15-348 Embedded Systems
Spring 2017
Assignment 3

Due Date:
Wednesday February 22.
Code on Autolab by 10pm
Demo during lab on February 23.

This is a programming homework. You should demo your code and submit all .c files zipped as a single file on autolab by 10:00pm on February 22.

Task 1: (30 points) Program the controller to accept input from a 4x4 keypad.

In this task, you will program the controller so that it is able to receive input from a 4x4 keypad. A 4x4 keypad consists of sixteen keys arranged in a matrix of four rows and four columns as shown in the figure below:

In an input device like this keypad, the buttons are not connected individually to input pins on a controller since that would require many input pins (consider what would happen on a keyboard with 101 keys). Instead, the interface to the keypad consists of Input/Output divided into rows and columns. The details of how this interface works can be found at:

http://pcbheaven.com/wikipages/How_Key_Matrices_Works/

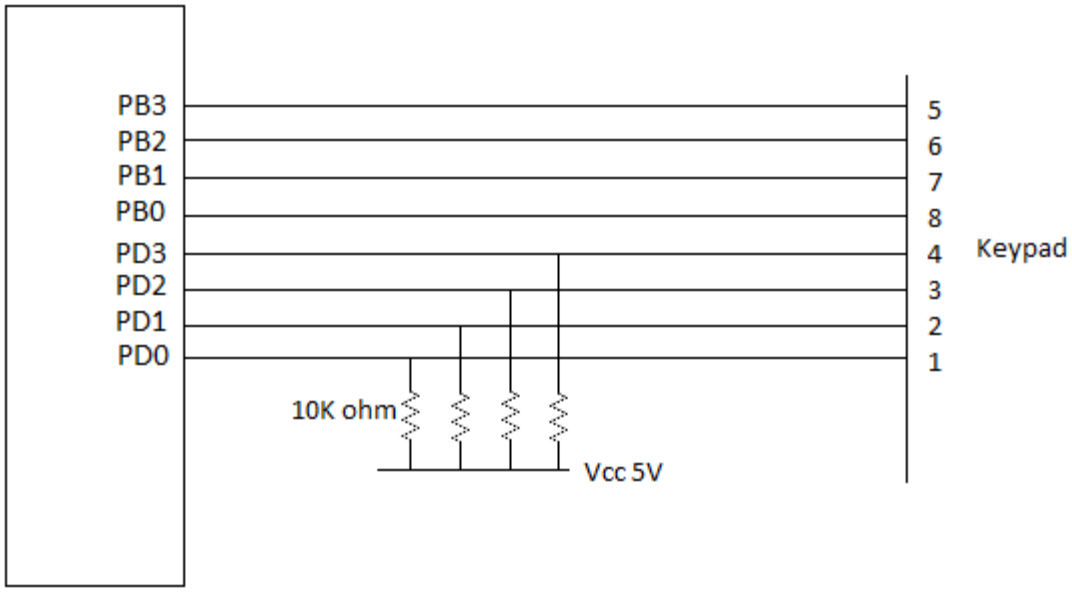
Read the above reference and get yourself familiar with the basics of this interface.

The keypad provided to you is divided into rows and columns as given below:

		Columns				
		1	2	3	4	Keypad
Rows	1	A	B	C	D	8
	2	3	6	9	#	7
	3	2	5	8	0	6
	4	1	4	7	*	5
	keypad	1	2	3	4	

Here are the steps you will need to do for task 1.

1. Make a circuit as shown in the figure below:



2. To determine which key is pressed, follow the rules listed below:
    a. PB0-PB4 are configured as output ports
    b. PD0-PD3 are configure as input ports
    c. You will enable one row at a time and then read the columns to see which key was pressed.

d. Writing 1 to a row disables it and writing a 0 enables it. For example, if we set PB3, PB2, and PB1 to 1 and PB0 to 0, this will enable row1. Once a row is enabled, you need to check if any key in that row is pressed. If a key is pressed, its corresponding bit at the input pins will become 0, otherwise the pins would be 1. For example, if row1 is enabled and if Button B is pressed, then value at PD1 would be 0 and values at PD0, PD2, and PD3 would be 1. You need to cycle through each row and check if any key in that row is pressed.

e. You are given a file called Serial.c and Serial.h on the course resource page. Use those files to write the key pressed on the keypad to the Serial port so you can view it on your PC.

Task 2: (40 points) Design and Implement a State machine to input text from a 4x4 keypad.

In this task, you will design and implement a state machine that will allow you to enter text using the 4x4 keypad, similar to the techniques used in old phones. If you look at the keypads, each key has a sequence of alphabets printed above the main key number. Number 2 contains ABC, Number 3 contains DEF, and so on. In order to enter B, I can press key 2 twice, in quick succession. If I need A, I can press 2 once and then pause for a little bit for the system to register that I wanted A.

1. Design a state machine that replicates the behavior of text entry on old phones following the following principles.

    a. If a key is pressed nth number of times, the nth alphabet is displayed on the lcd screen. Pressing a number 4 times will generate that number. Pressing 2 four times will produce number 2.

    b. If a key is pressed n times, followed by a pause of 1 second, the system will treat that as the end of sequence for that button and decode the entered number.

    c. If a key is pressed n times, and then a different key is entered, this will indicate an end of the previous entry and start of a new entry. The machine should register the output of the previous entry.

2. Implement this state machine on the controller using task1 as input source. As each character is typed, it should be displayed on the terminal on your computer through the serial port.