Digitalized Enigma Machine Reconstruction (DEMR)

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Introduction:

Main purpose of this project is to recreate a simplified and digitilized version of Enigma Ciphering Machine. Our project demonstrates the cryptology concept that enigma machine utilizes. Although it does not provide a new encryption concept, it does provide a simpler and physical version. In our point of view this is especially important, because it is extremely difficult to find an original machine or even replica. There are only 318 enigma machines exist globally and many of them are either in unusable condition, stored by collectioners or rarely sold on auctions for astronomical amounts (Ranging from $190,000 to $250,000).

Review of Similar Projects

There are many versions of replicas and recreations. The most valuable and relevant ones we found are following;

1) **Enigma Machine Emulator:** This emulator helped us a lot during the project because it practically has every feature. So, testing and understanding the behavior becomes much more efficient. It also has definitions for German keywords, which again helped us to figure out the meanings from real enigma ciphering sheets. In addition, this project is open-source and it was coded on Javascript, so it enables us to examine the algorithm. [2]

2) **A Modern But Classical Enigma Machine:** This project is what inspired us the most. It is almost a masterpiece. It was completed in 9 months and it has crucial enigma features which implemented digitally. [4]

3) **Enigma Simulator:** This project is very similar to Enigma Machine Emulator but on a smaller scale. It features all of the essential components of an Enigma Machine. It also has clean and simple code, which is written in Processing. [3]

Improvement over general concept:

Mechanical enigma machine is a very complex encryption device. It involves large number of mechanical parts. (To give a perspective a single Enigma Machine has 2698 parts). [5]

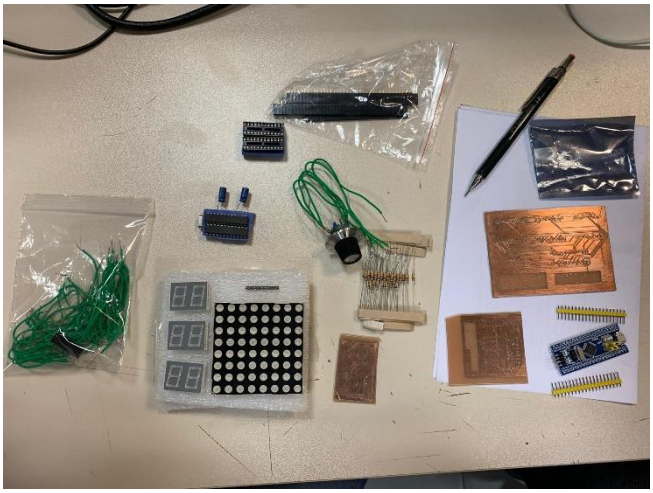
Our main improvements are following;

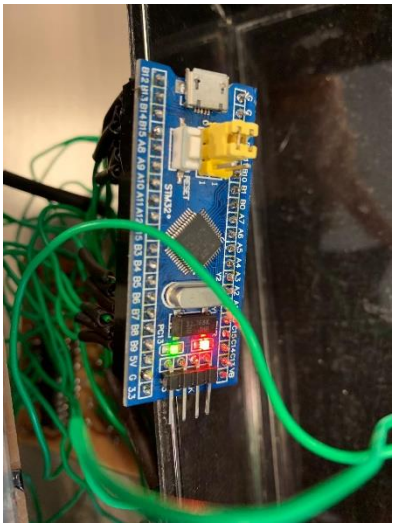
- Size reduction.
- Removal of plug board and additional rotors.
- Removal of keyboard. In our proposal, we plan to use a keyboard for input but for the complexity and simplicity, we removed the keyboard.
- Easily operable interface. Removal of unnecessary buttons.
- We implemented the algorithm for Arduino which replaced all mechanical parts.

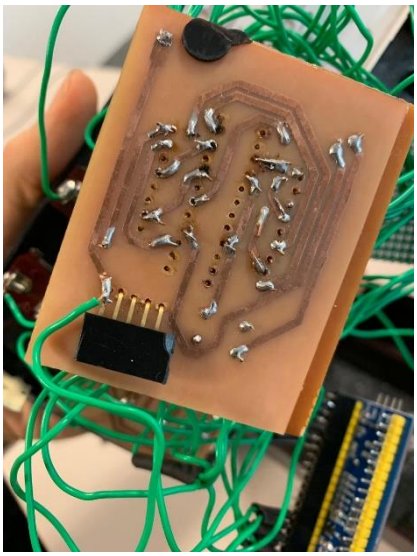
Project Progression:

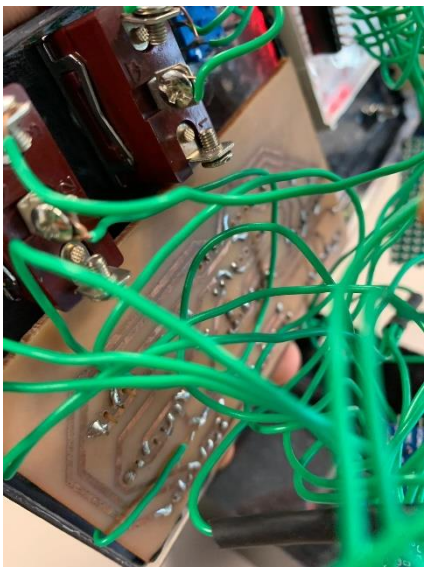
1) We designed the schematic in three ways. First one is for 7 segment display, second for rotary encoder and the third for dot matrix.
2) We tested the circuits on the breadboard and make the necessary changes.
3) After the breadboard testing completed successfully, we proceed to designing the PCB. Initially we went with a single sided PCB. However, once we etched the PCB and try to solder on, we found out that traces are too thin and way too close to each other. As a result, they turned out to be way too fragile and create too many short circuits to handle by hand.
4) After the failure we decided to go with double sided PCB, but we do not have double sided copper plate. Buying one will cost us money and time. So, we found alternate solution by using two single sided PCBs to form a double-sided PCB and gluing them together. By doing that we significantly increased the trace width. Therefore, our previous issues are solved.
5) Once we have finished assembling and soldering components to the PCB's, we wired up the three modules together and connected all to STM32.
6) We wrote the code based on our tests, resources and libraries.
7) We packed all of the components into a plastic enclosure make the machine more usable. We also wrapped it with carbon fiber vinyl wrap and finally we assembled the embossed enigma logo.

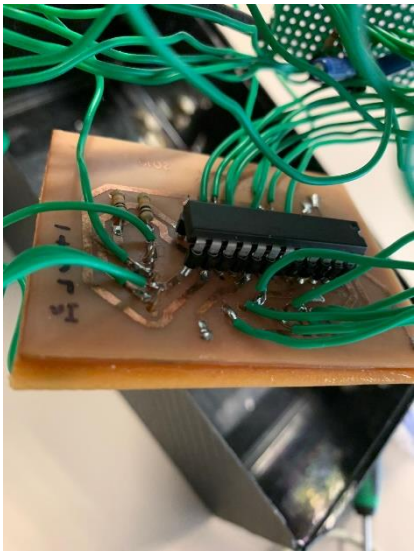
Photos

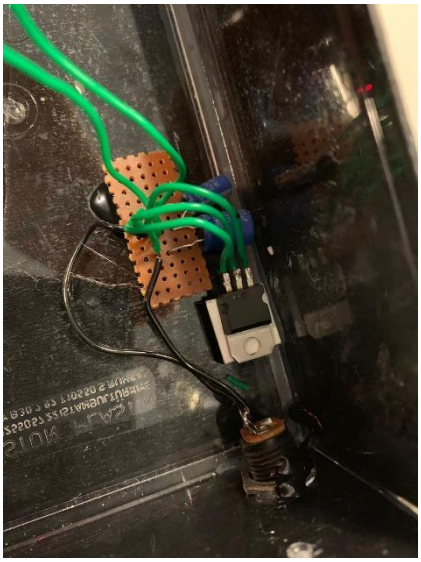




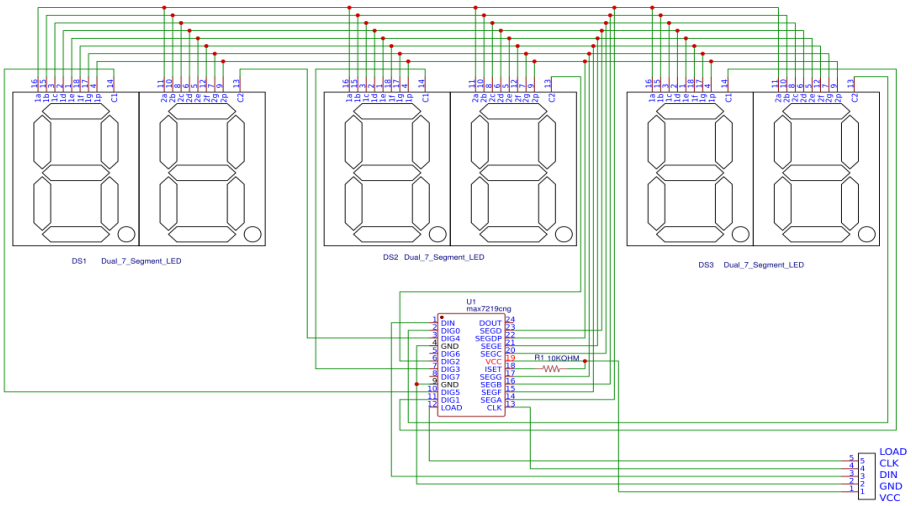




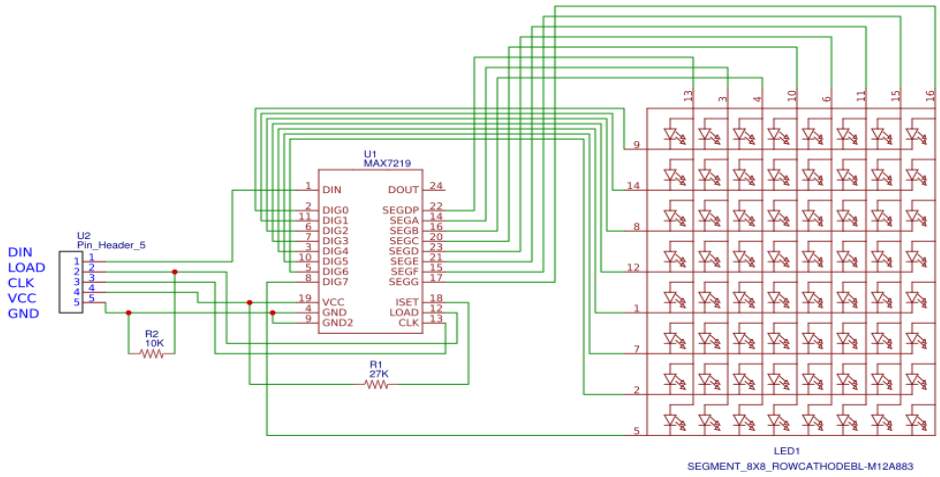




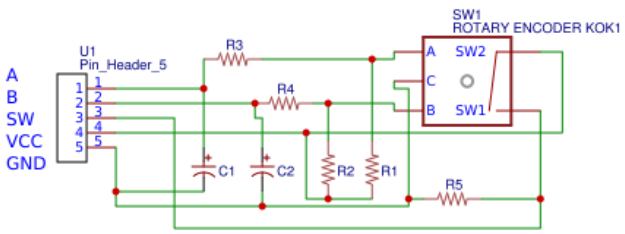
Schematics



7-Segment / MAX7219 Circuit

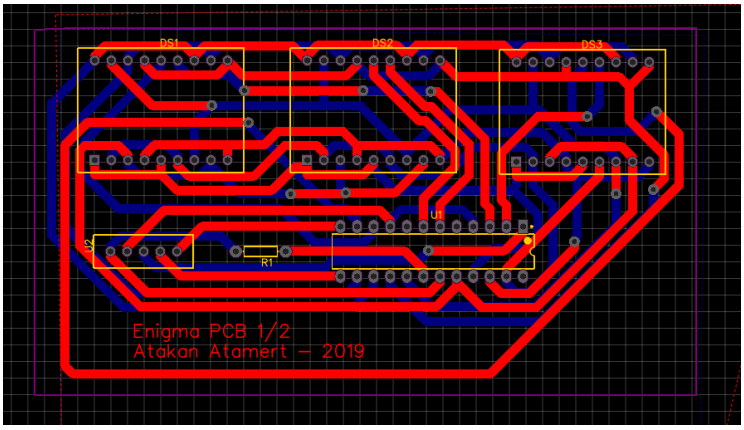


8x8 Dot Matrix / MAX7219 Circuit

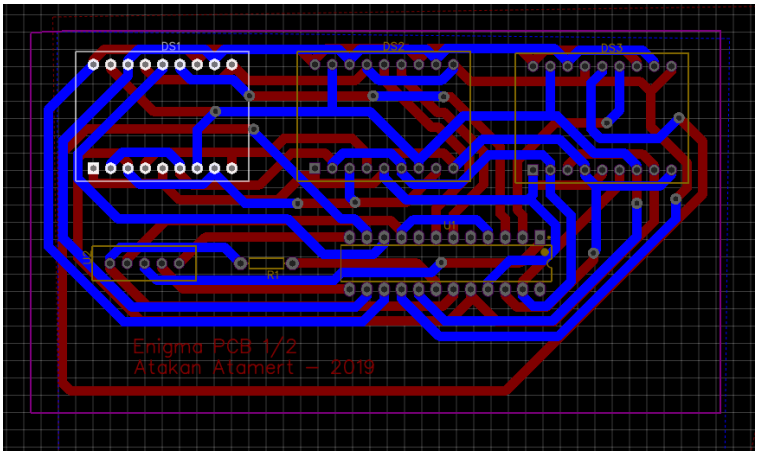


Rotary Encoder Circuit w/Debouncer

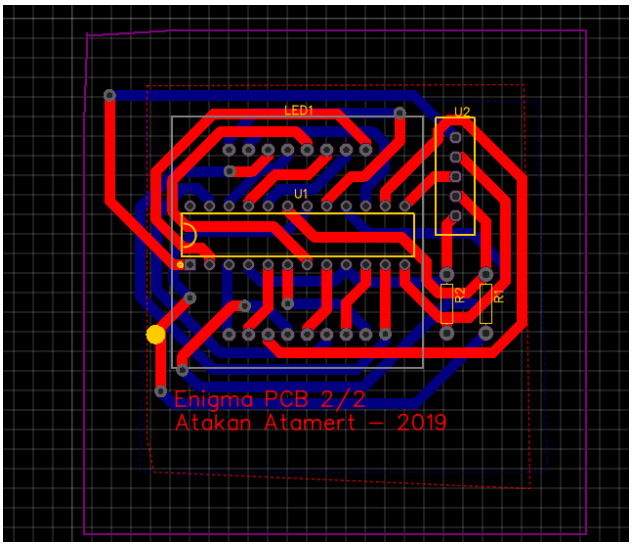
PCB’s

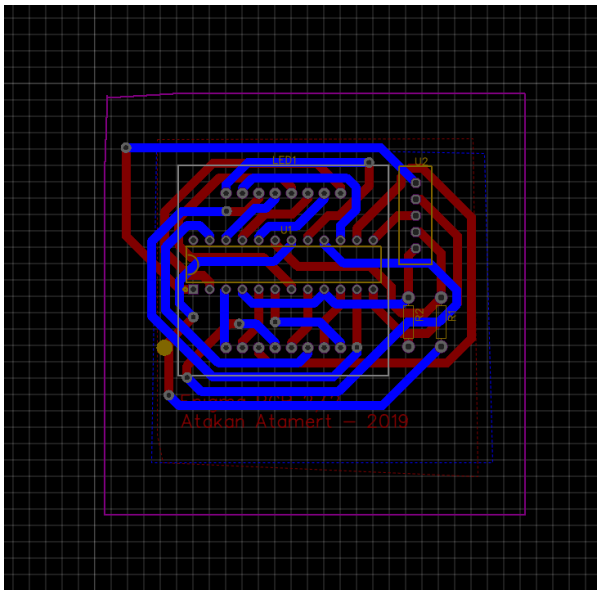


7-Segment PCB Top



7-Segment PCB Bottom





Dot Matrix PCB Top

Dot Matrix PCB Bottom

Referred & Similar Projects

1. LedControl Library [Web log post]. (n.d.). Retrieved from https://www.pjrc.com/teensy/td_libs_LedControl.html
2. Dade, L. (n.d.). Enigma Machine Emulator. Retrieved from http://enigma.louisedade.co.uk/
3. Code-Bullet. (2018, June 14). Code-Bullet/Enigma-Simulator. Retrieved from https://github.com/Code-Bullet/Enigma-Simulator
4. Eggebraaten, A. (2016, May 24). A MODERN BUT CLASSIC ENIGMA MACHINE [Web log post]. Retrieved March 31, 2019, from https://hackaday.com/2016/05/24/a-modern-but-classic-enigma-machine/
5. Ertel, Wolfgang & Jans, Lucia & Herzhauser, Walter & Fessler, Joachim. (2011). An Enigma Replica and its Blueprints. Cryptologia. 35. 16-21. 10.1080/01611194.2010.533256.