```
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00001             LIST       N=83,C=110,B=4,P=16F18323
                     00002             ERRORLEVEL  -302   ;ignore banking messages
                     00003     title    "----- Track Occupation Sensor Program, (C) LWH brainware 2021"
                     00004     subtitle "----- Main Program"
                     00005 ;=========================================================================
                     00006 ;-  Track Occupation Sensor Program for BSense2PIC Board
                     00007 ;-  (C) LWH brainware 2021
                     00008 ;=========================================================================
                     00009 ;-  210412  lwh created
                     00010 ;-------------------------------------------------------------------------
                     00011     #include    "P16F18323.inc"
                     00001         LIST
                     00002
                     00003 ;==========================================================================
                     00004 ; Build date : May 15 2016
                     00005 ;  MPASM PIC16F18323 processor include
                     00006 ;
                     00007 ;  (c) Copyright 1999-2016 Microchip Technology, All rights reserved
                     00008 ;==========================================================================
                     00009
                     02489         LIST
                     00012 ;-------------------------------------------------------------------------
                     00013 ;-  General Adresses and Registers for PIC16F182x
                     00014 ;-------------------------------------------------------------------------
                     00015 ;-  Addresses
                     00016 ;-------------------------------------------------------------------------
  00000100           00017 CODE_START      EQU     0x100       ; start of program space
  00000000           00018 RESET_ADR       EQU     0x000       ; reset vector
  00000004           00019 INTER_ADR       EQU     0x004       ; interrupt vector
                     00020 ;       Memory addresses
                     00021 ; last common RAM address declared so far (0070..007F)
  00000070           00022 LASTCOMMON      SET     H'070'      ; initialize to 0070, updated later
                     00023 ;-------------------------------------------------------------------------
                     00024 ;-  User ID words 0..3
                     00025 ;-
                     00026 UserID  code    0x8000
                     00027         ; first word corresponds to EHwType from ITrainHardware interface (?)
8000   0102          00028         dw      0x0102      ; BSense2PIC
8001   3FFF          00029         dw      0x3FFF      ; not used
8002   0010          00030         dw      0x0010      ; board version
8003   0100          00031         dw      0x0100      ; version 1.0
                     00032 ;-------------------------------------------------------------------------
                     00033 ;-  Configuration bits
                     00034 ;-  - ecternal oscillator off
                     00035 ;-  - use internal oscillator
                     00036 ;-  - no clock output on pin OSC2
                     00037 ;-  - clock switching by software allowed
                     00038 ;-  - Fail-Safe Clock Monitor is disabled
8007   1FEC          00039     __config    _CONFIG1, _FEXTOSC_OFF & _RSTOSC_HFINT1 & _CLKOUTEN_OFF & _CSWEN_O
                           N & _FCMEN_OFF & H'3FFF'
                     00040 ;-  - debugging off unless managed by debugger tool
                     00041 ;-  - Stack Overflow or Underflow will cause a Reset
                     00042 ;-  - PPS can be used repeatedly
                     00043 ;-  - Brown-out reset voltage is low (2.45V)
                     00044 ;-  - Brown-out will cause a reset
                     00045 ;-  - watchdog timer is off
                     00046 ;-  - power-up timer is on
                     00047 ;-  - RA3 is !MCLR
8008   37F1          00048     __config    _CONFIG2, _DEBUG_OFF & _STVREN_ON & _PPS1WAY_OFF & _BORV_LOW & _BO
                           REN_ON & _WDTE_OFF & _PWRTE_ON & _MCLRE_ON & H'3FFF'
                     00049 ;-  - low voltage programming off
                     00050 ;-  - write-protection off (for now)
8009   1FFF          00051     __config    _CONFIG3, _LVP_OFF & _WRT_OFF & H'3FFF'
                     00052 ;-  - EEPROM code protection off
                     00053 ;-  - Program code protection off (for now)
800A   3FFF          00054     __config    _CONFIG4, _CPD_OFF & _CP_OFF & H'3FFF'
                     00055
                     00056         ORG RESET_ADR                   ; reset vector
                     00057 ;-------------------------------------------------------------------------
                     00058 ;-  Program
                     00059 ;-------------------------------------------------------------------------
0000   2???          00060         GOTO    init                ; start with initialization
                     00061
                     00062     ORG INTER_ADR                   ; interrupt vector
                     00063 ;-------------------------------------------------------------------------
                     00064 ;-  Interrupt handling
                     00065 ;-------------------------------------------------------------------------
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
----- Main Program
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

0004                 00066 intINT:     ; check general interrupt
0004   0020          00067         banksel PIR0
0005   1010          00068         BCF     PIR0, INTF      ; clear interrupt (not used here)
                     00069         ;--------------------------------------------------------------
0006                 00070 intComp1    ; check comparator 1 (track 1 negative flank)
0006   0020          00071         banksel PIR2
0007   1E92          00072         BTFSS   PIR2, C1IF      ; check if comparator 1 interrupt is set
0008   2???          00073         GOTO    intComp2        ; if not, check next
                     00074         ; handle comparator 1 interrupt
0009   1292          00075         BCF     PIR2, C1IF      ; first, clear interrupt flag
000A   2???          00076         CALL    onFlank1
                     00077         ;--------------------------------------------------------------
000B                 00078 intComp2    ; check comparator 2 (track 2 negative flank)
000B   0020          00079         banksel PIR2
000C   1F12          00080         BTFSS   PIR2, C2IF      ; check if comparator 2 interrupt is set
000D   2???          00081         GOTO    intTmr0
                     00082         ; handle comparator 2 interrupt
000E   1312          00083         BCF     PIR2, C2IF      ; first, clear interrupt flag
000F   2???          00084         CALL    onFlank2
                     00085         ;--------------------------------------------------------------
0010                 00086 intTmr0:    ; check timer 0 interrupt (track1 time expired)
0010   0020          00087         banksel PIR0
0011   1E90          00088         BTFSS   PIR0, TMR0IF    ; check if timer0 interrupt is set
0012   2???          00089         GOTO    intTmr1         ; if not, check next
                     00090         ; handle timer0 interrupts
0013   1290          00091         BCF     PIR0, TMR0IF    ; first, clear interrupt flag
0014   2???          00092         CALL    onTimerEnd1
                     00093         ;--------------------------------------------------------------
0015                 00094 intTmr1:    ; check timer 1 interrupt (track2 time expired)
0015   0020          00095         banksel PIR1
0016   1C11          00096         BTFSS   PIR1, TMR1IF    ; check if timer1 interrupt is set
0017   2???          00097         GOTO    intDone         ; if not, check next
                     00098         ; handle timer1 interrupts
0018   1011          00099         BCF     PIR1, TMR1IF    ; first, clear interrupt flag
0019   2???          00100         CALL    onTimerEnd2
                     00101
                     00102 ;--------------------------------------------------------------
001A                 00103 intDone:        ; interrupts checked and handled
001A   0009          00104         RETFIE                  ; return from interrupt
                     00105
                     00106     ORG CODE_START
                     00107 ;-------------------------------------------------------------------------
                     00108 ;-  Controller Initialization
                     00109 ;-------------------------------------------------------------------------
                     00110 ;-  internal oscillator setup to 250kHz, allowing max timer period 4.2 sec
0100                 00111 init:
0100   0032          00112         banksel OSCCON1
0101   3062          00113         MOVLW   B'01100010'
                     00114         ;         x|||++++---   postscaler set to 1:4
                     00115         ;          +++-------   HF internal oscillator, 1MHz (just in case)
0102   0099          00116         MOVWF   OSCCON1
0103   3000          00117         MOVLW   B'00000000'
                     00118         ;         xxxx++++---   HFINTOSC set to 1MHZ
0104   009F          00119         MOVWF   OSCFRQ
0105   3000          00120         MOVLW   0x00
0106   009E          00121         MOVWF   OSCTUNE             ; fix osctune bug (from the errata doc)
0107   171D          00122         BSF     OSCEN, HFOEN        ; enable oscillator
                     00123         ; now there may be a 2µs delay until oscillator has changed
                     00124         ; wait until oscillator is ready
                     00125 #ifndef TESTSIM
0108   1F1C          00126         BTFSS   OSCSTAT1, HFOR      ; is HFINTOSC ready?
0109   2???          00127         GOTO    $-1                 ; if not, test again
                     00128 #endif
                     00129
                     00130 ;-  set DAC to supply reference voltage for comparators positive input
010A   0022          00131         banksel DACCON0
010B   3080          00132         MOVLW   B'10000000'
                     00133         ;         |x|x||x+---   negative source is Vss (GND)
                     00134         ;         | | ++-----   positive source is Vdd (+5V)
                     00135         ;         | +--------   no DAC1OUT pin
                     00136         ;         +----------   DAC is enabled
010C   0098          00137         MOVWF   DACCON0
010D   3019          00138         MOVLW   D'25'           ;set DAC output to xx/32 * 5V
010E   0099          00139         MOVWF   DACCON1
                     00140
010F   2???          00141         CALL    setupDetect1    ; set up sensor 1
0110   2???          00142         CALL    setupDetect2    ; set up sensor 2
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
----- Main Program
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00143
                     00144 ;-  lock peripheral setup (?)
0111   0020          00145         banksel INTCON
0112   138B          00146         BCF     INTCON, GIE         ; disable interrupts
0113   003C          00147         banksel PPSLOCK
                     00148         ; required sequence:
0114   3055          00149         MOVLW   0x55
0115   008F          00150         MOVWF   PPSLOCK
0116   30AA          00151         MOVLW   0xAA
0117   008F          00152         MOVWF   PPSLOCK
0118   140F          00153         BSF     PPSLOCK, PPSLOCKED  ; disable further writes
                     00154 ;-  enable interrupts
0119   0020          00155         banksel INTCON
011A   178B          00156         BSF     INTCON, GIE         ; reenable interrupts
011B   170B          00157         BSF     INTCON, PEIE        ; enable peripheral interrupts
                     00158 ;--------------------------------------------------------------------------
                     00159 ;-  idle loop
                     00160 ;--------------------------------------------------------------------------
011C                 00161 idle:
011C   0000          00162         NOP
                     00163 ;TODO everything else
011D   2???          00164         GOTO    idle
                     00165 ;--------------------------------------------------------------------------
                     00166 ;-  End main program
                     00167 ;--------------------------------------------------------------------------
                     00168     include "inc/BSense1.inc"
                     00001     subtitle    "-----  Occupation Detection Sensor 1"
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
-----  Occupation Detection Sensor 1
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00002     PAGE
                     00003 ;*******************************************************************************
                     00004 ;-  Detection setup and logic for sensor 1
                     00005 ;-  (C) LWH brainware 2021
                     00006 ;*******************************************************************************
                     00007 ;-  210412  lwh created
                     00008 ;-------------------------------------------------------------------------------
                     00009 ;-  Detection is done by comparing the detection input to an internal reference
                     00010 ;-  voltage. If it is lower, a timer is (re)started setting the output to
                     00011 ;-  "Occupied" (L).
                     00012 ;-  detection input is  RC1
                     00013 ;-  signal output is    RC4
                     00014 ;-  timer used is       TMR0
                     00015 ;-------------------------------------------------------------------------------
                     00016 ;-  memory registers
                     00017 ;-------------------------------------------------------------------------------
                     00018 ;-  Common RAM
                     00019 #if (LASTCOMMON > H'7F')
                     00020     error "Running out of common memory!"
                     00021 #endif
                     00022 ;-------------------------------------------------------------------------------
                     00023 ;-  Constants
  0000C567           00024 TMR0PERIOD  EQU     H'C567' ; 15000 cycles until FFFF for approx 2sec
                     00025 ;-------------------------------------------------------------------------------
                     00026 ;-  Configure ports, comparator, timer and interrupts
  011E               00027 setupDetect1:
                     00028         ;   set RC1 as analog input
  011E   0020        00029         banksel PORTC
  011F   108E        00030         BCF     PORTC,  RC1             ; clear port pin
  0120   0021        00031         banksel TRISC
  0121   148E        00032         BSF     TRISC,  TRISC1          ; set to 1 (in)
  0122   0023        00033         banksel ANSELC
  0123   148E        00034         BSF     ANSELC, ANSC1           ; set as analog input
                     00035         ;   set RC4 as digital output
  0124   0021        00036         banksel TRISC
  0125   120E        00037         BCF     TRISC,  TRISC4          ; set to 0 (out)
  0126   0020        00038         banksel PORTC
  0127   160E        00039         BSF     PORTC,  RC4             ; set port (free)
  0128   0023        00040         banksel ANSELC
  0129   120E        00041         BCF     ANSELC, ANSC4           ; set as digital (output)
  012A   0025        00042         banksel ODCONC
  012B   160E        00043         BSF     ODCONC, ODCC4           ; sink current only (open collector)
                     00044         ;   setup comparator mode
  012C   0022        00045         banksel CM1CON0
  012D   3096        00046         MOVLW   B'10010110'
                     00047         ;         |Rx|x||+---   C1SYNC  no sync with timer1
                     00048         ;         |  | |+----   C1HYS   hysteresis enabled
                     00049         ;         |  | +-----   C1SP    speed mode (always 1)
                     00050         ;         |  +-------   C1POL   output inverted
                     00051         ;         +----------   C1ON    comparator on
  012E   0091        00052         MOVWF   CM1CON0
                     00053         ;   setup comparator pins
  012F   3069        00054         MOVLW   B'01101001'
                     00055         ;         |||||+++---   C1NCH   connect negative to C1IN1-
                     00056         ;         ||+++------   C1PCH   connect positive to DAC
                     00057         ;         |+---------   C1INTN  interrupt on negative transition (in < DAC
                           )
                     00058         ;         +----------   C1INTP  no interrupt on positive transition
  0130   0092        00059         MOVWF   CM1CON1
                     00060         ;   setup timer
  0131   0020        00061         banksel T0CON0
  0132   3010        00062         MOVLW   B'00010000'
                     00063         ;         |xR|++++---   T0OUTPS postscaler to 1
                     00064         ;         |  +-------   T016BIT 16bit timer
                     00065         ;         +----------   T0EN    disabled for now
  0133   0097        00066         MOVWF   T0CON0
  0134   3053        00067         MOVLW   B'01010011'
                     00068         ;         ||||++++---   T0CKPS  prescaler to 8
                     00069         ;         |||+-------   T0ASYNC no synchronization required
                     00070         ;         +++--------   T0CS    clock is Fosc/4
  0135   0098        00071         MOVWF   T0CON1
                     00072         ;   enable interrupts
  0136   0021        00073         banksel PIE2
  0137   1692        00074         BSF     PIE2,   C1IE            ; enable comparator interrupts
  0138               00075 enableTmrInt1:
  0138   0020        00076         banksel PIR0
  0139   1290        00077         BCF     PIR0, TMR0IF            ; clear any lingering interrupts
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
-----  Occupation Detection Sensor 1
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

013A   0021           00078         banksel PIE0
013B   1690           00079         BSF     PIE0, TMR0IE
013C   0008           00080     RETURN
                      00081 ;--------------------------------------------------------------------------
                      00082 ;-  When a (negative) flank was detected, set the track to "occupied"
                      00083 ;-  and (re)start the timer.
013D                  00084 onFlank1:
013D   0020           00085         banksel PORTC
013E   120E           00086         BCF     PORTC,  RC4         ; clear port (occupied)
013F   0020           00087         banksel T0CON0
0140   1397           00088         BCF     T0CON0, T0EN        ; stop timer
0141   30C5           00089         MOVLW   HIGH    TMR0PERIOD
0142   0096           00090         MOVWF   TMR0H
0143   3067           00091         MOVLW   LOW     TMR0PERIOD
0144   0095           00092         MOVWF   TMR0L
0145   1797           00093         BSF     T0CON0, T0EN        ; start timer
0146   0008           00094     RETURN
                      00095 ;--------------------------------------------------------------------------
                      00096 ;-  When the timer expires, check whether the track is free.
                      00097 ;-  If yes, set the output accordingly
                      00098 ;-  if no, restart the timer
0147                  00099 onTimerEnd1:
0147   0022           00100         banksel CMOUT
0148   1C15           00101         BTFSS   CMOUT,  MC1OUT      ; check comparator output
0149   2???           00102         GOTO    onFlank1            ; if L, start another timer cycle
                      00103         ;   if H, track is free
014A   0020           00104         banksel PORTC
014B   160E           00105         BSF     PORTC,  RC4         ; set port (free)
014C   0008           00106     RETURN
                      00107 ;==========================================================================
                      00169     include "inc/BSense2.inc"
                      00001     subtitle    "-----  Occupation Detection Sensor 2"
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
-----  Occupation Detection Sensor 2
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

                     00002     PAGE
                     00003 ;*******************************************************************************
                     00004 ;-  Detection setup and logic for sensor 2
                     00005 ;-  (C) LWH brainware 2021
                     00006 ;*******************************************************************************
                     00007 ;-  210413  lwh copied from BSense1
                     00008 ;-------------------------------------------------------------------------------
                     00009 ;-  Detection is done by comparing the detection input to an internal reference
                     00010 ;-  voltage. If it is lower, a timer is (re)started setting the output to
                     00011 ;-  "Occupied" (L).
                     00012 ;-  detection input is  RC2
                     00013 ;-  signal output is    RC3
                     00014 ;-  timer used is       TMR1
                     00015 ;-------------------------------------------------------------------------------
                     00016 ;-  memory registers
                     00017 ;-------------------------------------------------------------------------------
                     00018 ;-  Common RAM
                     00019 #if (LASTCOMMON > H'7F')
                     00020     error "Running out of common memory!"
                     00021 #endif
                     00022 ;-------------------------------------------------------------------------------
                     00023 ;-  Constants
  0000C567           00024 TMR1PERIOD  EQU     H'C567' ; 15000 cycles until FFFF for approx 2sec
                     00025 ;-------------------------------------------------------------------------------
                     00026 ;-  Configure ports, comparator, timer and interrupts
  014D               00027 setupDetect2:
                     00028         ;   set RC1 as analog input
  014D   0020        00029         banksel PORTC
  014E   110E        00030         BCF     PORTC,  RC2             ; clear port pin
  014F   0021        00031         banksel TRISC
  0150   150E        00032         BSF     TRISC,  TRISC2          ; set to 1 (in)
  0151   0023        00033         banksel ANSELC
  0152   150E        00034         BSF     ANSELC, ANSC2           ; set as analog input
                     00035         ;   set RC4 as digital output
  0153   0021        00036         banksel TRISC
  0154   118E        00037         BCF     TRISC,  TRISC3          ; set to 0 (out)
  0155   0020        00038         banksel PORTC
  0156   158E        00039         BSF     PORTC,  RC3             ; set port (free)
  0157   0023        00040         banksel ANSELC
  0158   118E        00041         BCF     ANSELC, ANSC3           ; set as digital (output)
  0159   0025        00042         banksel ODCONC
  015A   158E        00043         BSF     ODCONC, ODCC3           ; sink current only (open collector)
                     00044         ;   setup comparator mode
  015B   0022        00045         banksel CM2CON0
  015C   3096        00046         MOVLW   B'10010110'
                     00047         ;         |Rx|x||+---   C1SYNC  no sync with timer1
                     00048         ;         |  | |+----   C1HYS   hysteresis enabled
                     00049         ;         |  | +-----   C1SP    speed mode (always 1)
                     00050         ;         |  +-------   C1POL   output inverted
                     00051         ;         +----------   C1ON    comparator on
  015D   0093        00052         MOVWF   CM2CON0
                     00053         ;   setup comparator pins
  015E   306A        00054         MOVLW   B'01101010'
                     00055         ;         |||||+++---   C1NCH   connect negative to C1IN2-
                     00056         ;         ||+++------   C1PCH   connect positive to DAC
                     00057         ;         |+---------   C1INTN  interrupt on negative transition (in < DAC
                           )
                     00058         ;         +----------   C1INTP  no interrupt on positive transition
  015F   0094        00059         MOVWF   CM2CON1
                     00060         ;   setup timer
  0160   0020        00061         banksel T1CON
  0161   3034        00062         MOVLW   B'00110100'
                     00063         ;         ||||||x+---   TMR1ON  disabled for now
                     00064         ;         |||||+-----   T1SYNC  no synchronization required
                     00065         ;         ||||+------   T1SOSC  ??
                     00066         ;         ||++-------   T1CKPS  prescaler to 8
                     00067         ;         ++---------   TMR1CS  clock is Fosc/4
  0162   009B        00068         MOVWF   T1CON
  0163   019C        00069         CLRF    T1GCON                  ; clear all gate settings (just in case)
                     00070         ;   enable interrupts
  0164   0021        00071         banksel PIE2
  0165   1712        00072         BSF     PIE2,   C2IE        ; enable comparator interrupts
  0166               00073 enableTmrInt2:
  0166   0020        00074         banksel PIR1
  0167   1011        00075         BCF     PIR1, TMR1IF        ; clear any lingering interrupts
  0168   0021        00076         banksel PIE1
  0169   1411        00077         BSF     PIE1, TMR1IE
```

```
----- Track Occupation Sensor Program, (C) LWH brainware 2021
-----  Occupation Detection Sensor 2
LOC  OBJECT CODE     LINE SOURCE TEXT
  VALUE

016A   0008           00078     RETURN
                      00079 ;--------------------------------------------------------------------------
                      00080 ;-  When a (negative) flank was detected, set the track to "occupied"
                      00081 ;-  and (re)start the timer.
016B                  00082 onFlank2:
016B   0020           00083         banksel PORTC
016C   118E           00084         BCF     PORTC,  RC3         ; clear port (occupied)
016D   0020           00085         banksel T1CON
016E   101B           00086         BCF     T1CON,  TMR1ON      ; stop timer
016F   30C5           00087         MOVLW   HIGH    TMR1PERIOD
0170   009A           00088         MOVWF   TMR1H
0171   3067           00089         MOVLW   LOW     TMR1PERIOD
0172   0099           00090         MOVWF   TMR1L
0173   141B           00091         BSF     T1CON,  TMR1ON      ; start timer
0174   0008           00092     RETURN
                      00093 ;--------------------------------------------------------------------------
                      00094 ;-  When the timer expires, check whether the track is free.
                      00095 ;-  If yes, set the output accordingly
                      00096 ;-  if no, restart the timer
0175                  00097 onTimerEnd2:
0175   0022           00098         banksel CMOUT
0176   1C95           00099         BTFSS   CMOUT,  MC2OUT      ; check comparator output
0177   2???           00100         GOTO    onFlank2            ; if L, start another timer cycle
                      00101         ;   if H, track is free
0178   0020           00102         banksel PORTC
0179   158E           00103         BSF     PORTC,  RC3         ; set port (free)
017A   0008           00104     RETURN
                      00105 ;==========================================================================
                      00170
                      00171 ;==========================================================================
1FEC 37F1 1FFF 3FFF   00172         END                         ; end of program code
```