Toaster Reflow Oven (Easy Bake PCBs)

ECE 445 - Project Proposal

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1. Introduction

1.1. Objective

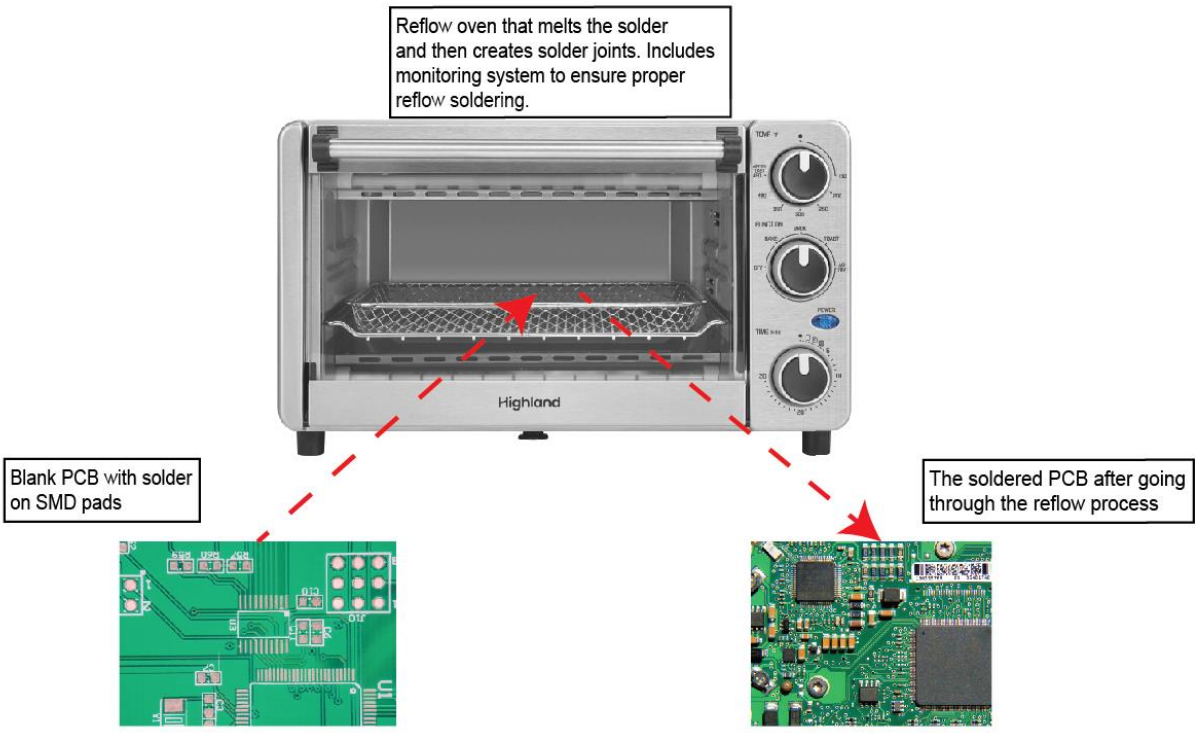
Surface Mount Devices (SMD) are electrical components used daily on Printed Circuit Boards (PCBs). These components can be as small 0.016in by 0.008in and can be incredibly difficult to solder onto PCBs. The most common size SMDs are 0402 and 0603 SMD package types and are small enough to require tweezers to be able to safely solder the components. Due to the precision required to properly solder these components, often there is lots of time wasted debugging and correcting poor soldering jobs.

To increase efficiency and reduce the number of errors, a reflow oven is a tool that can be used to solder SMD components. The issues with commercial reflow ovens is they are not an affordable tool for everyone and fail to perform to its cost. Thus, we propose creating a Do-It-Yourself (DIY) Reflow oven using almost any generic Toaster Oven. This will be built with an affordable price point in mind and be commercially available for all.

1.2. Background

Soldering is the process “used to join different types of metals together by melting solder” which is a metal alloy made of tin and lead [1]. The first uses of soldering were for jewelry, cookware, etc. and have evolved to include processes such as soldering plumbing and electronic components onto PCBs. With the rising popularity of PCBs, more efficient soldering techniques were created such as wave soldering and reflow soldering. These new technologies allowed for mass production of PCBs which allow for many people to create their own personal projects. Similar projects of DIY Reflow Ovens kits have been done before, but they are rarely in stock and hard to find parts for.

1.3. Physical Design

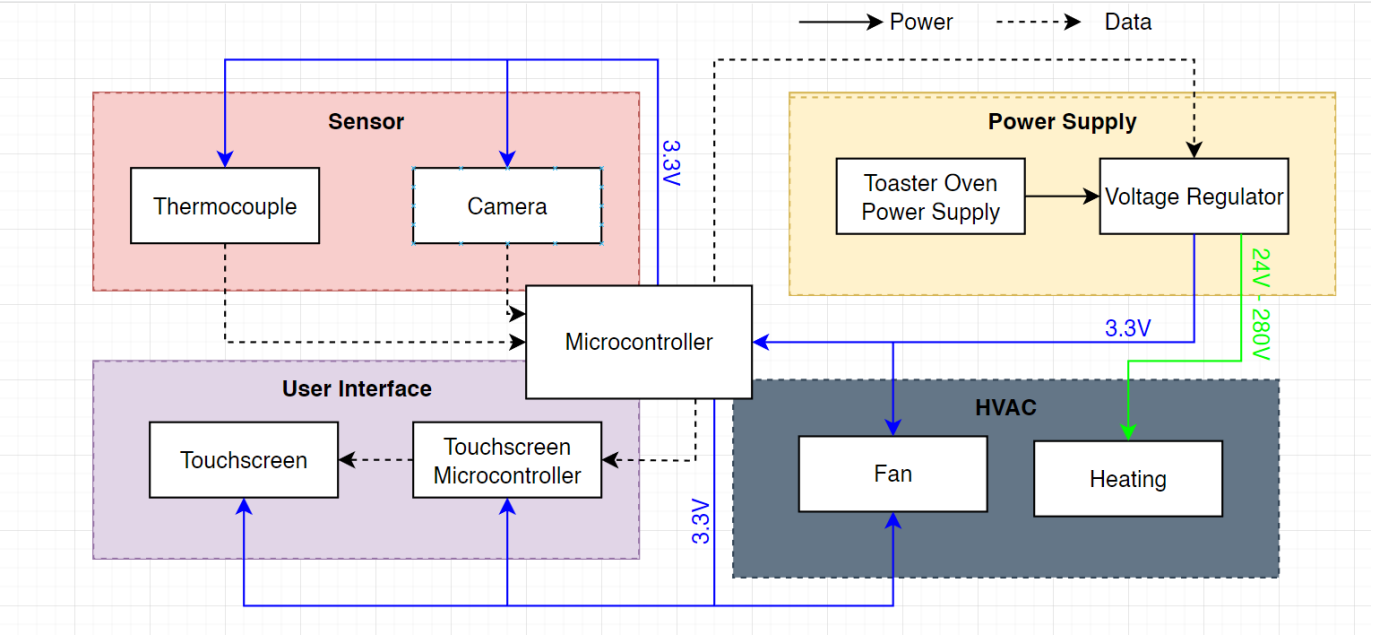


1.4. High-Level Requirements List

- Reflow solder PCBs with 10% margin of error
- Detect when a component covers less than 70% of the pad and alert the user (further testing required to determine how far a component is allowed to move and still be viable)
- Build this entire product, including the toaster oven, for under $200

2. Design

2.1 Block Diagram



2.2 Subsystem Overview

2.2.1 Sensors:

Thermocouple (Thermocouple Amplifier MAX31855):

The thermocouple will communicate the temperature inside the reflow oven to the microcontroller. The communication with the microcontroller will be using SPI.

Requirements:

- *Thermocouple must be able to relay temperature readings every 0.5 ± 0.1 seconds.*
- *Thermocouple must be accurate to within ± 2°C*

Part:

- *Thermocouple Type-K Glass Braid Insulated Stainless Steel Tip (https://www.adafruit.com/product/3245#description)*

Camera:

The camera will monitor the soldering and send to the microcontroller the data that will be used to determine if any pieces have moved out of place.

Requirements:

- *Camera must have enough resolution to detect when a component is less than 70% on the pad (~1 cm)*

Parts:

- *Raspberry Pi Camera Board v2 - 8 Megapixels (https://www.adafruit.com/product/3099)*

2.2.2 HVAC:

Heating:

The heating system will be used to heat the system quickly for soldering. The heating will follow a preprogrammed heating cycle that will be the most efficient way of soldering and will ensure that it provides the best solder joint.

Requirements:

- *Account for quick temperature changes*
- *Maintain temperatures when no change is present*
- *Be able to reach a maximum temperature of 270°C ± 10°C*
- *Must be able to heat up at a maximum of 3°C per second*

Parts:

- *Internal Coil Heating in a Toaster Oven*

Fan:

The fan system will be used to cool the system quickly for soldering. It will be used similarly to the heating component to provide cooling to the heating chamber to cool down the PCB and ensure that we do not damage components and ensure solder joints are proper.

Requirements:

- *Account for quick temperature changes and lower temperature when needed*
- *Maintain temperatures when no change is present*
- *A minimum of 5CFM fan is necessary to still be able to push air through the filter*
- *Must be able to effectively cool a 10L chamber at a maximum of 6°C per second*

Parts:

- *Internal Blower Fan in a Toaster Oven*

2.2.3 User Interface:

Touchscreen:

The touchscreen will be used as a UI component for our project so that the user can interact with the reflow oven. There will be preset settings available for the user to quickly solder with set temperature settings.

Requirements:

- *Register 97% ± 3% of user inputs*
- *Save and store preset soldering settings*

Parts:

- *Adafruit PyPortal (https://www.adafruit.com/product/4116)*

2.2.4 Power Supply:

Toaster Oven Power Supply:

The power supply will provide electricity to all required components. We will be using the Power Supply that is built into the toast oven to provide electricity to our breakout system.

Requirement:

- *The power supply must be able to supply the buck-boost converter and the heating element with the necessary voltage with a ±0.5V tolerance.*
- *Be able to power the heating element so a temperature of 270°C is achievable*

Parts:

- *Internal Toaster Oven Power Supply*

Voltage Regulator:

The voltage regulator will be a boost-buck converter that will allow for stepping down/boosting the voltage to 3.3V to power the electronics on our PCB.

Requirement:

- *The Voltage Regulator must be able to supply 3.3V with a ± 0.3V tolerance.*
- *The second Voltage Regulator must be able to supply 5V with a ± 0.3V tolerance.*

Parts:

- *LinkSwitch-TN2 (https://www.power.com/products/linkswitch/linkswitch-tn2#product_details)*

Microcontroller:

The microcontroller will talk to the Thermocouple and Camera sensors to determine if the reflow process is working correctly and will determine if the heating element or the fan needs to be activated depending on the current cycle as well.

Requirement:

- *Can determine if heat or cooling is desired for the proper reflow process.*
- *Provide 3.3V with a ± 0.3V tolerance output as PWM signals*
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Parts:

- *ATmega128 (https://www.microchip.com/en-us/product/ATmega128)*

2.3 Risk Analysis

The block that poses the most difficulty will be the microcontroller as it will have to handle the data from multiple sensors including the camera. The microcontroller must be able to use the data given to it by the camera to distinguish between components on the PCB and figure out when these components have moved to the point that they only cover less than 70% of their respective pad.

3. Ethics and Safety

Ethics and safety are something we will take extremely seriously when designing our reflow oven. With the use of high temperatures, safety is something that poses a threat. This poses a threat because the high temperatures could either hurt our user or combust our product completely. We will avoid this safety hazard by thoroughly monitoring the soldering process with the use of our sensors to prevent anything from going wrong. Another safety issue that comes about are health hazards from soldering. This includes rosin exposure which can cause irritation in the eyes, throat, and lungs. In order to prevent this issue from affecting our user, we will contain our soldering fumes to the best of our abilities and strongly suggest the use of proper labware when operating our product. We will ensure that the user of our product does not have any safety issues when using our tool and will “hold paramount the safety, health, and welfare of the public” [2]. We will also follow the ACM code of ethics stating to ‘avoid harm’ while still achieving high quality.

References

[1] “What is soldering? A full guide (meaning, definition and types),” *TWI*. [Online]. Available: https://www.twi-global.com/technical-knowledge/faqs/what-is-soldering. [Accessed: 06-Feb 2023].

[2] “IEEE code of ethics,” IEEE, Jun-2020. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 06-Feb-2023].