Automatic Solder Dispenser

DESIGN DOCUMENT

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List of Definitions

ETG: Electronics and Technology Group

ISU: Iowa State University

Coover Hall: The dedicated electrical and computer engineering hall at Iowa State University

ID: Identification

NOTE: This template is a work in progress. When in doubt, please consult the project plan assignment document and associated grading rubric.

1 Introduction

1.1 Acknowledgement

The team would like to thank the Coover Hall ETG Department at Iowa State University. Without their assistance and funding, this project would not be possible. We would like to specifically thank Leland Harker, our client and advisor. He has a great passion for engineering and is more than willing to share his knowledge and resources with us.

1.2 Problem and Project Statement

ETG has seen an increase in solder use in Coover Hall. Students will come to ETG asking for solder, but often don't know what kind they should be using. An ETG employee would then explain the different types, help the student decide which one is best for their unique situation, and give them approximately 12-18 inches of the requested solder. This is a very frequent and repetitive occurrence. ETG has requested that an automatic solder dispenser is designed and created to allow more efficient allocation of ETG employee time.

The solder dispenser should be contained in a box with a clear top, with the dimensions similar to that of a typical shoe box. The box will have an interactive display and card reader attached to it. The interactive display should guide users through the process of selecting solder, including useful information about each type and how it should be used. The user can then swipe their ISU ID card, select which solder type they decide is best suited for their project, and the machine will eject 12-18 inches of solder. The student will then be unable to receive more solder for twenty minutes. This ensures that students will not waste solder or easily steal large amounts.

The dispenser should be designed in a way that students cannot cheat the system. In other words, unplugging the machine should not delete its user memory, and students should not be able to pull more solder out as it is being dispensed. The clear top will allow students to study and understand both the mechanical and electrical parts in the machine, which will further expand their learning experience.

A dedicated administrator should be able to perform maintenance on the machine by swiping their ISU ID card. An administrator page on the screen will pop-up, and here the administrator can check solder levels and inform the machine of changed solder rolls. In the event of a jam or a solder roll is getting low, the machine will send an email to ETG, to make them aware of the issue. Emails will be periodically sent out detailing the usage rates of each type of solder.

1.3 Operational Environment

The automatic solder dispenser will be located in various labs in Coover Hall. The dispenser must be strong and enduring, because malicious engineering students will tend to hit and tilt the machine. Special care must be taken to ensure that the machine is not easily damageable and that normal wear will not interfere with its functionality. There will not be any harsh precipitation or temperature changes, and the labs are generally kept clean.

1.4 Intended Users and Uses

The automatic solder dispenser will have to main users: students and administrators. Students will be in need of solder throughout the semester, and this machine needs to be easily accessible for those in need of solder. Students will swipe their ISU ID, navigate through the solder descriptions, decide which solder type is best for them, and select it.

Students will benefit from this machine due to it being accessible at all hours, every day. Currently, if a student is working on a project late at night and needs solder, the student would be out of luck because ETG would be closed.

Administrators will care for the machine and replace solder rolls when needed. The administrators will be ETG employees, and they will receive emails when the machine jams or needs a roll replaced. They can then swipe their ISU ID card into the machine and gain access to the administrator page on the touchscreen. Here they can view usage rates and errors, and they can notify the machine when a solder roll has been replaced.

1.5 Assumptions and Limitations

Assumptions:

- Multiple solder dispensers will eventually be created using our designs.
- If multiple dispensers are made, students will only be locked out of the individual machine they used for 20 minutes.
- Multiple rolls of the same type of solder will not be placed in one machine.
- 120V AC will be available for the dispenser to use.
- A stand or table will be available for the dispenser to sit on in order to be at customer level.

Limitations:

- Each student will need their ISU ID card present when needing solder.

- The cost of each solder dispenser will be several hundred dollars.
- Changing the structure of emails or programming will be difficult for those unfamiliar with the software.
- The size of the box should be approximately shoe-box sized.

1.6 Expected End Product and Deliverables

The final deliverables for this project will include one fully-working solder dispenser machine, as well as the necessary designs needed to create additional dispensers in the future.

The solder dispenser will be fully operational and tested. The user will be able to obtain the solder they selected, and the machine will then wait 20 minutes before allowing that user to receive more. Administrators will be able to view usage statistics as well as perform maintenance on the machine.

The designs we will include in the final project will consist of circuit schematics, layout designs, codes, and parts lists. Using this information, more dispensers can be created in the future. The layout designs will include an assembled layout of the box.

We will test the solder dispenser by allowing students to use it for several weeks during the spring. The dispenser should be completed and ready to be tested by March 18, 2019. The final version with any corrected pieces or parts should be completed by April 15, 2019.

2. Specifications and Analysis

2.1 Proposed Design

Our design can be broken into three main categories: electrical, programming, and mechanical work. Each of the following will be discussed.

Electrical Work

The electrical work includes the power requirements for the dispenser, determining which microcontroller is best, designing and creating a PCB circuit board containing drivers, and determining which servos and motors to use. The electrical team decided to use a Raspberry Pi for the microcontroller, which uses 5V for power. From previous designs and input from our client, it was decided that 2 standard servos will be used for cutting the solder, and 4 stepper motors will be used for pulling the solder off of the roll.

The PCB circuit board has four Adafruit TB6612 stepper motor drivers, one for each stepper motor. It also contains pins for power, servos, and future sensors. Future sensors

may be implemented to inform administrators when the box is opened, as well as determining when a jam has occurred.

Programming

On the programming side, a database has been created to store the ISU card numbers of users, which is read from a USB magnetic stripe reader. By using the database, the dispenser can prohibit users from getting more solder within the next 20 minutes. The program will be written to control both the stepper and servo motors. The stepper motor can be rotated a specific number of degrees, which will allow us to dispense a preset length of solder. The servo motors will be used to cut the solder.

We plan to use a 7" touchscreen display with the Raspberry Pi, which will be programmed so that users can operate the dispenser and administrators can replace spools and view status reports.

Mechanical Work

The mechanical work includes determining what designs have already been created, as well as determining if the designs work correctly and are optimal. Four extruders will be created, which will each connect to a stepper motor, and each motor will control the solder on a spool. The extruder has a spring mechanism in order to keep tension on the solder at all times.

After the extruder piece, a collector will be connected. The collector will combine the outputs of all four extruders into one single output. In order to have only one cutter, all four different solder spools must end up going to the same place, no matter which type is chosen.

Connected to the output of the collector is 12-18 inches of tubing, which will be formed into a tight spiral. when the solder is pushed through the tubing, it will keep its spiral shape. This is optimal for dispensing, since we don't want the user to have access to the solder until after it is cut. The cutter is made up of two servos, with a design very similar to a cigar cutter (Figure 2).

Figure 1: Guillotine Cigar Cutter (Amazon.co.uk, 2018)

After being cut, the solder will fall into a position either inside or outside of the box that is accessible to the user. It is important that the solder is cut first in order to ensure that users cannot pull out more solder directly from the spool.

2.2 Design Analysis

So far the team has made designs for the hardware, software, and mechanical areas of the project. We started by addressing the types of designs that each area needed. The electrical portion of the project requires the connection of different hardware elements, including the microcontroller, stepper motor, motor drivers, and servo motors. These elements will then be connected inside the enclosure. Before the entire electrical system can be built and tested, a printed circuit board must be designed so that all the hardware can be connected. Once the specific hardware elements were selected, we focused on designing the printed circuit board. For the software side of the project, the designated lead began working on the user interface for the administrators, and the database for student IDs. When designing the user interface, we had to choose a GUI library that worked best for the application of our project. In terms of the mechanical area of the project, we have to choose an enclosure and design some of the parts. So far, we have designed the collector and began making improvements to the existing extruder and solder-cutter models. Furthermore, we must design a mechanism for where the solder will be stored before it is cut and ready for the user to retrieve. For the enclosure, we must choose a size that fits all of our components and select where the components will be placed so that the space is optimized. The following sections discuss some of our designs, how they are working, and ideas on how to improve them.

Electrical Designs

Once we selected which motor drivers to use, we began working on the circuit design. We began by using a variety of components, like MOSFET transistors, diodes, and resistors. We decided to remove those components and mainly feature the motor drivers in order to simplify the board. After testing the motor drivers, we began the printed circuit board layout. The board has motor drivers, capacitors, and connectors such as terminal blocks and header pins. Besides the components, the board also has power connection pins for other hardware like the LCD screen and the microcontroller. We just sent our PCB file for manufacturing, so we will be able to further evaluate our electrical designs and make future changes when the board is fabricated. Also, we can start testing multiple hardware components together with the fabricated PCB.

Software Designs

Our strategy for designing the software is to break it up into parts, and work on one software feature at a time. So far, the software lead has been designing the user interface for the administrators and the database for student ID information. Although the administrator interface is functioning well, the current GUI library is difficult to work with. Therefore, we are in the process of selecting a different library that will allow us to resize the buttons and images in an easier way. The only drawback to using this new GUI library is that it will take more time to learn the syntax.

Mechanical Designs

The mechanical area of our project requires the creation of new designs as well as making improvements to existing designs supplied by our client. Primarily, we must choose the proper enclosure that will fit all of our components in the arrangement that we desire. The original enclosure that we chose would only fit 80 percent of our components, so we are in the process of selecting a larger enclosure. We must also carefully decide where the components will be placed inside the enclosure in order to optimize the space we are given. The current design for our enclosure and the arrangement of the parts can be seen in Figure 2 below. Fortunately, our client provided us with designs for the cutter and extruder. We are currently working on improving the extruder model. Our goal is to make changes to the design in order minimize both the complexity of the model and the cost to 3D print it.We will move on to improving the cutter prototype after we are satisfied with the new extruder model. The designs for the collector are still in the beginning stages, as we will not need to test it until we get the motors and extruders working together. Lastly, we need to design a feature that will hold onto the solder until the cutting is finished. Our initial idea for this was a tail-like tube that will keep the user from pulling the solder out until the cutting is finished. We believe that a better device can be used in this instance, so we are in the process of coming up with new ideas for this feature.

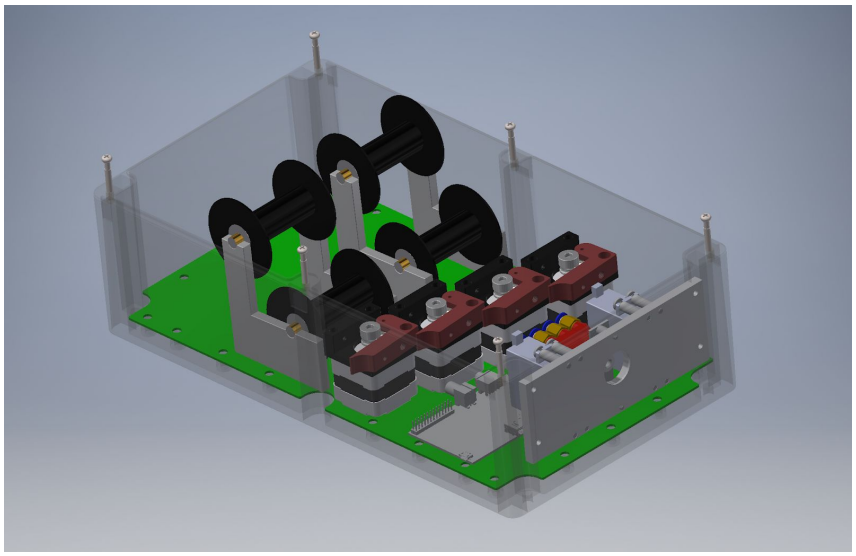

Figure 2: Assembly of Enclosure

3 Testing and Implementation

3.1 Functional Testing

To test the machine's functionality, we will repeatedly iterate through the process that a user will experience. we will vigorously test the touchscreen functionality, the ability to accurately distribute solder, determine when jams occur, keep track of how much solder is left on each roll, and email ETG staff when a roll is empty or a jam occurred.

3.2 Non-Functional Testing

In order to test the usability of our soldering dispenser, we will allow a trial period where people can use it. During this time we will ask for feedback from users, as well as ensuring that our dispenser is secure, fool-proof, and safe. Unplugging the machine should not cause the database to be cleared, and the box should be durable.

3.3 Process

Figure 3 shows our design process. We iterate through a sequence of planning, designing, testing, and evaluating until we reach an acceptable outcome. As you can see, each subsection (circuit design, coding, and mechanical designs) was tested separately, as well as evaluated after being assembled together.

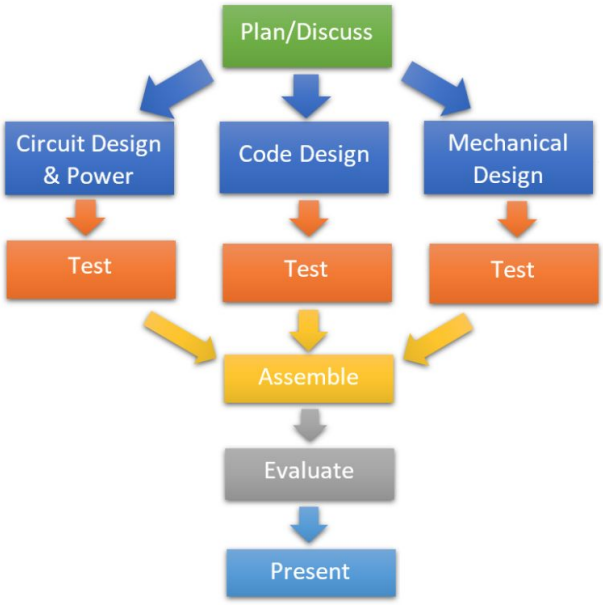

Figure 3: Flow Diagram of Design Process

The PCB circuit board that contains stepper motor drivers was tested after creation. We used the Raspberry Pi to test each driver, and ensure that each stepper motor moves correctly. We also tested the power supplies, ensuring that each driver and motor can be operated without exceeding the ratings of the power supply.

We tested the code in different sections. The code that controls the motors was tested with the PCB board and stepper motors. The code that implemented the database was tested with the cardreader. Each user and administrator screen was carefully tested to ensure that no dead-ends occur during use, and all functions are executing as expected.

Each mechanical design, including the extruder, collector, and cutter, was tested separately. The extruder was tested using the stepper motors, a driver, and voltage generator. The cutter was tested using the Raspberry Pi, where it controlled both servos moving in opposite directions. The cutter cut the solder, although we did have issues with the metal pieces not gliding well. We discussed different lubricants, and received a new cam design. The new cam design allowed four bolts to connect the servos to the cutting device, instead of two bolts with the old design.

3.4 Results

When we tested the solder cutting device, we tried running both servos on the same PWM signal. This created problems because it was hard to calibrate the two blades just right. Having two separate signals allows more controllability, and therefore more accuracy.

When we first decided on a driver, we ordered one from Amazon in order to test its functionality. We successfully operated the stepper motor with the driver, and decided to use the driver design in our PCB board design.

4 Closing Material

4.1 Conclusion

Our solder dispenser design is simple, inexpensive, yet durable. We have carefully thought about each piece of hardware and software, and have discussed alternatives and modifications to ensure the best solution is incorporated. Our goal is to create a solder dispenser that users can access 24/7. A student can swipe his or her ID, select from 4 different solder types, and receive 12" of that solder.

So far we have decided on what microcontroller and motors to use. We have also created the database needed to store students ID numbers, and we designed the PCB containing drivers for the stepper motors. On the mechanical side, we have taken the designs previously made by our client, discussed any changes that are necessary, and began creating the physical components. A layout has also been made that shows where each component will go inside the box. We have a plan in place and are currently working on designing and completing the work.

4.2 References

"Guillotine Cigar Cutter: Amazon.co.uk: Garden & Outdoors." Dorling Kindersley Science Encyclopedia: Amazon.co.uk: Dorling Kindersley Publishing: 9780751356410: Books, www.amazon.co.uk/Oval-Shaped-Cigar-Guillotine-Cutter/dp/B000H681DK.