AME 494/598

Programming for IOT

Modular Temperature-Controlled Extruder

Project By:

Chris and Poojan

Professor Tejaswi Gowda

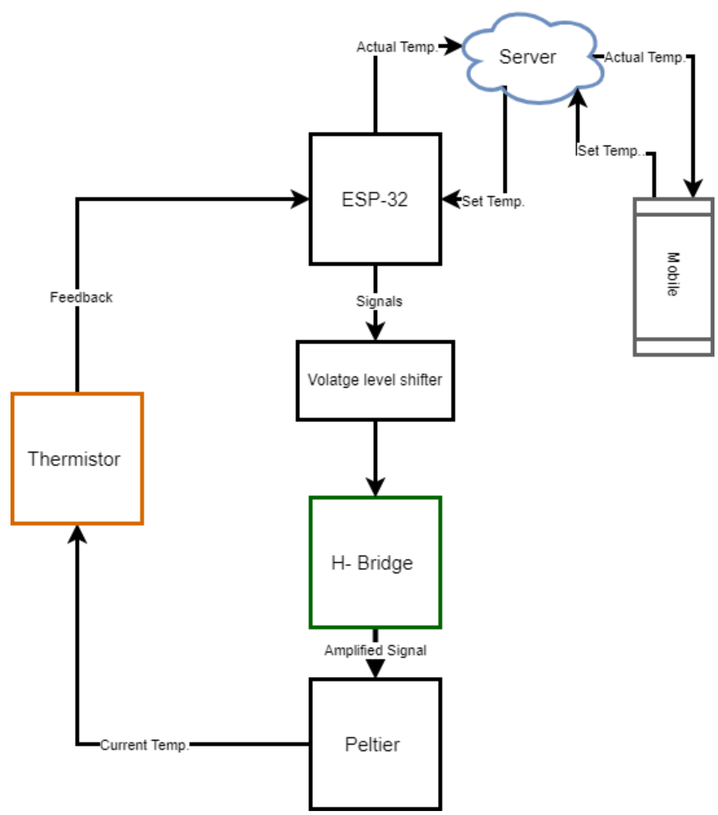
Introduction

The Extruder is an essential component for 3D printing. All extruders have heating capabilities to melt polymers. There is a new type of 3D printing known as bioprinting. Bioprinting is used to reproduce tissues, organs, or organoids. The extruders used in 3D bioprinting has heating and cooling capabilities. For our project, we created the Modular Temperature-controlled Extruder. It is created to ensure precise temperature control throughout the printing process. The reason why we are created this extruder is because 3D bioprinting is carried out in a clean room without any human contaminants. However, if someone wants to change the temperature, they would need to decontaminate themselves to enter the clean room and change temperature. That is a time consuming process and it risks wasting the expensive material used in the printing process. Our extruder fixes that issue by introducing wireless compatibility that doesn't require people to go through the decontamination process.

Methodology

List of hardware:

- ESP-32 C3 dev module
- Voltage Shifter
- H-bridge
- Thermoelectric Cooler
- Heat Sink
- 5V 5A DC Power Supply
- Mobile Device



How it works is simple: we start from the mobile device and it sends data to the server, the server rediriects the data to the ESP-32. The ESP-32 sends the data of current temperature from the thermistor and sends it the server and displays that information on the mobile device. Then based on the user input, the ESP-32 sends the data to the peltier via voltage shifter and h-bridge as shown in the image above, it will achieve the desired temperature.

The Process

Expected Initial Challenges

Before we started working on our project, the main challenges we expect to encounter were establishing a stable and constant connection between the microcontroller and the web and reducing the latency for a better user experience.

Beginning Challenges

As we started our project,we began collecting our components. We looked online for the right components and worked with the professor to get the right components. Once we got our desired components, we began testing it with some code that we had made. Our code was supposed to give us the temperature data that the controller was reading. That was when we encountered our first real problem. The components we had did not work with the code at first. The outputs that we saw were inaccurate. So in order to make our class work productive, we tried figuring out what was wrong with the code. After some time, it continued to not work. So we focused on our next task, we went to the electronics lab to assemble our thermistor. Then overnight, we worked, trouble shooted, and spent time redoing the code to make it work. By the time we finished, the code was able to fetch the temperature data from the thermistor and display on the screen. That meant the hardware we had worked and code worked. From there, we designed a MOSFET circuit to process the low current signal to operate a high current device. After that, we designed a voltage shifter to process the signal coming to the MOSFET circuit. Then we created another component where the heat sink is on the bottom, the peltier was above the heat sink, and the thermistor was placed on top of the peltier. The thermistor gives us the temperature data of the peltier and the heat sink dissipates the residue heat.

The Next Challenge

The moment our hardware was assembled and we brought it to class to attach to our overall project, the next problem occurred. The microcontroller module did not work. The microontroller is the brain of our project, so we immediately grabbed our entire project and went to the electronic labs. We asked the staff for help and we learned that we needed to use a different microcontroller module with the desired voltage. So we were given a new microcontroller module. It was recently soldered so we had to make it brand new. After some time, we reconnected everything and realized one mistake. The component for our thermistor circuit was made incompatible with the new module, it provided the wrong data and then we had to change the entire circuit. So after class, we spent the entire night reassembling the entire hardware.

The Last Challenge

After getting the hardware and the code to work in every aspect. We encounter our final challenge, establishing a stable and constant connection between the microcontroller and the web. It was what we expected and we were right. Even with the code we made, the data from the microcontrollers are having a hard time connecting to the servers for some reason. In order to solve this problem, we are using the MQTT protocol to establish connection between the microcontroller and the web.

Design Gap

What we had planned for the entire project did not change. Although we had to rework a few components, the final output were within our expectations. Our expectations were stated earlier, we wanted to make a wireless extruder that prevents the waste of 3D bioprinting material.

Feedback

1. Thanks to the readings and workshops provided in this class, we learned to set up AWS servers. That helped with our project because it requires a server in order to transfer data to and from the mobile server and the microcontroller.
2. The work in class shifted the way we envision our research goals not by much. We had a goal in mind was the same but the professor helped us in important bits and pieces that allowed our project to reach our expectations.
3. Right now, we have created the extruder, which is a small yet critical part of the entire system but our goal is to operate the entire 3D printing system wirelessly.