Exercise 1: Keyboard Interrupt

EG-252 Group Design Exercise – Microcontroller Laboratory

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September 2014

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 (4 marks).
- Adjust the sample program to use the onboard switches to control the display of your student number (6 marks).

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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 the evaluation board to configure peripheral device inputs and generate interrupts.

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

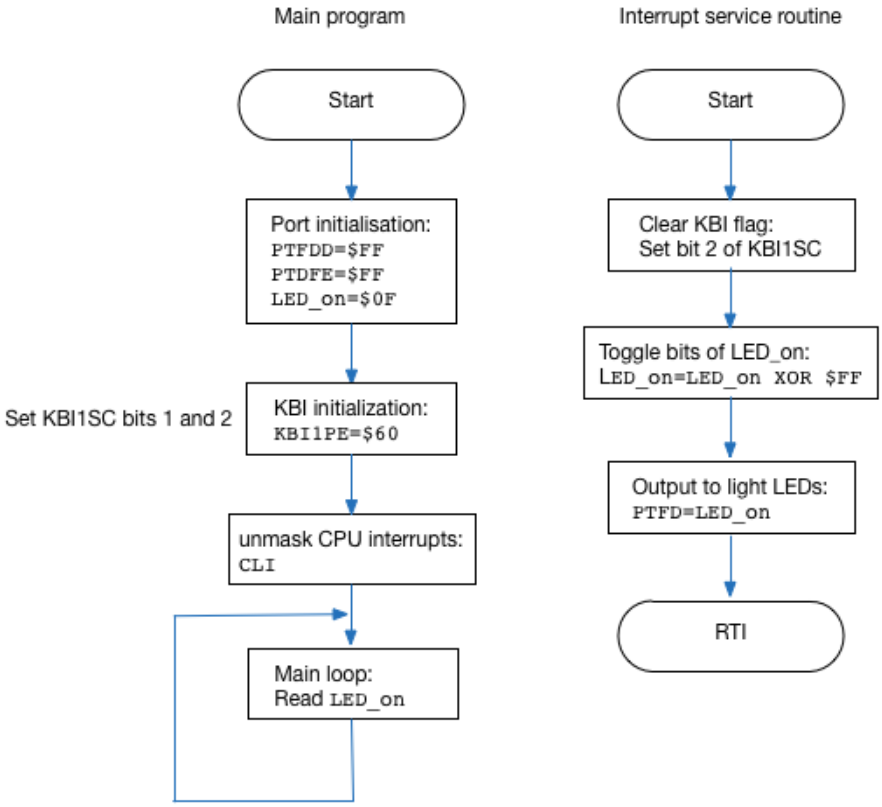

Figure 1: Figure 1. Flowchart of the keyboard interrupt program

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 the 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 the detection of a 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 the slightly modified sample C programme, 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 the register panel in the real-time debugger window.
2. Explain why the stack content changes as you have observed.

Make a careful note of your observations as you will need them for the assessment later.

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 the 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 the pushbutton `SW4` is pressed.

You are required to design and debug the ISR program (using the C language), and submit the completed program as a single file named `kbi_SN.c` (where SN is your student number). The assessment point on Canvas LMS is called **Assessment of Microntrollers Laboratory Exercise 1**.

Appendix A

Sample Program in C

```c
/* kbi_interrupt.c */

#include <hidef.h>                  /* for EnableInterrupts macro */
#include "derivative.h"         /* include peripheral declarations */
#define VNkeyboard 22   /* Interrupt vector for Keyboard */

typedef unsigned char muint8;
typedef unsigned short muint16;
typedef unsigned long muint32;

typedef char mint8;
typedef short mint16;
typedef long mint32;

/* to clear or set single bits in a byte variable */
#define b_SetBit(bit_ID, varID)                (varID |= (muint8)(1<<bit_ID))
#define b_ClearBit(bit_ID, varID)         (varID &= ~(muint8)(1<<bit_ID))
#define b_XorBit(bit_ID, varID)                (varID ^= (muint8)(1<<bit_ID))

muint8 LED_onseq;

void main(void) {
        EnableInterrupts;         /* enable interrupts */
        SOPT = 0x00;                 /* disable COP */

        /* begin LED/switch test */
```

```
27
28          PTDPE = 0xFF;                /* enable port D pullups for push button switch interr
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
37          b_ClearBit(0, KBI1SC);         /* KBI1SC: KBIMOD=0, select edge-only detection */
38
39          /* in defaut 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 genereated if SW3 or SW4 are pressed.          *
12  ;*****************************************************************************
13
```

```
; Include derivative-specific definitions
                INCLUDE 'derivative.inc'

FLASH        EQU               $2000
RAM               EQU               $0070
WATCH        EQU               $1802

                ORG               RAM
LED_on        DS.B        1              ; Define a variable VAR_D with a size of 1 byte

;Start program after reset
                ORG               FLASH
START_UP
                LDA               #$00
                STA               WATCH                         ; Turn off the watchdog time

;Init_GPIO init code
                LDA     #$FF
                STA     PTFDD
                MOV     #$0F, LED_on    ; Initialize VAR_D, used to control the LEDs
                LDA     #$FF
                STA     PTDPE           ; Port D is enabled with pull-up
                RSP                                                 ; Reset stack pointer

;Enable interrupt for Keyboard input
                LDA     #$60
                STA     KBI1PE           ; KBI1PE: KBIPE7=1, enable KBI function for pins 5
                BSET    $02, KBI1SC      ; KBI1SC: KBACK=1, to clear KBI flag
                BSET    $01, KBI1SC      ; KBI1SC: KBIE=1, enable KBI

                CLI                      ; Enable interrupt

MAINLOOP
                LDA     LED_on           ; Simple routine
                BRA               MAINLOOP

;Interrupt service routine for a keyboard interrupt generated upon the press of a pushbutton
;with a falling edge (transition from high logic level "1" to low logic level "0")
LED_SWITCH
                BSET    $02, KBI1SC     ; clear KBI flag
                LDA     LED_on
                EOR     #$FF            ; Toggle bits in VAR_D
                STA     PTFD            ; Output to light LEDs (port F)
                STA     LED_on          ; Store the new value to VAR_D
                RTI

```

```
60  ;INT_VECTOR
61                      ORG     $FFD2
62                      DC.W    LED_SWITCH
63
64                      ORG     $FFFE
65                      DC.W    START_UP
```

View on GitHub