Lab 3: Liquid Crystal Display (LCD) Driver in C

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Goals

1. Understand alternative function of GPIO pins.
2. Understand basic concepts of an LCD driver, particularly ***Bias*** and ***Duty Ratio.***
3. Understand concepts of double buffering to ensure the coherency of displayed information.
4. Understand clock configurations of GPIO pins and LCD drivers.

Grading Rubrics (Total = 100 points)

1. **Pre-lab assignment:** 10 points.
2. **Attendance and Class Participation:** 8 points.
3. **Code Organization:** 8 points.
4. **Lab demo questions:** 10 points.
5. **First Objective:** 50 points.
6. **Second Objective:** 14 points.

Pre-lab Assignments:

1. Read Chapter 17 of Textbook.
2. Watch a Youtube Tutorial:
   - Lecture 14. LCD (http://web.eece.maine.edu/~zhu/book/tutorials.php)
3. **Complete the Pre-Lab** assignment available in a separate file on D2L (**10 points**).
   - **Due date for Monday labs:** April 01, 2019.
   - **Due date for Wednesday labs:** April 03, 2019.

Lab Objectives - Overview:

More details about each objective is presented at the end of this document.

1. **First Objective (50 points):**
   a. **Due date:**
      i. **For Monday labs:** April 08, 2019.
      ii. **For Wednesday labs:** April 10, 2019.
   b. Write a C program to display the first six letters of your last name in the LCD.
2. **Second Objective (14 points):**
   a. **Due date:**
      i. **For Monday labs:** April 15, 2019.
      ii. **For Wednesday labs:** April 17, 2019.
   b. Create a generic LCD driver in C to display any letter in any display position.

Introduction

PIN configuration: A total of 28 GPIO pins from Port A, B, and C drive the LCD display, as shown below. The duty ratio of this LCD is 4 and therefore there are four common terminals (COM0-COM3), which are connected to four GPIO pins. The other 24 GPIO pins are mapped to pixel bits stored in the internal LCD RAM. The mapping between GPIO pins and LCD RAM are given in the textbook. Each pin should be configured as Alternative Function 11 (LCD Driver).

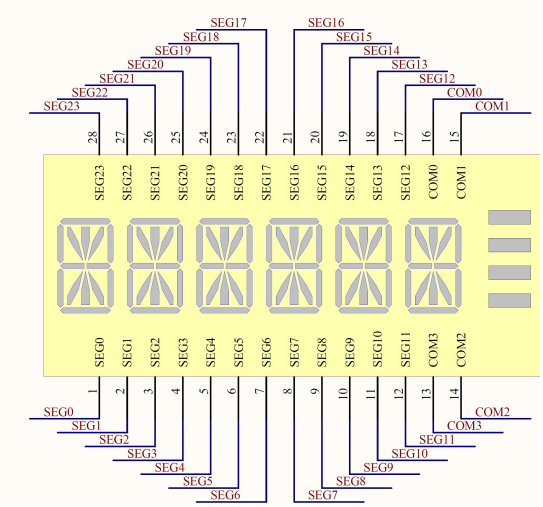

Figure 1. PIN connection to six 14-segment digits and 4 bars.

LCD (24 segments, 4 commons, multiplexed 1/4 duty, 1/3 bias) on DIP28 connector

VLCD = PC3			
COM0 = PA8 (LCD_COM0)	COM1 = PA9 (LCD_COM1)	COM2 = PA10 (LCD_COM2)	COM3 = PB9 (LCD_COM3)
SEG0 = PA7 (LCD_SEG4)	SEG6 = PD11 (LCD_SEG31)	SEG12 = PB5 (CD_SEG9)	SEG18 = PD8 (LCD_SEG28)
SEG1 = PC5 (LCD_SEG23)	SEG7 = PD13 (LCD_SEG33)	SEG13 = PC8 (LCD_SEG26)	SEG19 = PB14 (LCD_SEG14)
SEG2 = PB1 (LCD_SEG6)	SEG8 = PD15 (LCD_SEG35)	SEG14 = PC6 (LCD_SEG24)	SEG20 = PB12 (LCD_SEG12)
SEG3 = PB13 (LCD_SEG13)	SEG9 = PC7 (LCD_SEG25)	SEG15 = PD14 (LCD_SEG34)	SEG21 = PB0 (LCD_SEG5)
SEG4 = PB15 (LCD_SEG15)	SEG10 = PA15 (LCD_SEG17)	SEG16 = PD12 (LCD_SEG32)	SEG22 = PC4 (LCD_SEG22)
SEG5 = PD9 (LCD_SEG29)	SEG11 = PB4 (LCD_SEG8)	SEG17 = PD10 (LCD_SEG30)	SEG23 = PA6 (LCD_SEG3)

	LCD					
STM32L Pin	**LCD Pin**	**COM3**	**COM2**	**COM1**	**COM0**	**LCD Pin**
PA7 (LCD_SEG4)	1	1N	1P	1D	1E	SEG 0
PC5 (LCD_SEG23)	2	1DP	1COLON	1C	1M	SEG 1
PB1 (LCD_SEG6)	3	2N	2P	2D	2E	SEG 2
PB13 (LCD_SEG13)	4	2DP	2COLON	2C	2M	SEG 3
PB15 (LCD_SEG15)	5	3N	3P	3D	3E	SEG 4
PD9 (LCD_SEG29)	6	3DP	3COLON	3C	3M	SEG 5
PD11 (LCD_SEG31)	7	4N	4P	4D	4E	SEG 6
PD13 (LCD_SEG33)	8	4DP	4COLON	4C	4M	SEG 7
PD15 (LCD_SEG35)	9	5N	5P	5D	5E	SEG 8
PC7 (LCD_SEG25)	10	BAR2	BAR3	5C	5M	SEG 9
PA15 (LCD_SEG17)	11	6N	6P	6D	6E	SEG 10
PB4 (LCD_SEG8)	12	BAR0	BAR1	6C	6M	SEG 11
PB9 (LCD_COM3)	13	**COM3**				
PA10 (LCD_COM2)	14		**COM2**			
PA9 (LCD_COM1)	15			**COM1**		
PA8 (LCD_COM0)	16				**COM0**	
PB5 (LCD_SEG9)	17	6J	6K	6A	6B	SEG 12
PC8 (LCD_SEG26)	18	6H	6Q	6F	6G	SEG 13
PC6 (LCD_SEG24)	19	5J	5K	5A	5B	SEG 14
PD14 (LCD_SEG34)	20	5H	5Q	5F	5G	SEG 15
PD12 (LCD_SEG32)	21	4J	4K	4A	4B	SEG 16
PD10 (LCD_SEG30)	22	4H	4Q	4F	4G	SEG 17
PD8 (LCD_SEG28)	23	3J	3K	3A	3B	SEG 18
PB14 (LCD_SEG14)	24	3H	3Q	3F	3G	SEG 19
PB12 (LCD_SEG12)	25	2J	2K	2A	2B	SEG 20
PB0 (LCD_SEG5)	26	2H	2Q	2F	2G	SEG 21
PC4 (LCD_SEG22)	27	1J	1K	1A	1B	SEG 22
PA6 (LCD_SEG3)	28	1H	1Q	1F	1G	SEG 23

Lab 3: Lab Assignment

First Objective:

- **Write a C program to display the first six letters of your last name in the LCD.**
  - A startup code is provided on D2L under Lab 3 section (filename: *Lab 3 – Startup Code.zip*) containing the following files: **LCD.c**, **LCD.h**, **main.c**, and **stm32l476.h**.
    - **Download** and **extract** the startup code.
    - Create a new C Project using System Workbench for STM32 IDE.
    - Move the files **main.c** and **LCD.c** to your project's **src** folder.
    - Move the files **LCD.h** and **stm32l476xx.h** to your project's **inc** folder.
  - **For the first objective, all your code should be written in the *LCD.c* file.**
  - **You are required to complete four functions:**
    - ***LCD_PIN_Init***() that enables GPIO clocks and configures GPIO pins as the alternative function 11 (Pre-Lab, Questions 1 to 4) .
    - ***LCD_Configure***() that performs the LCD configuration in the flowchart (Pre-Lab, Question 5).
    - ***LCD_Display_Name***() that display the first six letters of your last name by setting up the LCD_RAM registers (Pre-Lab, Question 6).

Second Objective:

- **Create a generic LCD driver in C to display any letter in any LCD position.**
  - You are required to complete **LCD_WriteChar()** function located in the **LCD.c** file.