INTRODUCTION
The DS1307 Serial Real Time Clock, which incorporates a 2–wire serial interface, can be controlled using an 8051 compatible DS5000 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 drivers, 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 VDD voltage is 5V, Rp = 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 DS5000 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

![Typical 2-Wire Bus Configuration Diagram](image-url)
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/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/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/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

<table>
<thead>
<tr>
<th>S</th>
<th>1101000</th>
<th>0</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>S=START</td>
<td>A=ACKNOWLEDGE</td>
<td>P=STOP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA TRANSFERRED</td>
<td>(X+1 BYTES + ACKNOWLEDGE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**DATA READ – SLAVE TRANSMITTER MODE**  
Figure 4

<table>
<thead>
<tr>
<th>S</th>
<th>1101000</th>
<th>1</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>XXXXXXXX</th>
<th>A</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>S=START</td>
<td>A=ACKNOWLEDGE</td>
<td>P=STOP</td>
<td>X=NOT ACKNOWLEDGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA TRANSFERRED</td>
<td>(X+1 BYTES + ACKNOWLEDGE)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>ACTUAL</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCL Clock Frequency</td>
<td>( t_{SCL} )</td>
<td>59</td>
<td>KHz</td>
</tr>
<tr>
<td>Bus Free Time Between a STOP and START Condition</td>
<td>( t_{BUF} )</td>
<td>5.7</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Hold Time (repeated) START Condition</td>
<td>( t_{HD:STA} )</td>
<td>6.2</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>LOW Period of SCL Clock</td>
<td>( t_{LOW} )</td>
<td>10.5</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>HIGH Period of SCL Clock</td>
<td>( t_{HIGH} )</td>
<td>6.5</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Set–up Time for a Repeated START Condition</td>
<td>( t_{SU:STA} )</td>
<td>5.3</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Data Hold Time</td>
<td>( t_{HD:DAT} )</td>
<td>5.5</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Data Set–up Time</td>
<td>( t_{SU:DAT} )</td>
<td>3.1</td>
<td>( \mu s )</td>
</tr>
<tr>
<td>Rise Time of Both SDA and SCL Signals</td>
<td>( t_{R} )</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Fall Time of Both SDA and SCL Signals</td>
<td>( t_{F} )</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>Set–up Time for STOP Condition</td>
<td>( t_{SU:STO} )</td>
<td>5.4</td>
<td>( \mu s )</td>
</tr>
</tbody>
</table>

### CONCLUSION

It has been shown that it is very straightforward 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
;
; $MOD51

CR EQU 0DH
LF EQU 0AH
MCON EQU 0C6H
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
BYTECOUNT 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, #0F8H ; serial port
MOV TL1, #0FAH ; for 9600
ORL PCON, #80H ; baud.

050996 6/19
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,#20H

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_CLOCK
JMP MASTER–CONTROLLER ; RETURN TO MAIN MENU

NOTA:
CJNE A,#'B',NOTB ; CALL SET RAM FUNCTION AND
LCALL SET_RAM
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',NOTE ; 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
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 SQW CONTROL FUNCTION
CLR SQW ; CLR SQW FLAG - ON
LCALL SQW_CONTROL
JMP MASTER-CONTROLLER ; RETURN TO MAIN MENU

NOTG:
CJNE A,#'H',NOTH ; CALL SQW CONTROL FUNCTION
SETB SQW ; SET SQW FLAG - OFF
LCALL SQW_CONTROL
JMP MASTER_CONTROLLER ; RETURN TO MAIN MENU

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 ; SCL ^START CONDITION
CLR SDA ;
LCALL DELAY ; SCL ^START CONDITION
CLR SCL ;
RET

FAULT:
SETB BUS_FAULT ; SET FAULT STATUS
RET ; AND RETURN

SEND_STOP:
CLR SDA ;
LCALL SCL_HIGH ; SDA
CLR SDA ;
LCALL DELAY ; SCL ^STOP CONDITION
CLR SCL ;
RET

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

READ_BITS:

MOV BITCOUNT, #008H ; SET COUNTER FOR 8 BITS OF DATA

MOV A, #00H ; 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 TRANSMIT

CLR SCL ; ACKNOWLEDGE

RET

-----THIS SUB READS ONE BYTE OF DATA FROM THE DS1307-----

READ_BITS:

MOV BITCOUNT, #008H ; SET COUNTER FOR 8 BITS OF DATA

MOV A, #00H ; 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 TRANSMIT

CLR SCL ; ACKNOWLEDGE

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
SET_CLOCK:
    MOV R1,#2EH ; SET R1 TO SCRATCHPAD MEMORY
    MOV DPTR, #YEAR ; FOR DATE/TIME
    LCALL WRITE_TEXT ; GET THE DATE/TIME
    LCALL READ_BCD ; INFORMATION FROM THE
    LCALL WRITE_TEXT ; USER. WRITE THE DATE/TIME
    LCALL READ_BCD ; TO SCRATCHPAD
    MOV @R1,A ; MEMORY
    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
;–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
; THIS SUB SETS THE DS1307 USER RAM TO THE VALUE IN 'BYTE'
;–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
SET_RAM:
;–––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––––
};
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 ; SET DS1307 DATA POINTER TO
MOV A,#08H ; 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 CONDITION
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 ; IF LAST READ SET LASTREAD
  SETB 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
LCALL WRITE_TEXT

DISP_ADDR:
LCALL DISP_LOC

DIS_LOOP:
MOV A,@R1
LCALL WRITE_BCD
INC R1
INC BITCOUNT
MOV A,#20H
LCALL WRITE_DATA
MOV A,BITCOUNT
CJNE A,#08H,DIS_LOOP
MOV BITCOUNT,#00H
MOV DPTR,#TEXT3
LCALL WRITE_TEXT
CJNE R1,#68H,DISP_ADDR
RET

; THIS SUB WRITES THE RAM LOCATION OF THE DATA
;---------------------------------------------------------------
DISP_LOC:
MOV A,R1
ADD A,#–28H
LCALL WRITE_BCD
MOV A,#20H
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
LCALL WRITE_TEXT

READ_AGAIN:
MOV R1,#28H
MOV BYTECOUNT,#00H
CLR LASTREAD

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 2WI RE 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 SECONDS REGISTER

OSC_SET:
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

SQW_CONTROL:
LCALL SEND_START ; SEND START CONDITION
MOV A,#DS1307W ; SET POINTER TO REG 07H ON DS1307
LCALL SEND_BYTE
MOV A,#07H
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 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,NUMBER ; JUMP IF NOT A–F
ADD A,#–07H ; IF A–F SUBTRACT 7

NUMBER:
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
SJMPE 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
TEXTO:
DB CR, LF, '******* DALLAS SEMICONDUCTOR ******* ',
DB CR, LF, ' DS1307 DEMONSTRATION PROGRAM ’, CR, LF
DB CR, LF, 'PLEASE CHOOSE AN OPTION TO CONTINUE ’
DB CR, LF, '--------------------------------------------- ’
DB CR,LF,'A. SET TIME' 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,'G. SQW/OUT ON-1HZ' H. SQW/OUT OFF '
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