Lab 3: Interfacing Keypad
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Fall 2018

Goals

1. Understand I/O matrix technique.
2. Be familiar with keypad scanning algorithms.

Grading Rubrics (Total = 100 points)

1. Pre-lab assignment (10 points).
2. Lab demonstration (75 points).
3. Something cool (15 points).

NOTE: Completing the basic requirement will only get you up to 75 points. If you want to get 100 points in this lab, you will have to complete the pre-lab assignment, the basic lab requirement, and do something cool.

Pre-lab Assignment (Due on October 15, 2018 at the beginning of class)

1. Read Textbook **Chapter 14.9 Keypad Scan**.
2. Complete the pre-lab assignment located at the end of this handout.

In-lab Assignment (Due on October 29, 2018)

1. Use polling method to scan keypad and display the inputs on LCD **(75 points)**:
   a. When a key is pressed, its value is then displayed on the LCD. The LCD should be able to display up to six digits.
   b. The basic requirement is to display only the numerical digits from the keypad. However, you are free to use other keys to do something cool and different.

2. Something cool **(15 points)**. The following gives a few examples.
   a. When a key is pressed for a long time, generate a periodical input with an interval of 2 seconds.
   b. Use the "*" key to delete the previous input. Pressing "*" key again keeps deleting the previous input.
   c. Use the "#" key to repeat the previous inputs.
   d. Detect and recognize if multiple keys are pressed simultaneously.

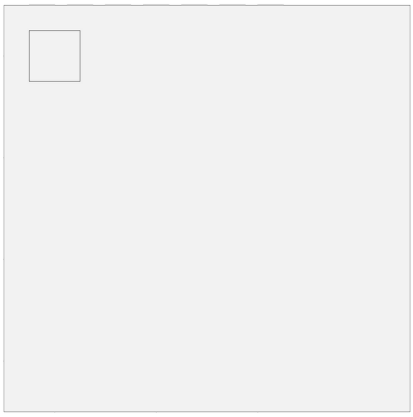
Keyboard Interface

The 4x4 keypad used in this lab requires 8 pins (four row pins and four column pins). In this lab, the connection between the keypad and the discovery kit is as the following table.

Row	R1 → PE 10	R2 → PE 11	R3 → PE 12	R4 → PE 13
Column	C1 → PA 1	C2 → PA 2	C3 → PA 3	C4 → PA 5

All pins of the input port (C1, C2, C3, and C4) are pulled up to 3V via a 2.2KΩ resistor. Within the processor, each GPIO pin can be pulled up via an internal resistor (between 20 and 55 KΩ, typically 40 KΩ). However, the internal pull-up capability is too weak and thus an external pull-up is required.

When looking at the front side of the keypad, the pins on the back from left to right are: `R1 – R2 – R3 – R4 – C1 – C2 – C3 – C4`.



The maximum current a GPIO pin can source or sink is 20 mA. When calculating the value of external pull-up resistors, make sure that the current should not exceed 20 mA.

$$\frac{3\,V}{2.2\,K\,\Omega} = 1.4\ \ mA$$

On the STM32L4 board, all pins in the input port (PA1, PA2, PA3, and PA5) are connected to ground via a 100nF capacitor, as shown in the figure below. Therefore, due to these capacitors, the voltage output on these pins won't immediately changes to Vcc or ground. ***A very short delay should be added before reading the input port.*** Specifically, delays are needed between setting GPIOE outputs and reading GPIOA inputs.

Pre-Lab Assignment (10 points)
Lab 3: Interfacing Keypad
Due on October 15, 2018 at the beginning of class
Print, answer, and hand it back to T.A.
(NO Dropbox submission!)

Student Name: _____

Date: _____

1. Configure Port E: Pin 10, 11, 12, and 13 as Digital Output

GPIO Mode: Digital Input (00), Digital Output (01), Alternative Function (10), Analog (11)

Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MODER	MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[1:0]		MODER7[1:0]		MODER6[1:0]		MODER5[1:0]		MODER4[1:0]		MODER3[1:0]		MODER2[1:0]		MODER1[1:0]		MODER0[1:0]	
MASK (Clear)																																
MASK (Set)																																
Desired Output	-	-	-	-	0	1	0	1	0	1	0	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

GPIOA Mode Register MASK (Clear) Value = 0x_____ (in HEX)
GPIOA Mode Register MASK (Set) Value = 0x_____ (in HEX)

2. Configure Port A: Pin 1, 2, 3, and 5 as Digital Input

GPIO Mode: Digital Input (00), Digital Output (01), Alternative Function (10), Analog (11)

Register	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MODER	MODER15[1:0]		MODER14[1:0]		MODER13[1:0]		MODER12[1:0]		MODER11[1:0]		MODER10[1:0]		MODER9[1:0]		MODER8[1:0]		MODER7[1:0]		MODER6[1:0]		MODER5[1:0]		MODER4[1:0]		MODER3[1:0]		MODER2[1:0]		MODER1[1:0]		MODER0[1:0]	
MASK (Clear)																																
Desired Output	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-

GPIOB Mode Register MASK (Clear) Value = 0x_____ (in HEX)

Lab 3: In-lab Assignment

Grading: up to 90 points (75 points + 15 points for something cool)

Classes for this lab will be on Oct. 15, Oct. 22 and Oct. 29, 2018 (three weeks)

The basic requirement for this lab is to display the correct digit in the LCD when the user presses a key in the keypad.

NOTE: Completing the basic requirement will only get you up to 75 points. If you want to get 100 points in this lab, you will have to complete the pre-lab assignment, the basic lab requirement, and do something cool.

- A startup Keil uVision project is available online. It contains the following files: ***main.c***, ***LCD.c***, and ***keypad.c***.
- In order to complete the basic lab requirement, you only have to write code in the ***keypad.c*** file.
- More specifically, you should complete two methods: ***Keypad_Init()*** and ***Keypad_Scan()***.

- **Keypad_Init() (10 points)**:
  - This is based on this and previous pre-labs (complete the missing masks).

- **Keypad_Scan() (65 points)**:
  - You should complete this method by following the scanning algorithm found on **Figure 14-26** in the textbook.
  - This function is mostly empty. You should figure out by yourselves the correct code to be written. Also, try to follow the instructions located in the **keypad.c** file.

- **Academic Integrity Notice:**
  - Students are supposed to work individually! Copied code will incur in reduced grade!

- **Good News! There will be no post-lab!**