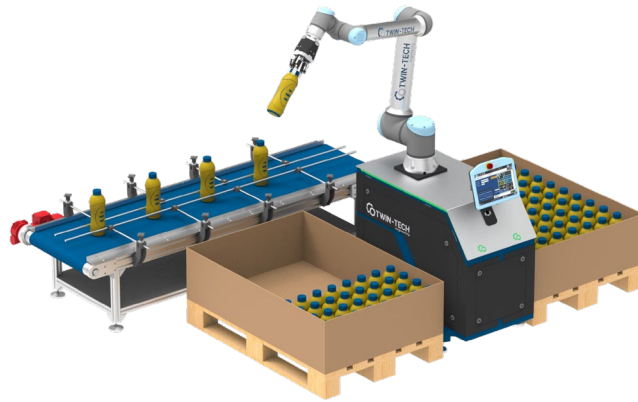


Automated Bottle Capping System Project



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INDA B150-62H

Professor Murray

November 19, 2025

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Biography

Ryan Mcspirit:

My name is Ryan McSpirit. I am enrolled in the Industrial Automation Baccalaureate program at Bakersfield College, and am now enrolled in the capstone senior project course. I currently have an Associate's Degree in Industrial Automation, and one in Liberal Arts. I also have two certifications, in Automation and Electronics. This required general education, motors, instrumentation, telecommunications, electronics (AC and DC), computer aided design, and programming ability (using Studio 5000 and RS Logix 500). I have used my academic achievements to work in the energy sector as a SCADA programmer, and I am simultaneously taking courses for my Bachelor's degree. These courses focus on integrating the fundamentals of the lower division courses into broader and more career specific concepts and learning management skills. I am set to graduate in Spring of 2026.

Tony Marquez:

Hello. I'm Tony Marquez and I'm a student at Bakersfield College. I am in the Industrial Automation program, currently working on my senior project. I have my associates degree and am expected to graduate with my bachelors Spring of 2026. During my time here at BC I've learned the basics of electronics, how to program PLC's, draw and design using CAD software, how to control collaborative robots, telecommunications, safety, and management in the workplace. Although I haven't had a chance to work in the automation field, I'm excited to use my skills to contribute to it.

Executive Summary

This paper presents the design and implementation of an automated bottle capping system with a 3D printed conveyor system designed to sort and transport objects. The goal is to explore how additive manufacturing can make automation more accessible to small scale manufacturers where resources may be limited. The system integrates mechanical actuation, sensor feedback, and programmable control to streamline the capping process while adapting to varying bottle types. This project reflects a broader commitment to accessible automation. It serves as a foundation for further exploration into low-cost industrial solutions.

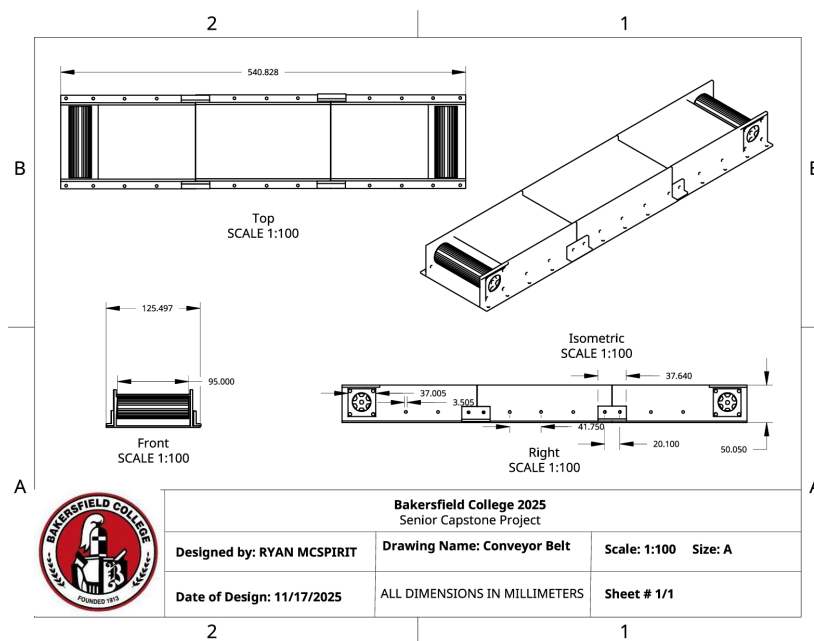


Figure 1: Conveyor Schematic

Literature Review

The concept behind this project stems from a growing need for low cost, customizable automation solutions in educational and small- scale industrial environments. This project charter proposes an automated pick-and-place bottle capping system with a 3D printed conveyor system

designed to sort and transport objects. The objective is to explore how additive manufacturing can enhance the accessibility of automation for independent manufacturers.

The team reviewed the article *Design and Control of an Open-Source, Low Cost, 3D Printed Dynamic Quadruped Robot* by Kim et al. (2021), which has close parallels to their pick-and-place project. Both projects use additive manufacturing and off-the-shelf components to create affordable and customizable robotic platforms. While Kim et al. focused on dynamic locomotion in a quadruped robot, their use of 3D printed structural parts directly supports the team's approach to building a low cost automation system. Their application of finite element analysis (FEA) to check mechanical durability under stress also informs the need to test the conveyor's durability.

The article *Robotic Pick-and-Place Operations in Multifunctional Liquid Crystal Elastomers* by Lyu et al. (2022) offers a compelling perspective on advanced gripping mechanisms that can help the design of the gripper for the robot. While their work focuses on soft robotics and bio-inspired actuation, precise object manipulation in a 3D space directly parallels with the project's goals. Their cephalopod gripper, which operates without external pressure systems, highlights the potential for gripping solutions that could be adapted to low-cost robotic arms. The project will be needing a gripper that can hold a bottle firm, and will allow for rotation of the bottle cap.

To better refine the research done, the team met with librarian Matthew McCoy at Bakersfield College Library. He helped navigate the Applied Science & Technology Source database, and suggested using search terms like "3D printed automation," "additive manufacturing" and "three-dimensional printing".

In conclusion, while several studies have explored pick-and-place robotics and conveyor systems, few have combined them using 3D printed components. This gap presents a compelling opportunity to prototype a scalable, cost-effective automation system that can be used for training, sorting, or light manufacturing.

Project Plan

After conducting the literature review and exploring the topic of automation, the idea of an automated bottle capping system with a 3d printed conveyor system was supplanted. This paper will go through the evolution of the project from initial concept, design decisions, implementation challenges, and final outcomes.

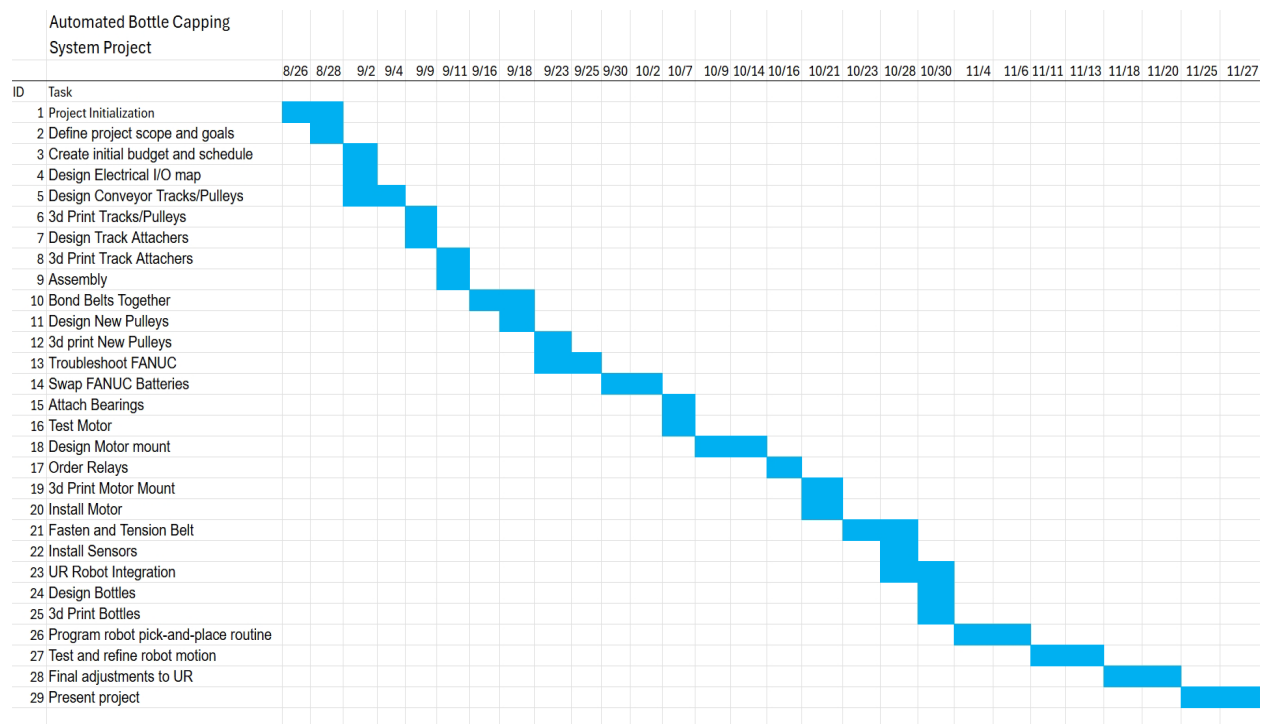


Figure 2: Gantt Chart

The first idea was to use a FANUC robot in which inputs and outputs could be hardwired into the IO module. The FANUC robot, similar to the KUKA robot, is a robotic arm used in

manufacturing environments for tasks such as welding and assembly. It is controlled and programmable by a teach pendant. Its reliability with IO systems made it an appealing choice for the bottle capping system, especially since it could be programmed to respond to sensor feedback and to control the gripper.

The conveyor system was designed using OnShape software. An Ender 3 V3 KE printer was used to print the parts. It has automatic bed leveling and network/remote access abilities. The belt structure is a series of PLA links with a path to feed the belt through, with small plastic screw-in pieces to connect each link. This made the length of the belt fully customizable. It has holes at the end to insert bearings for the motor shaft, and cylinder PLA rolling pieces to animate the mechanism. It is planned to mount it to a table originally used for a FANUC robot.

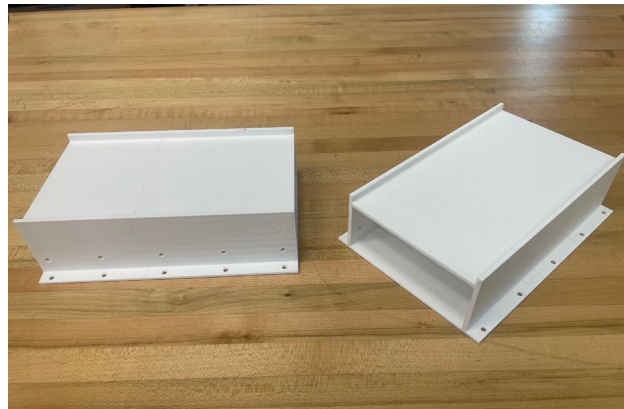


Figure 3: Conveyor Tracks

The conveyor belt as well as the motor was salvaged from existing material stores. Two thin conveyor belts from previous projects were found that fit into the 3d printed track. A bonding cement was used to connect the two belts together so that there would be ample room for the 3D printed bottles.

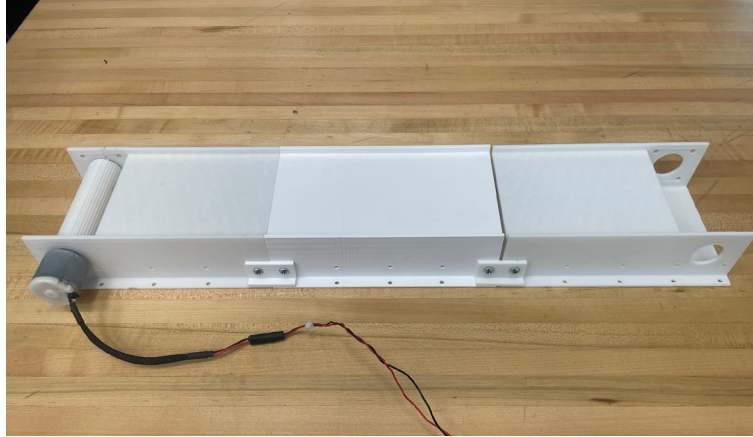


Figure 4: Conveyor Assembly

The first issue encountered was with the FANUC robot. It had a low battery in the side panel, and simply replacing the battery was not an ample solution because there is a software procedure that must follow the replacement. Because of time constraints, it was decided to use a Universal Robot. This would be easier regardless because it would not require soldering the inputs and outputs. All inputs and outputs can be hardwired in the cabinet below the robot.

As soon as the relays that were ordered from Automation Direct arrived, electrical integration between the conveyor system and the universal robot began. The four (3 orange and 1 yellow) terminals served as the negative side of the circuit, and the four red ones as the positive. They are powered by an adjustable power supply unit plugged into a standard 120V outlet. This allows control of the voltage to ensure that it is both high enough to animate a belt but low enough to not cause voltage overload or a violently shaking belt system. The relay on the right controls the inductive sensor, and the motor on the left controls the 12V DC motor. Power to the sensor is supplied directly from the robot I/O cabinet. The two relays are inversely connected, so when a bottle hits the sensor, the sensor controlling relay shuts off and supplies power to the motor controlling relay. This made the programming straightforward.

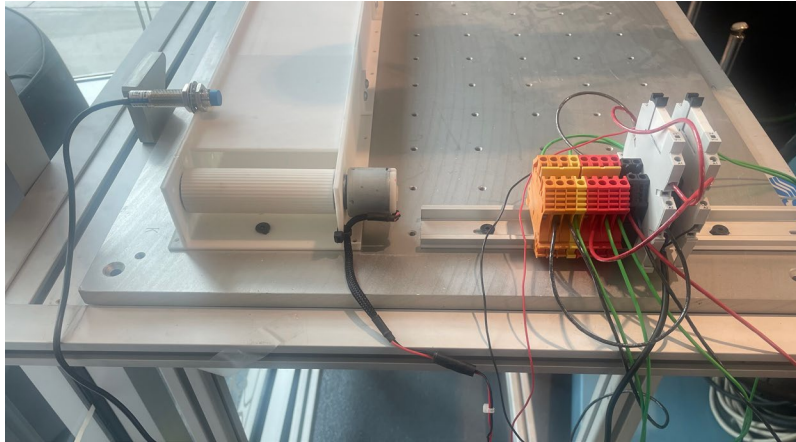


Figure 5: Relay Integration

In the final stage of assembly, the conveyor belt was ready to be mounted and integrated with the system, however the next challenge emerged when the motor proved insufficient to drive the belt. Despite careful alignment of the 3D-printed track and the salvaged belt, the torque output of the 12V DC motor was not strong enough to overcome the friction and weight of the assembled components and caused it to smoke. As a last resort, the 3D-printed conveyor system was replaced with a pre-assembled conveyor from a FANUC setup. While the custom design had demonstrated promise in terms of flexibility and innovation, the limitations of the available motor ultimately prevented the belt from operating reliably under load. The pre-assembled FANUC conveyor provided a proven, industrial-grade solution that eliminated the mechanical and power issues encountered with the printed system.

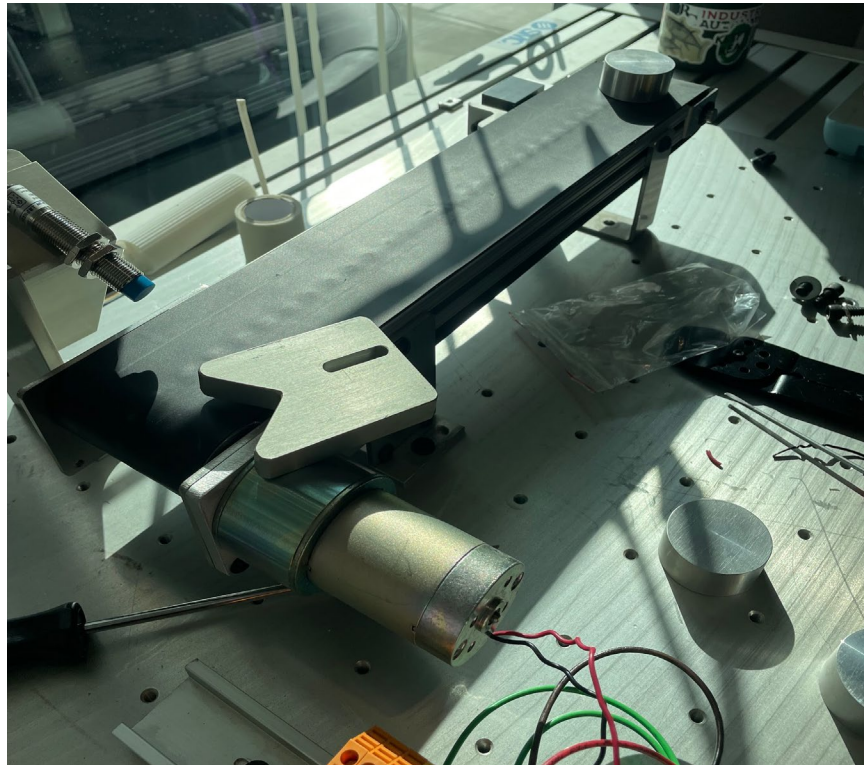
In the final stage of the project, programming the Universal Robot and integrating the inductive sensor worked smoothly and demonstrated the effectiveness of the system design. At this stage, the use of metal and plastic cups as test objects proved highly successful, as the inductive sensor consistently detected the metal cups' presence and triggered the programmed response without false signals. These outcomes confirmed that, despite earlier mechanical challenges, the automation process concluded with reliable sensor integration and effective robot

programming, marking a strong finish to the project's development.

Figure 6: Final Assembly

Conclusion

This project represents a meaningful step toward accessible automation for small-scale and educational environments. By combining additive manufacturing with robotic control and sensor integration, a scalable platform was created that demonstrates the viability of low-cost



industrial solutions. Although we encountered challenges such as the limitations of the 3D-printed conveyor system and the motor's inability to drive the belt, we were able to adapt by integrating a pre-assembled conveyor, ensuring the project reached completion. Looking ahead, the original 3D-printed concept remains valuable, as it highlights the potential for customizable, low-cost solutions that could be refined in future iterations. The system could be expanded to handle multiple bottle sizes, integrated with advanced gripping. This project not only showcases

the technical capabilities of the team but also reflects the idea of making automation more accessible.

References

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Appendices

Figure 1: Conveyor Schematic

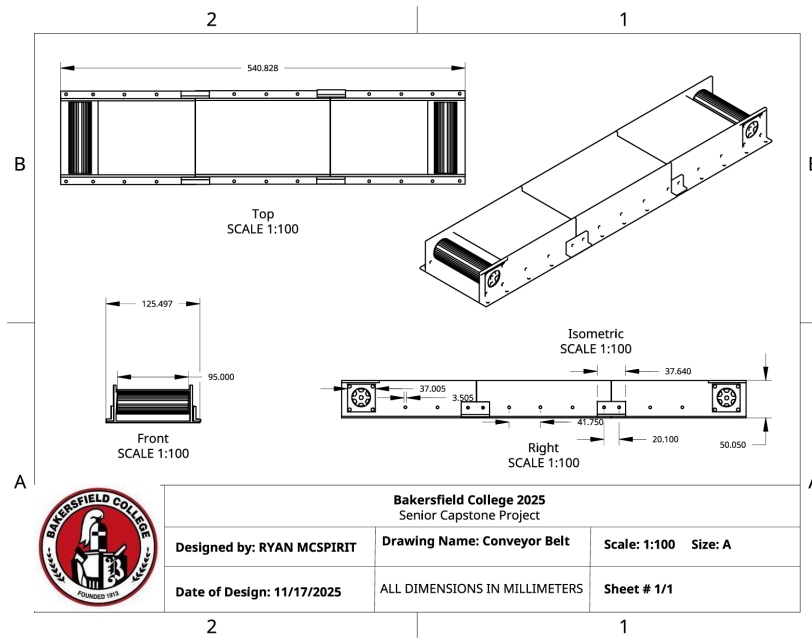


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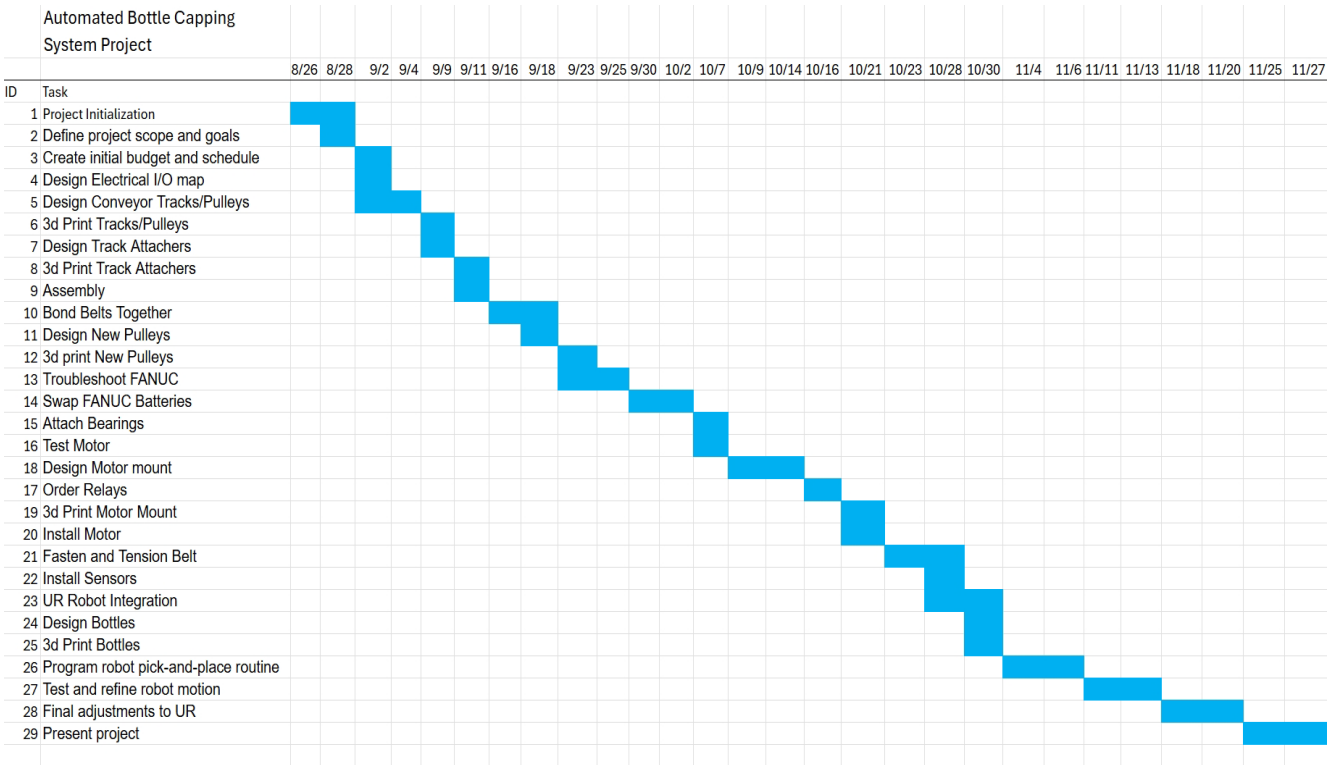


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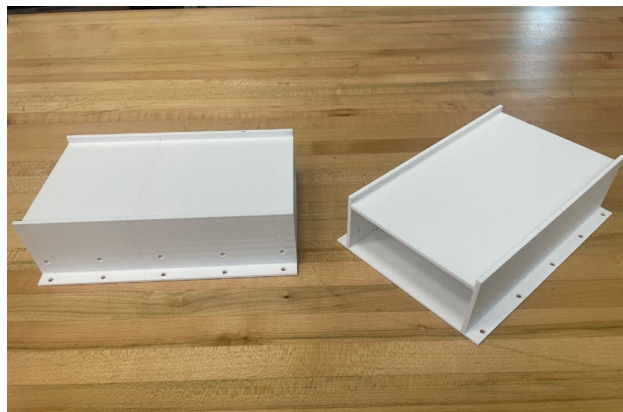


Figure 4: Conveyor Assembly

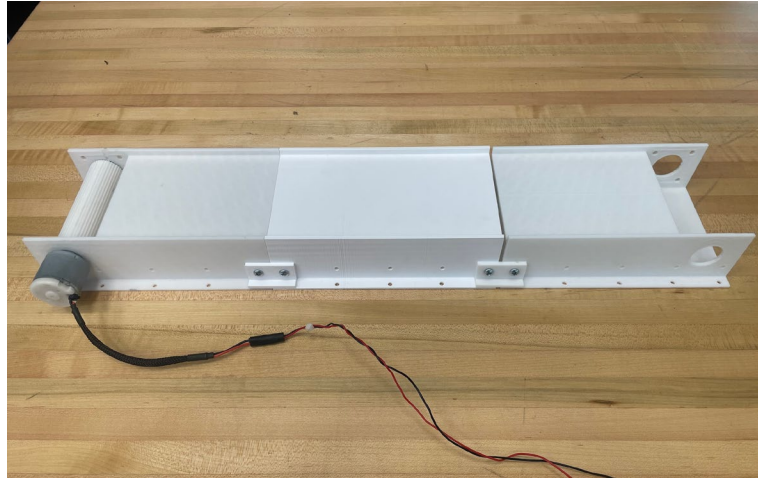


Figure 5: Relay Integration



Figure 6: Final Assembly