Lab 4

IMPORTANT NOTICE:

- The labels on PORTL are reversed, i.e., PLi is actually PL7-i (i=0, 1, …, 7).
- The labels on PORTC are also reversed, i.e., PCi is actually PC7-i (i=0, 1, …, 7).

Board Settings:
- Connect the four columns C0~C3 of the keypad to PL3~PL0 of PORTL and the four rows R0~R3 to PL7~PL4 of PORTL.
- Connect LCD data pins D0-D7 to PF0-7 of PORTF.
- Connect the four LCD control pins BE-RS to PA4-7 of PORTA.

1. Objectives

In this lab, you will learn assembly programming using keypad and LCD.

2. Preparations

Before coming to the Laboratory, you should
- Read through the specifications of this lab in detail.
- Read through the sample program keypad.asm to understand how keypad scanning works. **Notice that you need to convert the internal code of each key into the ASCII code in order to display it correctly on the LCD.**
- Read through the LCD Manual and the sample program for LCD lcd.asm to understand how to program the LCD. All the LCD instructions are included in the LCD manual.
- The LCD manual and the ASCII table can be found by clicking on "AVR Resources" in the left pane of the course homepage.

3. Tasks

There are three tasks in this lab. It may take several hours to read the relevant material before you can start. So you need to finish reading all the relevant material and work out most of the code at home.

3.1 Task A: A Software Clock (5 marks)

Write an AVR assembly program named clock.asm that displays on the LCD the time that has passed since your program started running **by using Timer0 Overflow Interrupt**. For simplicity, you may assume that the time consists of two components: minutes and seconds. For example, 10:30 means ten minutes and thirty seconds has passed. Your program needs to update the time on the LCD every second.

Assemble your program using AVR Studio, download the hex file onto your board, and show your working program to your tutor.

3.2 Task B: An Echo Program (5 marks)

Write an AVR assembly program which receives each character typed from the keypad and displays it on the LCD. Choose one line display. When a line is full, clear the whole line and place the cursor at the beginning of the line. For each key, display the character on that key. If a key is labelled with multiple characters, display the primary character (0, 2-9) in the lower row.

Assemble your program using AVR Studio, download the hex file on to your board and show your working program to your tutor.

3.3 Task C: A Simple Calculator (10 marks)

Write an AVR assembly program to evaluate an arithmetic expression typed via the keypad and display its result on the LCD. The expression is recursively defined as follows:
 Expression:= Expression+Expression
 Expression:= Expression–Expression
 Expression:= Integer
 Expression:= –Integer
 where Integer is a base 10 integer containing digits 0-9 only.
 Examples of expressions are –20+30020–14010+150, and 2001–1010–201+31200.

Your program must meet the following requirements:
1. An expression is typed via the keypad.
2. –, + and= are generated by using the keys A, B and C, respectively.
3. 2 bytes are used to store the intermediate results and the final result of an expression.
4. If 2's complement overflow occurs during the process of evaluating an expression, "Overflow occurred." is displayed on the LCD.
5. When a character is typed, it is displayed on the LCD immediately.
6. When "=" is typed, the expression typed is evaluated and its result in base 10 is displayed on the LCD immediately. For example, after 1230+120–100–10= is typed, 1230+120–100–10=1240 will be displayed on the LCD.
7. If an expression is syntactically incorrect, "Incorrect expression" is displayed on the LCD. For example, if 1234+120h–1= is typed, 1234+120h–1=incorrect expression will be displayed on the LCD.

Assemble your program using AVR Studio, download the hex file onto the board, and show your working program to your tutor.

4 Deadline

The deadline of this lab is Week 9.