**EMBEDDED SYSTEMS DESIGN**
**Lab 3 – A/D CONVERSION**

**Distributed: February 7th 2022**

**Due: Sunday, February 27th 2022**

## 1. Instructions

In this lab, you will:

- Learn how to use analog input from the potentiometer on your PICkit 3 development board.
- In this lab you will make use of the ADC module in the PIC16F886 chip. The four LEDs on board will glow according to the voltage levels detected from the potentiometer.
- Write a correct, well-documented program to use values from the potentiometer to control the LEDs on your board.
- Write and submit an accurate and complete lab report.

When formatting your Lab Report, follow these guidelines:

- List the names of your group members at the top of your submission sheet.
- List the Lab number and title
- Follow the format described below
- Submit a single .pdf file on or before the due date.

## 2. Tasks

- **Setup.** Read and understand Lessons 3 and 4 in the PICkit 3 Starter Kit User's Guide.
- **Procedure.** Please follow the tasks bellow:

**Tasks:**

➔ Identify the part name on board for the potentiometer from the 28 pin LIN DEMO board user manual.

➔ Identify the pin connected to the potentiometer and note down the register that pin is a part of.

➔ Look at the CONFIG1 register in the PIC16F886 datasheet and set/clear a certain bit so that led4/RB3 can be used as digital I/O pin. Make sure to turn OFF WDTE watchdog timer.

➔ Turn to the ADC section in the datasheet. There are a couple of registers here we need to initialize. Read 9.1 ADC configuration in the datasheet and note down the steps.

➔ The pin connected to the potentiometer needs to be set as input pin and as analog input pin. Read at 9.1.1 Port configuration.

➔ The ANSEL (Analog Select Register) register needs to be initialized to configure the pin as analog input. Check the I/O ports section in the datasheet and you will see the ANSEL bit for this particular pin.

➔ The ADCON0 register under section 9.0 ADC chooses what channel/pin is considered while sampling analog input.

➔ In the same ADCON0 register we set the ADC conversion rate. Look at table 9-1 for available options.

➔ Leave the ADC disabled for now. We will enable the module after we are finished with the configuration. Leave the A/D conversion status bit as 0 too for now. ➔ We then set the voltage references and the left/right justification for the result. You can have a look at the registers 9-3 through 9-6 and see the differences. The ADFM bit decides the result format. The bit 5 and bit 4 in ADCON1 register need to be set/clear to select VDD, VSS.

➔ The result is a 10-bit number stored in the registers together. Two bits are stored in one and the rest eight in the other.

➔ Read 9.1.5 Interrupts section to understand how you get to know when the conversion is done.

➔ Under 2.0 - Memory organization in the datasheet there is data on the PIE1, PIR1 registers. What you need is on pages 34 and 36. The ADC interrupt enable, and flag bits are bit addressable.

➔ Read the ADC conversion procedure detailed under 9.2.6. Follow the steps under number 3 in the list.

➔ Enable the ADC module and introduce some delay before setting the GO bit. The GO/DONE bit is referenced as GO. Look at Example 9-1 A/D conversion and find BSF ADCON0, GO.

➔ Read the ADC result and glow the LEDs to indicate the voltage level. The led states 0000 indicate the lowest ADC result and 1111 indicate the highest result. We have 16 possible levels with 4 bits/4 leds –0000,0001,0010,0011, …, 1000,1001, ….1100,1101,1110,1111.

➔ The ADC flag bit must be cleared before a new conversion.

**Exercise** 1. How could you change your program to display the MSbs *and* the LSbs using only the 4 LEDs on the board?

**Exercise 2.** The A/D conversion is yielded in 10 bits, yet we only see the top 4 most-significant bits of this conversion. Why are these bits the same if the conversion was yielded in only 4 bits?

## 3. Reporting

As always, record your results and observations so that you may report on the overall lab process, in the manner described below.

1. **Objectives and Problem Description.** A short word-description of the goals and objectives of the design experiment; what you are trying to *accomplish* and *observe.*

2. **Procedure.** A step-by-step account of the way you prepared for the experimental setup. This begins with a word-description of the problem or sub-problem and continues with any formal specifications or statements required (such as truth-tables, equations), any theoretical analysis done, description of the design including flow-charts, circuit diagrams if applicable, discussion of the design alternatives considered and trade-offs, experimental setup etc.

3. **Expected Results.** Describe the expected results precisely and clearly.

4. **Experiment and Design Revisions**. Describe how the experiment proceeded including any debugging necessary and how it was accomplished. Include a discussion of design revisions and the final design.

5. **Observations.** Record the actual observations and compare them with your expected results. Include photos of your working experiment.

6. **Discussion.** If the expected results differ from the actual ones, explain why you think it happened so, and explain what you learned from the experiment. Include points that may not be obvious so others may share the wisdom of your experience, engineering practice, and scientific judgment.

7. **Exercises.** Include any solutions to the exercise 1 & 2.

8. **Explain how you divided up the work to complete this lab.**

9. **Programs.** Attach the program code used and make sure your programs are well-formatted and have good comments!