**Lab 3 Report**

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3360:0001 - Embedded Systems

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## Introduction

Embedded Systems Lab 3 builds on the concepts and circuitry implemented in lab 2. Once again, we are using the 74HC595 Shift Register, 5161AS 7-Segment Display, and an enable low push button. However, the focus of this lab was working with timer/counters in the Atmel studio environment as delay loops, lookup tables, and utilizing an RPG for user inputs. The goal of the lab using the hardware described below was to create a simple electronic door lock system that accepts a 5-digit hexadecimal code. Digits selected for the code are to be scrolled through with the RPG and then selected with a push button press of less than one second. In this report, we will outline the new concepts that were employed to achieve this result and focus less on information from the prior lab.

Listed below is an exhaustive list of hardware required to replicate the lab 3 circuit. Please note that an Arduino Uno contains the microcontroller needed and is sufficient for use in lab. We opted to use the Arduino Uno for simplicity when developing the circuit.

|  |  |  |
| --- | --- | --- |
| Hardware | Quantity | Description |
| Atmega 328P µC | 1 | Programmable µC |
| 74HC595 Shift Register | 1 | Storage of hex codes for 7-Segment display |
| 5161AS 7-Segment Display | 1 | Display current counter |
| Enable Low Push Button | 1 | Enables user input interaction with display |
| 560Ω Resistor | 8 | Resist current into 7-Segment display LEDs |
| 10KΩ Resistor | 5 | RC low pass filtering, Pull-up resistor for RPG |
| 100KΩ Resistor | 1 | Pull-up resistor for push button |
| 0.01µF Capacitor | 4 | µC Decoupling & push button RC low pass filtering |
| EVE-GA1F2012B Encoder | 1 | Rotary pulse generator |

Figure 1: Materials List

## Schematic

A computer screen shot of a computer program

AI-generated content may be incorrect.

Figure 2: Electrical circuit schematic created using KiCAD

The lab 3 circuit was built off the existing 7-segment display, shift register, and push button circuit utilized in lab 2. The main difference is found in the addition of the RPG and two new input lines to the microcontroller.

The pinout of the RPG is as shown below with pin A being the A signal, pin B being the B signal and pin C being the signal ground.

A screenshot of a computer

AI-generated content may be incorrect.

The wiring of the RPG is as follows. To read the signals from pins B and A we connected pin B to PD7 and pin A to PD6 and configured these as inputs. Each pin, A and B, has a low pass RC filter connected to help with debouncing. These were created with 0.01µF capacitors and 10KΩ resistors. Then there is also a 10-kiloohm resistor that acts as a pullup resistor keeping the pins at defined states when the RPG is not being turned. Pin C is tied to the ground signal of the microcontroller.

Reading of the RPG was dependent on the signals that the RPG generates when it is turned either clockwise or counterclockwise. When turning the RPG, you can hear clicking sounds and there are defined points or grooves within the RPG called detents. These detents and the values (1 or 0) of the two signals are crucial to reading user RPG inputs. A signal being “off” is represented by 1, and a signal that is “on” is represented by a 0. When turning the RPG clockwise the B signal is the first to be on, followed by the A signal because of a 90-degree phase lag. When turning counterclockwise the A signal is the first to be on, followed by the B signal because of the 90-degree phase lag. Following a gray code system, which is reflected binary code such that only one bit at a time from 1->0 or vice versa, we can see the order that the signals will change when rotating the dial in each direction.

A clockwise rotation pattern for the signals in the order BA is as follows,

00 🡪 01 🡪 11 🡪 10 🡪 00 …

A counterclockwise rotation pattern for the signals in the order BA is as follows,

00 🡪 10 🡪 11 🡪 01 🡪 00 …

The difference in these signal patterns becomes relevant in the code section. A detent that represents the end of a “turn” of the RPG is the signal combination 00.

## 3. Discussion

Lookup table and modified finding

## 4. Conclusion

Rome was not built in a day, and neither is any million-dollar idea. Lab 3 builds on existing knowledge gained during Lab 2, extending the circuit's functionality to a rudimentary electrical locking system. We learned foundational skills of digital signal processing utilizing hardware to de-bounce and de-chatter the rotary pulse generator with pull-up resistors and low-pass filters. We also utilized software to recognize the sequencing of A and B RPG signals using low-level AVR assembly. Although we are far off creating the next big thing, we are making bounds towards the expertise required.

## 5. Appendix A: Source Code

## 6. Appendix B: References

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