Electromechanical Switch Replacement

Bright Idea Light Timer, Junior

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APPLICATION OPERATION

Overview

The “Bright Idea” Light Timer, Jr. (BILTJR) is a digital version of the venerable lamp on/off timers that you use when you go on vacation to make it look like someone is home. I use two of these old timers (but not for much longer!) on an everyday basis, just so I don't have to turn lamps on by their switches when it gets dark and turn them off when I go to bed. The BILTJR has an advantage over the old lamp timers: it can be programmed to turn lights on and off at different times for each day of the week. It features 1 or 2 pairs of on/off times per day for 6 days with 10-minute resolution. The seventh day of the week shares its on/off times with the first day. The circuit consists of a PIC12C508 and a Dallas® DS1202 Serial Timekeeping chip, with very few required support components. The timer times are reprogrammable at any time using a connection to a PC’s parallel port to the Dallas chip's battery-backed RAM.

Theory of Operation

The BILTJR is prepared for use by programming the on and off times for the various days of the week, as well as the current time and day of the week. This is done by connecting the circuit to a PC parallel port via the programming cable and running the programming software.

The on and off times are programmed with 10-minute resolution from midnight (0:00) to midnight of the following day (24:00). For example, if on-time #1 is set for 8 p.m. (20:00) and off-time #1 is set for 9:40 p.m. (21:40), the light output will be on between those times. The light is always extinguished as one day rolls over into the next, so programming either off-time as 24:00 will keep the light on until the day changes. The light can be kept on through midnight by programming off-time #2 for day x to be 24:00 and on-time #1 of day x+1 to be 0:00.

Each day of the week can have 0, 1 or 2 pairs of on/off times for the light connected to the output of the BILTJR. To have the connected light remain off for the entire day, program 24:00 for on-time #1, off-time #1, on-time #2, and off-time #2. To have the light come on and go off only one time during the day, program on-time #1 and off-time #1 with the desired times, and program 24:00 for on-time #2 and off-time #2. To have the light come on and go off two times during the day, program the desired times for on-time #1, off-time #1, on-time #2, and off-time #2.

Once the circuit is programmed, while power is applied the output will follow the programmed times. For any given day, it will be off/low before on-time #1, on/high after on-time #1 but before off-time #1, off/low after off-time #1 but before on-time #2, on/high after on-time #2 but before off-time #2, and off/low after off-time #2. The programming of the on/off times is held in non-volatile memory (battery-backed RAM) so the settings are not lost when the main power supply is removed.

The BILTJR circuit described herein has an LED and resistor for testing purposes. In a real application, the LED and resistor would be replaced by some circuitry to switch a 110 volt AC line. Also, the power supply for the circuit would also be derived from the household AC line voltage.

HARDWARE

The BILTJR circuit consists of a PIC12C508 8-pin microcontroller, a DS1202 serial timekeeping chip, an output indicator LED, a resistor, a crystal, a battery, some diodes, some decoupling capacitors, and a cable connection header.

The light on/off output is connected to the GP5 I/O pin, and the chip select output, clock output, and data I/O lines for accessing the DS1202 are connected to GP2, GP1, and GP0, respectively. GP4 is a no-connect for now, future expansion may configure it as a light override/toggle switch input. The lines

to access the DS1202 are also brought to a connector for ease of connecting a programming cable. Ground and the PIC's GP3/$\overline{\text{MCLR}}$ input are brought to this connector as well. During programming, the PIC12C508 is held in reset by a jumper built into the programming cable so the PC parallel port (hopefully with some buffering!) can drive the DS1202 lines without interference from the PIC.

For non-volatile storage of the setup data, a 3 volt battery is used to maintain the DS1202's time and RAM storage areas. One diode prevents the battery from providing power to the PIC12C508 when the main circuit supply is down and one diode prevents the battery from presenting a load to the main supply when the supply is on. A 32.768 KHz watch crystal creates an accurate timetable for the timekeeping chip and completes the DS1202 connections.

The PIC12C508 is configured to use the internal 4MHz RC oscillator, and the GP3/$\overline{\text{MCLR}}$ pin is programmed to function as an $\overline{\text{MCLR}}$ input. For testing, it was necessary to program the on/off times using the PIC12C508 itself. Since this circuit was meant to be generic, all I/O was left as logic level. No power supply circuit was included in this circuit for the same reason; thus, a external +5V supply is necessary to power the circuit.

The test bed for the BILTJR was a PIC16C84-based circuit which will not be described in detail; however, its schematic is enclosed. The '84-based circuit is a superset of the PIC12C508 schematic described above. It adds an RS-232 port for debugging purposes.

Software

The software was originally written for a PIC12C508 or PIC16C84 application. For ease of testing (the inevitable compile-burn-test cycle), an PIC16C84 was used for most of the testing for “Junior”. That is why there are a lot of `ifdef` in the code; either the PIC12C508 or the PIC16C84 version can still be built.

The software consists of subroutines, some start-up code, and an infinite loop. The utility subroutines are for reading the clock and data areas of the DS1202 timekeeping chip and other various things such as binary-to-bcd conversions. The start-up code gets the PIC12C508 up and running and the infinite loop does the actual light timer output control. The loose flow diagram below illustrates the functionality of the infinite loop. That and the well-commented source code make the program flow easy to follow for the most part.

The only obscure parts of the software are the storage of the on/off time data and the day of the week in the DS1202. This is described below:

Byte 0: day 1/7 on time #1
Byte 1: day 1/7 off time #1
Byte 2: day 1/7 on time #2
Byte 3: day 1/7 off time #2
Byte 4: day 2 on time #1
…
Byte 22: day 6 on time #2
Byte 23: day 6 off time #2

The time bytes stored in the DS1202 RAM are formatted as follows:

- HHHHHTTT (MS bit to LS bit) where HHHHH is the hour and TTT is the number of ten-minute blocks.

  For example, 10:40pm is stored as b'10110100' where b'10110' is the hour (22) and b'100' is the ten-minutes (4).

- The valid range for HHHHH is b'00000' - b'11000' (0, 1, …, 24).
- The valid range for TTT is b'000' - b'101' (0, 10, …, 50).
- The day of the week is stored in the clock area of the DS1202 as follows:

  Day 1: Sunday
  Day 2: Monday
  Day 3: Tuesday
  Day 4: Wednesday
  Day 5: Thursday
  Day 6: Friday
  Day 7: Saturday

Note 1: Day 7 (Saturday) duplicates the time schedule set for Day 1 (Sunday).

2: The day numbering scheme shown above is just one possible scenario; you could have Day 1 be Wednesday (and then Day 2 would be Thursday, etc., in which case Tuesday (Day 7) would be have the same on/off schedule as Wednesday (Day 1).

MICROCHIP HARDWARE DEVELOPMENT TOOLS USED

All debugging was done using the PIC16C84 test bed circuit..

Assembler/Compiler version

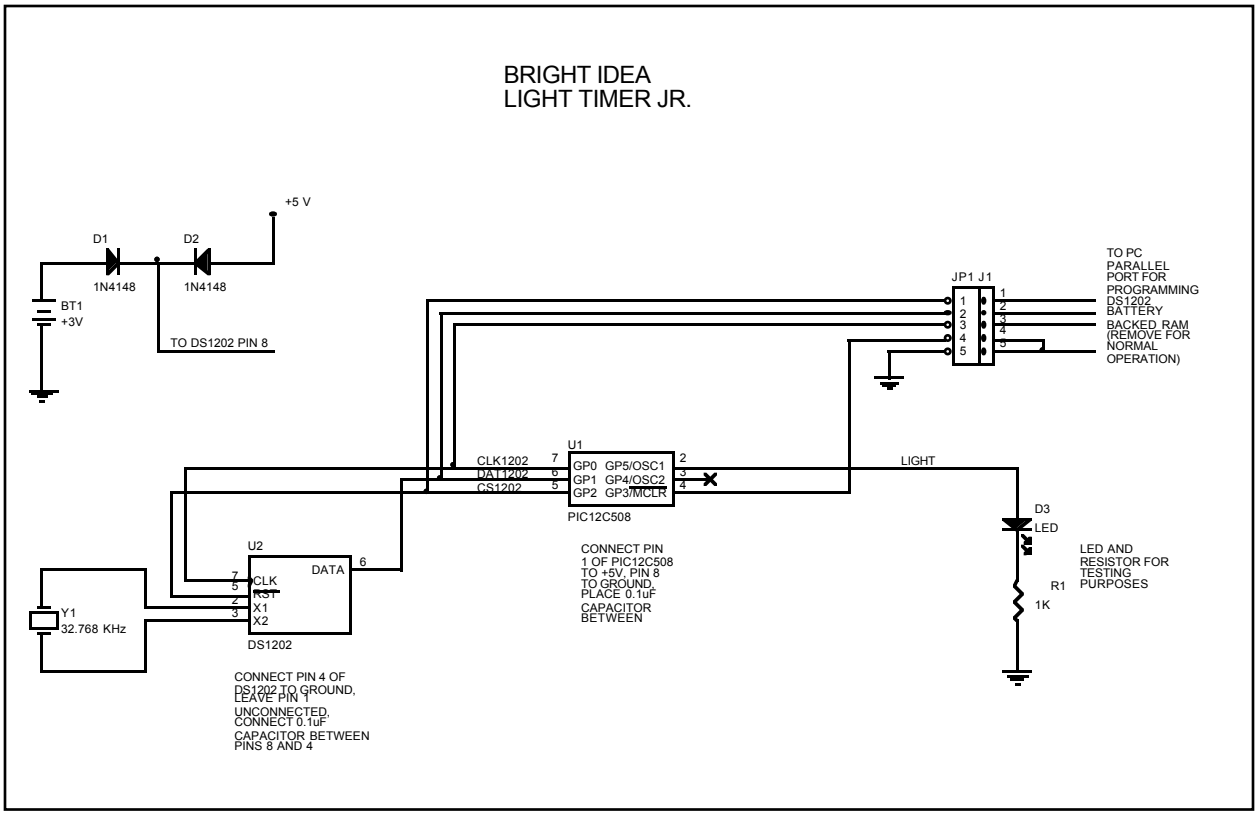
MPLAB 3.22.00 development software with MPASM version 1.50.

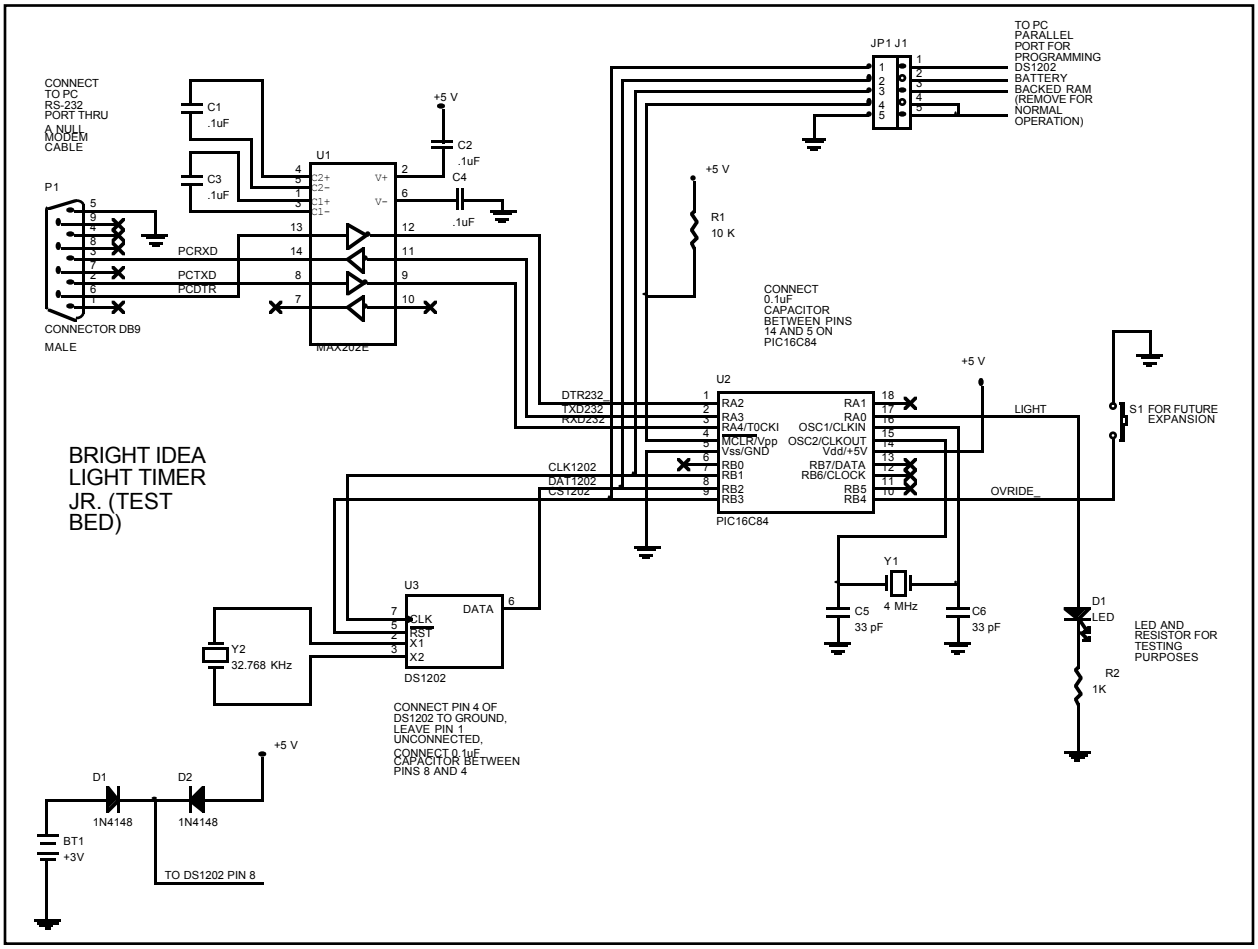
SOFTWARE OVERVIEW

The following is a loose description of what the software does once the PIC12C508 has come out of reset and has had its hardware registers and RAM variables initialized. Only logic concerned with the application is described and only in the most general terms for ease of understanding. Things like resetting the watchdog timer, etc., are left out for clarity.

```
(A) once per minute, do the following:
read the present time (hours, minutes, and day of week) from DS1202
subtract 1 from day of week to put it in the range 0 - 6
if day of week is 6, set the local copy to be day 0 (now day ranges 0 - 5)
if day of week has changed since last time through
        turn output off
        set state variable to be before on #1 time
        (B) calculate an index into DS1202 RAM (day of week * 4 + state)
        read DS1202 RAM location index to retrieve next output change time
        convert next change hours and ten-minutes to binary coded decimal
if state is after off #2 time, go to (A)
if the present time is equal to the next change time
        toggle the state of the output shadow bit
        advance to the next state
        if the state is not after off #2 time, go to (B)
update the real output from the output shadow bit
go to (A)
```

GRAPHICAL HARDWARE REPRESENTATION





APPENDIX A: SOURCE CODE

```
;/----------------------\
;| Assembler directives |
;\----------------------/

;comment out one or the other of the two following lines
;       list    p=16C84         ;build code for 16C84 microcontroller
        list    p=12C508        ;build code for 12C508 microcontroller

        list    r=DEC           ;default radix is decimal
        list    x=ON            ;expand inline macros
;       errorlevel 1,-302       ;turn off msgs caused by .inc file
;       errorlevel 1,-205       ;turn off directive found in column 1 msgs


;/-------------------------\
;| Assembly control #define |
;\-------------------------/

        ifdef __16C84
#define DEBUG                   ;include debugging code with 16C84 version
        endif


;/---------------------------------\
;| Processor specific include file |
;\---------------------------------/

        ifdef __16C84
#include "p16c84.inc"
        else                    ;__12C508
#include "p12c508.inc"
        endif


;/---------------------------\
;| General system information |
;\---------------------------/

;assembled using MPASM 1.50

;time byte data is stored in DS1202 RAM area as follows:
;byte  0:  day 1/7  on time #1
;byte  1:  day 1/7 off time #1
;byte  2:  day 1/7  on time #2
;byte  3:  day 1/7 off time #2
;byte  4:  day 2    on time #1
;...
;byte 23:  day 6   off time #2

;format for time byte:
;HHHHHTTT (MS bit to LS bit) where HHHHH is the hour and TTT is the number
; of ten-minute blocks
;for example, 10:40pm is stored as b'10110100' where b'10110' is the
; hour (22) and b'100' is the ten-minutes (4)
;valid range for HHHHH is b'00000' - b'11000' (0, 1, ..., 24)
;use b'11000' as off time #2 to keep output on until midnight
;valid range for TTT is b'000' - b'101' (0, 10, ..., 50)

;day 1:  sunday
;day 2:  monday
;day 3:  tuesday
;day 4:  wednesday
;day 5:  thursday
;day 6:  friday
;day 7:  saturday
```

```
;note:  day 7 (saturday) duplicates the time schedule set for day 1 (sunday)
;note:  the day numbering scheme shown above is just one possible scenario;
; you could have day 1 be wednesday (and then day 2 would be thursday, etc.,
; in which case tuesday (day 7) would be the same as wednesday (day 1)


;/--------------------------\
;| System timing information |
;\--------------------------/

;clock speed:  4MHz
;instruction clock speed:  4MHz / 4 = 1MHz
;time per non-branching instruction:  1us
;time per branching instruction:  2us

ITIMENS equ     1000            ;non-branching instruction time in ns


;/-------\
;| Fuses |
;\-------/

        ifdef __16C84

        __config _HS_OSC & _WDT_ON & _PWRTE_ON & _CP_OFF

        else                    ;__12C508

        __config _MCLRE_ON & _CP_OFF & _WDT_ON & _IntRC_OSC

        endif


;/-----------------------------------------------------\
;| Miscellaneous equates, #defines, macro definitions |
;\-----------------------------------------------------/

        ifdef __16C84
MINRAM  equ     h'0c'           ;first RAM location
MAXRAM  equ     h'2f'           ;last RAM location
MAXROM  equ     h'03ff'         ;last program word
        else                    ;__12C508
MINRAM  equ     h'07'           ;first RAM location
MAXRAM  equ     h'1f'           ;last RAM location
MAXROM  equ     h'01fe'         ;last program word
        endif

RESET   equ     h'0000'         ;location where jump to on reset

#define subwl   sublw           ;fix for microchip's bad mnemonic
#define SUBWL   sublw           ; both upper and lower case

SKPLTZ  macro                   ;used after a subtract instruction, this macro
        btfsc   STATUS,C        ; will skip the next instruction if the result
        endm                    ; of the subtraction is < 0

SKPGEZ  macro                   ;used after a subtract instruction, this macro
        btfss   STATUS,C        ; will skip the next instruction if the result
        endm                    ; of the subtraction is >= 0

#define INSTRS (((usec*1000)/ITIMENS)-4)
DELAYUS macro   usec            ;this macro forms a wrapper around the delay
                                ; subroutine, autocalculating the parameters
                                ; needed by that subroutine using the
                                ; argument to this macro (the approximate
                                ; number of microseconds to delay);
```

```
        if INSTRS < 20
        error   "delay time is too small!"
        endif
        if INSTRS > 65535
        error   "delay time is too large!"
        endif
        if low ((INSTRS / 4) * 4) != low INSTRS
        messg   "delay will not be quite exact!"
        endif
        movlw   low INSTRS
        movwf   dlyL
        movlw   high INSTRS
        movwf   dlyH
        call    delay
        endm


;/--------------------------------------------------\
;| Microchip's one-line special instruction mnemonics |
;\--------------------------------------------------/

;CLRC, SETC, CLRDC, SETDC, CLRZ, SETZ, SKPC, SKPNC,
;SKPDC, SKPNDC, SKPZ, SKPNZ, TSTF, MOVFW
;(can use in upper or lower case)


;/------------------------------------------------------\
;| Equates for RAM variables in page 0 (h'0c' to h'2f') |
;\------------------------------------------------------/

        cblock  MINRAM
;note:  sec1202 thru wp1202 must remain in order & contiguous
sec1202                         ;seconds to read/write from/to DS1202
min1202                         ;minutes to read/write from/to DS1202
hr1202                          ;hours to read/write from/to DS1202
day1202                         ;days to read/write from/to DS1202
mon1202                         ;months to read/write from/to DS1202
dow1202                         ;day of the week to read/write from/to DS1202
yr1202                          ;years to read/write from/to DS1202
wp1202                          ;write enable/disable the DS1202 clock
;note:  sec1202 thru wp1202 must remain in order & contiguous
addrEe                          ;PIC12C508 eeprom address to read/write
dataEe                          ;PIC12C508 eeprom data to write
eye                             ;loop counter variable
jay                             ;loop counter variable
kay                             ;loop variable used by clkByte subroutine
adr1202                         ;address in DS1202 to read or write
dat1202                         ;data value read from or to write into DS1202
temp                            ;temporary storage
bitVars                         ;unrelated one-bit variables
prevMin                         ;last minute value from DS1202 variable
state                           ;on#/off# state variable
chgHrs                          ;hours of next state change variable
chgMins                         ;ten minutes of next state change variable
prevDay                         ;variable used to detect when day changes
bcdL                            ;LSB of result of binary to BCD conversion
bcdH                            ;MSB of result of binary to BCD conversion
ENDRAM1                         ;dummy value used to see if over RAM limit
        endc
        ifdef __16C84
        cblock ENDRAM1
txData                          ;RS-232 transmit data value
dlyH                            ;variable used by delay subroutine
dlyL                            ;variable used by delay subroutine
dlyTemp                         ;variable used by delay subroutine
ENDRAM2                         ;dummy value used to see if over RAM limit
```

```
        endc
        endif

        ifdef __16C84

        if (ENDRAM2 - 1 > MAXRAM)
        error "too many RAM variables defined!"
        endif

        else                    ;__12C508

        if (ENDRAM1 - 1 > MAXRAM)
        error "too many RAM variables defined!"
        endif

        endif


;/-------------------------------------------------------------\
;| I/O port bit #defines and data direction equates for port a |
;\-------------------------------------------------------------/

        ifdef __16C84

#define RXD232  PORTA,4         ;RS-232 receive data (i) (o.c. out./s.t. in.)
#define TXD232  PORTA,3         ;RS-232 transmit data (o)
#define DTR232_ PORTA,2         ;RS-232 data terminal ready (i)
#define UNUSED1 PORTA,1         ;unused (o)
#define LIGHT   PORTA,0         ;;solid state relay control to power light (o)
PORTAIO equ     b'00010100'     ;direction bits for port A (3 MSBs don't care)

        endif


;/-------------------------------------------------------------\
;| I/O port bit #defines and data direction equates for port b |
;\-------------------------------------------------------------/

        ifdef __16C84

#define UNUSED2 PORTB,7         ;unused (i) (weak pull-up)
#define UNUSED3 PORTB,6         ;unused (i) (w.p.u.)
#define UNUSED4 PORTB,5         ;unused (i) (w.p.u.)
#define OVRIDE_ PORTB,4         ;override toggle pushbutton (i) (w.p.u.)
#define CS1202  PORTB,3         ;chip select for DS1202 clock chip (o)
#define IOPIN   2               ;line that is both an input and an output
#define DAT1202 PORTB,IOPIN     ;serial data line to DS1202 clock chip (i/o)
#define CLK1202 PORTB,1         ;serial clock line to DS1202 clock chip (o)
#define UNUSED5 PORTB,0         ;unused (o)

PORTBIO equ     b'11110100'     ;direction bits for port B

        if (PORTBIO < b'11000000')
        error "to do in-circuit programming, rb7 and rb6 must be inputs!"
        endif

        endif


;/---------------------------------------------------------------\
;| I/O port bit #defines and data direction equates for gpio port |
;\---------------------------------------------------------------/

        ifdef __12C508

#define LIGHT   GPIO,5        ;solid state relay control to power light (o)
```

```
#define UNUSED  GPIO,4        ;override toggle pushbutton (i)
#define RESET_  GPIO,3        ;reset line for PIC12C508 (i) (w.p.u)
#define CS1202  GPIO,2        ;chip select for DS1202 clock chip (o)
#define DAT1202 GPIO,1        ;serial data line to DS1202 clock chip (i/o)
#define CLK1202 GPIO,0        ;serial clock line to DS1202 clock chip (o)

DATAINP equ     b'00011010'   ;direction bits for gpio port (DAT1202 input)
DATAOUT equ     b'00011000'   ;direction bits for gpio port (DAT1202 output)

        endif


;/---------------------------\
;| Equate for option register |
;\---------------------------/

        ifdef __12C508
OPTREG  equ     b'11001000'     ;disable wake-up, diable pull-ups, 1:1 w-dog
        endif


;/-----------------------------------\
;| DS1202 equates  and bit definitions |
;\-----------------------------------/

BURSTRD equ     b'10111111'     ;burst read clock portion of DS1202
BURSTWR equ     b'10111110'     ;burst write clock portion of DS1202

RD1202  equ     0               ;read/not write bit in DS1202 command
RAM1202 equ     6               ;RAM/not clock bit in DS1202 command

SEC1202 equ     b'00000'        ;DS1202 seconds register address

CTL1202 equ     b'00111'        ;DS1202 control register address
WEN1202 equ     b'00000000'     ;data to allow clock writes to DS1202
WPR1202 equ     b'10000000'     ;data to disallow clock writes to DS1202


;/----------------------\
;| Miscellaneous equates |
;\----------------------/

        ifdef __16C84
#define CR      13              ;carriage return ASCII code
#define LF      10              ;line feed ASCII code
        endif

#define PREON1  0               ;state before on time #1
#define PREOFF1 1               ;state after on time #1 but before off time #1
#define PREON2  2               ;state after off time #1 but before on time #2
#define PREOFF2 3               ;state after on time #2 but before off time #2
#define PSTOFF2 4               ;state after off time #2


;/-------------------------\
;| bitVars bit definitions |
;\-------------------------/

#define RAMNCLK bitVars,0       ;access DS1202 RAM/not clock indicator
#define LITESHD bitVars,1       ;output on/off shadow bit


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


;/---------------------------------\
```

```
;| Setup reset and interrupt vectors |
;\-----------------------------------/

        org     RESET           ;reset sends execution here

        ifdef __12C508
        movwf   OSCCAL          ;trim internal RC oscillator
        endif

        goto    initHW          ;assure jump over hardcoded isr


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


;/-----------------------------------------------------------------------\
;| Routine for sending a data byte serially at 9600 baud.                |
;|                                                                       |
;| Inputs:  w, data to send                                              |
;|                                                                       |
;| Outputs:  none                                                        |
;|                                                                       |
;| Calls:  none                                                          |
;\-----------------------------------------------------------------------/

        ifdef __16C84

send232 movwf   txData          ;save data to send

        movlw   8 + 1 + 1       ;8 bits of data, 1 start, 1 stop bit
        movwf   jay

loop232 movlw   high jmpStrt    ;get high order bits of program counter
        movwf   PCLATH          ; and save so adding to pc low works ok
        decf    jay,w

jmpStrt addwf   PCL,f           ;determine what to do and take the same
        goto    stop            ; amount of time no matter what
        FILL    (goto rotate),8
jmpEnd  goto    start

stop    goto    $ + 1           ;waste 3 cycles (includes nop at send1L1)
        goto    send1L1         ;sending a stop bit (stop bit is logic 1)

rotate  rrf     txData,f        ;figure out value of data bit to send
        SKPNC
        goto    send1L1
        goto    send0

start   goto    $ + 1           ;waste 3 cycles
        nop
        goto    send0           ;sending a start bit (start bit is logic 0)

send1L1 nop                     ;equalize inter-bit delays
send1   bsf     TXD232          ;output a 1
        goto    endLoop

send0   bcf     TXD232          ;output a 0
        goto    endLoop         ;equalize inter-bit delays

endLoop DELAYUS 86              ;104 us (1 bit time) - 18 us (loop time)

        decfsz  jay,f           ;skip next if done with data and framing bits
        goto    loop232         ;not done, go get another bit

        return
```

```
        if (high jmpStrt != high jmpEnd)
        error   "jump table crosses page boundary in subroutine send232!"
        endif

        endif                   ;__16C84


;/-------------------------------------------------------------------------\
;| Routine for burst reading clock data from the Dallas 1202 Serial        |
;| Timekeeping chip.                                                       |
;|                                                                         |
;| Inputs:  none                                                           |
;|                                                                         |
;| Outputs:  sec1202 thru wp1202                                           |
;|                                                                         |
;| Calls:  none                                                            |
;\-------------------------------------------------------------------------/

rdClock bsf     CS1202          ;activate the chip by selecting it
        bcf     CLK1202         ;start out with the clock low

        movlw   sec1202         ;point indirect addressing to the first byte
        movwf   FSR             ; in PIC12C508 RAM to fill

        movlw   8               ;command to DS1202 is 8 bits long
        movwf   jay

        movlw   BURSTRD         ;burst read clock data command
        movwf   sec1202

        ifdef __16C84
        bsf     STATUS,RP0
        bcf     TRISB,IOPIN     ;make the data i/o pin an output temporarily
        bcf     STATUS,RP0
        else                    ;__12C508
        movlw   DATAOUT
        tris    GPIO            ;make the data i/o pin an output temporarily
        endif

rdLoop1 bcf     CLK1202         ;lower the clock

        bcf     DAT1202         ;assume command bit is going to be a 0
        rrf     sec1202,f       ;look at actual command bit
        SKPNC                   ;skip next if it really was 0
        bsf     DAT1202         ;not a 0, correct it to be a 1

        bsf     CLK1202         ;command data gets clocked in on rising edge

        decfsz  jay,f           ;skip next if clocked in all 8 command bits
        goto    rdLoop1         ;continue clocking in command bits

        ifdef __16C84
        bsf     STATUS,RP0      ;done outputting command to DS1202
        bsf     TRISB,IOPIN     ;revert data i/o pin back to an input
        bcf     STATUS,RP0
        else
        movlw   DATAINP         ;__12C508
        tris    GPIO            ;revert data i/o pin back to an input
        endif

        movlw   8               ;we're getting 8 bytes of data from DS1202
        movwf   jay

rdLoop2 movlw   8               ;each byte is 8 bits
        movwf   kay
```

```
rdLoop3 bcf     CLK1202         ;clock out a data bit on clock falling edge

        CLRC                    ;assume data bit is going to be a 0
        btfsc   DAT1202         ;skip next if actual data bit was a 0
        SETC                    ;not a 0, correct it to be a 1
        rrf     INDF,f          ;rotate data bit into current PIC12C508 RAM location

        bsf     CLK1202         ;raise the clock in preparation of next bit

        decfsz  kay,f           ;skip next if done with current data byte
        goto    rdLoop3         ;keep working on getting current data byte

        incf    FSR,f           ;point to destination for next data byte

        decfsz  jay,f           ;skip next if done getting all data bytes
        goto    rdLoop2         ;contine getting next data byte

        bcf     CLK1202         ;leave the clock low
        bcf     CS1202          ;deselect the clock chip
        retlw   0


;/-------------------------------------------------------------------------\
;| Routine for burst writing clock data to the Dallas 1202 Serial          |
;| Timekeeping chip.                                                       |
;|                                                                         |
;| Inputs:  sec1202 thru wp1202                                            |
;|                                                                         |
;| Outputs:  none                                                          |
;|                                                                         |
;| Calls:  none                                                            |
;|                                                                         |
;| Note:  Need to write-enable DS1202 before & write-protect it after      |
;\-------------------------------------------------------------------------/

        ifdef __16C84

wrClock bsf     CS1202          ;activate the chip by selecting it
        bcf     CLK1202         ;start out with the clock low

        movlw   sec1202         ;point indirect addressing to the first byte
        movwf   FSR             ; in PIC12C508 RAM to get data from

        movlw   8               ;command to DS1202 is 8 bits long
        movwf   jay

        movlw   BURSTWR         ;burst write clock data command
        movwf   eye

        bsf     STATUS,RP0
        bcf     TRISB,IOPIN     ;make the data i/o pin an output temporarily
        bcf     STATUS,RP0

wrLoop1 bcf     CLK1202         ;lower the clock

        bcf     DAT1202         ;assume command bit is going to be a 0
        rrf     eye,f           ;look at actual command bit
        SKPNC                   ;skip next if it really was 0
        bsf     DAT1202         ;not a 0, correct it to be a 1

        bsf     CLK1202         ;command data gets clocked in on rising edge

        decfsz  jay,f           ;skip next if clocked in all 8 command bits
        goto    wrLoop1         ;continue clocking in command bits
```

```
        movlw   8               ;we're putting 8 bytes of data in the DS1202
        movwf   jay

wrLoop2 movlw   8               ;each byte is 8 bits
        movwf   kay

wrLoop3 bcf     CLK1202         ;lower the clock

        bcf     DAT1202         ;assume data bit is going to be a 0
        rrf     INDF,f          ;rotate data bit from current PIC12C508 RAM location
        SKPNC                   ;skip next if it really was 0
        bsf     DAT1202         ;not a 0, correct it to be a 1

        bsf     CLK1202         ;clock in the data bit

        decfsz  kay,f           ;skip next if done with current data byte
        goto    wrLoop3         ;keep working on getting current data byte

        incf    FSR,f           ;point to destination for next data byte

        decfsz  jay,f           ;skip next if done getting all data bytes
        goto    wrLoop2         ;contine getting next data byte

        ifdef __16C84
        bsf     STATUS,RP0      ;done outputting command to DS1202
        bsf     TRISB,IOPIN     ;revert data i/o pin back to an input
        bcf     STATUS,RP0
        else                    ;__12C508
        movlw   DATAINP
        tris    GPIO            ;revert data i/o pin back to an input
        endif

        bcf     CLK1202         ;leave the clock low
        bcf     CS1202          ;deselect the clock chip

        retlw   0

        endif


;/-------------------------------------------------------------------------\
;| Routine for reading 1 byte of data from the Dallas 1202 Serial          |
;| Timekeeping chip.                                                       |
;|                                                                         |
;| Inputs:  adr1202                                                        |
;|          bitVars bit RAMNCLK (read from RAM/not clock area of DS1202)   |
;|                                                                         |
;| Outputs:  dat1202                                                       |
;|                                                                         |
;| Calls:  none                                                            |
;\-------------------------------------------------------------------------/

rd1202  bsf     CS1202          ;activate the chip by selecting it
        bcf     CLK1202         ;start out with the clock low

        movlw   8               ;command to DS1202 is 8 bits long
        movwf   jay

        MOVFW   adr1202         ;don't destroy DS1202 address
        movwf   temp            ;turn address into a valid DS1202 command
        rlf     temp,f          ; byte
        bsf     temp,RD1202     ;set read/not write bit in DS1202 command
        bsf     temp,7          ;this bit is always set in valid command

        bsf     temp,RAM1202    ;assume writing to RAM area of DS1202
        btfss   RAMNCLK         ;skip next if really writing to RAM area
```

```
        bcf     temp,RAM1202    ;really writing to clock area of DS1202

        ifdef __16C84
        bsf     STATUS,RP0
        bcf     TRISB,IOPIN     ;make the data i/o pin an output temporarily
        bcf     STATUS,RP0
        else                    ;__12C508
        movlw   DATAOUT
        tris    GPIO            ;make the data i/o pin an output temporarily
        endif

r1202lp bcf     CLK1202         ;lower the clock

        bcf     DAT1202         ;assume command bit is going to be a 0
        rrf     temp,f          ;look at actual command bit
        SKPNC                   ;skip next if it really was 0
        bsf     DAT1202         ;not a 0, correct it to be a 1

        bsf     CLK1202         ;command data gets clocked in on rising edge

        decfsz  jay,f           ;skip next if clocked in all 8 command bits
        goto    r1202lp         ;continue clocking in command bits

        ifdef __16C84
        bsf     STATUS,RP0      ;done outputting command to DS1202
        bsf     TRISB,IOPIN     ;revert data i/o pin back to an input
        bcf     STATUS,RP0
        else                    ;__12C508
        movlw   DATAINP
        tris    GPIO            ;revert data i/o pin back to an input
        endif

        movlw   8               ;retrieving 8 bits of data
        movwf   jay

r1202l2 bcf     CLK1202         ;clock out a data bit on clock falling edge

        CLRC                    ;assume data bit is going to be a 0
        btfsc   DAT1202         ;skip next if actual data bit was a 0
        SETC                    ;not a 0, correct it to be a 1
        rrf     dat1202,f       ;rotate data bit into current PIC12C508 RAM

        bsf     CLK1202         ;raise the clock in preparation of next bit

        decfsz  jay,f           ;skip next if done retrieving data byte
        goto    r1202l2         ;keep working on getting data byte

        bcf     CLK1202         ;leave the clock low
        bcf     CS1202          ;deselect the clock chip
        retlw   0


;/-------------------------------------------------------------------------\
;| Routine for writing 1 byte of data to the Dallas 1202 Serial Timekeeping |
;| chip.                                                                   |
;|                                                                         |
;| Inputs:  adr1202 (the address in the DS1202 to write)                   |
;|          dat1202 (the data to write to the specified address)           |
;|                                                                         |
;|          bitVars bit RAMNCLK (write to RAM/not clock area of DS1202)    |
;|                                                                         |
;| Outputs:  none                                                          |
;|                                                                         |
;| Calls:  none                                                            |
;|                                                                         |
;| Note:  Need to write-enable DS1202 before & write-protect it after      |
```

```
;\-------------------------------------------------------------------------/

        ifdef __16C84

wr1202  bsf     CS1202          ;activate the chip by selecting it
        bcf     CLK1202         ;start out with the clock low

        movlw   16              ;command & data to DS1202 are each 8 bits
        movwf   jay

        MOVFW   adr1202         ;don't destroy DS1202 address
        movwf   temp            ;turn address into a valid DS1202 command
        rlf     temp,f          ; byte
        bcf     temp,RD1202     ;clear read/not write bit in DS1202 command
        bsf     temp,7          ;this bit is always set in valid command

        bsf     temp,RAM1202    ;assume writing to RAM area of DS1202
        btfss   RAMNCLK         ;skip next if really writing to RAM area
        bcf     temp,RAM1202    ;really writing to clock area of DS1202

        bsf     STATUS,RP0
        bcf     TRISB,IOPIN     ;make the data i/o pin an output temporarily
        bcf     STATUS,RP0

w1202lp bcf     CLK1202         ;lower the clock

        bcf     DAT1202         ;assume command bit is going to be a 0
        rrf     temp,f           ;look at actual command bit
        SKPNC                   ;skip next if it really was 0
        bsf     DAT1202         ;not a 0, correct it to be a 1

        bsf     CLK1202         ;command data gets clocked in on rising edge

        movlw   9               ;jay will be 9 when we've clocked out 8 bits
        xorwf   jay,w
        SKPZ                    ;skip next if done with 8 bit command
        goto    w1202ov         ;keep working on command bits
        MOVFW   dat1202         ;done with command bits, switch to data bits
        movwf   temp

w1202ov decfsz  jay,f           ;skip next if clocked in all 16 bits
        goto    w1202lp         ;continue clocking in command bits

        bsf     STATUS,RP0      ;done outputting command to DS1202
        bsf     TRISB,IOPIN     ;revert data i/o pin back to an input
        bcf     STATUS,RP0

        bcf     CLK1202         ;leave the clock low
        bcf     CS1202          ;deselect the clock chip
        retlw   0

        endif


;/-------------------------------------------------------------------------\
;| Routine for converting a BCD digit (0 - 9) to ASCII.                    |
;|                                                                         |
;| Inputs:  w (the BCD digit (only lower nibble is relevant))              |
;|                                                                         |
;| Outputs:  w (the converted ASCII code)                                  |
;|                                                                         |
;| Calls:  none                                                            |
;\-------------------------------------------------------------------------/

        ifdef __16C84
```

```
bcd2asc andlw   h'0f'           ;clear upper nibble
        iorlw   h'30'           ;set bits 4 & 5 to make valid ASCII code
        return

        endif                   ;__16C84


;/-------------------------------------------------------------------------\
;| Routine for converting a 1-byte binary value to a 2-byte binary-coded    |
;| decimal value (2 digits) (taken from AN526 "PIC12C508 16C5X/16CXX        |
;| Math Utility Routines" from Microchip .                                  |
 |   Embedded Control Handbook, page 5-119)                                 |
;|                                                                          |
;| Inputs:  w, the binary value to convert (h'00'-h'63')                    |
;|                                                                          |
;| Outputs:  bcdH,bcdL                                                      |
;|                                                                          |
;| Calls:  none                                                             |
;\-------------------------------------------------------------------------/

bin2bcd clrf    bcdH
        movwf   bcdL
gtenth  movlw   10
        subwf   bcdL,w
        btfss   STATUS,C
        goto    endBcd
        movwf   bcdL
        incf    bcdH,f
        goto    gtenth
endBcd  return


;/-------------------------------------------------------------------------\
;| Routine for generating a programmable delay (routine written by Philip   |
;| Doucet - obtained from Electronics Design - August 8, 1994, page 26ES)   |
;| This "delay" subroutine requires three registers.  The 16-bit argument   |
;| is in dlyH and dlyL.  Minimum value of the argument is 20.  Register     |
;| dlyTemp is needed for temporary storage.  This routine will delay 20     |
;| or more instruction cycles.  For exact accuracy, the delay parameter     |
;| must be a multiple of 4.                                                 |
;|                                                                          |
;| Inputs:  # of instructions to delay in dlyL and dlyH                     |
;|                                                                          |
;| Outputs:  none                                                           |
;|                                                                          |
;| Calls:  none                                                             |
;\-------------------------------------------------------------------------/

        ifdef __16C84

delay   movlw   20              ;subtract minimum # of instructions to
        subwf   dlyL,f          ; execute this routine from requested delay
        SKPC                    ;check for borrow & decrement high byte if
        decf    dlyH,f          ; there was one
        CLRC                    ;divide by 4 to determine how many times to
        rrf     dlyL,f          ; execute dlyL loop
        CLRC
        rrf     dlyL,f
        movf    dlyH,f          ;check to see if dlyH = 0 & skip dlyH loop if
        SKPNZ                   ; it is
        goto    delay3
        nop                     ;nop equalizes timing between paths
delay1  movlw   62              ;since each dlyH loop needs 256 cycle, or 64
        movwf   dlyTemp         ; times thru inner loop of cycles, minus
        nop                     ; cycle setup, so 64 - 2 = 62
        goto    delay2          ;add a 2 cycle delay
```

```
delay2  nop                     ;inner loop for dlyH
        decfsz  dlyTemp,f
        goto    delay2
        nop
        decfsz  dlyH,f          ;outer loop for dlyH
        goto    delay1
        nop
delay3  movf    dlyL,f          ;if dlyL = 0, skip loop
        SKPNZ
        goto    dlyEnd
        nop
delay4  nop                     ;loop for dlyL
        decfsz  dlyL,f
        goto    delay4
        nop
dlyEnd  return                  ;return from subroutine

        endif                   ;__16C84


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


;Do PIC12C508 initialization here, including setting up I/O and configuring control
; registers.  Timer 0 is set up as a timer to drive the application clock at
; 64 ticks per second and to blink the LEDs when necessary.  ;Clear system
; interrupt flags, and enable interrupts (they are disabled on reset or
; powerup).  Other initialization is self-explanatory.

initHW

        ifdef __16C84

        clrf    PORTA           ;set port output latches to a known state
        clrf    PORTB

        bcf     INTCON,GIE      ;disable all interrupt sources

        bcf     EEADR,7         ;avoid higher than necessary current drain
        bcf     EEADR,6

        bsf     STATUS,RP0      ;select page 1 (powerup default is page 0)

        bcf     OPTION_REG,NOT_RBPU ;enable weak pullups on port B

        bsf     OPTION_REG,T0CS ;select external source for timer 0
        bsf     OPTION_REG,T0SE ;select falling edge as timer 0 increment

        bsf     OPTION_REG,PSA  ;assign prescaler to watchdog timer
        bcf     OPTION_REG,PS2
        bcf     OPTION_REG,PS1
        bcf     OPTION_REG,PS0  ;1:1 prescale watchdog timer (18 ms)

        MOVFW   TRISA
        andlw   b'11100000'
        iorlw   PORTAIO;port A input/output pin configuration
        movwf   TRISA           ; (leave 3 most-significant bits alone)

        movlw   PORTBIO         ;port B input/output pin configuration
        movwf   TRISB

        bcf     STATUS,RP0      ;set default page back to 0

        else                    ;__12C508

        clrf    GPIO            ;set port output latches to a known state
```

```
        movlw   OPTREG
        option                  ;disable wake-up, disable pull-ups, 1:1 w-dog

        movlw   DATAINP
        tris    GPIO            ;gpio port input/output pin configuration

        endif

endHW


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


;Set up initial variables and define initial conditions here.

initSW  movlw   h'ff'
        movwf   prevDay         ;initialize to an invalid value
        movwf   prevMin         ;initialize to an invalid value

        bcf     CS1202          ;make sure DS1202 is deselected

        movlw   WPR1202         ;this variable never changes; it is needed
        movwf   wp1202          ; for the burst write

        bcf     LITESHD         ;shadow bit for output starts out off
        bcf     LIGHT           ;make sure light output starts out off


        ifdef __16C84
        bsf     TXD232          ;set RS-232 transmit line to marking state
        endif

endSW


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


        ifdef DEBUG

        movlw   CTL1202         ;hard program DS1202 with '84 instead of
        movwf   adr1202         ; using the PC's parallel port for easier
        movlw   WEN1202         ; debugging
        movwf   dat1202
        bcf     RAMNCLK
        call    wr1202          ;allow writes to DS1202

        movlw   h'45'
        movwf   sec1202

        movlw   h'58'
        movwf   min1202

        movlw   h'23'
        movwf   hr1202

        movlw   h'20'
        movwf   day1202

        movlw   h'11'
        movwf   mon1202

        movlw   h'1'
        movwf   dow1202
```

```
movlw   h'96'
movwf   yr1202

call    wrClock         ;initialize clock time in DS1202

movlw   0
movwf   adr1202
movlw   h'ba'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   1
movwf   adr1202
movlw   h'bb'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   2
movwf   adr1202
movlw   h'bc'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   3
movwf   adr1202
movlw   h'bd'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   4
movwf   adr1202
movlw   h'0'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   5
movwf   adr1202
movlw   h'1'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   6
movwf   adr1202
movlw   h'2'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   7
movwf   adr1202
movlw   h'3'
movwf   dat1202
bsf     RAMNCLK
call    wr1202

movlw   CTL1202
movwf   adr1202
movlw   WPR1202
movwf   dat1202
```

```
        bcf     RAMNCLK
        call    wr1202          ;disallow writes to DS1202

        endif                   ;DEBUG

infLoop clrwdt                  ;pet the dog to keep him happy

        call    rdClock         ;get current day and time info

        MOVFW   prevMin         ;retrieve old minute data
        xorwf   min1202,w       ;compare to current minute data
        SKPNZ                   ;skip next if minute has changed
        goto    infLoop         ;we're still in the same minute

        MOVFW   min1202         ;minute has changed
        movwf   prevMin         ;update old minute so we remember next time

        ifdef DEBUG
        MOVFW   hr1202          ;output HH:MM to RS-232 port
        movwf   bcdL
        rrf     bcdL,f
        rrf     bcdL,f
        rrf     bcdL,f
        rrf     bcdL,w
        call    bcd2asc
        call    send232
        MOVFW   hr1202
        call    bcd2asc
        call    send232
        movlw   ':'
        call    send232
        MOVFW   min1202
        movwf   bcdL
        rrf     bcdL,f
        rrf     bcdL,f
        rrf     bcdL,f
        rrf     bcdL,w
        call    bcd2asc
        call    send232
        MOVFW   min1202
        call    bcd2asc
        call    send232
        movlw   CR
        call    send232
        movlw   LF
        call    send232
        endif

        decf    dow1202,f       ;convert day with range 1 - 7 to 0 - 6
        movlw   6
        xorwf   dow1202,w       ;compare current day of week with 6
        SKPNZ                   ;skip next if not 6
        clrf    dow1202         ;wrap day 6 to be the same as day 0

        MOVFW   dow1202         ;retrieve day of week in range 0 - 5
        xorwf   prevDay,w       ;has the day changed on us?
        SKPNZ                   ;skip next if it has
        goto    sameDay

        MOVFW   dow1202         ;day changed
        movwf   prevDay         ;set previous day variable to same as current

        movlw   PREON1          ;since day changed we are before on time #1
        movwf   state           ;remember that

        bcf     LITESHD         ;turn output device off
```

```
rdNxChg MOVFW   dow1202         ;calculate next output transition time
        movwf   temp
        CLRC
        rlf     temp,f
        CLRC
        rlf     temp,f          ;calculate day of week * 4

        MOVFW   state
        addwf   temp,w          ;w = day of week * 4 + state
        movwf   adr1202         ;store index as RAM location to read in DS1202

        bsf     RAMNCLK
        call    rd1202          ;read DS1202 RAM location [day * 4 + state]

        MOVFW   dat1202         ;retrieve HHHHHTTT binary data
        movwf   temp            ;save it for rotating
        rrf     temp,f          ;rotate to get CHHHHHTT
        rrf     temp,f          ;rotate to get CCHHHHHT
        rrf     temp,w          ;rotate to get CCCHHHHH
        andlw   b'00011111'     ;mask to get 000HHHHH
        call    bin2bcd         ;convert to 2 BCD digits
        rlf     bcdH,f          ;rotate MS BCD digit to get 000MMMMC
        rlf     bcdH,f          ;rotate MS BCD digit to get 00MMMMCC
        rlf     bcdH,f          ;rotate MS BCD digit to get 0MMMMCCC
        rlf     bcdH,w          ;rotate MS BCD digit to get MMMMCCCC
        andlw   b'11110000'     ;mask to get MMMM0000
        iorwf   bcdL,w          ;combine to get MMMMLLLL hours
        movwf   chgHrs          ;save for comparison to current hours later

        clrf    temp            ;clear the addition accumulator
        MOVFW   dat1202         ;retrieve HHHHHTTT binary data
        andlw   b'00000111'     ;mask out hours to get 00000TTT
        movwf   eye             ;i = TTT = number of ten minute blocks
        movlw   10              ;add 10 to accumulated sum each time thru
addLoop TSTF    eye             ;i down to 0 yet?
        SKPNZ                   ;skip next if i > 0
        goto    addDone         ;i down to 0, now have minutes calculated
        addwf   temp,f          ;sum = sum + 10
        decf    eye,f           ;i = i - 1
        goto    addLoop         ;continue adding
addDone MOVFW   temp            ;retrieve minutes
        call    bin2bcd         ;;convert to 2 BCD digits
        rlf     bcdH,f          ;rotate MS BCD digit to get 000MMMMC
        rlf     bcdH,f          ;rotate MS BCD digit to get 00MMMMCC
        rlf     bcdH,f          ;rotate MS BCD digit to get 0MMMMCCC
        rlf     bcdH,w          ;rotate MS BCD digit to get MMMMCCCC
        andlw   b'11110000'     ;mask to get MMMM0000
        iorwf   bcdL,w          ;combine to get MMMMLLLL minutes
        movwf   chgMins         ;save for comparison to current minutes later

sameDay MOVFW   state           ;retrieve current state
        xorlw   PSTOFF2         ;is current state after off time #2?
        SKPNZ                   ;skip next if not
        goto    infLoop         ;time is after 2nd turn off time, recycle

chkTime MOVFW   chgHrs
        subwf   hr1202,w        ;w = current hours - next change hours
        SKPGEZ                  ;skip next if current >= next change
        goto    updShdw         ;go update output from shadow bit
        SKPZ                    ;skip next if current equals change
        goto    change          ;go toggle shadow output bit
        MOVFW   chgMins
        subwf   min1202,w       ;w = current minutes - next change ten minutes
        SKPGEZ                  ;skip next if current >= next change
        goto    updShdw         ;go update output from shadow bit
```

```
        SKPZ                    ;skip next if current equals next change
        goto    updShdw         ;go update output from shadow bit

change  btfss   LITESHD         ;skip next if shadow bit is currently on
        goto    shdwOn          ;shadow bit off, go turn it on
        bcf     LITESHD         ;turn shadow bit off
        goto    endChg          ;done with shadow bit, get out of this section
shdwOn  bsf     LITESHD         ;turn shadow bit on
endChg

        incf    state,f         ;advance to next state in the on/off machine

        MOVFW   state
        xorlw   PSTOFF2         ;are we now after off time #2?
        SKPZ                    ;skip next if we are
        goto    rdNxChg         ;haven't turned off for the last time today;
                                ; need to read the next time for state change

updShdw btfss   LITESHD         ;skip next if shadow says output should be on
        goto    outOff          ;output should be off so go make it so
        bsf     LIGHT           ;turn output on
        goto    endUpdt         ;done with output, get out of this section
outOff  bcf     LIGHT           ;turn output off
endUpdt

        goto    infLoop         ;repeat ad nauseum


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


;/------------------------------\
;| End of program watchdog fill |
;\------------------------------/

endProg fill    (goto wdReset),(MAXROM - $)
        org     MAXROM          ;set breakpoints on endProg thru wdtRst
wdReset goto    wdReset         ;force watchdog to fire


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


;/--------------\
;| End assembly |
;\--------------/

        end
```

NOTES:

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