MECHATRONICS SYSTEM INTEGRATION

MCTA 3203

WEEK 2:

DIGITAL LOGIC SYSTEM

SECTION 1

SEMESTER 1, 2025/20256

INSTRUCTOR:

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DATE OF SUBMISSION: 22 OCTOBER 2025

GROUP 8

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Abstract

This activity focuses on developing a digital number display mainly utilizing a seven segment display and an Arduino Mega microcontroller chip. The main objective is to design and make a simple, effective and working circuit and code to display numbers from 0 to 9 in order at a press of a button. The system is programmed using Arduino IDE, where the microcontroller sends output signals to the seven-segment display through digital pins to control each segment. After testing, we have achieved the desired output of increasing the displayed digit by one with each press of a button. We also added another button to reset the count. This project reflects the modern digital clock and its inner workings, implementing digital electronics.

Introduction

The purpose of this experiment is to understand and implement digital logic interfacing between Arduino and external display devices, 7-segment display. This lab focuses on displaying numerical outputs (0–5) on a common cathode 7-segment display and controlling the display using pushbuttons. Through this exercise, we will learn how microcontrollers can be used to manage digital circuits efficiently, which is fundamental in mechatronic system integration.

In digital electronics, a 7-segment display is a widely used device for representing decimal numbers and certain alphabets. Each segment can be individually controlled to form numerical patterns. This experiment utilizes basic logic control through an Arduino Uno, where output pins are programmed to light up specific segments based on binary-coded decimal (BCD) logic. The interfacing process also applies electronic circuit concepts, including current-limiting resistors, input/output pin configuration, and signal timing using delay functions in Arduino programming.

It is expected that the Arduino will successfully control the 7-segment display to show the numbers 0 through 5 in sequence. When the circuit is correctly wired and programmed, pressing the pushbuttons should change the displayed number accordingly. This outcome will verify correct interfacing between the Arduino, the 7-segment display, and the pushbuttons, demonstrating effective application of digital logic and circuit control principles.

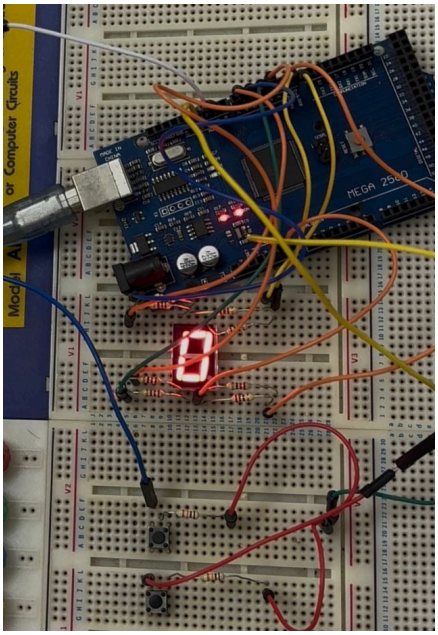
Materials and Equipment

1. Arduino Mega 2560 board
2. Common cathode 7-segment display
3. 220-Ohm resistors (7)
4. Pushbuttons (2)
5. Jumper wires
6. Breadboard

Experimental Setup

1. The common cathode pins of the 7-segment display were connected to the GND of the Arduino. Each segment pin (labeled a–g) was connected to individual digital output pins on the Arduino (D2 to D8).
2. 220-ohm resistors were placed in series with each segment connection to limit the current and protect both the display and the microcontroller. This configuration allows the Arduino to control each segment independently by sending HIGH or LOW signals.
3. Two pushbuttons were added to allow manual control of the displayed numbers. The first pushbutton was connected to digital pin 9 and functions as the reset button, returning the displayed number to 0 when pressed. The second pushbutton was connected to digital pin 10 and serves as the increment button, increasing the displayed number by 1 each time it is pressed.
4. Each pushbutton was wired using a 10 kΩ resistor (brown–black–orange) as a pull-down resistor. This configuration ensures that the input pins read LOW when the button is not pressed and HIGH when pressed, preventing false triggering or floating input states.
5. One terminal of each pushbutton was connected to the 5V supply through a resistor, and the other terminal was connected to GND.
6. The breadboard's power rails were used to distribute 5V and GND from the Arduino. All components shared a common ground to ensure consistent voltage references across the circuit.
7. After wiring, the Arduino Uno was connected to a computer via USB for programming using the Arduino IDE. The uploaded program controlled the segment outputs to display numbers 0–5 sequentially, with timing delays implemented between each transition.

When the first pushbutton is pressed, the displayed number increments . When the second pushbutton is pressed, the displayed number will reset.



Methodology

1. **Overview.**

   The project was to design, construct and develop a simple counting display on a seven segment display using an Arduino Mega Microcontroller chip. The main idea was to program a system capable of counting 0 to 9 with every press of the button. And resetting to zero when another one was pressed. The processes we went through were Hardware setup, circuit mapping, program design and testing.

2. Hardware Setup

1. Arduino Mega 2560	Microcontroller board used as the main control unit
2. Seven Segment Display	To display the number sequences
3. Resistors (220 ohms)	To limit the current going into the LED within the Seven Segment Display
4. Breadboard	A plane to connect the wires
5. Jumper Wires	To produce electrical connection
6. Usb cable	To transfer the code from the IDE
7. Push buttons	A source of input

3. Circuit Design

Each segment of the display (A-G) is connected to pin (1-7) on the microcontroller. Each output is connected with the resistor to reduce the amount of current flowing into the segment. The common cathode on the display is connected to the ground. Everything was connected to a breadboard.

4. Program Development

For the programming part, we used the provided code to test the waters. After understanding the process, we used our knowledge on Arduino programming to produce the rest of the coding using IDE. With some help from the technical advisor, we produced a simplified code that achieved what we desired.

5. **Testing and Verification**

   After uploading the code to the Microcontroller, we tested the code to make sure it works in practice. After some minor hurdles, we managed to finish and complete the project.

Data Collection

During the experiment, data was collected by observing the output of 7-segment display when the increment and reset push-button were pressed. The Arduino Mega 2560 was programmed to count 0-9, and the current count value was shown in 7-segment display. The Serial Monitor was used to verify that the internal counter value matched the number displayed.

Button Action	**Expected Display**	**Actual Display**	**Observation**
Power ON/Reset Pressed	0	0	Display resets to 0 succesfully
Increment (1st pressed)	1	1	Number displayed correctly
Increment (2nd pressed)	2	2	Number displayed correctly
Increment (3th pressed)	3	3	Number displayed correctly
Increment (4th pressed)	4	4	Number displayed correctly
Increment (5th pressed)	5	5	Number displayed correctly
Increment (6th pressed)	6	6	Number displayed correctly
Increment (7th pressed)	7	7	Number displayed correctly
Increment (8th pressed)	8	8	Number displayed correctly
Increment (9th pressed)	9	9	Number displayed correctly
Increment (10th pressed)	0	0	Display resets to 0 (loop works)

Data Analysis

The collected data confirms that:

1. Each button pressed produce the correct increment in the displayed value.
2. The reset button returned the count number into 0.
3. The display pattern followed the correct segment combination defined in the code.

Digit	Active Segment (a-g)	Observed Display
0	a,b,c,d,e,f	Correct
1	b,c	Correct
2	a,b,g,e,d	Correct
3	a,b,c,d,g	Correct
4	f,g,b,c	Correct
5	a,f,g,c,d	Correct
6	a,f,g,e,c,d	Correct
7	a,b,c	Correct
8	a,b,c,d,e,f,g	Correct
9	a,b,c,d,f,g	Correct

Analysis:

1. No faulty segments were found.
2. Button inputs responded correctly without noise of false triggering.

Results

The experiment successfully demonstrated manual control of a 7-segment display using an Arduino Mega 2560 and push buttons.

1. The 7-segment display correctly showed digits **0–9** in sequence.
2. The **increment button** advanced the number by one each press.
3. The **reset button** returned the display to zero.
4. The **Arduino code logic** correctly mapped each number to the appropriate LED segments.
5. The display operated **stably** with no flickering or incorrect output.

The experiment objectives were fully achieved without any errors or malfunctions. The 7-segment display responded correctly to each button press, and all circuit components functioned as expected, demonstrating successful interfacing between the Arduino and the display.

Discussion

1. Interpretation of Results and Implications

   The results indicate that the hardware and software were correctly designed and implemented. The successful display of digits from 0 to 9 confirms that the pin configuration between the Arduino Mega 2560 and the 7-segment display was properly established. The system also demonstrated reliable performance, showing that the circuit connections were appropriate for the experiment's objectives. The correct operation of

both push buttons implies that the digital input pins were configured correctly, and the program logic for incrementing and resetting the display was functioning as intended.

2. Discrepancies Between Expected and Observed Outcomes

   There were no major discrepancies observed during the experiment. The displayed output matched the expected results, and the circuit performed according to the design.

3. Sources of Error and Experimental Limitations
   a) Mechanical Button Bounce: Push buttons naturally produce multiple electrical transitions with each press. Without software or hardware debouncing, this may occasionally result in multiple counts per press.
   b) Human Reaction Time and Consistency: Since the increment and reset buttons were manually pressed, variations in pressing speed and duration could cause inconsistent results or missed counts.

Conclusion

This project successfully demonstrated the design and implementation of a seven-segment display system using an Arduino microcontroller. The system was able to display numerical digits from 0 to 9 accurately by controlling the output signals sent to each segment. After going through the process of putting the circuit together, coding it and testing, the project achieved its main objective that is - understand and implement digital logic interfacing between Arduino and external display devices, 7-segment display.

In terms of understanding, we now know how to code a counting machine and as for implementing, we are confident in the reenactability of this project. The results proved that even

simple electronic systems can be effectively developed through systematic design and logical programming.

For an Islamic reflection, this project highlights the importance of seeking knowledge (Ilm') seen in our objective to understand its inner workings. Knowledge is a gift from Allah that enables mankind to understand and control the world around them. By exploring the principles of electronics and control systems, we recognize the precision and order that Allah has placed in creation.

Recommendations

1. **Improve Display Range:**

Extend the counter to include two 7-segment displays to show two-digit numbers (00–99). This can be achieved by using multiplexing techniques or connecting an additional display with separate control pins.

2. **Enhance User Interface:**

Add more push buttons to provide additional functions such as decrement, pause, or auto-count mode to make the system more interactive.

3. **Add Sound or Light Indicators:**

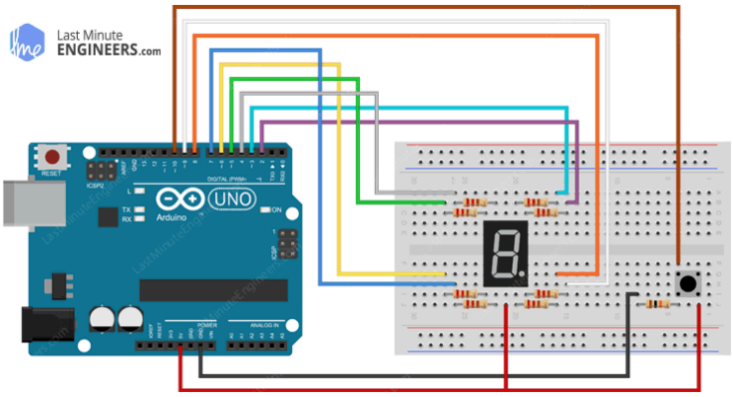
Connect a buzzer or LED to indicate button presses or when the counter resets to zero for better user feedback.

References

- In depth guide on Seven Segment Display

  (https://lastminuteengineers.com/seven-segment-arduino-tutorial)

Appendices



Acknowledgments

Alhamdulillah, all praise and gratitude be to Allah SWT for His blessings, guidance, and mercy that enabled us to successfully complete this project entitled *"Digital Logic System."* Throughout the development process, we faced several challenges, but with His will and guidance, we managed to overcome them and complete the project successfully.

We would also like to express our heartfelt appreciation to our lecturer for their continuous guidance, support, and valuable feedback throughout this project. Their advice has greatly helped us in understanding both the theoretical and practical aspects of microcontroller systems and digital display design.

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.**

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