LAB: GPIO Digital InOut 7-segment(eval board)

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Github:
https://github.com/henny041520-commits/EC-DJLee-042/tree/main/lab/LAB%20GPIO%20Digital%20InOut%207-segment

Demo Video: https://youtube.com/shorts/G5XIK69HttQ?feature=share

PDF version: https://github.com/henny041520-commits/EC-DJLee-042/blob/main/report/%5BEC%2024-2%5D%20LAB%20GPIO%20Digital%20InOut%207-segment.pdf

Introduction

In this lab, you are required to create a simple program to control a 7-segment display to show a decimal number (0~9) that increases by pressing a push-button.

You must submit

- LAB Report (*.pdf)
- Zip source files(lab***.c, ecRCC2.h, ecGPIO2.h etc...).
  - Only the source files. Do not submit project files

Requirement

Hardware

- MCU
  - NUCLEO-F411RE
- Actuator/Sensor/Others:
  - eval board

Software

- PlatformIO, CMSIS, EC_HAL library

Exercise

Fill in the table

Port/Pin	Description	Register setting
Port B Pin 5	Clear Pin5 mode	GPIOB->MODER &=~(3<<(5*2))
Port B Pin 5	Set Pin5 mode = Output	GPIOB->MODER |=1<<(5*2)
Port B Pin 6	Clear Pin6 mode	GPIOB->MODER &=~(3<<(6*2))
Port B Pin 6	Set Pin6 mode = Output	GPIOB->MODER |=1<<(6*2)
Port B Pin Y	Clear PinY mode	GPIOB->MODER &=~(3<<(Y*2))
Port B Pin Y	Set PinY mode = Output	GPIOB->MODER |=1<<(Y*2)
Port B Pin 5~9	Clear Pin5~9 mode	for(int i =5;5<10;i++) {GPIOB->MODER &=~(3<<(i*2))}
	Set Pin5~9 mode = Output	for(int i =5;5<10;i++) {GPIOB->MODER |=1<<(i*2)}
Port X Pin Y	Clear Pin Y mode	GPIOX->MODER &=~(3<<(Y*2))
	Set Pin Y mode = Output	GPIOX->MODER |=1<<(Y*2)
Port B Pin5	Set Pin5 otype=push-pull	GPIOB->OTYPER & = ~(1<<(5*2))
Port B PinY	Set PinY otype=push-pull	GPIOB-> OTYPER & = ~(Y<<(5*2))
Port B Pin5	Set Pin5 ospeed=Fast	GPIOB->OSPEEDR |=2<<(5*2)
Port B PinY	Set PinY ospeed=Fast	GPIOB-> OSPEEDR |=2<<(Y*2)
Port B Pin 5	Set Pin5 PUPD=no pullup/down	GPIOB->OTYPER &=~(3<<(5*2)))
Port B Pin Y	Set PinY PUPD=no pullup/down	GPIOB-> OTYPER &=~(3<<(Y*2)))

Problem 0: Preparation

Procedure

Complete the Tutorial: 7-segment Display.

{% embed url="https://ykkim.gitbook.io/ec/ec-course/tutorial/tutorial-7segment-display#option-3.-without-using-a-7-segment-decoder-on-jkit-evaluation-board" %}

You must check the 7-segment display can show all the number from 0 to 9.

- Give 'HIGH' signal to each 7-segment pin of 'a'~'g'
- Observe if that LED is turned ON or OFF
- Check another 7-segment display leds
  - Example: Connect VCC to all 'a'~'g' pins

Complete the required functions that displays numbers on 7-segment FND.

These functions must be moved to `ecGPIO2.h,ecGPIO2.c`

Update your library header

- **ecGPIO2.h, ecGPIO2.c**

```
PinName_t svgpinsFND[12]={PB_7, PB_6, PB_5, PB_4, PB_3, PB_2, PB_1, PB_0,
PC_3, PC_4, PA_11, PA_10};
PinName_t svgpinsnum[8]={PB_7, PB_6, PB_5, PB_4, PB_3, PB_2, PB_1, PB_0};
PinName_t svgpinsSelect[4]={ PC_3, PC_4, PA_11, PA_10};
/*
-----------------------------------------------------------------------

==Pin mapping==
- svgpinsFND[0..7]  : segment a,b,c,d,e,f,g,dp (8 pins)
- svgpinsFND[8..11] : digit select DIG0..DIG3 (4 pins)
- svgpinsnum[]      : segment pins ordered for bit-to-pin writes
- svgpinsSelect[]   : digit select pins
-----------------------------------------------------------------------
*/

 uint8_t svgvalue[10] = {
    0b00111111, //0
    0b00000110, //1
    0b01011011, //2
    0b01001111, //3
    0b01100110, //4
    0b01101101, //5
    0b01111101, //6
    0b00100111, //7
    0b01111111, //8
    0b01101111, //9
    };
 /*
-----------------------------------------------------------------------
==Digit bit patterns for 0-9 (common-cathode)==
```

```
- Bit order (LSB→MSB): a b c d e f g dp
- Example: 0b00111111 means g=0, f=1, e=1, d=1, c=1, b=1, a=1 (dp=0)
- dp is OFF by default
-------------------------------------------------------------------------  */
void seven_seg_FND_display(uint8_t  num, uint8_t select){
    // Activate the chosen digit (High)
    GPIO_write(svgpinsSelect[select], 1);
    for (int i=0; i<8;i++){
        //svgpinsnum[7~0] -> svgvalue[0~7]
         GPIO_write(svgpinsnum[7-i], (svgvalue[num]>>i )& 0x01);
    }
}
/*
-------------------------------------------------------------------------
 ==seven_seg_FND_display==
Show a single decimal digit (num: 0-9) on the selected position (select: 0-3).
Sequence:
1) Drive the selected digit line HIGH
2) Output the segment pattern of svgvalue[num] to svgpinsnum.
for array
arrangement : 01234567
for bit
arrangement : 76543210
this is why we reverse svgpinsnum's arrangement before we write svgvalue[num]
to it.
(if we set svgpinsnum[8]={PB_0,PB_1,PB_2, PB_3,PB_4,PB_5,PB_6,PB_7} like this,
reversing is not required)

-------------------------------------------------------------------------
*/
void seven_seg_FND_init(void){
    for(int i=0;i<12;i++)
    {
    GPIO_init(svgpinsFND[i], OUTPUT);
    GPIO_init(PA_4, INPUT);
    GPIO_otype(svgpinsFND[i], pushpull);
    GPIO_ospeed(svgpinsFND[i],mediumspeed);
    GPIO_pupd(svgpinsFND[i],nopupd);
    }
    GPIO_pupd(PA_4,pullup);
}
/*
-------------------------------------------------------------------------
==seven_seg_FND_init==
Initialize:
- 12 FND pins (8 segments + 4 digit selects) as Push-Pull, No Pull-up-Pull-
```

```
down, Medium Speed.
- Button on PA_4 as input with pull-up.
-------------------------------------------------------------------------
*/
int readButtonRising(PinName_t pinName){
    static int prev = 1;  // previous state
    int now = GPIO_read(pinName) ? 1 : 0; // 1 = released, 0 = pressed
    int rising = 0;
    // Detect 0→1 transition (release)
    if(prev==0 && now==1){
        //debounce(60~100 ms)
        for(volatile int i=0;i<160000;i++);
        rising = 1;
    }
    prev = now; // update state
    return rising; // Detect 0→1 transition -> 1 , not -> 0
}
/*
-------------------------------------------------------------------------
==readButtonRising(been made for other labs, not necessary for 7-segment
Display)
0→1 transition detected on the given pin return 1, else 0.
  Operation:
    1) Read current level (now).
    2) If prev==0 and now==1, a rising edge occurred.
        1.start : now = 1, prev = 1 -> if(x) -> now = 1, prev = 1
        2.pressed : now = 0, prev = 1 -> if(x) -> now = 0, prev = 0
        3.released : now = 1, prev = 0 -> if(o) -> now = 1, prev = 1
    3) if(O) -> Apply a short delay as a debounce, rising = 1
                                                 else rising = 0
    4)  return rising.
-------------------------------------------------------------------------
*/
```

Problem 1: Display a Number with Button Press

Procedure

Create a new project under the directory `\repos\EC\lab\LAB_GPIO_7segment`

- The project name is “**LAB_GPIO_7segment”.**
- Create a new source file named as “**LAB_GPIO_7segment.c”**
- Update `platformio.ini` for VS.Code : Read here for detail

Create a code that increases the displayed number from 0 to 9 with each button press.

- After the number '9', it should start from '0' again.

Configuration

Configure the MCU GPIO

Digital In for Button (B1)	Digital Out for 7-Segment
Digital In	Digital Out
PA4	PB7,PB6,PB5,PB4,PB3,PB2,PB1,PB0 ('a'~'h', respectively) PC3,PC4,PA11,PA10 ('FND_0'~FND_3, respectively)
PULL-UP	Push-Pull, No Pull-up-Pull-down, Medium Speed

Algorithm

Overview

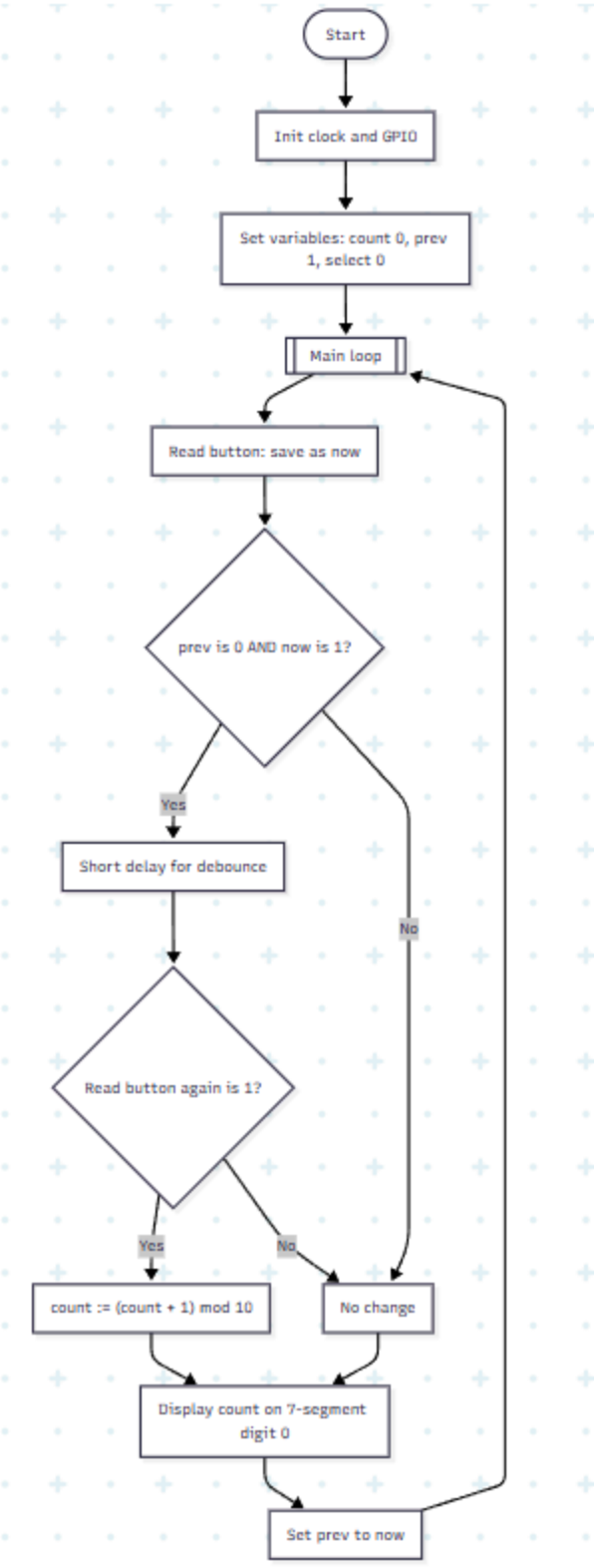
Mealy FSM Table — Button Counter with 7-Segment Display (1 Digit)

Present State	Input X (Button)	Condition	Next State	Output (Immediate)
S0 (IDLE_UP)	X=0 (pressed)	button goes low	**S1**	–
S0 (IDLE_UP)	X=1 (released)	still released	**S0**	–
S1 (PRESSED)	X=0 (pressed)	still pressed	**S1**	–
S1 (PRESSED)	X=1 (released)	**rising edge detected**	**S0**	**count ← (count+1) mod 10**; show on 7-seg digit 0

Output Logic

- `selectFND = 0` (only one digit enabled)
- `SEG = svgvalue[count]` (7-segment pattern from table svgvalue []`)

Flow chart



Code

Sample Code.

```
#include "stm32f4xx.h"
#include "ecGPIO2.h"
#include "ecRCC2.h"

#define BUTTON_PIN PA_4

void setup(void){
    // Intialize System Clock
    RCC_HSI_init();
    GPIO_init(BUTTON_PIN, INPUT);  // calls RCC_GPIOC_enable()
    // and Others
    // [YOUR CODE GOES HERE]
    seven_seg_FND_init();
};

int main(void) {
    setup();
    uint8 numDisplay=8;
    uint8 selectFND=0;

    while (1) {
        // [YOUR CODE GOES HERE]
        seven_seg_FND_display(numDisplay,selectFND);
        // [YOUR CODE GOES HERE]
        // [YOUR CODE GOES HERE]
    }
}
```

Your code goes here: ecGPIO2.c

> Explain your source code with necessary comments.

```
*/
void seven_seg_FND_display(uint8_t  num, uint8_t select){
    // Activate the chosen digit (High)
    GPIO_write(svgpinsSelect[select], 1);
    for (int i=0; i<8;i++){
        //svgpinsnum[7~0] -> svgvalue[0~7]
         GPIO_write(svgpinsnum[7-i], (svgvalue[num]>>i )& 0x01);
    }
```

```
}
/*
-------------------------------------------------------------------------
 ==seven_seg_FND_display==
Show a single decimal digit (num: 0-9) on the selected position (select: 0-3).
Sequence:
1) Drive the selected digit line HIGH
2) Output the segment pattern of svgvalue[num] to svgpinsnum.
for array
arrangement : 01234567
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this is why we reverse svgpinsnum's arrangement before we write svgvalue[num]
to it.
(if we set svgpinsnum[8]={PB_0,PB_1,PB_2, PB_3,PB_4,PB_5,PB_6,PB_7} like this,
reversing is not required)

-------------------------------------------------------------------------
*/
int readButtonRising(PinName_t pinName){
    static int prev = 1;  // previous state
    int now = GPIO_read(pinName) ? 1 : 0; // 1 = released, 0 = pressed
    int rising = 0;
    // Detect 0→1 transition (release)
    if(prev==0 && now==1){
        //debounce(busy-wait)
        for(volatile int i=0;i<160000;i++);
        rising = 1;
    }
    prev = now; // update state
    return rising; // Detect 0→1 transition -> 1 , not -> 0
}
/*
-------------------------------------------------------------------------
==readButtonRising(been made for other labs, not necessary for 7-segment
Display)
0→1 transition detected on the given pin return 1, else 0.
  Operation:
    1) Read current level (now).
    2) If prev==0 and now==1, a rising edge occurred.
        1.start : now = 1, prev = 1 -> if(x) -> now = 1, prev = 1
        2.pressed : now = 0, prev = 1 -> if(x) -> now = 0, prev = 0
        3.released : now = 1, prev = 0 -> if(o) -> now = 1, prev = 1
    3) if(O) -> Apply a short delay as a debounce, rising = 1
                                                else rising = 0
    4)  return rising.
```

```
--------------------------------------------------------------------------------
*/
```

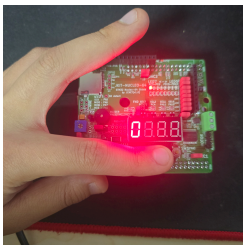
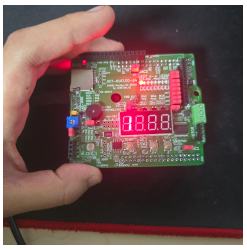
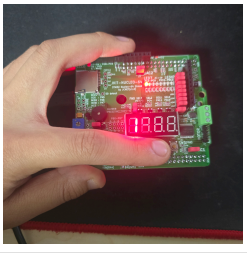
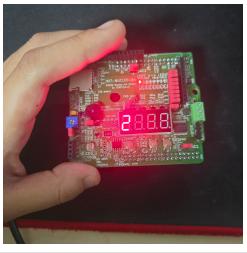
Your code goes here: LAB GPIO Digital InOut 7-segment.c

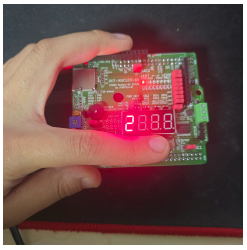
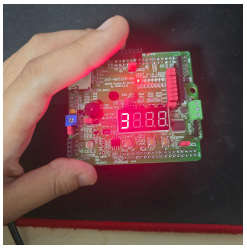
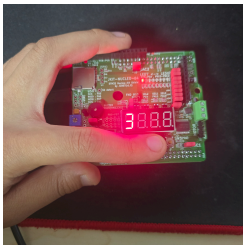
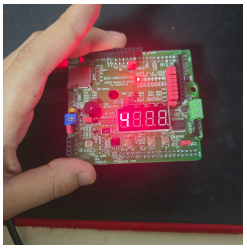
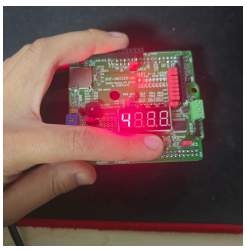
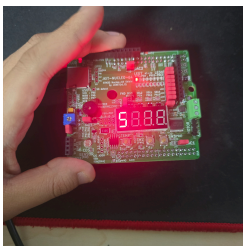
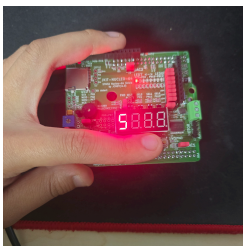
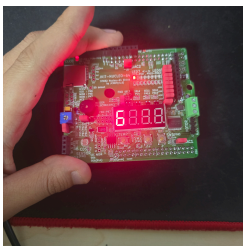
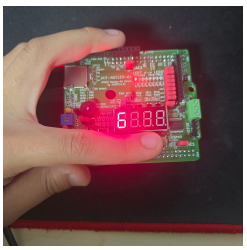
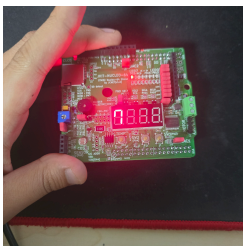
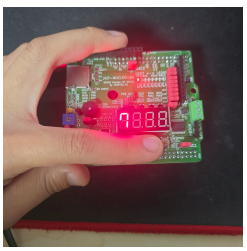
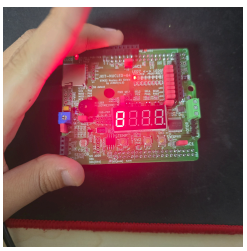
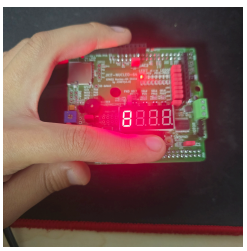
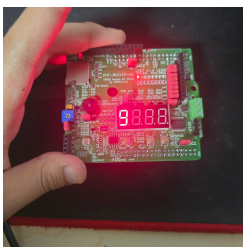
> Explain your source code with the necessary comments.

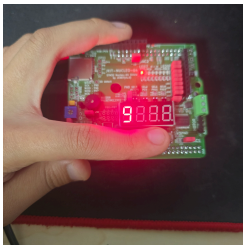
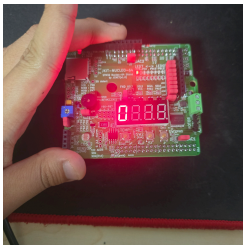
```c
int main(void) {
    setup();

    uint8_t selectFND=0;  // Which digit position to light (0..3)
    uint8_t count = 0; // Value to display (0..9)
    while (1) {
        // Edge-triggered count: button release -> increment once per .
        // readButtonRising(PA_4) should return 1 only on a 0->1 transition
        if(readButtonRising(PA_4)){
        count++;  //one step advance per release event
}
        if(count==10)
        {
            count=0; // reset display number to 0
        }
        seven_seg_FND_display(count,selectFND);
    }
}
```

Results

number	press	release
0		
1		

number	press	release
2		
3		
4		
5		
6		
7		
8		

number	press	release
9		

https://youtube.com/shorts/G5XIK69HttQ?feature=share

Discussion

1. Analyze the result and explain any other necessary discussion.
2. Draw the truth table for the BCD 7-segment decoder with the 4-bit input.

> Answer :
> Button release (0→1) is detected with `readButtonRising(PA_4)` → counter increments once per release
> One digit is shown with `seven_seg_FND_display(count, selectFND)`

A3	A2	A1	A0	Dec	a	b	c	d	e	f	g	dp
0	0	0	0	0	1	1	1	1	1	1	0	0
0	0	0	1	1	0	1	1	0	0	0	0	0
0	0	1	0	2	1	1	0	1	1	0	1	0
0	0	1	1	3	1	1	1	1	0	0	1	0
0	1	0	0	4	0	1	1	0	0	1	1	0
0	1	0	1	5	1	0	1	1	0	1	1	0
0	1	1	0	6	1	0	1	1	1	1	1	0
0	1	1	1	7	1	1	1	0	0	1	0	0
1	0	0	0	8	1	1	1	1	1	1	1	0
1	0	0	1	9	1	1	1	1	0	1	1	0
1	0	1	0	10	x	x	x	x	x	x	x	x
1	0	1	1	11	x	x	x	x	x	x	x	x
1	1	0	0	12	x	x	x	x	x	x	x	x
1	1	0	1	13	x	x	x	x	x	x	x	x
1	1	1	0	14	x	x	x	x	x	x	x	x
1	1	1	1	15	x	x	x	x	x	x	x	x

3. What are the common cathode and common anode of 7-segment display?

> Answer :
> **Common Cathode (CC)(active-HIGH segments**): all LED segment cathodes are tied together to GND. To turn a segment ON -> HIGH
>
> **Common Anode (CA)(active-LOW segments)**: all LED segment anodes are tied together to VCC. To turn a segment ON -> LOW
> (VCC → common anode → LED → MCU pin to GND).

4. Does the LED of a 7-segment display (common anode) pin turn ON when 'HIGH' is given to the LED pin from the MCU?

> Answer :
> In common-anode, the common pin is at VCC. A segment lights when its cathode side is pulled LOW so current can flow.
> Turn ON a segment -> MCU LOW

Reference

BCD to 7 Segment Decoder : https://www.geeksforgeeks.org/digital-logic/bcd-to-7-segment-decoder/
