REPORT 1 : DIGITAL LOGIC SYSTEM

GROUP 4

MCTA 3203

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MECHATRONICS SYSTEM INTEGRATION

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NO	NAME	MATRIC NUMBER
1.	IRDINA NABIHAH BINTI MOHD NAZRI	2214772
2.	IZZAH ZAHIRA BINTI NORAZLEE	2217696
3.	NOR MAISARAH BINTI ISMAIL	2213080

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INTRODUCTION

In this experiment, we can learn about the fundamentals of digital logic systems through the interfacing of a 7-segment display with an Arduino Mega. A 7-segment display is a widely used electronic component that is capable of displaying numerical digits in the form of visual illumination of some of its segments. This experiment is designed to provide hands-on experience in electronic circuit interfacing, rudimentary programming, and fundamentals of microcontroller-based control of output devices. With the utilization of pushbuttons to reset and increment the displayed count, we discover the interaction of users with electronic systems and the daily applications of digital logic in mechatronics.

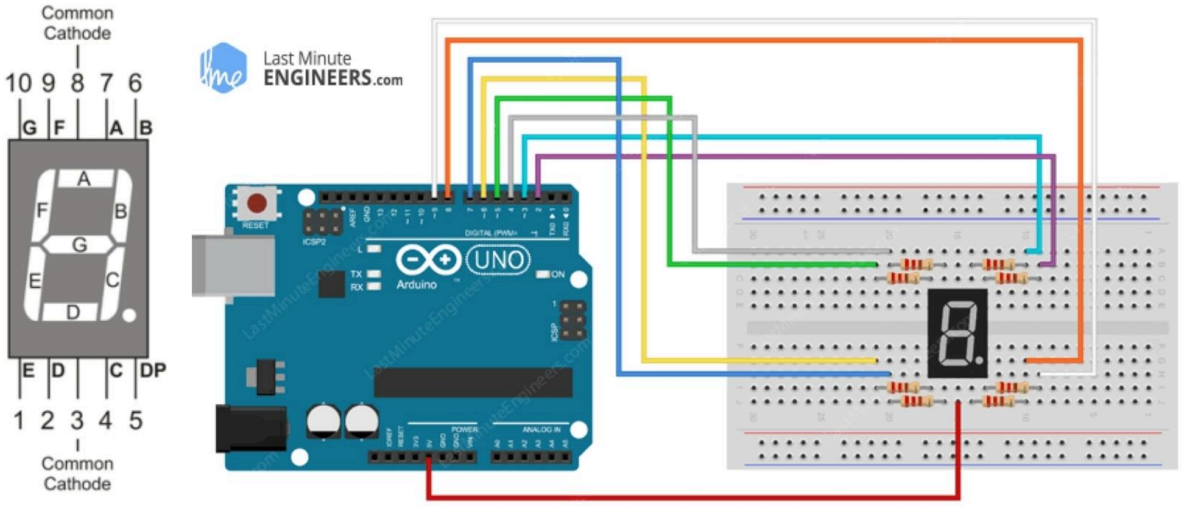
ABSTRACT

This experiment solely focuses on investigating the interfacing of a 7-segment display with an Arduino Mega to display the numerical sequences. Hence, the main goal was to comprehend the digital logic underlying manipulating the displayed numbers with pushbuttons and controlling particular parts. Using the resistors to control current flow, a common cathode 7-segment display was connected to the Arduino Mega via digital pins, and the microcontroller was programmed to control segment activation. Additionally, pushbuttons for resetting and increasing the display were part of the configuration. The main conclusions showed that the display could be successfully controlled by hand, with numerals sequentially cycling from 0 to 9. The basic ideas of digital logic systems, microcontroller interface, and hardware-software integration were strengthened by this experiment. Future additions might include I2C-based LCDs for more sophisticated applications or multiplexing numerous screens.

MATERIALS AND EQUIPMENT

1. Arduino Mega
2. 8 resistors
3. Half breadboard
4. Jumper wires
5. I2C LCD
6. Pushbuttons
7. Matrix LED

EXPERIMENTAL SETUP

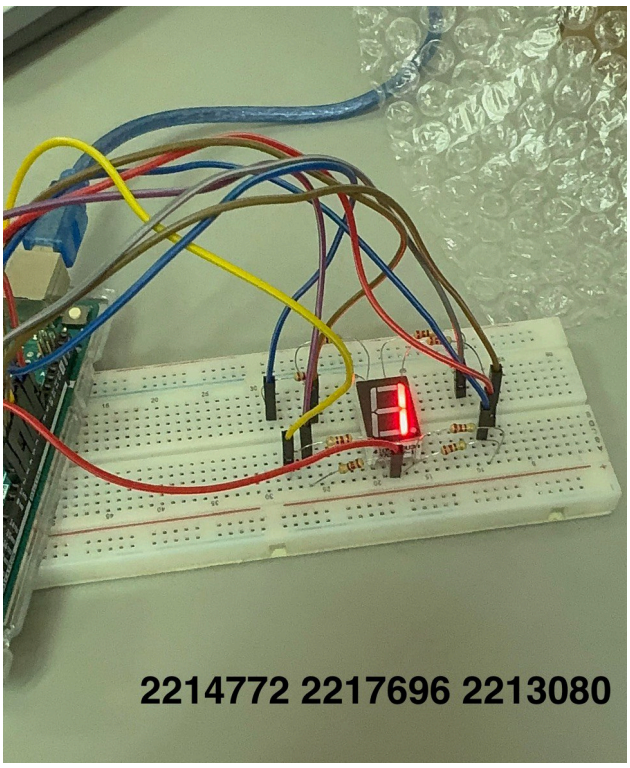


1. Build the circuit according to the circuit setup instructions.
2. Upload the provided Arduino code to your Arduino Uno.
3. Open Serial Monitor in the Arduino IDE.
4. Press the increment button to increase the count. The 7-segment display should show the numbers from 0 to 9 sequentially.
5. Press the reset button to reset the count

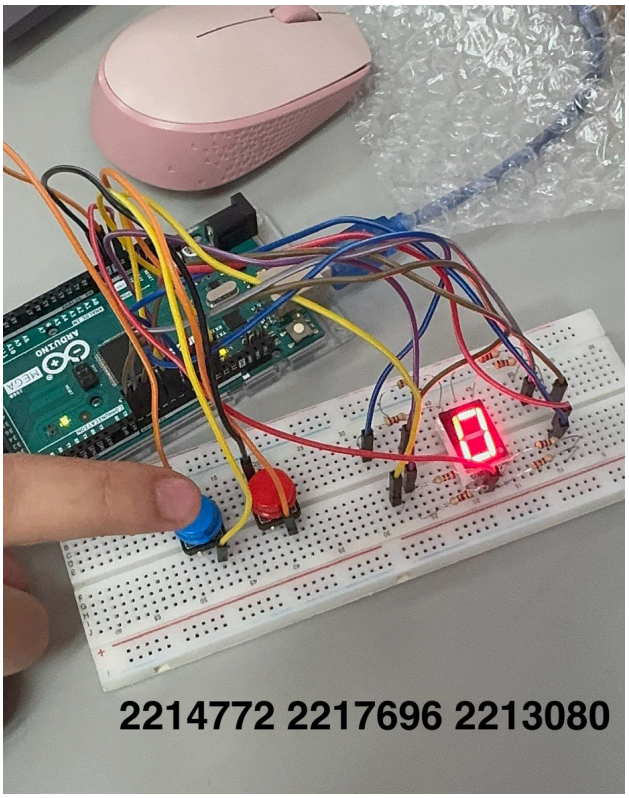
METHODOLOGY

1. **Materials Preparation:** Prepare all the materials needed, including an Arduino Uno board, a common cathode 7-segment display, 220-ohm resistors, pushbuttons, jumper wires, and a breadboard.
2. **Circuit Setup:**
    - -Connect each of the seven segments (named a to g) of the 7-segment display to separate digital pins on the Arduino (D0 to D6).
    - -Connect the common cathode pin of the display to the ground (GND) pin on the Arduino.
    - -Current-limit the current to each segment using 220-ohm resistors.
    - -Connect the pushbuttons to the Arduino by connecting one leg of each button to separate digital pins (e.g., D9 and D10) and the other leg to GND. Utilize 10K-ohm pull-up resistors to obtain clean reads from the buttons.
3. **Programming the Arduino:**
    - -Writing and loading the Arduino code that initializes the digital pins as outputs and includes the logic to represent the digits 0 to 9 on the 7-segment display.
    - -The code includes a loop that enables the segments for each digit in turn, with delays to control the timing of the display.
4. **Experiment Execution:**
    - -Open the Serial Monitor within the Arduino IDE to observe the output.
    - -Press the increment button to increment the displayed count, which should cycle through numbers 0 to 9.
    - -Press the reset button to reset the count to 0.
5. **Analysis and Extension:**
    - -Analyze the operation of the circuit and the efficacy of the code in controlling the display.
    - -Consider extending the experiment by adding additional features, such as additional displays or more complex counting systems, to pursue additional applications of digital logic.

RESULTS



https://github.com/irdinazri/MSI_G4/blob/main/VIDEO_WOBUTTON.mp4



https://github.com/irdinazri/MSI_G4/blob/main/VIDEO_WBUTTON.mp4

QUESTION

How to interface an I2C LCD with Arduino? Explain the coding principle behind it compared with 7 segments display and matrix LED.

1. Interfacing an I2C LCD with Arduino
    a. Hardware required
        i. Arduino Uno
        ii. I2C LCD with an I2C backpack (PCF8574)
        iii. Jumper wires
    b. Connections
        i. SDA → A4 pin
        ii. SCL → A5 pin
        iii. VCC → 5V
        iv. GND → GND
    c. Code Implementation

```
#include <Wire.h>
#include <LiquidCrystal_I2C.h>

// Define instance for LCD I2C display
LiquidCrystal_I2C lcd(0x27, 16, 2);

// Change 0x27 to 0x3F and retry if LCD screen does not show anything
// Change 16,2 to 20,4 if you are using LCD2004

void setup() {
  lcd.init();       // Initialize the LCD display screen
  lcd.backlight();  // Turn on backlight of LCD display screen.

  // Print a message to the LCD.
  lcd.setCursor(1, 0);          // Go to position column 2 & row 1
  lcd.print("Hello, world!");   // Print "Hello, World!"
}

void loop() {
  // No loopable program for this example
}
```

    d. How it works

i. The I2C protocol sends serial data using the Wire library.
ii. The LCD driver (PCF8574) expands the Arduino's I2C signal into multiple parallel control lines.
iii. The `lcd.print()` function sends characters over I2C to be displayed.

2. Comparison with 7-segment display and matrix LED

Feature	I2C LCD	7-Segment Display	Matrix LED Display
Interface	I2C (2 wires)	Multiplexing (many pins)	Multiplexing or I2C/SPI
Library Used	`LiquidCrystal_I2C.h`	`SevSeg.h` or manual	`Adafruit_GFX.h`, `Adafruit_LEDBackpack.h`
Data Sent	ASCII characters	Individual digit segments	LED pixel matrix (bits)
Coding Complexity	Easy	Medium (Multiplexing required)	High (pixel addressing)
Pins Required	2 (SDA, SCL)	7+ (for multiple digits)	Many (if multiplexed manually) or 2 (I2C)
Display Type	Text (16x2, 20x4, etc)	Numeric (0-9, limited chars)	Graphics & scrolling text

DISCUSSION

The experiment successfully demonstrated the interfacing of a 7-segment display with an Arduino Mega which allowed the display to cycle from 0 to 9 using the pushbuttons. The functions of the resistors to ensure proper current control and prevent damage to the pushbuttons. During the experiment, several observations were made regarding the functionality of the system. The pushbuttons worked as intended, incrementing and resetting the display correctly. The Arduino code also executed the logic as expected by showing sequential numerical output. However, the importance of debouncing in pushbutton may have been observed as improper debouncing could lead to unintended multiple counts. The 7-segment display proved to be a simple and efficient way to show numerical values. However, it required multiple digital pins for operation, unlike and I2C LCD, which only need two communication lines. A matrix LED display would offer more flexibility in displaying characters or graphics but requires more complex multiplexing. The challenges encountered while doing this experiment is possible wiring errors or loose connections could have affected the display output and ensuring all segments light up correctly required careful attention to pin assignments in the Arduino code as it could have affected the performance.

CONCLUSION

In order to show and control numerical sequences using pushbuttons, this experiment effectively illustrated how to interface an Arduino Mega with a common cathode 7-segment display. The primary results demonstrated that the pushbuttons successfully increased and reset the display, and that digital signals from the Arduino could precisely activate particular segments to produce numbers. Moreover, these findings demonstrate the foundational ideas of microcontroller programming, digital logic, and also electronic circuit interface.

To be more exact, the experiment's results confirmed the hypothesis that a 7-segment display could be successfully controlled using an Arduino via direct pin connections and programmed logic. The use of pushbuttons improved user interaction even more, also proving the effectiveness and its worthwhileness of digital input controls in the real-time applications. Beyond this experiment, the techniques used here have broader applications for embedded systems, automation, and display technologies. The ability to interface and control 7-segment displays is critical in applications like digital clocks, counters, and industrial readouts. Furthermore, future advancements may include multiplexing several displays or implementing more modern display technologies such as I2C-based LCDs and LED matrices to improve functionality and efficiency.

RECOMMENDATION

To improve the experiment, several enhancements can be made to increase the efficiency, functionality and reliability. One improvement can be made by adding a debouncing function in the code or using hardware-based debouncing like capacitors. It would ensure more stable and reliable button inputs since the pushbutton sometimes registered multiple unintended presses likely due to button bouncing. Then, this experiment also can be improved by multiplexing which would reduce the number of digital pin to control the 7-segment display. Another recommendation is to explore I2C-based display for more versatility since it would allow for more complex data representations like text or symbols using fewer pins. This would make the system more adaptable for future applications. Additionally, considering power management is important especially if additional components are added. Instead of relying solely on the Arduino's power supply, a dedicated external power source could improve the stability and prevent issues related to insufficient current especially for larger circuits. By implementing these improvements, the system would be more efficient, scalable, and practical for mechatronics applications, providing a deeper understanding of digital logic and microcontroller-based circuit design.

ACKNOWLEDGEMENTS

A special thanks goes out to Dr. Wahju Sediono and Dr. Zulkifli Bin Zainal Abidin, my teaching assistant, and my peers for their invaluable help and support in finishing this report. Their advice, feedback, and experience have greatly influenced the level of quality and understanding of this work. Their time, patience, and commitment to supporting my academic success are greatly appreciated.

STUDENT'S DECLARATION

Certificate of Originality and Authenticity

This is to certify that we are **responsible** for the work submitted in this report, that the original work is our own except as specified in the references and acknowledgement, and that the original work contained herein have not been untaken or done by unspecified sources or persons.

We hereby certify that this report has **not been done by only one individual** and **all of us have contributed to the report**. The length of contribution to the reports by each individual is noted within this certificate.

We also hereby certify that we have **read** and **understand** the content of the total report and no further improvement on the reports is needed from any of the individual's contributors to the report.

We therefore, agreed unanimously that this report shall be submitted for **marking** and this **final printed report** has been **verified by us**.

Signature: 
Name: IRDINA NABIHAH BINTI MOHD NAZRI
Matric Number: 2214772

Read ☑
Understand ☑
Agree ☑

Signature: 
Name: IZZAH ZAHIRA BINTI NORAZLEE
Matric Number: 2217696

Read ☑
Understand ☑
Agree ☑

Signature: 
Name: NOR MAISARAH BINTI ISMAIL
Matric Number: 2213080

Read ☑
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Agree ☑