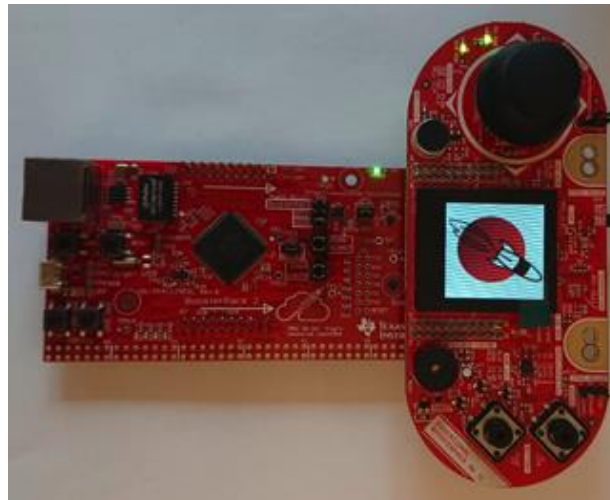# 1. Introduction

The goal of this lab is to investigate how to use the analog-to-digital converter driver (ADC) and Pulse Width Modulation (PWM) modules.

1.1 Hardware Setup

In this lab, you will use the booster pack provided to you, to generate a potentiometer signal. Start to connect the Educational Kit to the booster pack board as shown in the following figure.

The following subsections explain how you create projects, specific to the peripherals you are going to use in this lab, i.e., the ADC and the PWM frameworks.

1.2 Example project of how to initialize the LCD Screen

In other to utilize the LCD Screen you can the Graphics Library (grlib) provided by TivaWare C series and the display header file you can find in Files/Labs/Lab2 in Canvas. To include you need under the ARM Linker in your project add the grlib.lib file. Example file path: C:\ti\TivaWare_C_Series-2.1.4.178\grlib\ccs\Debug\grlib.lib (your TivaWare might differ).

Sometimes it is required to flash the program twice for the proper output on the LCD to appear.

1.3   Pulse-Width Modulation (PWM): PWM-> LED Brightness

Pulse-Width Modulation (PWM) is a modulation technique to allow control of the power supply of electrical devices. This can be for example the brightness of a LED or the speed of an engine. The voltage level is controlled by switching the supply voltage on and off. If the switching happens fast enough the sink experiences a voltage equivalent to the mean voltage value. However, switching needs to happen at a frequency much faster than what would be noticed by the sink.

In this example, we will control the brightness of RGB_LED_RED which is connected to PG0 (this signal is controlled by Module 0 PWM Generator 2).
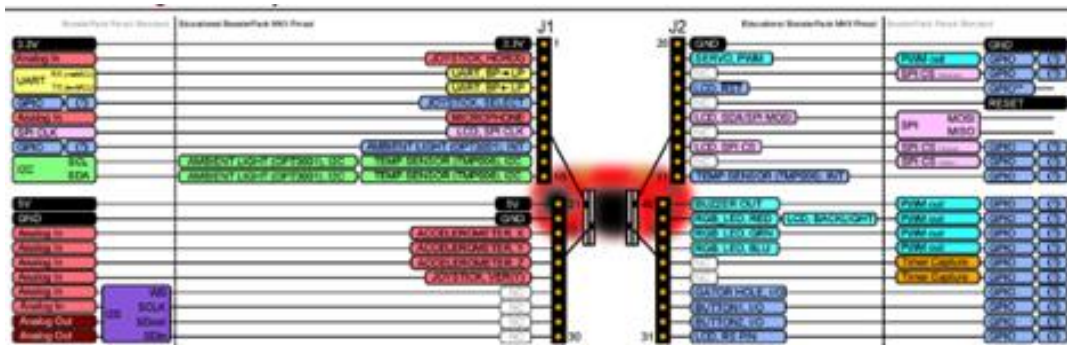
1. In Project Explorer, copy the project *Controlled* and paste it with the name *pwm_led*.

2. Copy the content of *pwm_led.c* and paste it into the file *main.c*

3. Build the project and load it.

4. By changing the PWMPulseWidthSet (line 59), the brightness of the red LED will be changed.

PWMPulseWidthSet – 1000   PWMPulseWidthSet – 100   PWMPulseWidthSet – 10

2   Assignments (1.5 bonus points if completed together with the report before the deadline, which is specified in Canvas for each assignment)

1. Write a program which lets the user decide on the brightness of a LED using the PWM library for the embedded system. The expressed values should be on a percentage basis (between 0% and 100%) and should represent the LED intensity. The program should be able to set any percentage of light. The program must handle 3 different cases. Two special cases of 0% and 100% should turn off and on the LED using UART (functions for LEDs used in lab 1), respectively. Other values of more than 0% and less than 100% should be expressed using PWM library.

2. Add another function, which uses the potentiometer values as the basis of input instead of the UART.

A tip: CCS has a terminal that can communicate with the TivaWare. Select Launch Terminal/Open Terminal and select Serial. This is simpler than using a second program (Teraterm etc.) to read/write via the UART.

The peripherals are encircled in the Figures below, refer to pages 11, 12, and 13 for more info regarding these peripherals.

Joystick   Microphone   Accelerometer
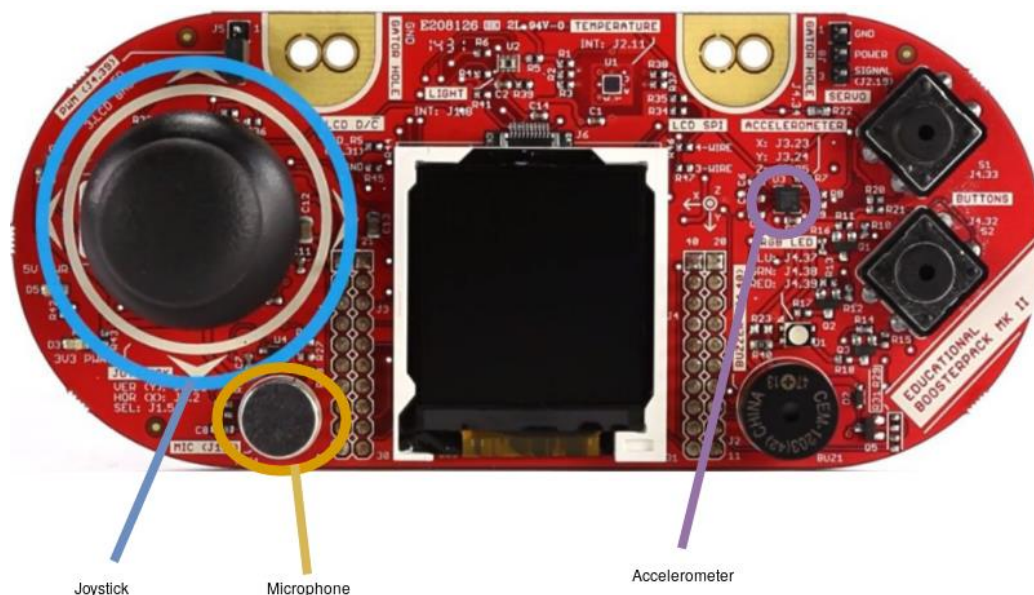
Hint 1: To utilize the UART, you can use the predefined UART functions in code composer studio. The code composer studio UART functions will be also used in Lab 3. You are allowed to use the UART example available in:

C:\ti\TivaWare_C_Series-2.1.4.178\examples\boards\ek-tm4c129exl in this lab.

3   Report

Explain the mechanism of changing the LED intensity by discussing what happens in the source code. Explain the key functionalities such as the duty cycle and others.

4   Optional Assignments (4 bonus points if you can implement 4 of the specified game and 2 bonus points for using LCD if completed before the deadline, which is specified in Canvas for each assignment)

4.1 Write a simple game on the platform. Do not feel limited by the small display area. Scroll the screen if you need more space. Implement 4 games to get 4 bonus points.

Examples:

(a) Snake

(b) Pong

(c) Space invaders

(d) Breakout

(e) Pacman

(f) Maze

You are welcome to make any other game that is not included in the above list. However, the game should be of equal complexity as compared to the games in the above list. Therefore, you must discuss the new game with the lab assistant and get approval before implementing it. **Note that you can get bonus points for a maximum of 4 games.**

4.2 Create a function that displays the values of the microphone, accelerometer, and potentiometer (joystick) on the LCD screen using the Tivaware LCD boosterpack**.** Since the values are jittery, you must take average readings, e.g., moving average filter. **You get 2 bonus points if you complete this assignment.**

Note: The bonus points collected after successfully completing the compulsory assignments and optional assignments before the corresponding deadlines will be added to your score in the final exam. These bonus points could help you in improving your final grade in the course.