



Application Note: Push Buttons & Path Switcher

Introduction

This application note presents programming techniques for implementing and debouncing from 1-4 push buttons. This implementation also demonstrates the use of a path switcher (combined with a simple real-time clock¹) to reduce the execution time of each interrupt. The program relies upon the SX's internal interrupt feature to allow background operation of the clock, buttons, and path_switcher as virtual peripherals.

How the circuit and program work

This firmware module requires no external circuitry, other the push buttons, their pull-up resistors, and an (optional²) oscillator crystal, making it quite straight forward. The real-time clock peripheral is described elsewhere (see note 1 below), and will not be discussed here other than that it passes control to the path switcher virtual peripheral once per millisecond.

The path_switch routine simply looks at the lower 2 bits of the real time clock's msec count and jumps to the corresponding push button vector. This allows for only one push button sequence to be run per interrupt and reduces the overall execution time of the interrupt sequence. This feature of path_switch may be used to select from amongst any number of code segments (including other than just push button modules) which do not require execution during each interrupt cycle. For such purposes, it does not even need to be combined with the real time clock³, which is used here to simplify push button debounce time processing.

The push buttons are wired directly from port B, pins 0-3* to ground, with a 100K pull-up resistor⁴ also connected to each port pin, but wired to V_{dd} .

Within a few⁵ milliseconds of any pushbutton press, the corresponding *pbx* (where $x=0-3$) push button code sequence will register the press. First, the program checks whether it is a new press by looking at the corresponding *pbx_down* flag. If it's not a new press, it is ignored. If it is new, the program makes sure the *pbx_down* flag is cleared and then begins incrementing the corresponding *debouncex* counter variable upon subsequent passes through the interrupt until it detects that the switch contacts have been sufficiently debounced⁶, in which case the *pbx_pressed* flag is set along with the *pbx_down* flag.

In this code example, it is the main program's responsibility, performed by the button_check main loop code sequence, to scan the *pbx_pressed* flags to watch for a button press, and to make sure they're reset (cleared) once the appropriate button action has been taken.

If the button actions are short, they may be placed directly in-line in the interrupt code segment for the corresponding button. This has the attractive benefit of avoiding the need for any main loop handling of the buttons whatsoever, but also carries the disadvantage of increasing the overall length of the interrupt routine (which is somewhat compensated for by the path_switcher code module).

¹ Described in more detail a separate application note: **Virtual Peripheral Real Time Clock**

² If a lot of accuracy is needed on the clock, the SX's internal oscillator may be used by adjusting the msec tick count value to the appropriate count, as described in the above application note.

³ If it is not to be combined with the real time clock module, some type of counter must still be maintained to control switching.

* From 1-4 push buttons may be used in this implementation. The user then sets the *num_buttons* parameter variable accordingly.

⁴ The value of the pull-up is not very crucial, since the push button port pins are always set as inputs (i.e. high impedance), and the duration of presses is usually insignificant in terms of power consumption. Lower or higher resistor values can therefore be used.

⁵ This value depends on how many push buttons are being used in total. It will range from 0-3 msec, depending.

⁶ The amount of time any given switch or button takes to debounce is not obvious by any means, and varies with switch type and press speed and pressure, etc. A good rule of thumb to assure catching rapid sequential presses while avoiding false double triggering is about 10-20 msec for an average "click" type push button (and most other switches). This value can always be experimented with.

Modifications and further options

If the need for processor power between timed events is minimal, the three module routine combination could be modified and set up in conjunction with the watchdog timer instead of the internal RTCC interrupt where the SX is put in sleep mode between watchdog time-outs. This allows for a tremendous savings in overall power consumption.

Program Listing

```
*****
;
;   Push Buttons & Path Switcher (with real time clock)
;
;
;   Length: >=74 bytes (depends upon number of buttons & clock type)
;   Author: Craig Webb
;   Written: 98/8/17
;
;   This program implements a software time clock virtual peripheral
;   that keeps a 16 bit count of elapsed time in milliseconds.
;   The option is available to include seconds, minutes, hours and even
;   days to this clock if desired.
;   The code takes advantage of the SX's internal RTCC-driven interrupt
;   to operate in the background while the main program loop is executing.
;
*****
;
;***** Assembler directives
;
; uses: SX28AC, 2 pages of program memory, 8 banks of RAM, high speed osc.
;       operating in turbo mode, with 8-level stack & extended option reg.
;
;           DEVICE pins28,pages2,banks8,oschs
;           DEVICE turbo,stackx,optionx
;           ID      'Buttons'                ;program ID label
;           RESET   reset_entry              ;set reset/boot address
;
;***** Program Variables *****
;
;***** Program Parameters
;
clock_type   =      0                ;16 bit msec count only
;clock_type  =      1                ;include sec, min, hours
;clock_type  =      2                ;include day counter
;
num_buttons  =      2                ;number of buttons (1-4)
;
;***** Program Constants
;
int_period   =      163               ;period between interrupts
;
hold_bit     =      4-(num_buttons/2) ;debounce period = 2^hold_bit msec
;
tick_lo      =      80                ;50000 = msec instruction count
tick_hi      =      195              ; for 50MHz, turbo, prescaler=1
;
mspersec_hi  =      1000/256         ;msec per second hi count
mspersec_lo  =      1000-(mspersec_hi*256) ;msec per second lo count
;
;***** Port definitions
;
button0      EQU      RB.0           ;Push button 0
button1      EQU      RB.1           ;Push button 1
button2      EQU      RB.2           ;Push button 2
button3      EQU      RB.3           ;Push button 3
;
;***** Register definitions
;
;           ORG      8                ;start of program registers
main         =      $                ;main bank
;
temp        DS      1                ;temporary storage
temp2       DS      1
;
```

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clock          ORG    010H          ;bank0 variables
clock          EQU    $            ;clock bank
buttons        EQU    $            ;push button bank
;
time_base_lo   DS     1            ;time base delay (low byte)
time_base_hi   DS     1            ;time base delay (high byte)
msec_lo        DS     1            ;millisecond count (low)
msec_hi        DS     1            ;millisecond count (high)

seconds        IF     clock_type>0  ;do we want sec, min, hours?
seconds        DS     1            ;seconds count
minutes        DS     1            ;minutes count
hours          DS     1            ;hours count
                ENDIF

days          IF     clock_type>1  ;do we want day count?
days          DS     1            ;days count
                ENDIF
;
;
debounce0      DS     1            ;push button 0 debounce count
debounce1      DS     1            ;push button 1 debounce count
debounce2      DS     1            ;push button 2 debounce count
debounce3      DS     1            ;push button 3 debounce count
pbflags        DS     1            ;push button status flags
pb0_pressed    EQU    pbflags.0    ;push button 0 action status
pb1_pressed    EQU    pbflags.1    ;push button 1 action status
pb2_pressed    EQU    pbflags.2    ;push button 2 action status
pb3_pressed    EQU    pbflags.3    ;push button 3 action status
pb0_down       EQU    pbflags.4    ;push button 0 down status
pb1_down       EQU    pbflags.5    ;push button 1 down status
pb2_down       EQU    pbflags.6    ;push button 2 down status
pb3_down       EQU    pbflags.7    ;push button 3 down status
;
;***** INTERRUPT VECTOR *****
;
; Note: The interrupt code must always originate at 0h.
;       A jump vector is not needed if there is no program data that needs
;       to be accessed by the IREAD instruction, or if it can all fit into
;       the lower half of page 0 with the interrupt routine.
;
                ORG     0            ;interrupt always at 0h
                JMP    interrupt    ;interrupt vector
;
;***** INTERRUPT CODE *****
;
; Note: Care should be taken to see that any very timing sensitive routines
;       (such as adcs, etc.) are placed before other peripherals or code
;       which may have varying execution rates (like the software clock, for
;       example).
;
interrupt      ;beginning of interrupt code
;
;***** Virtual Peripheral: Time Clock
;
; This routine maintains a real-time clock count (in msec) and allows processing
; of routines which only need to be run once every millisecond.
;
;       Input variable(s) : time_base_lo,time_base_hi,msec_lo,msec_hi
;                           seconds, minutes, hours, days
;       Output variable(s) : msec_lo,msec_hi
;                           seconds, minutes, hours, days
;       Variable(s) affected : time_base_lo,time_base_hi,msec_lo,msec_hi
;                           seconds, minutes, hours, days
;
;       Flag(s) affected :
;       Size : 17/39/45 bytes (depending upon clock type)
;               + 1 if bank select needed

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;      Timing (turbo) : [99.9% of time] 14 cycles
;                      [0.1% of time] 17/39/45 cycles (or less)
;                      + 1 if bank select needed
;
;      BANK    clock           ;select clock register bank
MOV     W,#int_period         ;load period between interrupts
ADD     time_base_lo,W        ;add it to time base
SNC                     ;skip ahead if no underflow
INC     time_base_hi          ;yes overflow, adjust high byte
MOV     W,#tick_hi           ;check for 1 msec click
MOV     W,time_base_hi-W      ;Is high byte above or equal?
MOV     W,#tick_lo           ;load instr. count low byte
SNZ                     ;If hi byte equal, skip ahead
MOV     W,time_base_lo-W      ;check low byte vs. time base
SC                      ;skip ahead if low

;commented out because of path_switcher/pushbutton routines which use msec count
;      JMP     :done_clock     ;If not, end clock routine
;      JMP     done_pbs        ;If not, end clock routine

:got_tick    CLR     time_base_hi      ;Yes, adjust time_base reg.'s
SUB     time_base_lo,#tick_lo ; leaving time remainder
INCSZ    msec_lo              ;And adjust msec count
DEC     msec_hi               ; making sure to adjust high
INC     msec_hi               ; byte as necessary

IF     clock_type>0          ;do we want sec, min, hours?
MOV     W,#mspersec_hi       ;check for 1000 msec (1 sec tick)
MOV     W,msec_hi-W          ;Is high byte above or equal?
MOV     W,#mspersec_lo       ;load #1000 low byte
SNZ                     ;If hi byte equal, skip ahead
MOV     W,msec_lo-W          ;check low byte vs. msec count
SC                      ;skip ahead if low
JMP     :done_clock         ;If not, end clock routine
INC     seconds              ;increment seconds count
CLR     msec_lo              ;clear msec counters
CLR     msec_hi              ;
MOV     W,#60                ;60 seconds per minute
MOV     W,seconds-W          ;are we at minute tick yet
JNZ     :done_clock         ;if not, jump
INC     minutes              ;increment minutes count
CLR     seconds              ;clear seconds count
MOV     W,#60                ;60 minutes/hour
MOV     W,minutes-W         ;are we at hour tick yet?
JNZ     :done_clock         ;if not, jump
INC     hours                 ;increment hours count
CLR     minutes              ;clear minutes count
ENDIF                       ;<if> we wanted sec, min, hours

IF     clock_type>1          ;do we want to count days?
MOV     W,#24                ;24 hours per day
MOV     W,hours-W           ;are we at midnight?
JNZ     :done_clock         ;if not, jump
INC     days                  ;increment days count
CLR     hours                 ;clear hours count
ENDIF                       ;<if> we wanted day count

:done_clock
;
;***** Virtual Peripheral: Path Switch
;
; This routine allows alternating execution of multiple modules which don't
; need to be run during every interrupt pass in order to reduce the overall
; execution time of the interrupt on any given pass (i.e. it helps the code
; run faster).
; This version runs with the software clock virtual peripheral msec_lo variable
; allowing alternation between the switch positions once each millisecond.
;

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;      Input variable(s) : msec_lo
;      Output variable(s) :
;      Variable(s) affected :
;      Flag(s) affected :
;      Size : 3 bytes + 1 bytes per jump location
;      Timing (turbo) : 8 cycles
;
:path_switch  MOV      W,msec_lo           ;load switch selector byte
              AND      W,#00000011b      ;keep low 2 bits - 4 position
              JMP      PC+W              ;jump to switch position pointer
:pos0        JMP      pb0                 ;pushbutton 0 checking routine
:pos1        JMP      pb1                 ;pushbutton 1 checking routine
:pos2        JMP      pb2                 ;pushbutton 2 checking routine
:pos3        JMP      pb3                 ;pushbutton 3 checking routine
;
;
;***** Virtual Peripheral: Push Buttons*
;
; This routine monitors any number of pushbuttons, debounces them properly
; as needed, and flags the main program code as valid presses are received.
; *Note: this routine requires the Time Clock virtual peripheral or similar
;       pre-processing timer routine.
;
;      Input variable(s) : pb0_down,pb1_down,debounce0,debounce1
;                          pb2_down,pb3_down,debounce2,debounce3
;      Output variable(s) : pb0_pressed, pb1_pressed, pb2_pressed, pb3_pressed
;      Variable(s) affected : debounce0, debounce1, debounce2, debounce3
;      Flag(s) affected : pb0_down,pb1_down,pb0_pressed,pb1_pressed
;                          pb2_down,pb3_down,pb2_pressed,pb3_pressed
;      Size : 12 bytes per pushbutton + actions (see below**)
;              + 1 byte if path switch not used
;      Timing (turbo) : 7,10, or 12 cycles/pushbutton (unless path switch used)
;                          + actions (see below**)
;
pb0
;
;      BANK      buttons                 ;select bank (if not done elsewhere)
;      JB        button0,:pb0_up         ;button0 pressed?
;      JB        pb0_down,:done_pb0      ;yes, but is it new press?
;      INC       debounce0               ; and adjust debounce count
;      JNB      debounce0.hold_bit,:done_pb0 ;wait till long enough
;      SETB     pb0_down                 ;yes, flag that button is down
;
; **If the button activity is short (a few bytes), it can fit here, though be
; careful that longest possible interrupt doesn't exceed int_period # of cycles.
;
; <short code segment can go here>
;
; **Otherwise, use this flag to process button press in main code (and don't
; forget to reset the flag once the button activity is complete).
;
;      SETB     pb0_pressed              ; and set pb0 action flag
;
;      SKIP     ;skip next instruction
:pb0_up      CLRB     pb0_down            ;button up, clear flag
;      CLR      debounce0                ; and clear debounce count
:done_pb0
;
;      JMP      done_pbs                 ;this needed only if path switch used

pb1
;
;      IF        num_buttons>1           ;more than 1 push button?
;      BANK     buttons                 ;do bank select (if not done elsewhere)
;      JB        button1,:pb1_up         ;button1 pressed?
;      JB        pb1_down,:done_pb1      ;yes, but is it new press?
;      INC       debounce1               ; and adjust debounce count
;      JNB      debounce1.hold_bit,:done_pb1 ;wait till long enough
;      SETB     pb1_down                 ;yes, flag that button is down

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; **If the button activity is short (a few bytes), it can fit here, though be
; careful that longest possible interrupt doesn't exceed int_period # of cycles.
;
; <short code segment can go here>
;
; **Otherwise, use this flag to process button press in main code (and don't
; forget to reset the flag once the button activity is complete).
        SETB    pb1_pressed          ; and set pb1 action flag

:pb1_up        SKIP                    ; skip next instruction
        CLRB    pb1_down             ; button up, clear flag
        CLR     debounce1           ; and clear debounce count

:done_pb1
;
        JMP     done_pbs             ; this needed only if path switch used
ENDIF        ; more than 1 push button

pb2
        IF     num_buttons>2         ; more than 2 push buttons?
;
        BANK   buttons              ; do bank select (if not done elsewhere)
        JB     button2, :pb2_up      ; button2 pressed?
        JB     pb2_down, :done_pb2   ; yes, but is it new press?
        INC    debounce2            ; and adjust debounce count
        JNB   debounce2.hold_bit, :done_pb2 ; wait till long enough
        SETB   pb2_down             ; yes, flag that button is down

; **If the button activity is short (a few bytes), it can fit here, though be
; careful that longest possible interrupt doesn't exceed int_period # of cycles.
;
; **Otherwise, use this flag to process button press in main code (and don't
; forget to reset the flag once the button activity is complete).
        SETB    pb2_pressed          ; and set pb2 action flag

:pb2_up        SKIP                    ; skip next instruction
        CLRB    pb2_down             ; button up, clear flag
        CLR     debounce2           ; and clear debounce count

:done_pb2
;
        JMP     done_pbs             ; this needed only if path switch used
ENDIF        ; more than 2 push buttons

pb3
        IF     num_buttons>3         ; more than 3 push buttons?
;
        BANK   buttons              ; do bank select (if not done elsewhere)
        JB     button3, :pb3_up      ; button3 pressed?
        JB     pb3_down, :done_pb3   ; yes, but is it new press?
        INC    debounce3            ; and adjust debounce count
        JNB   debounce3.hold_bit, :done_pb3 ; wait till long enough
        SETB   pb3_down             ; yes, flag that button is down

; **If the button activity is short (a few bytes), it can fit here, though be
; careful that longest possible interrupt doesn't exceed int_period # of cycles.
;
; **Otherwise, use this flag to process button press in main code (and don't
; forget to reset the flag once the button activity is complete).
        SETB    pb3_pressed          ; and set pb3 action flag

:pb3_up        SKIP                    ; skip next instruction
        CLRB    pb3_down             ; button up, clear flag
        CLR     debounce3           ; and clear debounce count

:done_pb3
        ENDIF        ; more than 3 push buttons
;
done_pbs
;

```

```

done_int      mov     w,#-int_period      ;interrupt every 'int_period' clocks
              retiw                      ;exit interrupt
;
;***** End of interrupt sequence
;
;***** RESET ENTRY POINT *****
;
reset_entry
;           PAGE    start                ;Set page bits and then
;           JMP     start                ; jump to start of code
;
;*****
;* Main Program Code *
;*****
;
start         mov     !rb,#%00001111     ;Set RB in/out directions
              CLR    FSR                 ;reset all ram starting at 08h
:zero_ram     SB     FSR.4                ;are we on low half of bank?
              SETB  FSR.3                ;If so, don't touch regs 0-7
              CLR   IND                  ;clear using indirect addressing
              IJNZ  FSR,:zero_ram        ;repeat until done

              MOV    !OPTION,#%10011111  ;enable rtcc interrupt
;
Main:loop
;
;the following code watches pb0-pb3 for presses and acts on them
button_check
;           BANK    buttons                ;select pb bank
              MOV    W,pbflags           ;load pushbutton flags
              AND    W,#00001111b        ;keep only 'pressed' flags
              JZ     :no_press           ;jump ahead if not pressed
              MOV    temp,W              ;store flags temporarily
              CLR    temp2               ;clear 2nd temp storage reg.
:which_pb     INC    temp2                ;increment 2nd temp value
              RR     temp                 ;check which button
              SC     ;skip ahead if not this one
              JMP    :which_pb           ;keep looping
              MOV    W,--temp2           ;get 2nd temp value (less 1)
              MOV    temp,W              ;save it in temp
              MOV    W,#11110000b        ;get clear mask for pbflags
              AND    pbflags,W           ;clear all "pressed" flags
              MOV    W,temp              ;get which button pressed
              JMP    PC+W                 ;Go do PB routines
:pb0          JMP    pb0_action          ;do pb0 action
:pb1          JMP    pb1_action          ;do pb1 action
:pb2          JMP    pb2_action          ;do pb2 action
:pb3          JMP    pb3_action          ;do pb3 action

:no_press
;
;           <main program code goes here>
;
              JMP    Main:loop           ;back to main loop
;
pb0_action
;
;           <pb0 action here>
;
              JMP    Main:loop
;
pb1_action
;
;           <pb1 action here>
;
              JMP    Main:loop

```



```
;
pb2_action
;
;      <pb2 action here>
;
;          JMP      Main:loop
;
pb3_action
;
;      <pb3 action here>
;
;          JMP      Main:loop
;
;*****
;          END                      ;End of program code
```