The University of Jordan

Embedded Systems Lab

Spring 2025

Project: Escape Room - Digital Fort

Group Size	Grading	Due Date
4 Students	20 Points	2025/5/31 11:59 PM

Project Details and Description

Overview

In the Digital Fort project, player enters a room with three challenges to escape. You are required to design un-lock functions using PIC assembly language which takes player from the locked room to outside.

In this project, you will be using a PIC16F877A microcontroller to design a simple control system that mimics the process of unlocking room using player input on switches, pushbuttons and potentiometer and display the output on LCD and 7-segment display. The structure of the system is shown in Figure 1.

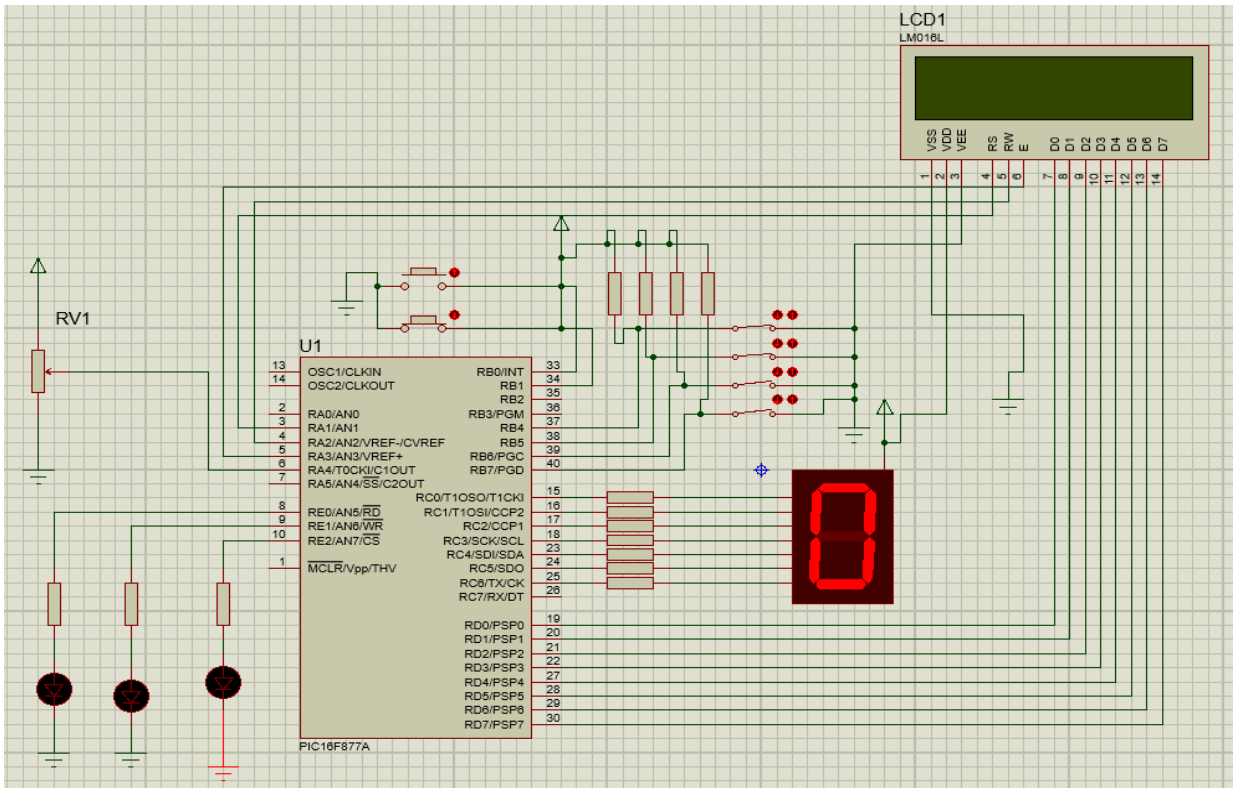

Figure 1. System structure

The system will start when the player enters the room and begin challenges, he/she has three challenges. Once all challenges are completed correctly in the following sequence, the system will automatically open the door to outside.

Challenges details are as follows:

Challenge 1:

Player is required to enter a 4-bit number using 4 switches. CORR1 Green Led will be ON if this number is prime, OFF otherwise. Also a 7-segment display should be used to display the result as Figure 2a, and Figure 2b.

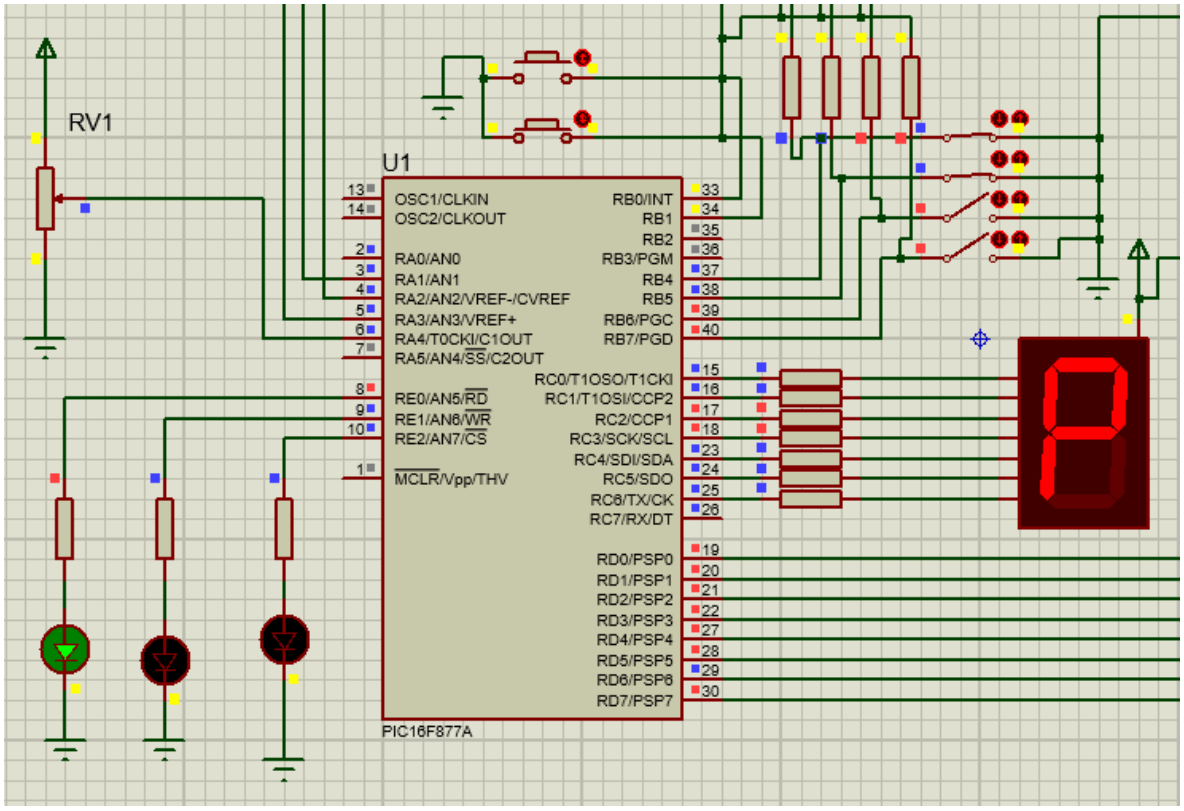

Figure 2a. Challenge 1 pass if the number is prime

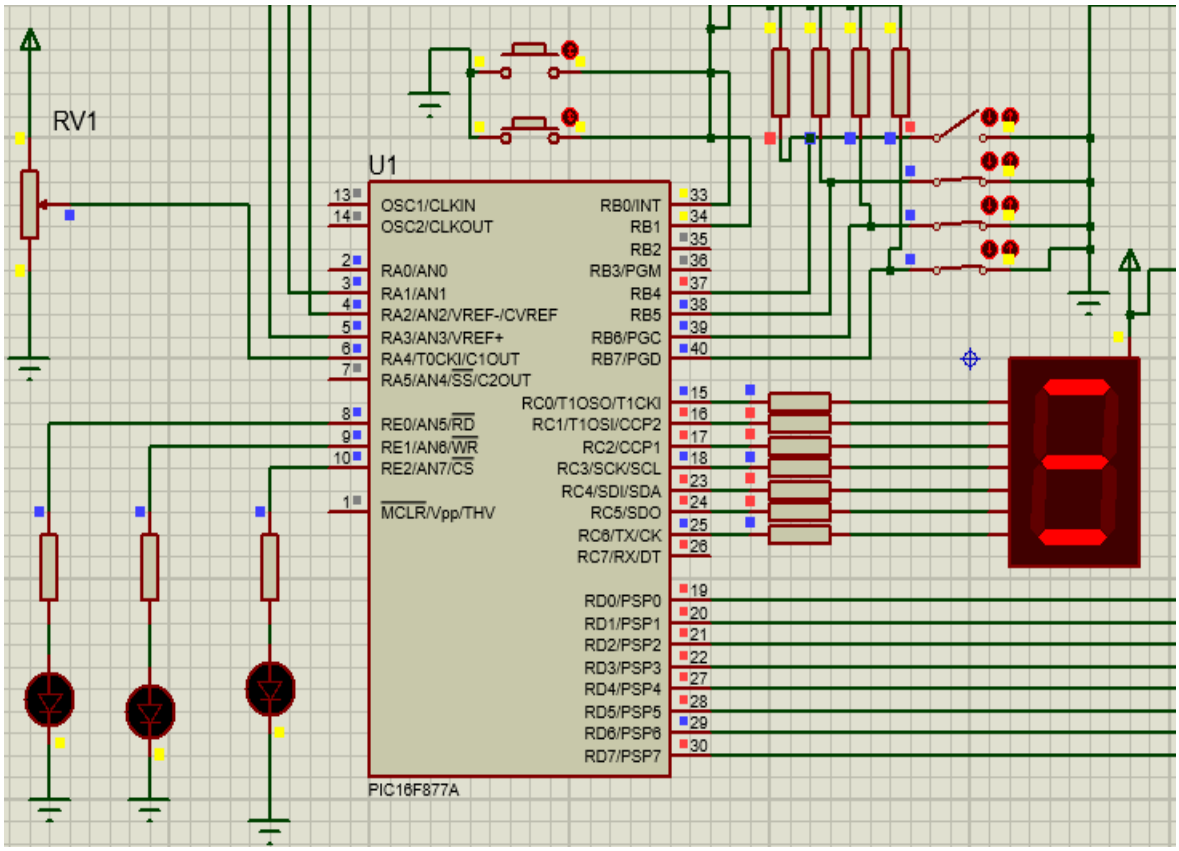

Figure 2b. Challenge 1 not pass if the number is not prime

Challenge 2:

Player rotates **Knob select function** (potentiometer) to change the voltage division inside the potentiometer and hence the output voltage changes.

The output voltage of the potentiometer is to be read by the microcontroller as analog input and converted to digital representation to specify the range. The relation between the read voltage and the range is given in Table 1.

Table 1. Potentiometer Ranges

Voltage	Ranges
0% ≤ Vref+ ≤ 20	R1
20% < Vref+ ≤ 40	R2
40% < Vref+ ≤ 60%	R3
60% < Vref+ ≤ 80%	R4
80% < Vref+ ≤ 100%	R5

The converted value should be compared with a **predefined value** in the code, CORR2 Green Led will be ON and player pass the challenge if the input value by player is in the same range with these predefined value, OFF otherwise.

As shown in Figure 3a and Figure 3b, player input value on potentiometer should be reflected on LCD output. LCD should show “You are correct” if player in the same range, or “You are so close” if player is close to the correct range (the range before or after the correct range) and nothing is user is far from the correct range.

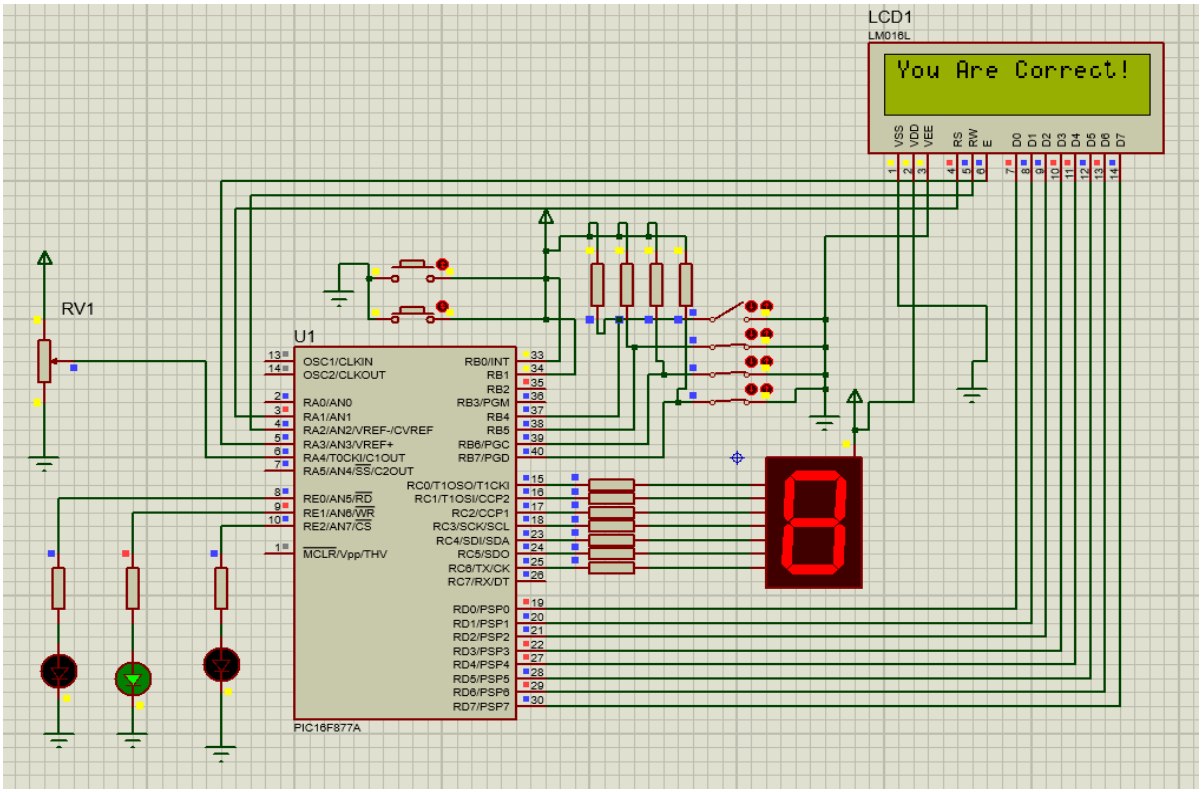

Figure 3a. Challenge 2 pass

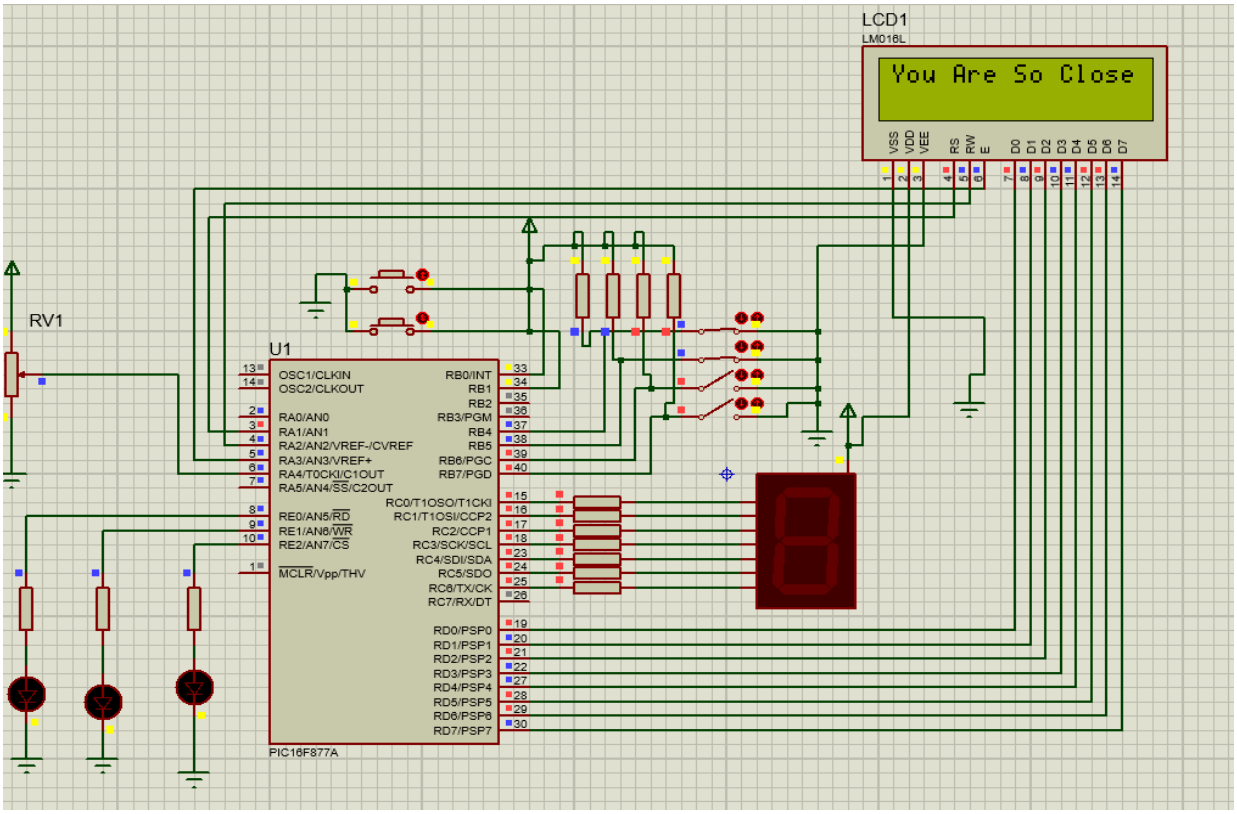

Figure 3b. Challenge 2 not pass

Challenge 3:

Player should press the **Start button** to display a random math problem on the LCD from five previously stored problems for this challenge as Figure 4. At this moment, a countdown timer will begin counting seconds from 9. To pass this challenge player should provide the correct solution using four switches and then press the **Finish button** before the countdown timer reaches 0. If that, CORR3 Green LED will be ON, OFF otherwise.

When player finish solving all challenges, all LEDs should start flashing, a sound from a buzzer should be heard for a certain time and the “YOU WIN! Escape” sentence should be displayed on the LCD as shown in Figure 5.

If player fails in one of the challenges the system should start from challenge 1 and the “hard Luck statement should be displayed on the LCD.

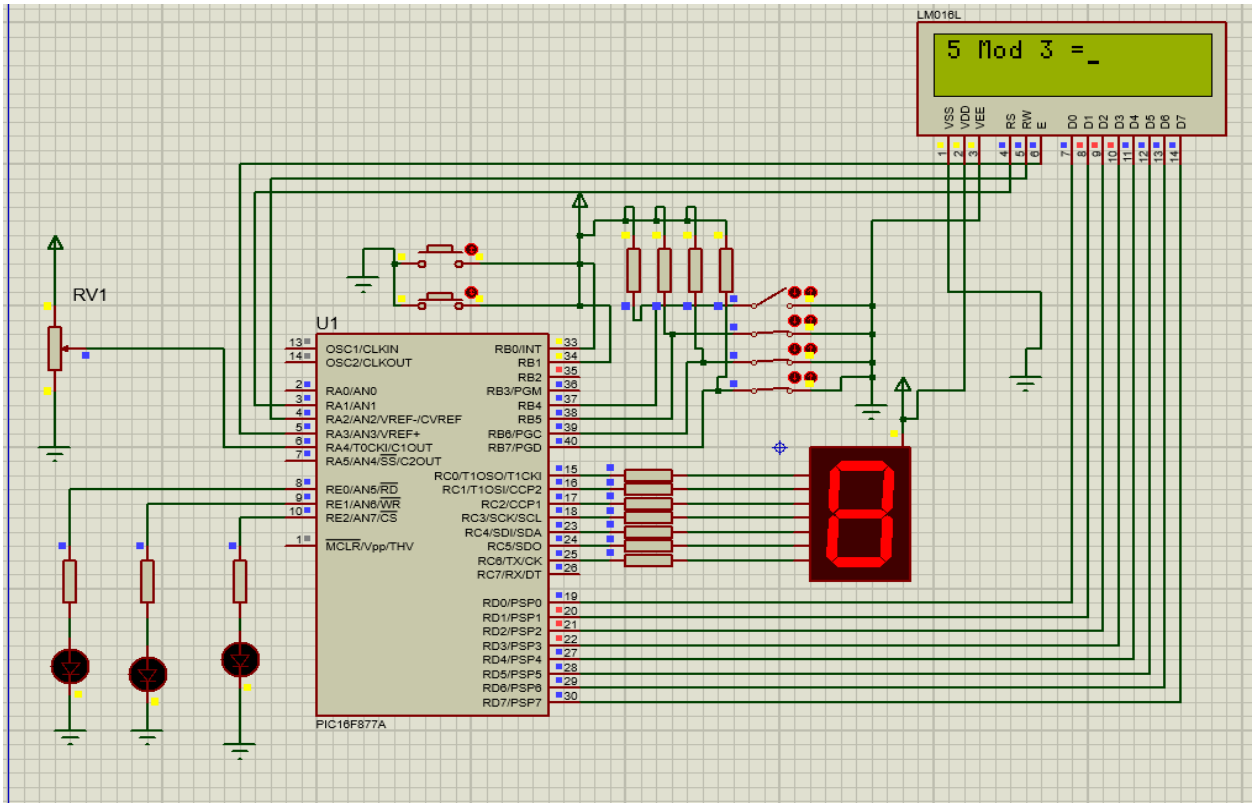

Figure 4. Challenge 3 pass

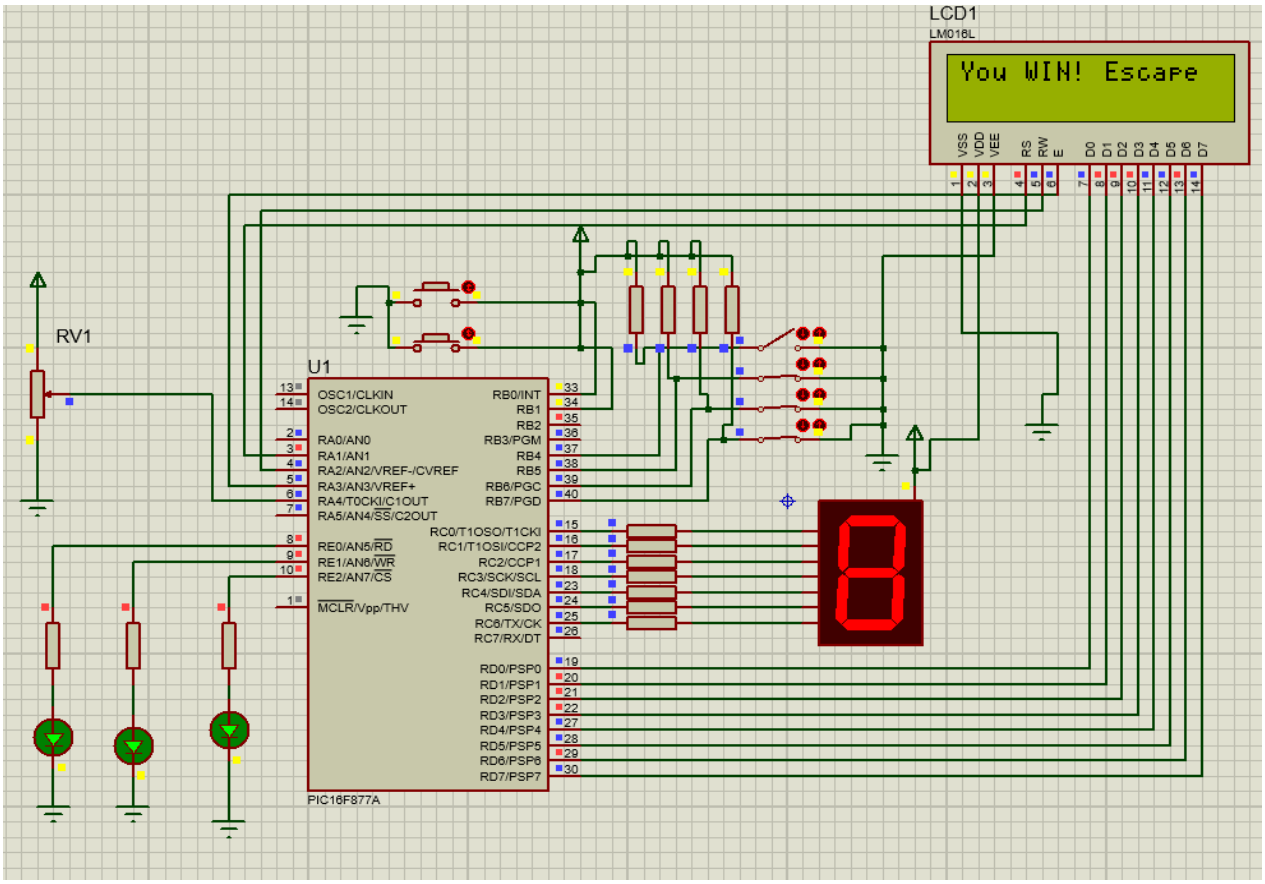

Figure 5. All Challenges pass

Project Programming Language and Simulation

For this project, you are required to design, implement and test the system in simulation using MPALB and Proteus, and then build the **hardware prototype for the system and test it**. For the software part, you need to **program in assembly**, and you are encouraged to maximize the use of interrupts, subroutines in your design. Make sure to include detailed explanation for your design and all the calculations that you do.

You are required to submit an **ASSEMBLY** code for this project. Any C submissions will be given a **straight zero** right away even if it is fully working. Any assembly code derived form a C compilation will be easily detected and given a grade of **zero**.

Project Groups

You must form groups of four students to work on this project. As you can see, the project can be divided into these major parts, each group member should be mapped to one or more of these parts:

- Processing the required arithmetic functions.
- The A/D configuration and programming to determine the range.
- Pushbuttons and Switches related to player input
- LCD, 7-segment display, system integration (putting everything together), and testing in Proteus.

We prefer that you form groups from within your own lab session, but if you cannot find a partner, then you can form a group with colleagues from the other sessions.

Grading for Code Efficiency and Generality

It is of the most importance to write codes which are minimum in size and execute quickly. We ask you to use subroutines, modular design and functional reuse whenever possible. **It is important not to forget to use functional comments.**

During the discussion, we will ask you to show us on MPLAB or Proteus how your code works under different conditions so be prepared for the generic case.

The instructors and engineers are in no way responsible for helping you form groups or solve issues if your partner(s) drop(s) out from the course or is not working at all on the project. Choose your partner wisely. You might end up doing the project by yourself. **We will accept no excuses.**

Important Notes

- Start as early as possible on your project, though the project description sounds simple, there is inherent complexity in both hardware and software aspects, so do not underestimate the time it needs, you will have many problems along the way which you will have to resolve!

- Never think of buying a model or commissioning someone to do it for you, not only will you get a zero in the project, but also your act will be considered as a direct violation to JU laws and your actions shall be reported as cheating in the exam!
- Code sharing between groups is NOT allowed and leads to 0 points.
- If you acquire a ***part*** of your software from a book, website, etc, then kindly reference it properly, else it will be considered as plagiarism.
- You are only allowed to base your project on PIC16877A.
- Your submitted work must be professional:
    - Software: your work should be fully documented, all inputs/outputs should be listed, and each subroutine/macro should be fully documented! Use functional comments!
- Divide the work such that each student is responsible for a specific task, **YET EVERY** student is required to answer for **ANY QUESTIONS** in relation to any submitted work of the project.

Report Guidelines

You should submit a hard copy of your report and it should contain the following parts:

• **Introduction.** In this section, you give a brief description of the overall project in your own technical language.

• **System Description.** Here you give a detailed description of the system design and how it was decomposed into subsystems.

• **Hardware System.** Here you must explain and elaborate on your system hardware design, its inputs and outputs. Present a clear and professional circuit design schematic. **Justify why you configured and initialized your system and modules in this way.**

• **System Testing and Results.** Present the complete methodology which you have undertaken to perform unit testing, system integration, and the final overall test. You must present the test cases which you have used to test your system for correct functionality. You must justify the choices for your test cases and whether or not they cover all possible regions of operation of your system. Provide technical discussion of the results or any abnormal operation you have witnessed during testing.

• **Conclusion.** Give a short summary of the project, your work, and the steps you have undertaken during the design process. Furthermore, you must clearly state the contribution of each student in the project. Discuss the major obstacles that you faced during the design process.

Submission

You will need to submit all the files that you use in your design including the MPLAB project, Proteus project and the report in one compressed file through MS Teams by 11:59 PM of 3/6/2025.