

Exercise 1: Keyboard Interrupt

EG-252 Group Design Exercise – Microcontroller Laboratory

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For this exercise you are provided sample keyboard interrupt programs in both C and Assembly in the appendices; make sure that you have downloaded electronic versions of the program from the [GitHub repository](#) before the exercise. The program uses the interrupt generated by push buttons to switch on/off the LEDs on the MC9S08AW60 evaluation board.

You are to carry out the following three tasks with this exercise:

- Use the sample program to practice using interrupt mechanism to interface peripheral devices with the evaluation board.
- Answer the questions related to the CPU interrupt procedure (2 marks).
- Adjust the sample program to use the onboard switches to control the display of your student number (6 marks).

The demonstration of your program on the board needs to be done no later than *Tuesday, 28 October 2014*.

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I. Experiment with the Sample Program

The sample program, “[kbi_interrupt.c](#)” and “[kbi_interrupt.asm](#)”, flashes on-board LEDs upon the interrupt requests generated by the keyboard inputs, which are SW3 and SW4 used as keyboard inputs 6 and 5, respectively. The flowchart of the program is shown in Figure 1. Enter it or copy the electronic file onto your CodeWarrior project, which is created targeting on HCS08 CPU family and MC9S08AW60 MCU.

After you create your own keyboard interrupt project, you can use the evaluation board to debug the sample keyboard interrupt program. Next we will introduce how to use evaluation board to configure peripheral device inputs and generate interrupts.

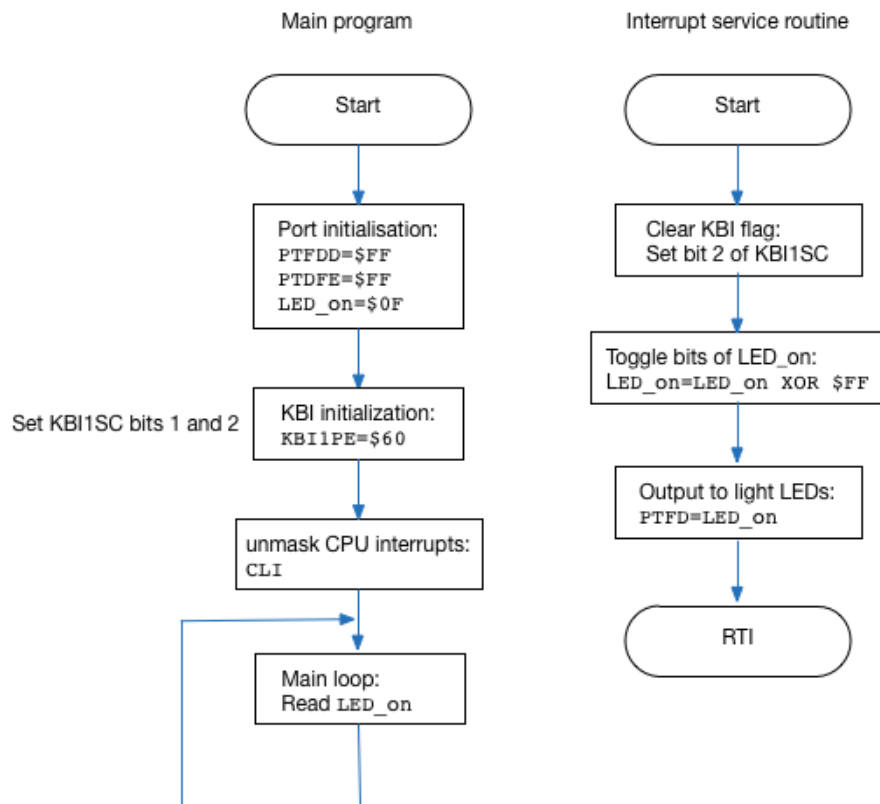


Figure 1: Figure 1. Flowchart of keyboard interrupt program

A. Interrupt Generation with the Evaluation Board

The evaluation board includes four pushbutton switches (SW1-SW4) which can provide momentary active low input for user applications. SW3 and SW4 are connected to MCU Port PTD3 and PTD2 respectively. If the pins of PTD3 and PTD2 are configured as KBI inputs, they will be read with “1” if the corresponding pushbutton is not pressed and “0” if pressed. Edge events and edge/level events can be easily generated by pressing SW3 and SW4. The KBI inputs can detect the selected events as configured by the programmer and generate interrupt requests if keyboard interrupt for the inputs is enabled.

B. Experiment with the Interrupt Mechanism

Once we know how to generate keyboard interrupt events, we can use the sample program and evaluation board kits to experiment with interrupt mechanism.

According to the interrupt procedure, CPU will leave the main program and run the interrupt service routine (ISR) if interrupt for the keyboard module is enabled. You can use “Single step” or set breakpoint(s) to observe how the CPU responds to interrupt requests. After the CPU finishes the ISR, it returns to the main program. You can generate as many keyboard interrupts as you like by pushing down the switches.

You can also experiment with detection of rising edge and rising edge/high level events and correspondingly generating keyboard interrupt events by configuring the keyboard interrupt status and control register.

II. Questions

By doing experiments with either slightly modified sample C or assembly program, you are required to answer the following questions.

- 1) Upon the generation of keyboard interrupt requests, the ISR will be run by the CPU. Experiment with the evaluation board, record and compare the content in the stack just before and after the CPU enters the ISR and just before and after the CPU leaves the ISR corresponding to a keyboard interrupt. You can get the stack pointer value from register panel in real-time debugger window.
- 2) Explain why the stack content changes as you have observed.

III. Adjust the Sample Program to Display your Student Numbers

All the eight KBI inputs share the KBI source. In this task you are required to adjust the ISR shown in the Appendix, in order to determine which of the two pushbuttons SW3 and SW4 triggered a KBI interrupt and correspondingly display a student number of a member in your team.

Suppose the student numbers for your team are 43210 and 12345, respectively. On reset, if pushbutton SW3 is pressed down, in your ISR you should light up the leftmost nonzero digit 4 in the first student number over LEDs (i.e., in a binary format using four LEDs). Then the CPU should leave the ISR and return to the main program. If SW3 is released and then pressed down again, the next digit 3 in the first student should be displayed over LED in your ISR. With more pressing of SW3, the following digits in the first student number are displayed sequentially. Note that after the rightmost digit 0 was displayed over LEDs upon the last pressing of SW3, the leftmost digit 4 will be displayed over LEDs upon new SW3 pressing. Similar operations are performed for the second student number 12345 if pushbutton SW4 is pressed.

You are required to design and debug the ISR program (using either Assembly or C language), and demonstrate the application to Dr Chris Jobling or Dr Tim Davies.

Appendix A

Sample Program in C

```
1  /* kbi_interrupt.c */
2
3  #include <hidef.h>                /* for EnableInterrupts macro */
4  #include "derivative.h"          /* include peripheral declarations */
5  #define VNkeyboard 22            /* Interrupt vector for Keyboard */
6
7  typedef unsigned char muint8;
8  typedef unsigned short muint16;
9  typedef unsigned long muint32;
10
11 typedef char mint8;
12 typedef short mint16;
13 typedef long mint32;
14
15 /* to clear or set single bits in a byte variable */
16 #define b_SetBit(bit_ID, varID)   (varID |= (muint8)(1<<bit_ID))
17 #define b_ClearBit(bit_ID, varID) (varID &= ~(muint8)(1<<bit_ID))
18 #define b_XorBit(bit_ID, varID)  (varID ^= (muint8)(1<<bit_ID))
```

```

19
20 uint8 LED_onseq;
21
22 void main(void) {
23     EnableInterrupts;          /* enable interrupts */
24     SOPT = 0x00;               /* disable COP */
25
26     /* begin LED/switch test */
27
28     PTDPE = 0xFF;              /* enable port D pullups for push button switch interrupt */
29
30     /* Init_GPIO init code */
31     PTFDD = 0xFF;              /* set port F as outputs for LED operation */
32     LED_onseq = 0x0F;          /* initialize LED_onseq */
33
34     /* enable interrupt for keyboard input */
35     b_ClearBit(1, KBI1SC);      /* KBI1SC: KBIE=0, disable KBI interrupt request */
36     KBI1PE = 0x60;             /* KBI1PE: KBIPE7=1, enable KBI function for port E */
37     b_ClearBit(0, KBI1SC);      /* KBI1SC: KBIMOD=0, select edge-only detection */
38
39     /* in default only falling edge events to be detected */
40     b_SetBit(2, KBI1SC);        /* KBI1SC: KBACK=1, to clear KBI flag */
41     b_SetBit(1, KBI1SC);        /* KBI1SC: KBIE=1, enable KBI */
42
43     for(;;) {
44         __RESET_WATCHDOG(); /* feeds the dog */
45     } /* loop forever */
46     /* please make sure that you never leave main */
47 }
48
49 interrupt VNkeyboard void intKBI_SW(){
50     KBI1SC_KBACK = 1;          /* acknowledge interrupt */
51     PTFD = LED_onseq;
52     LED_onseq ^= 0xFF;          /* toggle LED_onseq bits */
53 }

```

View on [GitHub](#)

Appendix B

Sample Program in Assembly

```

1 ;*****
2 ;*          kbi_interrupt.asm          *
3 ;*                                     *

```

```

4  ;*      MC9S08AW60 Evaluation board keyboard interrupt example      *
5  ;*      - Switch SW3 onboard connected to Port D pin 3, KBI pin6;  *
6  ;*      - Switch SW4 onboard connected to Port D pin 2, KBI pin5  *
7  ;*                                                                    *
8  ;*      Function:                                                  *
9  ;*      on reset all LEDs will light on. If SW3 or SW4 pressed,   *
10 ;*      an interrupt is generated, which set LEDs 0:3 to light on. *
11 ;*      More interrupts are generated if SW3 or SW4 are pressed.   *
12 ;*****
13
14 ; Include derivative-specific definitions
15     INCLUDE 'derivative.inc'
16
17 FLASH      EQU          $2000
18 RAM        EQU          $0070
19 WATCH      EQU          $1802
20
21             ORG          RAM
22 LED_on      DS.B         1      ; Define a variable VAR_D with a size of 1 byte
23
24 ;Start program after reset
25             ORG          FLASH
26 START_UP
27             LDA          #$00
28             STA          WATCH      ; Turn off the watchdog timer
29
30 ;Init_GPIO init code
31             LDA          #$FF
32             STA          PTFDD
33             MOV          #$0F, LED_on ; Initialize VAR_D, used to control the LEDs
34             LDA          #$FF
35             STA          PTDPE      ; Port D is enabled with pull-up
36             RSP              ; Reset stack pointer
37
38 ;Enable interrupt for Keyboard input
39             LDA          #$60
40             STA          KBI1PE      ; KBI1PE: KBIPE7=1, enable KBI function for pins 5
41             BSET         $02, KBI1SC ; KBI1SC: KBACK=1, to clear KBI flag
42             BSET         $01, KBI1SC ; KBI1SC: KBIE=1, enable KBI
43
44             CLI              ; Enable interrupt
45
46 MAINLOOP
47             LDA          LED_on      ; Simple routine
48             BRA          MAINLOOP
49

```

```

50 ;Interrupt service routine for a keyboard interrupt generated upon the press of a pushbutton
51 ;with a falling edge (transition from high logic level "1" to low logic level "0")
52 LED_SWITCH
53         BSET    $02, KBI1SC      ; clear KBI flag
54         LDA     LED_on
55         EOR     #$FF             ; Toggle bits in VAR_D
56         STA     PTFD             ; Output to light LEDs (port F)
57         STA     LED_on           ; Store the new value to VAR_D
58         RTI
59
60 ;INT_VECTOR
61         ORG     $FFD2
62         DC.W    LED_SWITCH
63
64         ORG     $FFFE
65         DC.W    START_UP

```

View on [GitHub](#)