BIT IS ACTIVE
                MOV                     A,#80H          ; TURN SQW/OUT OFF – OFF HIGH
SQW_SET1:
                LCALL           SEND_BYTE
                LCALL           SEND_STOP

                RET
;-------------------------------------------------------------------------
;
; THIS SUB CONTROLS THE SQW OUTPUT 8KHZ
;
 ;-------------------------------------------------------------------------
SQW_CONTROL_8KHZ:
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W        ; SET POINTER TO REG 07H ON
                                                        ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#07H
                LCALL           SEND_BYTE
                MOV                     A,#92H          ; SQW/OUT ON AT 1HZ
                JNB                     SQW,SQW_SET2    ; JUMP IF SQW BIT IS ACTIVE
                MOV                     A,#80H          ; TURN SQW/OUT OFF – OFF HIGH
SQW_SET2:
                LCALL           SEND_BYTE
                LCALL           SEND_STOP

                RET
;-------------------------------------------------------------------------
;
; THIS SUB CONTROLS THE SQW OUTPUT 32KHZ
;
;-------------------------------------------------------------------------


SQW_CONTROL_32KHZ:
                LCALL           SEND_START              ; SEND START CONDITION
                MOV                     A,#DS1307W        ; SET POINTER TO REG 07H ON

                                                        ; DS1307
                LCALL           SEND_BYTE
                MOV                     A,#07H
                LCALL           SEND_BYTE
                MOV                     A,#93H          ; SQW/OUT ON AT 1HZ
                JNB                     SQW,SQW_SET3    ; JUMP IF SQW BIT IS ACTIVE
                MOV                     A,#80H          ; TURN SQW/OUT OFF – OFF HIGH
SQW_SET3:

                LCALL           SEND_BYTE
                LCALL           SEND_STOP

                RET
```

```
;-----------------------------------------------------------------------
;
; THIS SUB IS A SCOPE TRIGGER BIT
;
;-----------------------------------------------------------------------
TRIGGER:
              CLR            TRIG
              SETB           TRIG
              LCALL   DELAY_4
              CLR            TRIG
              RET

;-----------------------------------------------------------------------
;
; THIS SUB READS DATA FROM THE SCREEN AND CONVERTS IT TO BCD FORM
;
; DATA SHOULD BE HEX DIGITS: 1,2,3...9,A,B,C,D,E,F
;-----------------------------------------------------------------------

READ_BCD:

              MOV                    R0,#0          ; CLEAR R0

BCD_LOOP:

              LCALL          READ_DATA              ; READ BYTE FROM KEYBOARD
              LCALL          WRITE_DATA             ; WRITE BYTE BACK TO SCREEN
              CJNE                   A, #0DH, BCD   ; CHECK FOR CR
              MOV                    A,R0              ; MOVE R0 TO ACC AND RETURN
              RET
BCD:
              ADD            A,#-30H                   ; BEGIN TO CONVERT TO
ACTUAL
                                                       ; VALUE
              JNB            ACC.4,DIGIT            ; JUMP IF NOT A-F
              ADD            A,#-07H                   ; IF A-F SUBTRACT 7
                                                       ;
DIGIT:
              ANL            A,#0FH                 ; ENSURE BITS 4-7 ARE CLEARED
              ANL            0,#0FH                 ; ENSURE BITS 4-7 ARE CLEARED
              XCH            A,R0                      ; EXCHANGE R0 AND ACC
              SWAP           A                         ; NIBBLE SWAP ACC
              ORL            A,R0                      ; INSERT BITS 0-3 OF R0
INTO
                                                       ; ACC
              MOV            R0,A                      ; MOVE ACC INTO R0
              SJMP           BCD_LOOP                  ; LOOP UNTIL CR ENCOUNTERED


;-----------------------------------------------------------------------
;
```

```
; THIS SUB WRITES THE BYTE TO THE SCREEN
;
;---------------------------------------------------------------------

WRITE_BCD:

               PUSH           ACC                     ; SAVE ACC ON STACK
               SWAP           A                       ; NIBBLE SWAP ACC
               ANL            A,#0FH                ; CLEAR BITS 4-7 OF ACC
               ADD            A,#07H                ; ADD 7 TO ACC TO CONVERT TO
                                                      ; ASCII HEX
               JNB            ACC.4,LESSNINE          ; CHECK TO SEE IF LESS THAN

                                                      ; NINE 0-8
               CJNE           A,#10H,NOTNINE          ; JUMP IS GREATER THAN NINE

                                                      ; A-F
LESSNINE:

               ADD            A,#-07H                 ; SUBTRACT 7 FOR 0-9

NOTNINE:

               ADD            A,#30H                ; ADD 30 TO CONVERT TO ASCII
                                                      ; EQUIVALENT
               LCALL   WRITE_DATA                   ; WRITE BYTE TO SCREEN
               POP            ACC                     ; RECALL ACC FROM STACK
               ANL            A,#0FH                ; PERFORM CONVERSION ON OTHER
                                                      ; HALF OF BYTE
               ADD            A,#07H
               JNB            ACC.4,NINE2
               CJNE           A,#10H,NOTNINE2
NINE2:
               ADD            A,#-07H
NOTNINE2:
               ADD            A,#30H
               LCALL   WRITE_DATA
               RET
;---------------------------------------------------------------------
;---------------------------------------------------------------------
READ_DATA:
               JNB            RI,READ_DATA          ; LOOP WHILE RI BIT IS LOW

               CLR            RI                      ;
               MOV            A,SBUF                ; GET DATA BYTE FROM SERIAL
                                                      ; BUFFER
               RET
;---------------------------------------------------------------------
;---------------------------------------------------------------------

WRITE_DATA:
```

```
                JNB             TI,WRITE_DATA           ; LOOP WHILE TI BIT IS LOW
                CLR             TI                        ;
                MOV             SBUF,A                  ; SEND DATA BYTE TO SERIAL
                                                           ; BUFFER
                RET

;-------------------------------------------------------------------------
;-------------------------------------------------------------------------

WRITE_TEXT:

                PUSH            ACC                     ; SAVE ACC BYTE ON STACK

WT1:

                CLR             A                       ; CLEAR ACC
                MOVC            A,@A+DPTR               ; MOVE FIRST BYTE OF STRING
                                                        ; TO ACC
                INC             DPTR                    ; INC DATA POINTER
                CJNE            A,#0,WT2                ; CHECK FOR STRING
                                                        ; TERMINATOR – 0
                POP             ACC
                                                        ; RESTORE ACC
                RET                                     ; RETURN WHEN STRING IS SENT

WT2:

                LCALL   WRITE_DATA              ; SEND BYTE OF STRING OVER
                                                        ; SERIAL PORT
                SJMP            WT1

;-------------------------------------------------------------------------
;
; TEXT STRINGS USED FOR USER INTERFACE OVER SERIAL PORT
;
;-------------------------------------------------------------------------


YEAR:
                DB      CR,LF,'YEAR (0 – 99) :           ',0
MONTH:
                DB      CR,LF,'MONTH (1 – 12) :       ',0
DAY:
                DB      CR,LF,'DAY OF MONTH :         ',0
DAYW:
                DB      CR,LF,'DAY OF WEEK :          ',0
HOUR:
                DB      CR,LF,'HOUR (0 – 23) :           ',0
MINUTE:
                DB      CR,LF,'MINUTE (0 – 59) :      ',0
```

```
SECOND:
               DB      CR,LF,'SECOND (0 - 59) :      ',0
TRIER:
               DB      CR,LF,'PRESS ANY KEY TO SET THIS TIME ',CR,LF,0

TEXT0:
               DB      CR,LF,'******* DALLAS SEMICONDUCTOR ******* '
               DB      CR,LF,' DS1307 TEST PROGRAM ',CR,LF
               DB      CR,LF,'PLEASE CHOOSE AN OPTION TO CONTINUE '
               DB      CR,LF,'------------------------------------ '
               DB      CR,LF,'A. SET TIME(MANUAL)    B. SET RAM '
               DB      CR,LF,'C. READ DATE/TIME      D. READ RAM '
               DB      CR,LF,'E. OSC ON              F. OSC OFF '
            DB    CR,LF
               DB      CR,LF,'G. SQW/OUT ON-1HZ      H. SQW/OUT ON-4KHZ'
               DB    CR,LF,'I. SQW/OUT ON-8KHZ     J. SQW/OUT ON-32KHZ'
            DB    CR,LF
            DB CR,LF,'K. SQW/OUT OFF'
            DB    CR,LF,'L. WRITE RAM UNIQUE PATTERN '
               DB      CR,LF,'ESC. TO QUIT ',0 TEXT1:
               DB      CR,'DATE: ',0
TEXT2:
               DB      'TIME: ',0
TEXT3:
               DB      CR,LF,0
TEXT4:
               DB      CR,LF,'PRESS ANY KEY TO RETURN'
               DB      CR,LF,0
TEXT5:
               DB      CR,LF,'ENTER THE BYTE VALUE WHICH WILL FILL THE RAM'
               DB      CR,LF,0
TEXT6:
               DB      CR,LF,'RAM RAM'
               DB      CR,LF,'ADDR DATA'
               DB      CR,LF,'-----------------------------'
               DB      CR,LF,0
;****************************************
;**** END OF PROGRAM ************
;****************************************
END
```