SMART MEAT DEFROSTER

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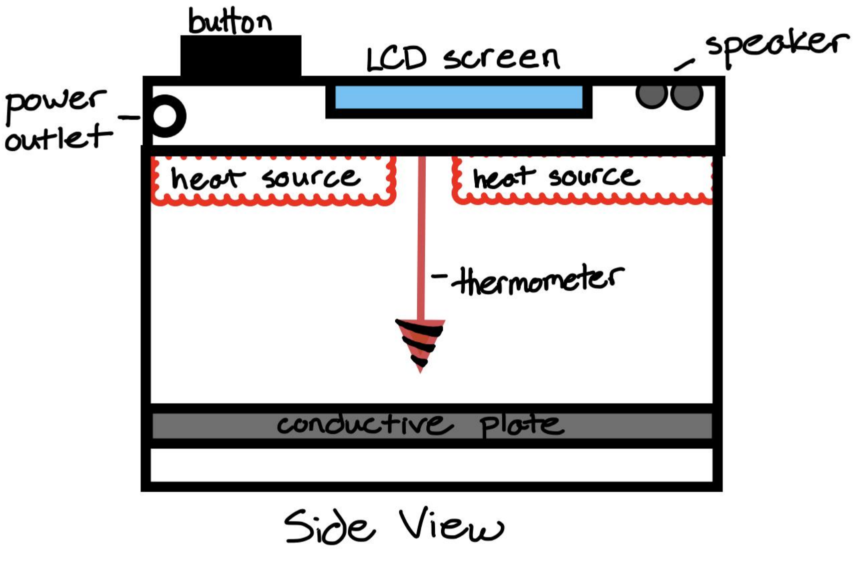
Problem:
Defrosting frozen meat is a very tedious process. There are a few common thawing techniques, each with its own issues. One, you can leave the meat in the fridge to thaw, but that takes around two days. Next, you could also heat your meat in the microwave, though this results in extremely uneven heating. The meat usually ends up being partially cooked and still frozen in some parts. Additionally, one can run water over the meat to help defrost, but it is a hands-on, tedious process that still takes extensive time to fully defrost. Lastly, one can leave the meat on a defroster plate [1,2], but the length of time varies with the quality of the plate and still takes a significant amount of time and interaction.

Solution:
We propose a meat defrosting container that uses a heating element to quickly defrost meat. It will be designed to defrost food very quickly and evenly without cooking it. The device will be extremely easy to use and provide a hands-off experience by turning off automatically once the food has finished defrosting. The container will use a heating device above and a conductive plate beneath to defrost the meat, while a thermometer measures the meat's temperature to detect when it has fully defrosted. This allows for a hands-off, quick, and versatile approach to defrosting meats.

Visual Aid:

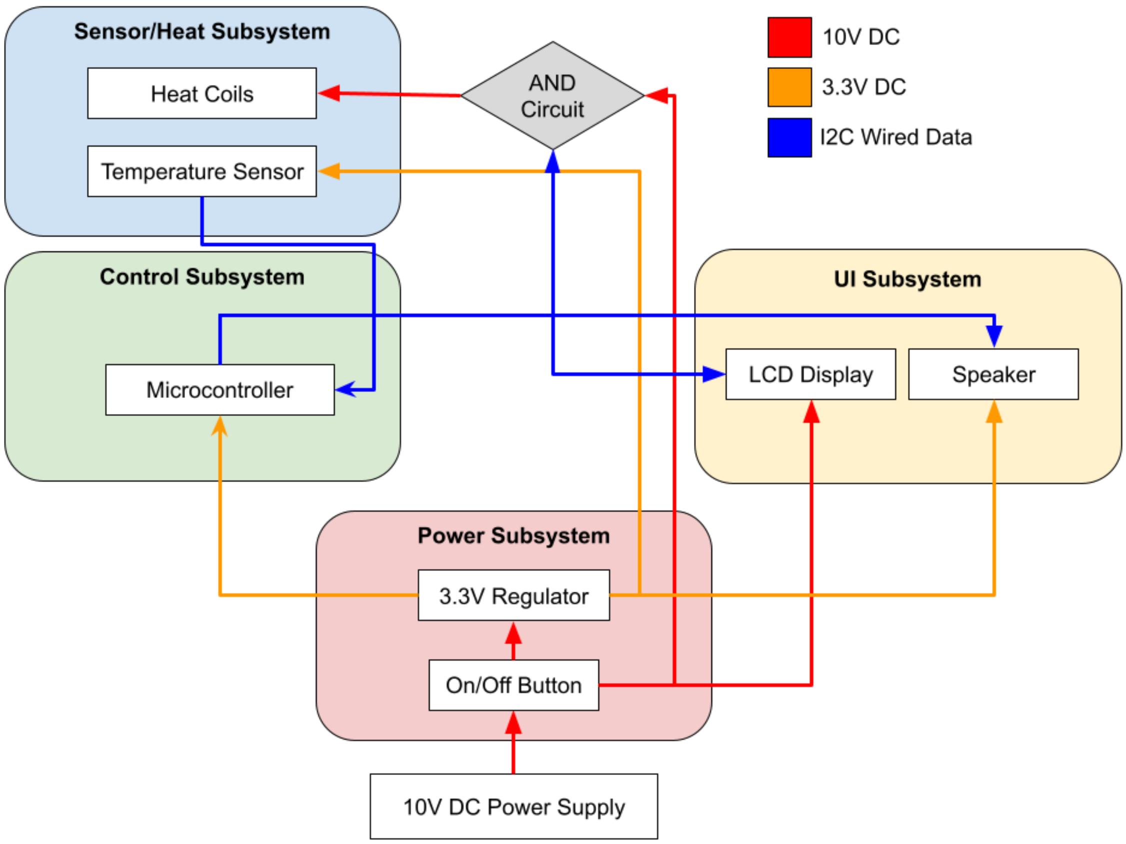


High-level requirements list:

- The device will shut off the heat when food has reached an internal temp above 35 ℉ Fahrenheit, then sound an alarm alerting the user that the food has been defrosted.
- Defrosts food faster than standard techniques (e.g. leaving it on the counter, placing food in warm water, etc.). We expect this time to be at least 20% better than standard techniques.
- The device is washable and reusable without damaging the electronic system.

Design:

Block Diagram:



Subsystem Overview:

Control Subsystem

The microcontroller (such as the ATMEGA328PB, [3]) takes in the temperature sensor's data of the current internal temperature of the meat. It passes the temperature to the LCD display. If the temperature hits above 35 ℉, it turns off the heating subsystem and turns on the audio subsystem which will increment how often it makes a noise based on how close the internal meat temperature is to 40 ℉, where bacteria on food will begin multiplying [4].

Requirements:
- State machine capabilities
- 1 data input, 3 data outputs

Sensor Subsystem

The temperature sensor measures the internal temperature of the meat. This is used to track the defrosting process and give the microcontroller the data needed for the other subsystem.

Requirements:
- Capable of penetrating frozen meats without breaking the rod
- Measure the internal temperature with high accuracy

User Interface Subsystem

The display and audio subsystem gives feedback to the user in order for them to be aware of how far along the meat is in the defrosting process. The LCD Display shows the current temperature of the meat for the entirety of the meat in the container. The audio will beep once the meat's internal temperature hits above 35 ℉ to notify the user the meat is defrosted. If the meat is kept in the container after defrosting, then the audio will beep more frequently as the internal temperature approaches the bacteria-growing temperature of 40 ℉.

Requirements:

LCD Display:
- Able to send input for hex display
- 3 hex digits

Audio:
- Speaker that can beep at an adjustable rate

Power Subsystem

A button-controlled power subsystem that regulates the power given to each subsystem. It also ensures the power given to each subsystem stays constant at the correct DC Voltage.

Requirements:
- Controllable by On/Off button
- 3.3V - 10V capability

Heat Subsystem

The heat is controlled by the microcontroller to give consistent heat to the meat for defrosting. The microcontroller will also turn off the heating subsystem once the internal temperature reaches above 35 ℉. We will use a low-voltage heating element for safety. The meat sits on a conductive plate to speed up the heating process. The plate conducts the air temperature onto the meat, and the meat temperature migrates into the plate lowering its overall temperature.

Requirements:
- Highly conductive metal plate
- Does not burn the container
- Does not damage other subsystems
- Does not alter the measured temperature of the thermometer sensor
- Stays at a temperature that defrosts

Tolerance Analysis:

One key aspect of our design that is sensitive to tolerance is the temperature sensor. Since we will be inserting a thermometer into our meat in order to gauge when to turn off the heating coils, this will be a large part of our design. It will be important for the thermometer to effectively penetrate the meat to gather an accurate reading.

For our heating element to function properly, we will need to ensure a 10V power supply (+- 1V).

We must also rely on the effectiveness of the container and seal to keep water from spreading into the electrical components, since our product will need to be used in the kitchen and washer periodically.

Ethics and Safety:

According to section 1 of the IEEE code of conduct, it is essential “to hold paramount the safety, health, and welfare of the public” [6]. As this is a product that assists in making food for human consumption, the system must be food-grade. This means that we will need to use high-quality components to provide a safe, reusable product. We will thoroughly test our product under a variety of conditions that could be experienced in the kitchen, where our device will be used. Throughout our engineering process, we will focus heavily on making sure our components are functioning properly and do not show signs of overheating, inaccuracy, etc. Additionally, since our device uses a heating element, we include warnings of this and instructions on how to use the product safely.

Sections 1.2 and 1.3 of the ACM code of conduct state that a computing professional should “avoid harm” and “be honest and trustworthy” [5]. In the case of a device that will generate heat and be in contact with food, it is crucial for us to maintain full honesty in our design process. This will allow others to verify that we are taking proper precautions, which will generate the best and safest possible product. Additionally, one of the ACM guidelines is to build things that are “robustly and usably secure” [5]. This means our design should not be able to be tampered with maliciously easily. To accomplish this we must securely wire our components (i.e. not make them easily accessible), and securely program our microcontroller to maintain proper functionality.

References

[1] “Amazon.com: Evelots meat thawing tray for frozen meat.” [Online]. Available: https://www.amazon.com/Evelots-Rapid-Defrosting-Frozen-Naturally/dp/B01K3A5X26.

[2] “What Is a Defrosting Tray and Does It Really Work?” [Online]. Available: https://www.thespruceeats.com/what-is-a-defrosting-tray-4782382.

[3] “ATMEGA328PB.” [Online]. Available: https://www.microchip.com/en-us/product/atmega328pb

[4] “The Big Thaw — Safe Defrosting Methods | Food Safety Inspection Service.” [Online]. Available: https://www.fsis.usda.gov/food-safety/safe-food-handling-and-preparation/food-safety-basics/big-thaw-safe-defrosting-methods.

[5] “ACM Code of Ethics and Professional Conduct.” [Online]. Available: https://www.acm.org/code-of-ethics [Accessed: Feb.9, 2023].

[6] “IEEE Code of Ethics”, IEEE. [Online]. Available:https://www.ieee.org/about/corporate/governance/p7-8.html [Accessed: Feb.9, 2023].