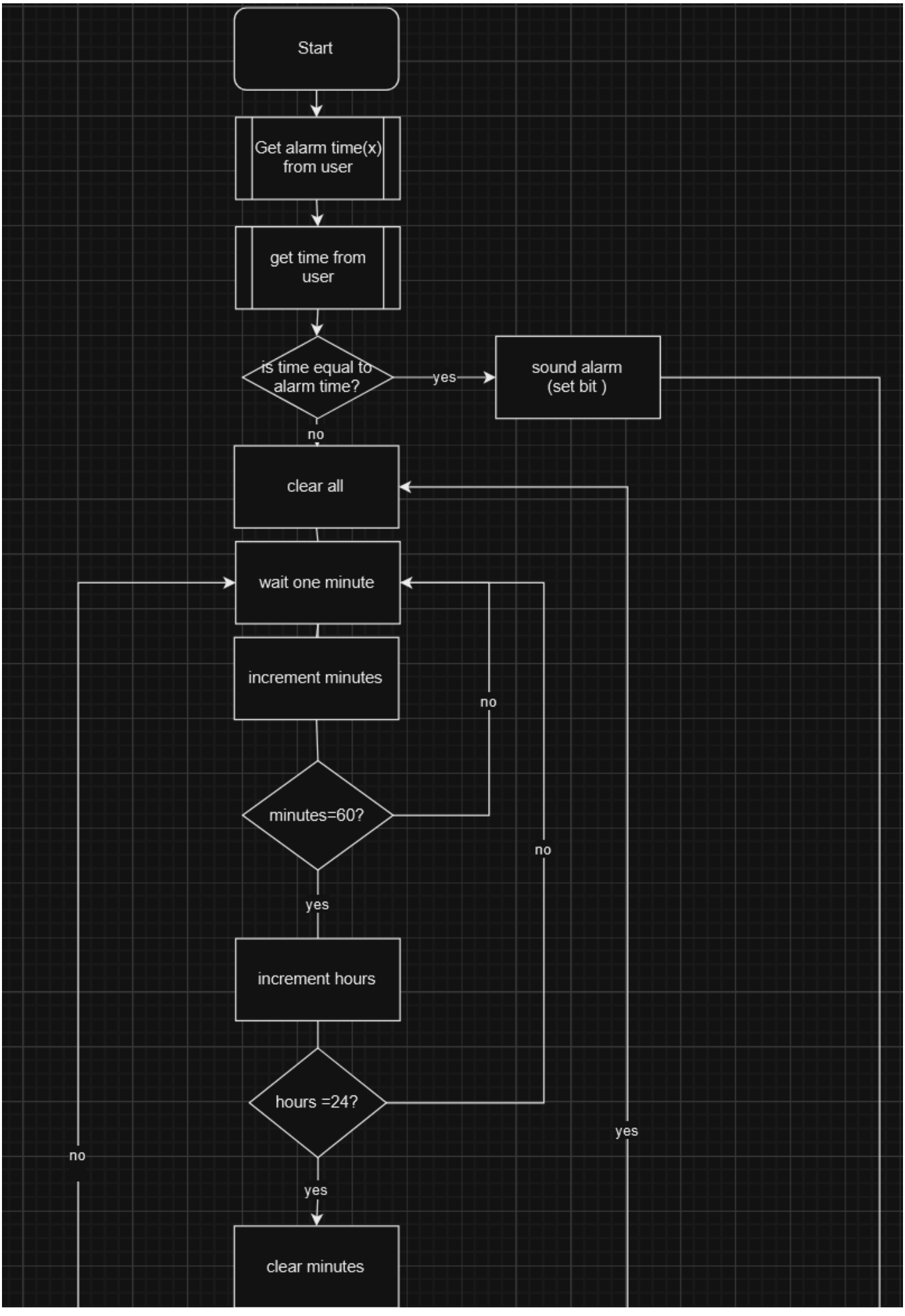
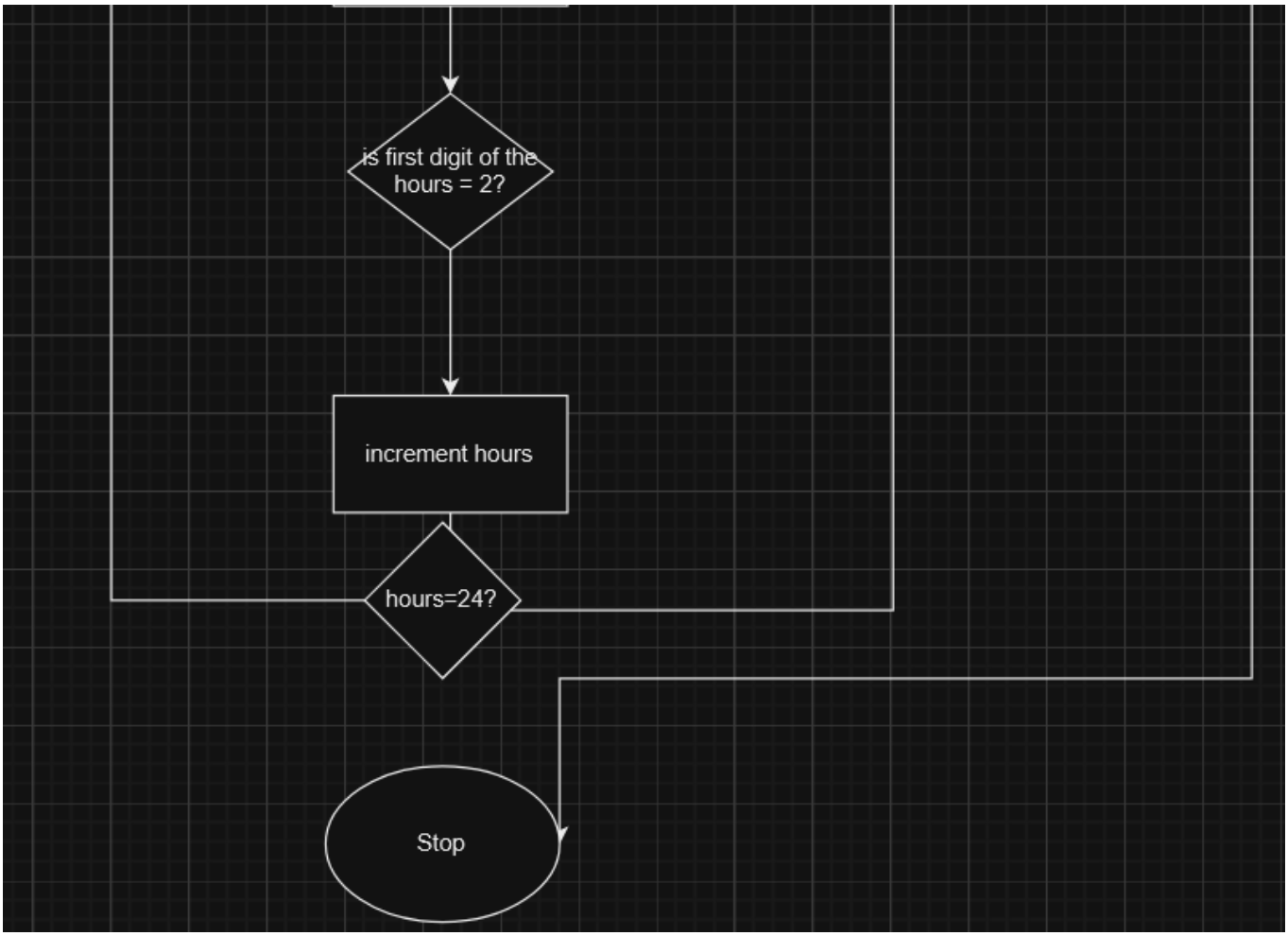
Introduction

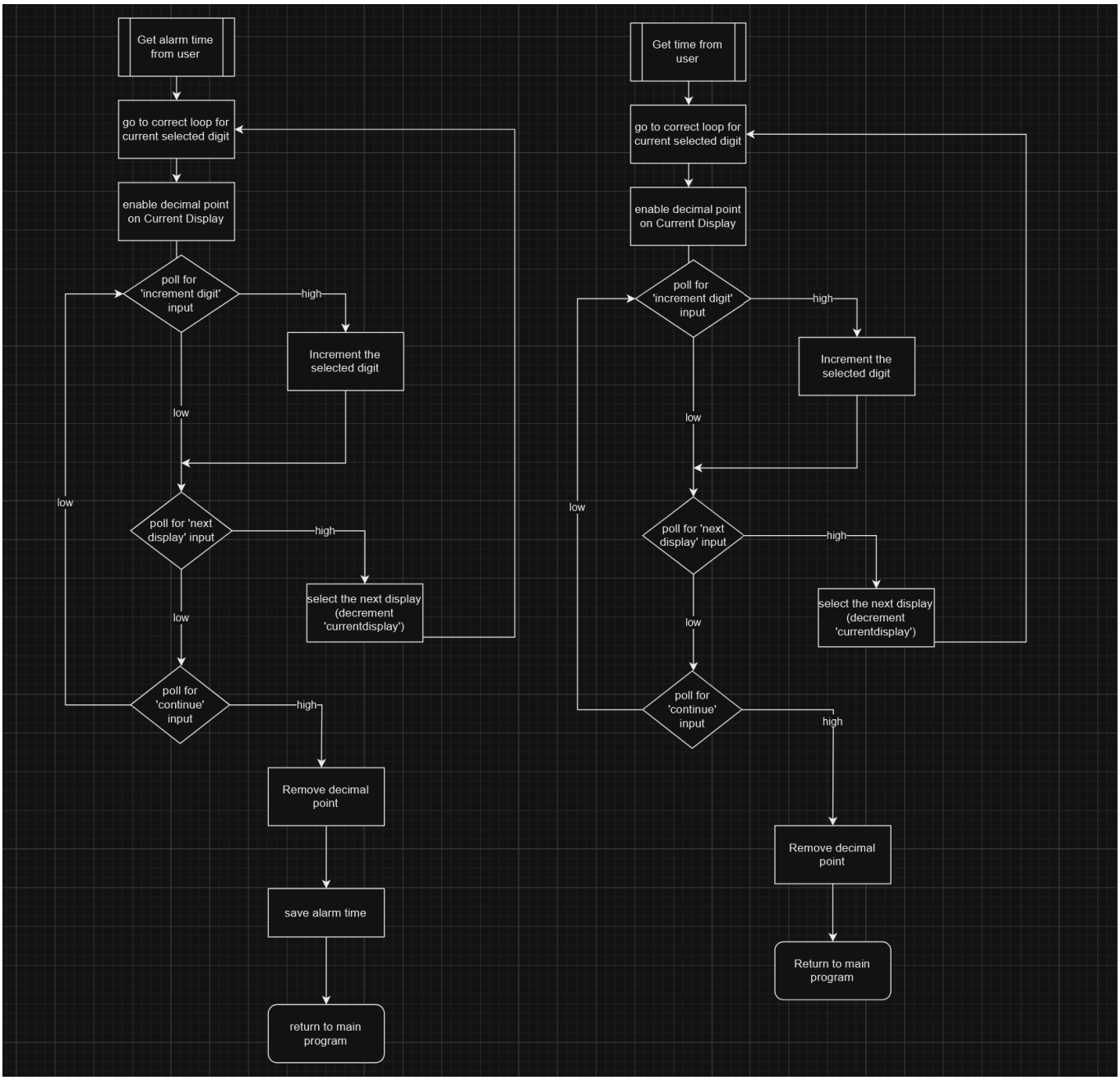
An alarm clock can be a vital part of some people's working lives guaranteeing that they do not sleep in, alternatively they can be used to ensure the user is not late for whatever they are doing that day be that getting a train or meeting a deadline.
Alarm clocks can help in these aspects by acting as notifications that it is a certain time telling the user what they had to do, i.e. The alarm goes off at 07:00 telling the user that it is time to get out of bed or the alarm goes off ten minuets before they have to leave for the train, reminding them that they have ten minuets to finish getting ready and leave. Such uses can allow a person to be more productive.

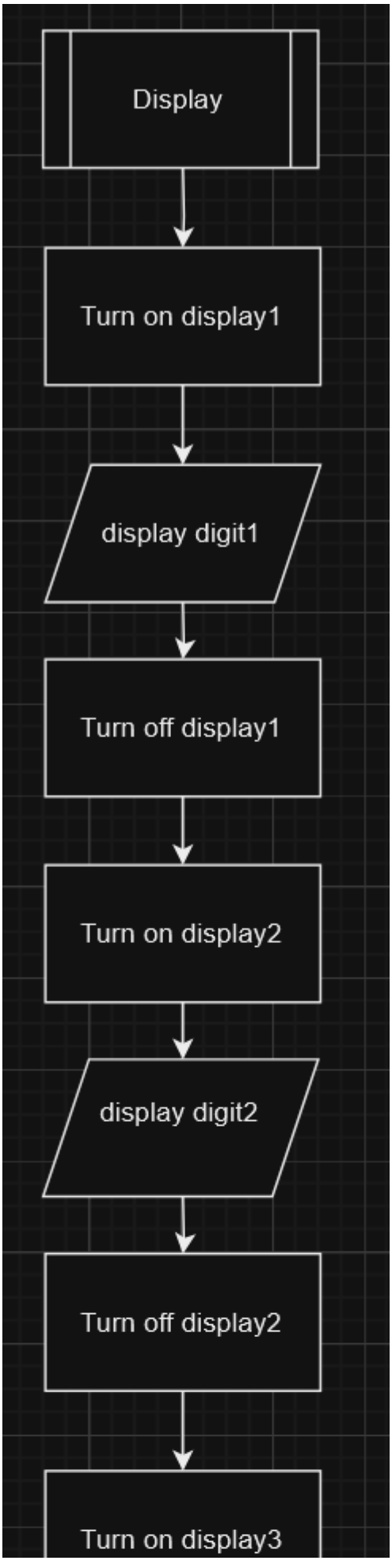
Specification

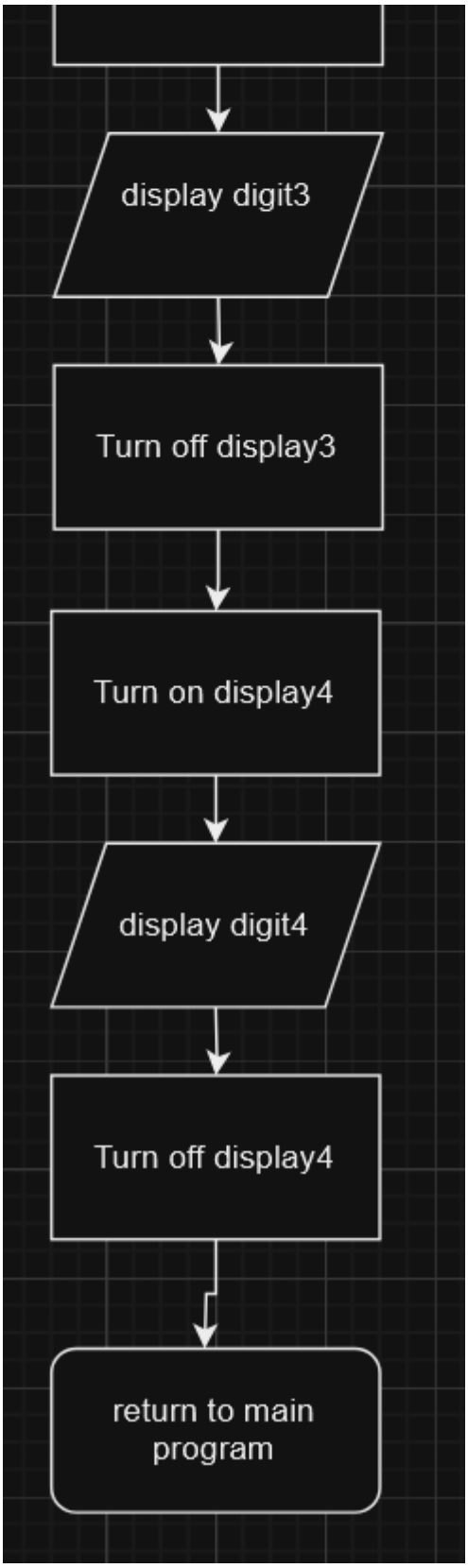
- Runs off a 5 ± 1v power supply
- Uses a PIC 16f88
- Outputs to four red seven segment LED displays
- Displays 24 hour time
- Takes input via three tactile switches
- All buttons are debounce
- Displays have no visible flickering
- Outputs sound through a piezo transducer
- The time is incremented every minute ± .5s


Start
Get alarm time(x) from user
get time from user
is time equal to alarm time?
yes
sound alarm (set bit)
no
clear all
wait one minute
increment minutes
no
minutes=60?
no
yes
increment hours
hours =24?
yes
no
yes
clear minutes


is first digit of the hours = 2?
increment hours
hours=24?
Stop


Get alarm time from user
go to correct loop for current selected digit
enable decimal point on Current Display
poll for 'increment digit' input
high
Increment the selected digit
low
poll for 'next display' input
high
select the next display (decrement 'currentdisplay')
low
poll for 'continue' input
high
low
Remove decimal point
save alarm time
return to main program
Get time from user
go to correct loop for current selected digit
enable decimal point on Current Display
poll for 'increment digit' input
high
Increment the selected digit
low
poll for 'next display' input
high
select the next display (decrement 'currentdisplay')
low
poll for 'continue' input
high
low
Remove decimal point
Return to main program


Display
Turn on display1
display digit1
Turn off display1
Turn on display2
display digit2
Turn off display2
Turn on display3



Meeting the specification

The clock runs off a +5-0Volt power supply counts in one second increments on four multiplexed seven-segment displays that display one of 20 digits, the first ten are human readable numbers 0-9 and the

last ten are the same digits only with the decimal point of the displays active, the decimal point is used to show which display is currently selected when the circuit is taking an input form the user.

The first digit is incremented every minute, once this reaches ten it resets to zero and the second digit is incremented, once the second digit is incremented to six it resets to zero and increments to 0. The Third digit will reset and increment the fourth once it reaches ten if the fourth digit is zero or one however if the Fourth digit is two the third will rollover at five, this prevents the clock from displaying illegal times such as 27:00 while still allowing it to display legal times where the Third digit is over four such as 17:00.

Theoretically the active display switches every 576ms as set by a precale of 1:32 and an operating clock speed of 8MHz, this results in a visually smooth display that doesn't flicker, however these numbers are not exact due to the inaccuracy of the internal RC circuit used for timing. The clock operates on 24 hour time meaning it counts to 2400 before resetting to 0000.

The three buttons connected to bits 4-6 of port A are debounced through the software running on the PIC instead of though a physical circuit, this is done by making the program wait for 200ms before executing the code attached to that input. The buttons are debounced this way because it is easier to build and design to produce the same effect, as a secondary benefit it also reduces the material cost of the circuit as there is no need for a dedicated RC circuit or any other hardware solutions.

Research

Most alarm clocks use a crystal oscillator instead of an RC circuit

- Operated from a 5 ±1
- Increments every minute ± .5s
- Operated with three tactile buttons
- All buttons debounced
- Digits are displayed on four RED seven segment LED displays
- Digits are displayed without visible flicker
- Uses Piezo Transducer as a speaker
- The program is run on a PIC 16f88

User Guide

After powering the system the user will be prompted to input the time they would like the alarm to go off, they can do this by using the leftmost button (Button6) select a digit, the currently selected digit is indicated by the decimal point. The user can then increment the selected digits as necessary using the middle button (Button5), after the user has set their desired alarm they can confirm their input by pressing the rightmost button (Button4), this will move them onto the next portion of the program setting the current time. The user will set the current time by using the same controls mentioned above, after the current time is set the user can start the clock and the alarm will sound at the set time.

Limitations

The displays cannot be photographed with a standard shutter speed and most video will show the displays cycling meaning that it is hard to read the output from a video.

The user also cannot set multiple alarms at the same time, a common feature that potentially allows for a better user experience, this could be added to the current system without a major re-design however it would result in a far larger program size.

While not a major problem there is a small inaccuracy caused by inherent inaccuracy present in the internal RC circuit that is used for timing. This can be fixed by using an external crystal oscillator to clock the timing. To do this I would change bit7 of PORTB to an input after the user has set their alarm and the time, I would do this because there are no spare pins in my design and bit7 serves no purpose after the user has finished their inputs as the decimal points are not used when the clock is keeping time.
The alarm cannot be silenced without turning off the clock, resetting the time and the alarm this could become annoying for the user as they would have to set the time and the alarm every time the alarm goes off.
The alarm is arguably too loud and the volume cannot be adjusted.

There is no snooze feature, silencing the alarm and re-sounding it after some time. This reduces the utility of the system.

Testing Logs

Starting 14/05/24

Display

1. 09:20 display subroutine written but does not give an output, presumed cause to be the digits incrementing past nine too quickly.
2. 10:32 display still has no output, display routine found to be at fault
3. 10:42 display Subroutine re-written, still no output

17/05/24
1. 11:49 display Subroutine re-written, still no output.
2. 11:56 moved display code to main program for testing, no output but the external interrupt light now shows on displays 1 and 4 instead of just display 4, not sure why this happens.
3. 12:00 disabled external interrupt, light now only shows on display 4.
4. 13:21 after re-writing the display subroutine it gives no output but the external interrupt light now moves between displays.
5. 13:29 - After clearing the digits before they are set nothing has changed

21/05/24

1. 09:31 - replaced the look-up table with test code to turn on all LEDs, upon running only displays 1 and 3 were lit.
2. 09:36 - set Current display to 4 at the start of the program, once run displays 3 and 4 displayed an 8 (equivalent to b'01s111111') despite being set to b'11111111'
3. 09:51 - after reverting changes from a test only display four has an output.
4. 09:58 - all displays now work, however the wrong numbers are displayed, 1011 instead of 4321.
5. 10:04 - all displays now give an output.
6. 10:40 - added code to increment numbers before they are displayed, this broke everything
7. 11:06 - changed code to display four fives and then increment them, the fives display but do not increment
8. 11:11 - added argument to "incf", this has changed nothing

9. 11:17 - changed program to manually change the digits, this has changed nothing, the PIC loves the number 5.
   24/05/24
10. 12:16 - changed display subroutine, now all displays light up and display a digit properly but the digit does not change between
11. 12:29 - changed display subroutine, display now works

Clock

04/06/24
1. 10:15 - Digit 1 now increments correctly
2. 10:30 - Digit 1 increments but the rest do not
3. 10:40 - All digits now increment, but this can inly display 20 hours of 24
4. 11:21 - code to determine when digit 3 should increment does not work :(, should increment digit3 to 10 until digit4 is 2 and then clear both when digit3 is 4.

11/06/24
1. 09:47 - Digit4 now resets at 2, all other digits working correctly
2. 09:52 - All digits function correctly
3.

Input

11/06/24
1. 11:20 Select code is unresponsive, just displays all zeroes

14/06/24
1. 11:42 - Program starts by displaying all zeroes (this is intended), but no way of showing the selected digit. When button 6 is pressed a seemingly random display shows a seemingly random number and all other displays turn off. The start button does work however.
2. 12:03 - Pressing button6 now always displays zero on display4
3. 12:20 - Button6 now increments the digits but is polled far too quickly, button5 does not do anything.
4. 12:26 - After re-writing the selected display logic there has been no change.
5. 13:19 - After changing the select display subroutine to decrement the selected display Button5 still does not work.
6. 13:30 - Button5 now changes the display just too quickly, Digits1 and 3 can also be incremented to ten, represented by a zero with a decimal point

7. 13:51 - after debouncing the buttons they no-longer work.
18/06/24
1. 09:21 - buttons five and six are now debounced and increment digits at an acceptable rate
2. 09:25 - In input mode only display4 is on and clock mode flickers with display4 being significantly brighter than the rest.
3. 09:57 - incrementing digits no-longer works and the decimal point is not removed when the display is no longer selected, the clock mode works again.
4. 10:06 - decimal point now deactivates until digit1 when the displays break.
5. 10:42 - decimal point now functions as intended however incrementing a digit leaves it on zero and deactivates all other digits.
6. 11:04 - if you change the selected digit after incrementing the display breaks.
7. 11:10 - if digit2 is selected clock mode is activated prematurely
8. 11:17 - you can now change the selected digits as intended but if the display is selected after the digit is incremented the display breaks
21/06/24
1. 12:00 - can now change digit after incrementing but if the timer is started after a digit is incremented the display breaks.
2. 12:07 - The timer will now start with incremented digits but all displays will quickly turn off, when changing the selected digit in input mode if you loop the selected digit back to the start display4 will flicker then dim instead of enabling the decimal point, if the display is incremented again displays 4 and 3 will have the decimal point while dispaly4 is still noticeably dimmer than the rest, if the selected digit is looped again all displays will turn off and the program will become unresponsive.
3. 13:34 - can now loop the selected digit as intended but if the timer is started digit4 will be changed to a dimmer copy of digit3 and the display will break when it rolls over, if digit2 is incremented the display will break when it tries to roll-over and if digit1 is incremented all displays will turn off when it tris to roll over.
4. 13:43 - The Time set function seems to be working as intended
5.

Change Logs

- 17/05/24
  - 10:01 - Re-Written selection logic of the display sub-routine so that it now uses the zero bit instead of the decfsz command.
  - 10:34 - Added notation to display subroutine.
  - 11:43 - commas are illegal characters.
  - 13:18 - Re written display subroutine so that it no longer copies CurrentDisplay to another file register.
  - 13:48 - set prescaler to 1:32
- 21/05/24
  - 09:13 - changed "movf PORTB" to "movwf PORTB" in the display subroutine
  - 09:40 - changed prescaler to 1:64
  - 09:51 - reverted changes from a test that meant the timer interrupt was not calling display
  - 09:56 - removed the code to set CurrentDisplay to 4 from the main loop, now happens before the main loop so that all displays are used
- 24/05/24
  - 09:21 - added return commands to subdisplay4 and the main display subroutine.
- 03/06/24
  - 13:33 - added code to increment digit 1
- 04/06/24
  - 10:17 - added code to increment digits 2 - 4
  - 10:39 - fixed code to increment all digits
  - 10:43 - added subroutine to wait a minute (Time is sped up to make testing easier)
- 11/06/24
  - 11:19 - added code to select time
- 14/06/24
  - 11:37 - changed code to input time so that it polls PORTA instead of PORTB
  - 11:57 - called display in the input-time subroutine in an attempt to keep the displays cycling after a digit is incremented
  - 12:13 - added code to clear the digits if they are above they need to be reset, i.e. they are above the point at which they increment.
  - 12:25 - re-written code to change the selected display

    - 13:16 - code to change the selected display to decrement the current display instead of increment.
    - 13:51 - debounced switches five and six by adding wait100ms subroutines after they
- 18/06/24
    - 09:16 - debounced switches five and six by adding wait100ms subroutines before functions of the buttons are executed
    - 09:24 - added code to show which display is selected
    - 11:04 - added code to remove decimal point when entering clock mode
- 21/06/24
    - 11:55 - changed sublw to subwf to stop negative numbers being fed into the digit table and breaking the display
    - 14:06 - fixed time set subroutine and added alarm set subroutine,
- 28/06/24
    - 09:44 - Fixed spelling mistakes in "GetAlarm" that were causing errors, fixed spelling mistakes in "Compare" that were causing errors, compare now calls buzz when all digits are the same as the alarm digits.
- 08/07/24
    - 12:16 added a subroutine to display alarm digits, now will not enter clock mode

Source Code

```
;*****************************************************************
;                              TEMPLATE PROVIDED BY CENTRE

;         TITLE:  #### Alarm Clock #####
;         AUTHOR: ######## Hamish Lindsay #########
;         DATE:   ####### 07/05/2024 ######
;

;*****************************************************************
; PROGRAM DESCRIPTION:
;
; ####  The Program takes the current time from the user and lets the user set an alarm,
;    when the alarm is reached the piezo buzzer will sound at 500hz.#######
;
;*****************************************************************
;                       DEFINITIONS
;*****************************************************************
    list    p=16F88                     ; tells the assembler which PIC chip to program for
    radix       dec                     ; set default number radix to decimal
    ;radix      hex                     uncomment this to  set  radix to hex
    __config h'2007', 0x3F50    ; internal oscillator, RA5 as i/o, wdt off
    __config h'2008', 0x3FFF
    errorlevel -302                     ; hide page warnings

W               EQU h'00'       ; pointer to Working register
F               EQU h'01'       ; pointer to file

;****** REGISTER USAGE ******

;For PIC16F88, user RAM starts at h'20'. The following definitions
;will be found useful in many programs.

; Register page 1
PCL EQU h'02'
TRISA   EQU h'85'       ; data direction registers
TRISB   EQU h'86'
OSCCON  EQU h'8F'       ; internal oscillator speed
ANSEL   EQU h'9B'       ; ADC port enable bits

; Register page 0
STATUS  EQU h'03'       ; status
PORTA   EQU h'05'       ; input / output ports
PORTB   EQU h'06'
INTCON  EQU h'0B'       ; interrupt control
ADRESH  EQU h'1E'       ; ADC result
ADCON0  EQU h'1F'       ; ADC control
OPTION_REG  EQU h'81'

B0      EQU h'20'       ; general use byte registers B0 to B27
B1      EQU h'21'
B2      EQU h'22'
B3      EQU h'23'
B4      EQU h'24'
```

```
B5      EQU h'25'
B6      EQU h'26'
B7      EQU h'27'
B8      EQU h'28'
B9      EQU h'29'
B10     EQU h'2A'
B11     EQU h'2B'
B12     EQU h'2C'
B13     EQU h'2D'
B14     EQU h'2E'
B15     EQU h'2F'
B16     EQU h'30'
B17     EQU h'31'
B18     EQU h'32'
B19     EQU h'33'
B20     EQU h'34'       ; used in interrupt routine
B21     EQU h'35'       ; used in interrupt routine
B22     EQU h'36'
B23     EQU h'37'
B24     EQU h'38'
B25     EQU h'39'
B26     EQU h'3A'
B27     EQU h'3B'

WAIT1   EQU h'3C'       ; counters used in wait delays
WAIT10  EQU h'3D'
WAIT100 EQU h'3E'
WAIT1000        EQU h'3F'
ADCTEMP EQU h'40'       ; adc loop counter
Digit1          EQU h'41'       ;minutes (will be sped up for testing)
Digit2          EQU h'42'       ;ten minutes
Digit3          EQU h'43'       ;hours
Digit4          EQU h'44'       ;ten hours
save1           EQU h'45'       ;register to copy digit1 to
save2           EQU h'46'       ;register to copy digit2 to
save3           EQU h'47'       ;register to copy digit3 to
save4           EQU h'48'       ;register to copy digit4 to
CurrentDisplay  EQU h'49' ;variable to indicate the current display
SaveDis         EQU h'4A'
AlarmDig1       EQU h'4C'       ;minutes used to compare the alarm to
AlarmDig2       EQU h'4D'       ;ten minutes used to compare the alarm to
AlarmDig3       EQU h'4E'       ;hours used to compare the alarm to
AlarmDig4       EQU h'4F'
count           EQU h'55'
SelectDis       EQU h'56'       ;Display selected for input
buzzCount       EQU h'57'       ;Used for buzz loop to time how long the piezo will sound
;****** REGISTER BITS ******

C               EQU h'00'       ; carry flag
Z               EQU h'02'       ; zero flag
RP0             EQU h'05'       ; register page bit
```

```
INT0IF          EQU h'01'       ; interrupt 0 flag
INT0IE          EQU h'04'       ; interrupt 0 enable
GIE             EQU h'07'       ; global interrupt enable
TMR0IE          EQU h'05'       ; Timer interrupt enable
TMR0IF          EQU h'02'       ; Timer interrupt flag

;*****************************************************************
;                       VECTORS
;*****************************************************************

;The PIC16F88 reset vectors

    ORG     h'00'               ; reset vector address
        goto    start   ; goes to first instruction on reset/power-up
    ORG     h'04'       ; interrupt vector address
        goto    interrupt
;
;*****************************************************************
;                       SUBROUTINES
;*****************************************************************
; Predefined wait subroutines - wait1ms, wait10ms, wait100ms, wait1000ms

wait1ms         ; (199 x 5) + 5 instructions = 1000us = 1ms @ 4MHz resonator
        movlw d'199'    ; 1
        movwf WAIT1     ; 1
loop5ns
        clrwdt          ; 1 this loop 1+1+1+2 = 5 instructions
        nop             ; 1
        decfsz WAIT1,F  ; 1
        goto loop5ns    ; 2
        nop             ; 1
        return                  ; 2
wait10ms
        movlw d'10'             ; 10 x 1ms = 10ms
        movwf WAIT10
loop10ms
        call    wait1ms
        decfsz  WAIT10,F
        goto    loop10ms
        return

wait100ms
        movlw d'100'    ; 100 x 1ms = 100ms
        movwf WAIT100
loop100ms
        call    wait1ms
        decfsz  WAIT100,F
        goto    loop100ms
        return
wait1min
        clrf count
minloop                     ; waits for one minute used to time the increments
        call wait1000ms
```

```
minloop                     ; waits for one minute used to time the increments
        call wait1000ms
        incf count
        movf count, 0
        sublw d'60'
        btfss STATUS, Z
        goto minloop
        return
wait1000ms
        movlw   d'10'     ; 10 x 100ms = 1000ms
        movwf   WAIT1000
loop1000ms
        call    wait100ms
        decfsz  WAIT1000,F
        goto    loop1000ms
        return
wait500ms
        call wait100ms
        call wait100ms
        call wait100ms
        call wait100ms
        call wait100ms
        return
wait200ms
        call wait100ms
        call wait100ms
        return
; Predefined ADC subroutines - readadc0, readac1, readadc2

readadc0
        movlw   b'00000001'     ; setup mask for pin A.0
        call    readadc ; do the adc conversion
        movwf   B0              ; save result in B0
        return
readadc1
        movlw   b'00000010'     ; setup mask for pin A.1
        call    readadc ; do the adc conversion
        movwf   B1              ; save result in B1
        return
readadc2
        movlw   b'00000100'     ; setup mask for pin A.2
        call    readadc ; do the adc conversion
        movwf   B2              ; save result in B2
        return

readadc
; Generic sub routine to read ADC 0, 1 or 2 (pass appropriate mask in W)
; To start conversion we need mask (001, 010, 100) in ANSEL bits 0-2
; but the actual channel number (0, 1, 2) in ADCON0 channel select bits
; Then set the ADCON0, GO bit to start the conversion

        bsf             STATUS,RP0      ; select register page 1
        movwf   ANSEL           ; move mask value 001,010,100 into ANSEL
```

```
        bcf             STATUS,RP0      ; select register page 0
        movwf   ADCTEMP ; 00000???      get mask value
        rlf             ADCTEMP,F       ; 0000???x      rotate twice
        rlf             ADCTEMP,W       ; 000???xx
        andlw   b'00011000'     ; 000??000      mask off the unwanted bits
        iorlw   b'00000001'     ; 000??001      set the 'ADC on' bit
        movwf   ADCON0  ; move working into ADCON0
        movlw           d'10'           ; 10 x 3 = 30us acquistion time
        movwf   ADCTEMP         ; re-use ADC1 register as a counter
loopacq
        decfsz          ADCTEMP,F       ; loop around to create short delay
        goto            loopacq         ; each loop is 1+2 = 3 instructions = 3us @ 4MHz
        bsf             ADCON0,2        ; now start the conversion
loopadc
        clrwdt                  ; pat the watchdog
        btfsc   ADCON0,2        ; is conversion finished?
        goto    loopadc ; no, so wait a bit more
        movf    ADRESH,W        ; move result into W
        return                          ; return with result in W

; NOTE for PICAXE users:  the following four specific subroutines and two instructions are not supported by PICAXE compiler
readtemp1:
readtemp2:
readtemp3:
debug:
lcd:
        clrw                            ; instruction not supported by this template
        return                  ; instruction not supported by this template

table                       ;lookup table for seven segment displays.
    addwf PCL
    retlw b'00111111'
    retlw b'00000110'
    retlw b'01011011'
    retlw b'01001111'
    retlw b'01100110'
    retlw b'01101101'
    retlw b'01111101'
    retlw b'00000111'
    retlw b'01111111'
    retlw b'01101111'
    retlw b'10111111'   ;table repeated with the decimal point lit.
    retlw b'10000110'
    retlw b'11011011'
    retlw b'11001111'
    retlw b'11100110'
    retlw b'11101101'
    retlw b'11111101'
    retlw b'10000111'
    retlw b'11111111'
    retlw b'11101111'
```

```
Display                     ;select the display to turn on
   movf CurrentDisplay, 0
   sublw d'4'
   btfsc STATUS, Z
   goto SubDisplay1         ;Subtract four from CurrentDisplay, if result is 0 goto SubDisplay1
   movf CurrentDisplay, 0
   sublw d'3'
   btfsc STATUS, Z
   goto SubDisplay2
   movf CurrentDisplay, 0
   sublw d'2'
   btfsc STATUS, Z
   goto SubDisplay3
   movf CurrentDisplay, 0
   sublw d'1'
   btfsc STATUS, Z
   goto SubDisplay4

SubDisplay1
    bcf PORTA, 3
    bsf PORTA, 0
    movf Digit1, 0
    call table
    movwf PORTB             ;Display value of Digit 1 on display 1
    decf CurrentDisplay, 1
    return                          ;Return to display selection
SubDisplay2                                 ;Repeat for other displays
    bcf PORTA, 0
    bsf PORTA, 1
    movf Digit2, 0
    call table
    movwf PORTB
    decf CurrentDisplay, 1
    return
SubDisplay3
    bcf PORTA, 1
    bsf PORTA, 2
    movf Digit3, 0
    call table
    movwf PORTB
    decf CurrentDisplay, 1
    return
SubDisplay4
    bcf PORTA, 2
    bsf PORTA, 3
    movf Digit4, 0
    call table
    movwf PORTB
    movlw d'4'
    movwf CurrentDisplay
    return
```

```
Compare
    movf Digit1, 0
    subwf AlarmDig1, 0
    btfsc STATUS, Z         ;Compare Digit1 of current time and digit =1 of the alarm, if they are the same check digit2, if they are not return to program
    goto Compare2
    return
Compare2
    movf Digit2, 0
    subwf AlarmDig2, 0
    btfsc STATUS, Z         ;Compare digit2 fo current time to digit2 of the alarm, if they are the same check digit3, if they are not return to program
    goto Compare3
    return
Compare3
    movf Digit3, 0
    subwf AlarmDig3, 0
    btfsc STATUS, Z        ;Compare digit3 o fcurrent time to digit3 of alarm, if they are the same check digit4, if they are not return to program
    goto Compare4
    return
Compare4
    movf Digit4, 0
    subwf AlarmDig4, 0
    btfsc STATUS, Z        ;Compare digit4 of current time to digit4 of the alarm, if they are the same sound the peizo, if they are not return to program
    goto test
    return
Buzz
buzzLoop
    bsf PORTA, 7
    call wait1ms
    call wait1ms
    bcf PORTA, 7
    call wait500ms
    goto buzzLoop
GetAlarm
        clrf Digit1         ;Set all digits to 0 and set Selectdis to 4
        clrf Digit2
        clrf Digit3
        clrf Digit4
        movlw d'4'
        movwf SelectDis
Alarmloop
        movf SelectDis, 0       ;if display4 is selected enter the loop to poll changes to digit4
        sublw d'4'
        btfsc STATUS, Z
        goto AlarmSelectIs4
        movf SelectDis, 0       ;if display3 is selected enter the loop to poll changes to digit3
        sublw d'3'
        btfsc STATUS, Z
        goto AlarmSelectIs3
        movf SelectDis, 0       ;if display2 is selected enter the loop to poll changes to digit2
        sublw d'2'
        btfsc STATUS, Z
        goto AlarmSelectIs2
        movf SelectDis, 0       ;if display1 is selected enter the loop to poll changes to digit1
```

```
AlarmSelectIs4                  ;add the decimal point to the selected digit
        movf Digit4, 0
        addlw d'10'
        movwf Digit4
AlarmSelectLoop4                ;poll the input bits and go to their according subroutines if they are high
        btfsc PORTA ,6
        goto Alarminc4
        btfsc PORTA ,5
        goto DecDis4
        btfsc PORTA ,4
        goto Alarmcontinue4
        goto AlarmSelectLoop4
AlarmSelectIs3                  ;add the decimal point to the selected digit
        movf Digit3, 0
        addlw d'10'
        movwf Digit3
AlarmSelectLoop3                ;poll the input bits and go to their according subroutines if they are high
        btfsc PORTA ,6
        goto Alarminc3
        btfsc PORTA ,5
        goto AlarmDecDis3
        btfsc PORTA ,4
        goto Alarmcontinue3
        goto AlarmSelectLoop3
AlarmSelectIs2                  ;add the decimal point to the selected digit
        movf Digit2, 0
        addlw d'10'
        movwf Digit2
AlarmSelectLoop2                ;poll the input bits and go to their according subroutines if they are high
        btfsc PORTA ,6
        goto Alarminc2
        btfsc PORTA ,5
        goto AlarmDecDis2
        btfsc PORTA ,4
        goto Alarmcontinue2
        goto AlarmSelectLoop2
AlarmSelectIs1                  ;add the decimal point to the selected digit
        movf Digit1, 0
        addlw d'10'
        movwf Digit1
AlarmSelectLoop1                ;poll the input bits and go to their according subroutines if they are high
        btfsc PORTA ,6
        goto Alarminc1
        btfsc PORTA ,5
        goto AlarmSetDis
        btfsc PORTA ,4
        goto Alarmcontinue1
        goto AlarmSelectLoop1
Alarminc4                       ;increment the digit4, if it is equal to 13 (three with a decimal point) set it to 10 (zero with a decimal point).
        call wait200ms
        incf Digit4, 1
        movf Digit4, 0
        sublw d'13'
```

```
        btfss STATUS, Z
        goto AlarmSelectLoop4
        movlw d'10'
        movwf Digit4
        goto AlarmSelectLoop4
Alarminc3                   ;increment the digit3, if it is equal to 20 (this would display an unintended digit) set it to 10 (zero with a decimal point).
        call wait200ms
        incf Digit3, 1
        movf Digit3, 0
        sublw d'20'
        btfss STATUS, Z
        goto AlarmSelectLoop3
        movlw d'10'
        movwf Digit3
        goto AlarmSelectLoop3
Alarminc2                   ;increment the digit2, if it is equal to 16 (six with a decimal point) set it to 10 (zero with a decimal point).
        call wait200ms
        incf Digit2, 1
        movf Digit2, 0
        sublw d'16'
        btfss STATUS, Z
        goto AlarmSelectLoop2
        movlw d'10'
        movwf Digit2
        goto AlarmSelectLoop2
Alarminc1                   ;increment the digit3, if it is equal to 20 (this would display an unintended digit) set it to 10 (zero with a decimal point).
        call wait200ms
        incf Digit1, 1
        movf Digit1, 0
        sublw d'20'
        btfss STATUS, Z
        goto AlarmSelectLoop1
        movlw d'10'
        movwf Digit1
        goto AlarmSelectLoop1
AlarmDecDis4                ;remove the decimal point and move to the subroutine to change the selected display
        movlw d'10'
        subwf Digit4, 1
        goto AlarmDecDis
AlarmDecDis3                ;remove the decimal point and move to the subroutine to change the selected display
        movlw d'10'
        subwf Digit3, 1
        goto AlarmDecDis
AlarmDecDis2                ;remove the decimal point and move to the subroutine to change the selected display
        movlw d'10'
        subwf Digit2, 1
        goto AlarmDecDis
AlarmDecDis                 ;remove the decimal point and move to the subroutine to change the selected display
        call wait200ms
        decf SelectDis, 1
        goto Alarmloop
AlarmSetDis                 ;remove the decimal point and change the selected display to display four.
        movlw d'10'
```

```
        subwf Digit1, 1
        call wait200ms
        movlw d'4'
        movwf SelectDis
        goto Alarmloop
Alarmcontinue1                  ;remove the decimal point and move to the exit point o fhte subroutine
        movlw d'10'
        subwf Digit1, 1
        Goto AlarmReturn
Alarmcontinue2                  ;remove the decimal point and move to the exit point o fhte subroutine
        movlw d'10'
        subwf Digit2, 1
        goto AlarmReturn
Alarmcontinue3                  ;remove the decimal point and move to the exit point o fhte subroutine
        movlw d'10'
        subwf Digit3, 1
        goto AlarmReturn
Alarmcontinue4                  ;remove the decimal point and move to the exit point o fhte subroutine
        movlw d'10'
        subwf Digit4, 1
        goto AlarmReturn
AlarmReturn                     ;save the time on the displays to Alarmdig1-4 before exitiing the subroutine.
        movf Digit1, 0
        movwf AlarmDig1
        movf Digit2, 0
        movwf AlarmDig2
        movf Digit3, 0
        movwf AlarmDig3
        movf Digit4, 0
        movwf AlarmDig4
        return
GetTime
        clrf Digit1
        clrf Digit2
        clrf Digit3
        clrf Digit4
        movlw d'4'
        movwf SelectDis
Timeloop
        movf SelectDis, 0
        sublw d'4'
        btfsc STATUS, Z
        goto SelectIs4
        movf SelectDis, 0
        sublw d'3'
        btfsc STATUS, Z
        goto SelectIs3
        movf SelectDis, 0
        sublw d'2'
        btfsc STATUS, Z
        goto SelectIs2
        movf SelectDis, 0
        sublw d'1'
```

```
        btfsc STATUS, Z
        goto SelectIs1
SelectIs4
        movf Digit4, 0
        addlw d'10'
        movwf Digit4
SelectLoop4
        btfsc PORTA ,6
        goto inc4
        btfsc PORTA ,5
        goto DecDis4
        btfsc PORTA ,4
        goto continue4
        goto SelectLoop4
SelectIs3
        movf Digit3, 0
        addlw d'10'
        movwf Digit3
SelectLoop3
        btfsc PORTA ,6
        goto inc3
        btfsc PORTA ,5
        goto DecDis3
        btfsc PORTA ,4
        goto continue3
        goto SelectLoop3
SelectIs2
        movf Digit2, 0
        addlw d'10'
        movwf Digit2
SelectLoop2
        btfsc PORTA ,6
        goto inc2
        btfsc PORTA ,5
        goto DecDis2
        btfsc PORTA ,4
        goto continue2
        goto SelectLoop2
```

```
SelectIs1
        movf Digit1, 0
        addlw d'10'
        movwf Digit1
SelectLoop1
        btfsc PORTA ,6
        goto inc1
        btfsc PORTA ,5
        goto SetDis
        btfsc PORTA ,4
        goto continue1
        goto SelectLoop1
inc4
        call wait200ms
        incf Digit4, 1
```

```
        movf Digit4, 0
        sublw d'13'
        btfss STATUS, Z
        goto SelectLoop4
        movlw d'10'
        movwf Digit4
        goto SelectLoop4
inc3
        call wait200ms
        incf Digit3, 1
        movf Digit3, 0
        sublw d'20'
        btfss STATUS, Z
        goto SelectLoop3
        movlw d'10'
        movwf Digit3
        goto SelectLoop3
inc2
        call wait200ms
        incf Digit2, 1
        movf Digit2, 0
        sublw d'16'
        btfss STATUS, Z
        goto SelectLoop2
        movlw d'10'
        movwf Digit2
        goto SelectLoop2
inc1
        call wait200ms
        incf Digit1, 1
        movf Digit1, 0
```

```
        sublw d'20'
        btfss STATUS, Z
        goto SelectLoop1
        movlw d'10'
        movwf Digit1
        goto SelectLoop1
DecDis4
        movlw d'10'
        subwf Digit4, 1
        goto DecDis
DecDis3
        movlw d'10'
        subwf Digit3, 1
        goto DecDis
DecDis2
        movlw d'10'
        subwf Digit2, 1
        goto DecDis
DecDis
        call wait200ms
        decf SelectDis, 1
        goto Timeloop
```

```
SetDis
        movlw d'10'
        subwf Digit1, 1
        call wait200ms
        movlw d'4'
        movwf SelectDis
        goto Timeloop
continue1
        movlw d'10'
        subwf Digit1, 1
        call wait200ms
        return
continue2
        movlw d'10'
        subwf Digit2, 1
        call wait200ms
        return
continue3
        movlw d'10'
        subwf Digit3, 1
        call wait200ms
        return
continue4
        movlw d'10'
        subwf Digit4, 1
        call wait200ms
        return
test
        bsf PORTA,7
        goto test
ShowAlarm
        movf AlarmDig1, 0
        movwf Digit1
        movf AlarmDig2, 0
        movwf Digit2
        movf AlarmDig3, 0
        movwf Digit3
        movf AlarmDig4, 0
        movfw Digit4
        call wait1000ms
        return

;*****************************************************************
;                       MAIN PROGRAM
;*****************************************************************

;****** INITIALISATION ******
start
        bsf             STATUS,RP0      ; select register page 1
        movlw   b'01100000'     ; set to 4MHz internal operation
        movwf   OSCCON
```

```
        movwf   OSCCON
        clrf    ANSEL           ; disable ADC (enabled at power-up)
        bcf             STATUS,RP0      ; select register page 0
;The data direction registers TRISA and TRISB live in the special register set. A '1' in
;these registers sets the corresponding port line to an Input, and a
;'0' makes the corresponding line an output.

Init
        clrf            PORTA           ; make sure PORTA output latches are low
        clrf            PORTB           ; make sure PORTB output latches are low
        bsf             STATUS,RP0      ; select register page 1
;Modify the next line to correspond with your input output reqirements
        movlw   b'01110000'     ; set port A data direction (0 = output bit, 1 = input bit)
        movwf   TRISA           ;
;Modify the next line to correspond with your input output requirements
        movlw   b'00000000'     ; set port B data direction (0 = output bit, 1 = input bit)
        movwf   TRISB           ;

        movlw   b'11000011'     ;set timer prescaler to 1:32
        movwf   OPTION_REG

        bcf             STATUS,RP0      ; select register page 0
        clrf AlarmDig1
        clrf AlarmDig2
        clrf AlarmDig3
        clrf AlarmDig4
;****** MAIN PROGRAM ******
;************* remove semicolons from next two lines to enable interrupt routine************
        ;bsf            INTCON,INT0IE  ; set external interrupt enable
        bsf             INTCON,GIE      ; enable all interrupts
        bsf             INTCON, TMR0IE      ;enable timer0 interrupt
main
        movlw d'4'
        movwf CurrentDisplay
        call GetAlarm
        call GetTime
Loop1
        call Compare
        call wait1min
        incf Digit1, 1
        movf Digit1, 0
        sublw d'10'
        btfss STATUS, Z
        goto Loop1
        clrf Digit1
Loop2
        call Compare
        incf Digit2, 1
        movf Digit2, 0
        sublw d'6'
        btfss STATUS, Z
        goto Loop1
        clrf Digit2
Loop3
        call Compare
        movf Digit4, 0
```

```
        sublw d'2'
        btfsc STATUS, Z
        goto Dig4is2       ;if digit4 is currently two, increment digit3 to four otherwise increment digit3 to ten.
        incf Digit3, 1
        movf Digit3, 0
        sublw d'10'
        btfss STATUS, Z
        goto Loop1
        clrf Digit3
        goto Loop4
Dig4is2
        call Compare
        incf Digit3, 1
        movf Digit3, 0
        sublw d'4'
        btfss STATUS, Z
        goto Loop1
        clrf Digit3
Loop4
        call Compare
        incf Digit4, 1
        movf Digit4, 0
        sublw d'3'
        btfss STATUS, Z
        goto Loop1
        clrf Digit4
        goto Loop1
;*********************************************************************
;*********************************************************************
;                       INTERRUPT SERVICE ROUTINE
;*********************************************************************

W_SAVE  EQU B20                 ; backup registers used in interrupts
interrupt
       movwf   W_SAVE  ; Copy W to save register

       btfss   INTCON,TMR0IF  ; check correct interrupt has occurred
       retfie                          ; no, so return and re-enable GIE
;**********The interrupt service routine (if required) goes here*********
       call Display
       bcf     INTCON,TMR0IF    ; clear interrupt flag
       movf    W_SAVE,W         ; restore W
       retfie                          ; return and re-set GIE bit
       END                             ; all programs must end with this
```