Project Title

DESIGN DOCUMENT

SDDEC01-22
Client: Mark Hansen from Minufacture
Faculty Advisor: Dr. Philip Jones
Evan Pasero - Team Leader
Rachel Teberg - Reporter/Historian
Stone Widder - Technical Lead
Charles Sang - Hardware Lead
Joshua Baringer - Software Lead
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Executive Summary

Development Standards & Practices Used

- Trade study for display and microcontroller
- Thermocouple Sensor Circuit
- Version control with GitLab
- PCB design using KiCad
- GUI implementation with Python
- Embedded Linux Operating System
- Code of Ethics
- IEEE 802.11-2020
- IEEE/ISO/IEC 29119-2-2021
- IEEE 15939-2008

Summary of Requirements

- Must combine temperature sensors into one control system
- Must track and send data to the cloud
- must cost 250 dollars or less
- must have a physical and web UI

Applicable Courses from Iowa State University Curriculum

- EE 201
- EE 230
- CPRE 288
- EE 324
- CPRE 488
- CPRE 308
- COM S 309
- COM S 252

New Skills/Knowledge acquired that was not taught in courses

- Project management
- Trade Studies + low level market analysis
- PCB design

Table of Contents

Team

1.1 Team Members:

1. Rachel Teberg
2. Joshua Baringer
3. Stone Widder
4. Evan Pasero
5. Charles Sang

1.2 Required Skill Sets for your Project:

1. Embedded Systems Programming
2. Website Design
3. PCB Design
4. Testing
5. Circuit Design
6. Management
7. General Programming

1.3 Skill Sets Covered by the Team:

1. Embedded Systems Programming - Josh, Stone, Rachel, Evan, Charles
2. Website Design - Josh, Stone, Rachel
3. PCB Design - Charles, Stone, Evan
4. Testing - Rachel, Stone, Josh, Charles
5. Circuit Design - Evan, Charles, Stone, Rachel
6. Management - Rachel, Josh, Stone, Charles, Evan
7. General Programming - Josh, Rachel, Stone, Charles

1.4 Project Management Style Adopted by the Team:

1. Waterfall

1.5 Initial Project Management Roles:

1. Rachel - Team organization/ Record keeper
2. Stone - Technical Lead
3. Evan - Project Lead
4. Joshua - Software Lead
5. Charles - Hardware Lead

2. Introduction

2.1 Problem Statement

Our client owns Minufacture which is a small company dedicated to helping hobbyists interested in sustainability by creating plastic models. They achieve this by shredding plastic, melting it at very specific temperatures, then molded through injection using a specialized machine that our client is merchandising. So, our client's problem is to be able to control and maintain temperature at those specific levels while also being able to control the machine wirelessly, upload tracked data like temperature, operating times to the cloud.

2.2 Requirements & Constraints

1. Functional requirements
    a. Must work with provided test stand
    b. Must combine temperature sensors into one control system
    c. Must track and send data to the cloud
2. Resource requirements
    a. must cost 250 dollars or less
3. Qualitative aesthetics requirements
    a. must fit the current design
4. Economic/market requirements
5. Environmental requirements
6. UI requirements
    a. must have a physical UI
    b. must have a web UI

2.3 Engineering Standards

1. IEEE 802.11-2020

    Technical corrections and clarifications to IEEE Std 802.11 for wireless local area networks (WLANs) as well as enhancements to the existing medium access control (MAC) and physical layer (PHY) functions are specified in this revision.

    a. We need to use wifi in order to connect our device to the internet so we can send information to AWS. We need to follow this standard in order to ensure good secure connection without interference on other communication signals.

2. [IEEE/ISO/IEC 29119-2-2021]

   This document specifies test processes that can be used to govern, manage and implement software testing for any organization, project or testing activity. It comprises generic test process descriptions that define the software testing processes.

   a. Since we will be using, implementing, testng of software to program the microcontroller and build the PID controller we need to be aware of the use of proprietary software and building generic testing software we need to adhere to safe standards and implementation.

3. [IEEE 15939-2008]

   This International Standard defines a measurement process applicable to system and software engineering and management disciplines. The process is described through a model that defines the activities of the measurement process that are required to adequately specify what measurement information is required, how the measures and analysis results are to be applied, and how to determine if the analysis results are valid.

   a. Our product will be taking temperature measurements from thermocouples and relaying it to microcontroller software while also being able to maintain it thus this standard provides great guidelines when designing such systems as ours to give confidence of a professional standard achieved during production.

2.4 Intended Users and Uses

1. This project is good for hobbyists and environmentalists. As a flexible injection molding machine, it is a perfect solution for people interested in a low cost way to create miniatures or functional molds. Additionally, it comes with and can use all recycled plastics, making it appealing to those dedicated to environmental causes.
2. Our addition to the Minufacture injection molder will make it more accessible to a wider variety of users, as our display and board will streamline the process of setting temperatures. The temperature setting process will also make the machine more versatile, as it will be able to safely and effectively hold the heating element at temperatures appropriate for a wider variety of plastics.
3. The PID controller can be expanded to include other different hobbyists including brewers and fermenters because the system is used to maintain certain levels of temperature and can be adjusted to include both positive and negative temperatures.

3 Project Plan

3.1 Project Management/Tracking Procedures

We are using the Waterfall project management style. We decided on this style because we felt that the linearity of the style would help us stay on track better. There is a lot of interdependence between the tasks thus the phase structure of the waterfall method fits well with our project. We use a combination of Gitlab and discord to keep track of our progress.

3.2 Task Decomposition

Phase 1

- Project Research
- Basic planning/ setup
- Design hardware block diagram
- Create software specifications document

Phase 2

- Basic prototype using off the shelf components
- Choose hardware components
- Choose software architecture
- Design circuits
- Create server
- implement PID on Prototype

Phase 3

- Design/print PCB
- Create Physical UI

Phase 4

- Integrate all systems
- Do whole system testing

Phase 5

- Create Web UI
- Research and develop cloud interface

Phase 6

- Final Testing
- Polishing

3.3 Project Proposed Milestones, Metrics, and Evaluation Criteria

Our project milestones can be broken down into six sections. The first three milestones can be worked on at the same time while the last three need to be completed in order.

- The first milestone that we need to complete is researching what existing products we can use, and do trade studies on various components in our system.
- The second milestone that needs to be completed is the research and gathering of software libraries to be used inorder to control the PIDs, read from the thermocouple, set up the GUI, and store the data for the profiles.
- The third milestone is the testing of circuits for the thermocouples, relays, and indicator LEDS.
- The fourth milestone is the implementation milestone, which is where we are currently in as we are combining all of our research to make out PCB, implement the GUI and software to control the heating elements.
- The fifth milestone is where we will debug problems with our system and work on finalizing our product.
- The last milestone is presenting our product to our client and making sure that we have documented everything well since the project is going to be open source and will have other teams working on it.

We are using an agile development process to complete each milestone in sprints. We use our clients' meetings to demo the things that we have worked on during the sprint. We then use his feedback to determine what we need to do in the coming weeks.

3.4 Project Timeline/Schedule

2/6/22 - Pros and Cons list for microcontroller options
2/13/22 - Final decision for microcontroller
2/13/22 - Initial Trade Study completed
2/20/22 - Final Block Diagrams for Hardware and Software
2/24/22 - Design Review #1 (Block Diagram and general Micro Direction) with Mr. Hansen
3/3/22 - Prototyping and Testing Process Begins
3/24/22 - Design Review #2 with Mr. Hansen - present initial prototypes
4/1/22 - EOS - Debug Project and prepare for summer session.

Gantt chart is in Appendices 8.4

3.5 Risks And Risk Management/Mitigation

1. Personal injury - Low (5-15)%
    a. Electronics that can cause a shock hazard
        i. Label shock hazards
    b. Heating elements can cause burn hazard
        i. Label any hot points to prevent burns
2. Equipment Damage - Low (5-10)%
    a. Improper shutdown can corrupt OS on Beaglebone
        i. Adding a gentle shutdown circuit
    b. Heating element can get too hot and melt casing
        i. keep close track of actual temperature while testing and shut off the device before it gets hot enough to melt the casing, after testing shouldn't be a problem as the control circuit will not allow it to get too hot.
3. Risk of missing a demo deadline - Low (5-15)%
    a. We have scheduled this project to be done in one semester when we have two
4. Risk of equipment failure - Low (5)%
    a. We only have one test stand, and if it fails, we would have to stop operations for a week until a new one got shipped
    b. Upside, we could possibly fix it ourselves

3.6 Personnel Effort Requirements

Include a detailed estimate in the form of a table accompanied by a textual reference and explanation. This estimate shall be done on a task-by-task basis and should be the projected effort in the total number of person-hours required to perform the task.

	Josh	Charles	Stone	Rachel	Evan
Board		4/wk			3/wk
Controls	1/wk	2/wk	3/wk	2/wk	1/wk
Software	4/wk		3/wk	2/wk	
Admin	1/wk			2/wk	2/wk

Per our milestones we are less interested in specific tasks and more interested in achieving milestones. These milestones are related to the system as a whole, and each of these sections (except for admin) relate to part of it. Board relates to the physical aspects of the system, where the EEs spend more time. Controls are also mostly handled by EEs and relate to the PID and low level software. Software refers to the website, IOT, and cloud connection. Josh will head this, but EEs will help him where he needs it.

3.7 Other Resource Requirements

Parts

- Beaglebones
- Test stand to verify our systems are working properly
- Thermocouples
- Realys
- Project boxes
- Will need to order a PCB
- Time

Software Resources

- PID libraries
- Element14 community forums
- Oscilloscope analysis of original PID controller
- Nginx web server datasheets

Hardware Resources

- Analog Digital Data sheets
- NIST Thermocouple Database
- Beaglebone Datasheets
- Display Datasheet

4 Design

4.1 Design Context

4.1.1 Broader Context

Area	**Description**	**Examples**
Public health, safety, and welfare	How does your project affect the general well-being of various stakeholder groups? These groups may be direct users or may be indirectly affected (e.g., solution is implemented in their communities)	Increasing/reducing exposure to pollutants and other harmful substances, increasing/reducing safety risks, increasing/reducing job opportunities
Global, cultural, and social	How well does your project reflect the values, practices, and aims of the cultural groups it affects? Groups may include but are not limited to specific communities, nations, professions, workplaces, and ethnic cultures.	Development or operation of the solution would violate a profession's code of ethics, implementation of the solution would require an undesired change in community practices
Environmental	What environmental impact might your project have? This can include indirect effects, such as deforestation or	Increasing/decreasing energy usage from nonrenewable sources, increasing/decreasing

	unsustainable practices related to materials manufacture or procurement.	usage/production of non-recyclable materials
Economic	What economic impact might your project have? This can include the financial viability of your product within your team or company, cost to consumers, or broader economic effects on communities, markets, nations, and other groups.	Product needs to remain affordable for target users, product creates or diminishes opportunities for economic advancement, high development cost creates risk for organization

4.1.2 User Needs

Injection molding hobbyists need a fun and interesting way to use recycled plastic because their hobby uses a lot of non-recycled plastic.

Designers need a way to include unique plastic molded parts into their products, because the inclusion of these pieces brings a new level of design into their products.

4.1.3 Prior Work/Solutions

PID controllers are plenty available in the market. Most of them are standalone systems with proprietary software which make them hard to customize to suit your project especially for temperature sensitive products

Our client already had a PID controller but he wanted one with more capabilities. The following are the pros and cons of our target system.

Pros

1. Lots of Input and Output pins
2. It will use Linux backend
3. Initial Setup can be done via USB and a web-interface
4. Can have a Web Interface on local area network
5. Has a greater community support
6. LCD integration can be easily achieved
7. Has various ways of booting

Cons

1. Unused Input and Output pins
2. It will use Linux backend
3. Various price points for different configurations.

4.1.4 Technical Complexity

1. The design consists of multiple components/subsystems that each utilize distinct scientific, mathematical, or engineering principles –AND–
    a. The four subsystems we will be focusing on are the display, which will require UI programming, the circuit board, which will require knowledge of embedded systems, electronics, and pcb design, the microcontroller, which will require knowledge of embedded systems, and recording data and sending it to the cloud, which will require knowledge of iot devices.

2. The problem scope contains multiple challenging requirements that match or exceed current solutions or industry standards.
    a. We did some research on other options for hobby injection molding, and while they exist, we believe that our project goal of increasing the accuracy of the minufacture machine's accuracy and PID protocol will exceed their offerings. Having an onboard microcontroller that can be reprogrammed with different settings for different plastics is a new feature, and our use of the cloud to increase accuracy further once data on performance is collected is certainly a new feature.

4.2 Design Exploration

4.2.1 Design Decisions

Design decisions including, but are not limited to, materials, subsystems, physical components, sensors/chips/devices, physical layout, like.

1. Display
2. Microcontroller
3. Pre-made/homemade Thermocouple circuit

4.2.2 Ideation

For the display we searched on digikey for displays that matched our constraints.

- Mikroe-55
- Mikroe-495
- E35KA-FW1000-N
- PH480272T005-IHC03
- 104990243
- ATM0430D19A
- AFY480272B0-4.3N12NTM-C

4.2.3 Decision-Making and Trade-Off

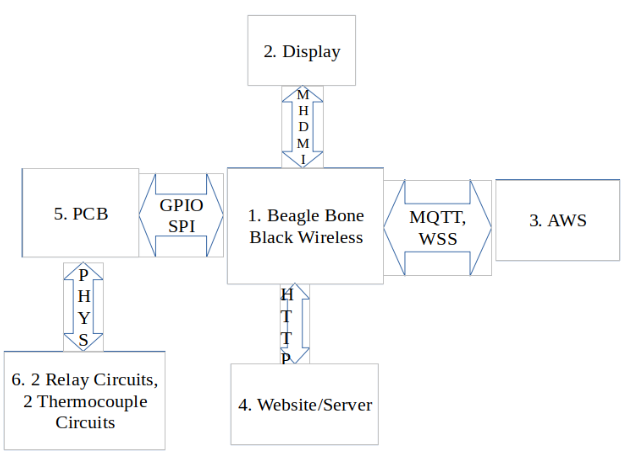
Problem	We need a microcontroller to run the PID loops, display, and cloud services					
Constraints	Less then 125$, Run an operating system		I want to note that when considering GPIO pins, the most quantifiable me			
Eval Criteria	Price	Memory	Pins	Size	Ease of use	Connectivity
Weight	1	1	3	1	2	2
1	125-101	Little memory	0-24	big	difficult to use	No internet
2	100-78		25-36			
3	75-51		37-48	medium		
4	50-26		49-60			
5	25-0	Lots of memory	<61	small	easy to use	On board wifi
Options	Beaglebone Black	Beaglebone Black Wireless	Raspberry Pi Ze	ESP32-solo-1	Arduino Uno	
Price	3	1	5	5	5	
Memory	5	5	5	3	1	
GPIO pins	5	5	3	2	1	
Size	1	1	3	5	3	
Ease of use	5	5	3	2	1	
Connectivity	3	5	5	4	1	
	40	**42**	**38**	**31**	**16**	
	Specs	Specs	Specs	Specs	Specs	
	52 - 65.14	107.60 -111.25	15	3.74	23	
	4GB flash	4GB flash		4MB	32KB	
	512MB RAM	512MB RAM	512MB	520KB SRAM	2KB	
	86.40 mm × 53.3 mm	86.40 mm × 53.3 mm	65X30mm	18×25.5×3.1 mm	68.6x53.4mm	
	65?	92?	40?	34	14	
				on board wifi + bluetooth		

We did trade studies to help us choose our microcontroller and display for our system. As you can see above, the results of our trade studies helped us determine which features were important and which ones didn't have as much of an effect on our choice.

4.3 Proposed Design

So far we have designed and ordered a custom PCB. It should be here the last week of the semester and we are going to do some basic tests on it to see what we will need to work on for the next semester. The GUI framework has been implemented and we are currently working on combining it with the command line interface so the user can control the entire system from the GUI.

4.3.1 Design Visual and Description



4.3.2 Functionality

Our design, at present, is meant to seamlessly combine an easy to understand UI and a highly responsive PID protocol which will keep the heating element within 10 degrees of its goal. Should our design achieve everything that it's meant to, a user will be able to select a mold (provided by our client), slot it into the machine, and press 'go.' Plastic in a funnel above the machine will be melted and pushed into the mold, from which the creation can be pulled out safely after a calculated cool down time.

4.3.3 Areas of Concern and Development

Based on your current design, what are your primary concerns for delivering a product/system that addresses requirements and meets user and client needs?

What are your immediate plans for developing the solution to address those concerns? What questions do you have for clients, TAs, and faculty advisers?

Currently our biggest concerns for development is the implementation of the UI and how it interacts with the command line. These concerns are due to a lack of work so far. However, These concerns are minor since we are working with python, which is good for writing command line programs and working with simple UIs.

Temperature sensitivity could pose a challenge if not calibrated right due to non linearity when the temperature sensor goes above certain temperature for us when we go over 400 degrees we have to account for non linearity

AWS Cloud	How will we effectively integrate our control system with the AWS cloud.
Circuit Board Design	Due to limited time we want to ensure that measurements are correct so that we can quickly test and implement the board.
Usability	It will work, but will it work intuitively? Will it be easy to use?

4.4 Technology Considerations

Problem	We need a microcontroller to run the PID loops, display, and cloud services					
Constraints	Less then 125$, Run an operating system					
Eval Criteria	Price	Memory	Pins	Size	Ease of use	Connectivity
Weight	1	1	3	1	2	2
1	125-101	Little memory	0-24	big	difficult to use	No internet
2	100-78		25-36			
3	75-51		37-48	medium		
4	50-26		49-60			
5	25-0	Lots of memory	<61	small	easy to use	On board wifi
Options	Beaglebone Black	Beaglebone Black Wireless	Raspberry Pi Zero 2 W	ESP32-solo-1	Arduino Uno	
Price	3	1	5	5	5	
Memory	5	5	5	3	1	
GPIO pins	5	5	3	2	1	
Size	1	1	3	5	3	
Ease of use	5	5	3	2	1	
Connectivity	3	5	5	4	1	
	40	**42**	**38**	**31**	**16**	
	Specs	Specs	Specs	Specs	Specs	
	52 - 65.14	107.60 -111.25	15	3.74	23	
	4GB flash	4GB flash		4MB	32KB	
	512MB RAM	512MB RAM	512MB	520KB SRAM	2KB	
	86.40 mm × 53.3 mm	86.40 mm × 53.3 mm	65X30mm	18×25.5×3.1 mm	68.6x53.4mm	
	65?	92?	40?	34	14	
				on board wifi + bluetooth		

Problem	We need a cost effective display that the user can quickly and easily use to set and start the machine						
Constraints	Less than $75 | Resolution falls in	a) whether or not the device has them and b) how usable they are if we choose to employ them. We are not suggesting that the display we choose "must" have on board controls.					
Eval Criteria	Price	Size	on board controls	connectivity	Resolution	Availability	
	1	2	1	2	2	2	
1	75	large	present and bad	Need to wire pin to pin(24 bit)	Low res	0-25	
2	60-74					26-50	
3	45-59	small		16(bit)		51-75	
4	30-44					76-100	
5	<30	middling	present and good	HDMI	High resolution	>100	
Options	Mikroe-55	Mikroe-495	E35KA-FW1000-N	PH480272T005-IHC03	104990243	ATM0430D19A	AFY480272B0-4.3N12NTM-C
Price	5	5	3	3	2	5	4
Size	3	4	5	4	2	4	4
OBC	3	5	3	3	5	3	5
Connectivity	3	1	3	5	5	1	1
Res	1	3	3	4	5	4	4
Amount Available	5	1	2	1	1	5	5
	32	**28**	**32**	**34**	**33**	**36**	**37**
	Specs	Specs	Specs	Specs	Specs		
	9.8	31	52.7	59.95	69		43.85
	80x36x10mm	88.52x55.37mm	48.96(W) x 73.44(I	109mm diagonal	5in diagonal (127mm)		4.3
		2.8in	3.5in	4.3in	5in		
	none	Touch	None	None	Touch		touch
	16 bit	24 bit	16 bit	HDMI/miniHDMI	HDMI		24-bit
	16x2	320x240	320x480	480x272	800x480		480x272
Amount Available	106	21	34	3	21	2000+	
							197

Supported Resolutions

The following is partial list of supported re
resolutions that the BeagleBone Black doe

1920x1080@30
1920x1080@24 (Audio)

1324x768@60

1280x1024@60
1280x800@60
1280x768@60
1280x720@60 (Audio)

1152x864@75

1024x768@76
1024x758@60

800x600@60
800x600@75

640x480@75

Above are the trade studies which we did to determine which display and microcontroller we would use. For the microcontroller we considered the price, memory, GPIO pins (as in how many there were, and what built in options existed), size, ease of use, and connectivity (as in how easy it would be for us to integrate it into the rest of our system. For the display we considered price, size, connectivity, resolution, and availability. We scored options from the market based on what we thought was most important for each, and used those scores to select our parts.

4.5 Design Analysis

Our design proposal from section 3.3 has worked out so far since we started out with research, moved into implementation. Once our PCB comes into it we are going to test it and we will head into the integration and testing phase when the fall semester starts. Overall, we feel as though we are in a good spot for the semester.

4.6 Design Plan

Our design plan is to use the milestones mentioned in section 3.3 and our meetings with our client to determine what needs to be worked on in each sprint. The interfaces in our design are between the PCB and the display, the PCB and the Beaglebone Black and the PCB and the thermocouples and relays.

5 Testing

5.1 Unit Testing

We have Four major parts of our system that need to be tested. They are:

- The GUI
  - Tested through software and use of system
  - Underline command line interface mace it easier to avoid and fix bugs
- The PID Controllers
  - Verify over multiple testing cycles that it remains within 10 degrees of setpoint including for different temperature profiles
  - Various testing methods with Beaglebone Black
- PCB
  - Use a signal generator to simulate use of our system.
  - Verify it can run everything alone at first then all together.
- AWS Information
  - We are going to test that our system is configured to send information to the AWS server via MQTT over WSS.

5.2 Interface Testing

In our design, there are four important interfaces. The first is from the beaglebone to the pcb. This interface will be tested with a function that we will write into the firmware. This function will test every important solder connection and throw an error light if it fails. The second important interface is between the pcb and the display. This interface will be tested by another embedded function at startup. The third interface will be between the thermocouples and the pcb. When the thermocouple sensors are not plugged in, the voltage from the connector will be ~0V. When they are plugged in, the voltage will be ~0.7V. The PCB will throw and error light if it senses a poor connection.

The final interface will be the communication between the beaglebone and the cloud. Our firmware will send several test packets to the aws server, and if they are successfully received the server will send a specific set of packets back.

5.3 Integration Testing

Our client has provided us with a test stand that simulates the integration with the current system. Once we have built a control structure that can accurately control that test stand, our client will integrate it with the actual product. As such, our project's scope will not include integration testing.

5.4 System Testing

For system level testing we are going Verify that a user can set, create or edit a temperature profile with the GUI. When ready the system will control the heating relays and react based on the temperature read from the thermocouple. When the system is done running, a packet of information including the profile used, and runtime will be sent to the AWS server if the system is connected to the internet.

5.5 Regression Testing

For physical pcbs, we will simply keep old revisions of the pcb in stock, as well as keeping our pcb design in our git repository. For our software work, we will continue to store old versions of the code in our git repository, and will reference them should we accidentally make changes.

5.6 Acceptance Testing

For our design requirements to be met, we have to show that the thermocouple is able to detect the temperature required for the designed profiles to within less than 3 degrees of the desired temperature. Secondly, the PID control software needs to ensure that the temperature is maintained within the needed range by holding the relay at the desired temperature of between 150 and 450 degrees. Thirdly, the beaglebone controller will be able to display the profiles, temperature and system status via integrated UI. Lastly, we have to show that the beaglebone is able to connect to the AWS server and upload data while also being able to be controlled via web UI.

Our client is updated every step of the way with his input taken into account. He will be able to log on and control the temperature to his desire and we will note any problems or errors that occur and his opinion on what is crucial and in need of improvement will be prioritized based on criticality to the overall system.

5.7 Security Testing (if applicable)

We are not sure how applicable this will be yet. We will be storing data about molding efficiency and molds used in the cloud, but no personal information. Depending on our clients wishes, he may like for this data to be open source, in which case, it would only need to be protected from being deleted, and I believe that the AWS cloud handles that.

5.8 Results

The results of our testing on the module during runs will ensure that our system is safe to use and that it will work properly. Our testing here in the lab will ensure that our control structure accurately holds the heating element at an appropriate temperature to melt a variety of different plastics. Unfortunately as our system is not fully assembled yet, we do not have graphs with any useful data as of yet.

6 Implementation

We have three major things that we need to do next semester:

- Test and debug the GUI
  - Includes testing the command line interface
- Test and Debug our PCB
  - Redesign PCB to be smaller
- Connect our program to the AWS cloud.
  - We will need to do everything for this part of our project.

7 Professionalism

7.1 Areas of Responsibility

Pick one of IEEE, ACM, or SE code of ethics. Add a column to Table 1 from the paper corresponding to the society-specific code of ethics selected above. State how it addresses each of the areas of seven professional responsibilities in the table. Briefly describe each entry added to the table in your own words. How does the IEEE, ACM, or SE code of ethics differ from the NSPE version for each area?

Area of Responsib	Definition	NSPE Canon	IEEE	Differences

ility				
Work Competence	Perform work of high quality, integrity, timeliness, and professional competence.	Perform services only in areas of their competence; Avoid deceptive acts.	6. to maintain and improve our technical competence and to undertake technological tasks for others only if qualified by training or experience, or after full disclosure of pertinent limitations;	The statement that we used to describe work competence paints a picture of continuously learning. The NSPE canon statement sounds like you should never try to go outside your realm of knowledge.
Financial Responsibility	Deliver products and services of realizable value and at reasonable costs.	Act for each employer or client as faithful agents or trustees.	4. To reject bribery in all its forms. 3. to be honest and realistic in stating claims or estimates based on available data;	Both NSPE and IEEE expect engineers to be honest and good faith ambassadors of employer or clients finances.
Communication Honesty	Report work truthfully, without deception, and understandable to stakeholders.	Issue public statements only in an objective and truthful manner; Avoid deceptive acts.	3. to be honest and realistic in stating claims or estimates based on available data; 7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;	The IEEE code requires followers to be honest in their mistastakes, criticisms, claims and biddings. This differs from the NSPE code as it is much more expansive and specific. It expects honesty in more than just public statements.
Health, Safety, Well-Being	Minimize risks to safety, health, and well-being of stakeholders.	Hold paramount the safety, health, and welfare of the public.	1.to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment; 9.to avoid injuring others, their property, reputation, or employment by false or malicious action;	The IEEE stresses caring for the public, property, and the environment in two of its statements while the NSPE just focuses on keeping the public safe.

Property Ownership	Respect property, ideas, and information of clients and others.	Act for each employer or client as faithful agents or trustees.	9. to avoid injuring others, their property, reputation, or employment by false or malicious action;	The two statements are very similar for this category. The IEEE goes into more detail about what a person should try to protect both themselves and their employer. The NSPE keeps it broad by just talking about how you should act.
Sustainability	Protect environment and natural resources locally and globally.		1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment	The IEEE code states that when making decisions followers must disclose and avoid decisions that are harmful to the environment. The NSPE has no statement regarding the safekeeping of the environment.
Social Responsibility	Produce products and services that benefit society and communities.	Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.	8. to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression; 9. to avoid injuring others, their property, reputation, or employment by false or malicious action;	NSPE and IEEE both agree that the society represented or being services be treated lawfully and honestly. IEEE goes further in requiring no injury to people and community.

7.2 Project Specific Professional Responsibility Areas

Area of Responsibility	Apply?	How?	Rating?	Why?
Work Competence	Yes	We must have the skills necessary to competently complete the project	Medium	With only one computer engineer and a lot of programming to do we will have to learn and get a little outside our comfort zone to complete the project.
Financial Responsibility	Yes	Our Client has a limited budget thus we have responsibility to keep our project under budget.	Medium	Our client is the driving factor of why this is important. He gave us a budget of $250 for our project, which is more than enough to complete it.
Communication Honesty	Yes	We have to be able to communicate our progress to our client and advisor. If we can't do this then we will not know what our client wants or how to ask for help from our advisor.	High	We have already demonstrated good communication with our client, advisor, and team mates.
Health, Safety, Well-Being	Yes	We are expected to maintain a high level of safety since our equipment has the ability to produce harm thus necessary precautions will be adhered to.	High	We have talked about the numerous ways this product could cause harm and have come up with strategies to mitigate them.
Property Ownership	Yes	If we are going to use any code libraries we need to make sure that the licenses with the libraries are free to use or that we are not violating anything by using them.	Medium	Violating any sort of terms and conditions or license could end up costing us money in fines. Luckily it is easy to know if code libraries are free to use, and what kind of license they have.
Sustainability	Yes	Our project is all about sustainability so we need to make sure our decisions are not harmful to the environment.	High	Because we have to make sure that the product we are creating isn't made of harmful components and can be recycled responsibly without harming the environment.
Social	Yes	Our open source project has	Medium	It is our basic

Responsibility		the ability to reach vast areas of the society hence our need to maintain a high level of accountability in completing our project		responsibility to make this project easy to work on sao that other people in the open-source project can work on it. Our focus is making sure that nobody can hurt themselves using our product since it has parts that can need to be as hot as 390F.

7.3 Most Applicable Professional Responsibility Area

Communication Honesty - This responsibility is important to our project because we have to be honest and realistic about what we are doing and what we can complete. It is also important for us to have good communication with each other so we can stay on the same page and produce a consistent project. We have demonstrated this responsibility by having many detailed conversations of where we are going and kept records of what we talked about. We also have good constant communication with our advisor and client. This has helped our project by making sure everyone was on the same page and has helped us bond as a team.

8 Closing Material

8.1 Discussion

So far the requirements of our product does not meet our requirements set out by our client because we currently do not have anything connected to the AWS server. We have tested out a GUI and it is connected to an underlying command line interface that handles the saving, editing, and deleting of profile sets and maintains the desired temperature within 10 degrees after starting. We also have a custom PCB ordered to connect everything in our system together.

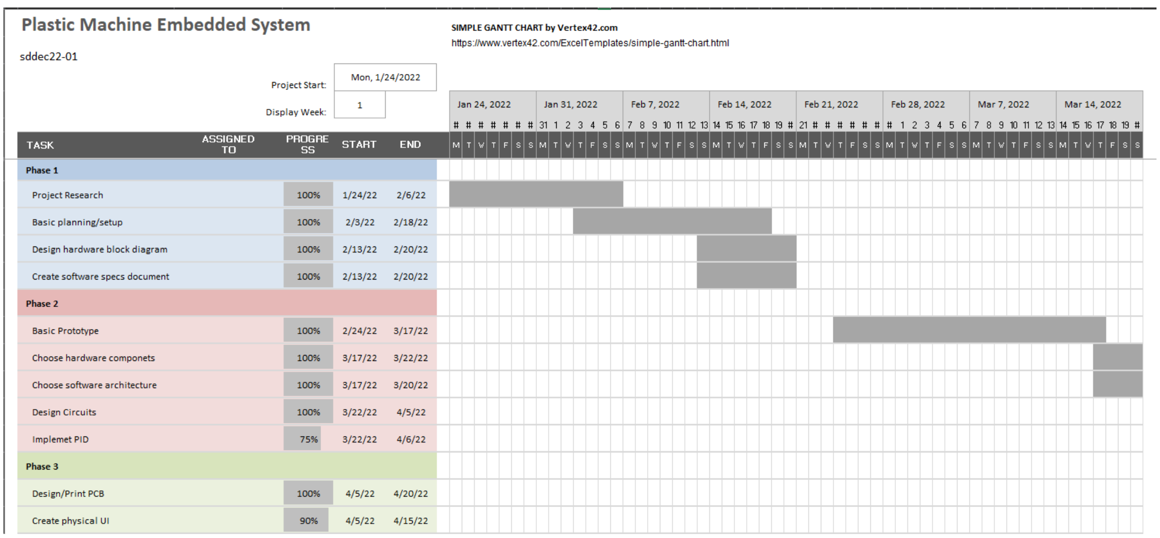
8.2 Conclusion

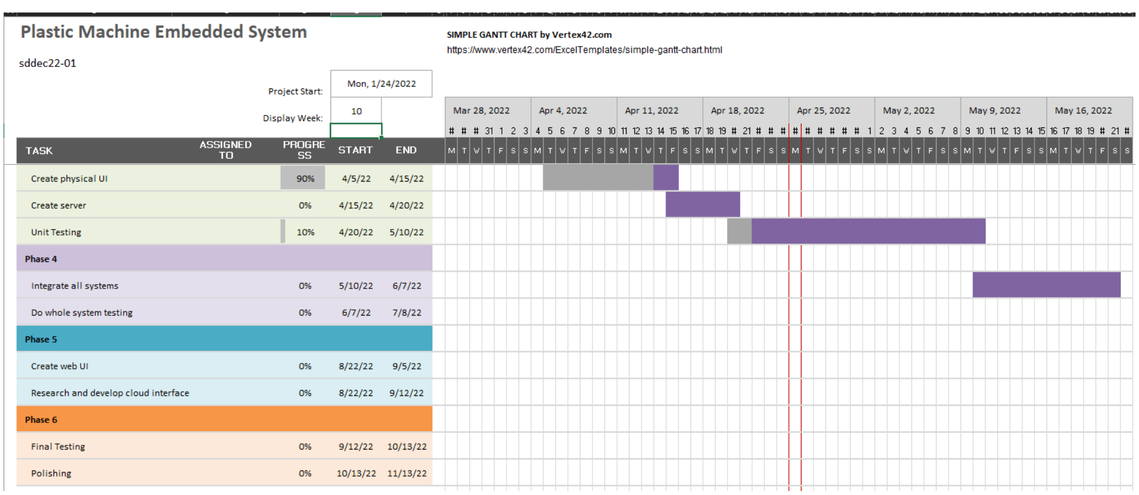
Our goals are to read the temperature from two thermocouples and use the reading to control a heating relay with a PID controller. Everything needs to be controlled from an easy to use GUI where the user can set, edit or select a temperature profile needed to melt their chosen plastic. As of right now we are waiting for our custom PCB to arrive and to test it out to see if it will meet our requirements. All of the components that are on the PCB have been tested on a breadboard prior to PCB being designed and manufactured. Currently the GUI framework is made and is connected to the command line interface in order to complete all of the backend control. What stopped us from completing the rest of our goals is the end of the semester, but we are confident that we will be able to complete everything next semester.

8.3 References

List technical references and related work / market survey references. Do professional citation style (ex. IEEE).

8.4 Appendices





8.4.1 Team Contract

Team Name SDDEC22-01 / PMEIC

Team Members:

1) Joshua Baringer
2) Rachel Teberg
3) Evan Pasero
4) Charles Sang
5) Stone Widder

Team Procedures

1. Day, time, and location (face-to-face or virtual) for regular team meetings:
    a. Monday 5-7pm Senior Design Lab
    b. Wednesday 6:30-8:30pm Senior Design Lab
    c. Thursday 8:30-9:00pm Virtual
2. Preferred method of communication updates, reminders, issues, and scheduling (e.g., e-mail, phone, app, face-to-face):
    a. Discord
3. Decision-making policy (e.g., consensus, majority vote):
    a. Consensus
4. Procedures for record keeping (i.e., who will keep meeting minutes, how will minutes be shared/archived):
    a. Rachel will be responsible for meeting minutes and notes, all to be put on the team google drive

Participation Expectations

1. Expected individual attendance, punctuality, and participation at all team meetings:
    a. Everybody should be at the meetings with the client, advisor and the group meetings on Thursday before our meeting with the client. Other meetings are not mandatory, but if they are missed team members should work on their own on individual goals.
2. Expected level of responsibility for fulfilling team assignments, timelines, and deadlines:
    a. Each team member is responsible for completing their parts of the weekly report, team activities and any other assignments. We have a general timeline to follow for the semester that we have presented to our advisor and client that we came up with as a team.
3. Expected level of communication with other team members:

    a. Team members should communicate with each other during weekly meetings and when working on the same project objective. Communication is also expected if a member foresees any circumstance that would hinder their ability to attend a meeting or uphold a deadline.
4. Expected level of commitment to team decisions and tasks:
    a. As a team we come to a consensus for all of our decisions, so if one team member has a problem with the final decision they should still try to learn or work on the task rather than slow the progress of the group.

Leadership

1. Leadership roles for each team member (e.g., team organization, client interaction, individual component design, testing, etc.):
    a. Rachel - Team organization/ Record keeper
    b. Stone - Technical Lead
    c. Evan - Project Lead
    d. Joshua - Software Lead
    e. Charles - Hardware Lead
2. Strategies for supporting and guiding the work of all team members:
    a. In our group we have two people tied to every task so that way they can have somebody to ask questions to while working on something.
    b. Asking the advisor and client for guidance if something seems unclear or vague. We will ask our advisor the more technical questions. We will ask the client more questions about the design of the product.
    c. Organizing lab days where we meet in the lab and work together exchanging ideas and updating our tasks as we proceed.
3. Strategies for recognizing the contributions of all team members:
    a. Everyone gets pizza
    b. Recognize progress during team meetings

Collaboration and Inclusion

1. Describe the skills, expertise, and unique perspectives each team member brings to the team.
    a. Stone - Has worked in a startup before, and our client is a startup so he understands what that environment needs

b. Charles - Worked on wind turbine control systems, completed embedded, signal and systems.
c. Rachel - Has had multiple internships working with control, automation, and manufacturing systems. Is currently in CPRE 288.
d. Joshua - Has taken CPRE 288, 488, which are classes for embedded systems using C. Also is the only code heavy major in the group.
e. Evan - Hands on embedded systems design experience + multiple internships in controls.

2. Strategies for encouraging and supporting contributions and ideas from all team members:
    a. Pizza
    b. Listening to the ideas, then talking about the pros and cons of the idea
3. Procedures for identifying and resolving collaboration or inclusion issues (e.g., how will a team member inform the team that the team environment is obstructing their opportunity or ability to contribute?)
    a. If a team member feels they are not being included or are having other problems with the team, they should bring it up at a team meeting so we can discuss possible solutions.
    b. If they feel uncomfortable bringing it up to the team as a whole they may bring it up to another team member who can bring it up to the group or to the person causing the issue.

Goal-Setting, Planning, and Execution

1. Team goals for this semester:
    a. By the end of the semester we should have some prototypes completed and set up to work on the IOT and bug fixes for the second semester.
2. Strategies for planning and assigning individual and team work:
    a. During team meetings figure out what needs to be worked on before the next meeting and who is going to do it. Otherwise, we have plenty of time during team meetings to get work done together as a group.
3. Strategies for keeping on task:
    a. Follow the schedule as best as we can and remake it if we need to.

Consequences for Not Adhering to Team Contract

1. How will you handle infractions of any of the obligations of this team contract?

    a. Talk to the team member and come up with strategies to prevent future infractions.
2. What will your team do if the infractions continue?
    a. If the infractions continue then we will talk to the professor and see what other options they have for us.

****

a) *I participated in formulating the standards, roles, and procedures as stated in this contract.*
b) *I understand that I am obligated to abide by these terms and conditions.*
c) *I understand that if I do not abide by these terms and conditions, I will suffer the consequences as stated in this contract.*

1) Rachel Teberg DATE: 2/13/2022
2) Joshua Baringer DATE: 2/13/2022
3) Charles Sang DATE: 2/13/2022
4) Evan Pasero DATE: 2/13/2022
5) Stone Widder DATE: 2/13/2022