Smart Toaster Oven For The Future

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Table of Contents

List of Figures

List of Tables

1. Executive Summary

Many Americans use a toaster oven to make their breakfast daily. This technology impacts millions every morning when they want their nice heated crispy toast. The thing is though, there hasn't been any innovation to the product. Sure the design has been modernized over the years. But what product hasn't. In the age of smart home technologies, the toaster oven is lacking. We see everything from smart fridges to smart thermostats to smart home alarm systems. Where is the smart toaster oven though? There should be a smart toaster oven that has more abilities than a standard run of the mill toaster. That's where we come in to build it.

For this project, we wanted to revolutionize the design of the toaster oven by adding smart capabilities to it. Features such as phone notifications and the ability to control toast capabilities. We felt this was a good starting point for moving the needle in the smart toaster oven development. By no means are we going out there and building a top of the line product, but we wanted to start a revolution in the industry that is lacking behind other household appliances. We wanted to add a LCD display, phone interactions, sensors, and a built-in timer to the smart toaster oven.

The LCD display allows users to have an updated UI to interact with the system rather than dealing with outdated dials. The phone lets users know when their toast is ready. We've all had times where we left the toast in the toaster oven to do another task. Unfortunately, sometimes we forget and the toast is burned. That nasty burnt smell goes through the house and the bread is wasted. Let's not do that. The sensors are able to determine the temperature inside and possibly the dryness. This allows users to set controls based on their preference of toast. And the timer can make sure toast is ready at a certain time. For example, if you want to start your toast then take a shower and get ready for the day, you might set the toast to 30 minutes. 30 minutes later, your toast is ready when you are finished and ready to start the day. No more delays waiting for the toast to cook.

The entirety of this process can even be done remotely from a mobile device. We made our own website that includes all the functionality as standing in front of the toaster oven, without having to be right in front of it. We even had plans to make your own profile on your device so your phone knows exactly how you like your food. And of course in case of emergency you are always free to stop this process whenever needed at a press of a single button, again on your phone for ease of access and safety reasons.

2. Project Description

For this year's Senior Design project our group came up with the idea of building a Smart toaster oven. When it came to coming up with this kind of idea we asked ourselves: "What is a very simple commonly used item that we can make more intevated?" We considered a few different items such as a mailbox, toaster, and microwave in which we settled on a toaster oven. The premise behind this smart toaster oven is that it is much more advanced than a standard toaster. In addition, it provides more advanced features that you typically will not see in a household toaster oven.

There are many different designs of toaster ovens on the market. One can simply research toaster ovens on a search engine and find a list of them available for purchase. The problem with these designs is that usually one needs to spend a few hundred dollars to buy a toaster oven that has a timer or a dial to control temperature. There does exist smart toaster ovens that are capable of doing the things we described however it is not widely known and expensive to make.

2.1. Motivation:

In this section, we will go over the four major motivations for the smart toaster oven senior design project. The love of toast, an open market, the ability to expand upon our limited programming skills, and the opportunity to have creative freedom while constructing and selecting the features for the project. These are the primary reasons why we ended up building a smart toaster oven over an interdisciplinary project or a sponsored project from a company like Lockheed Martin or Boeing.

We all enjoy eating toast for breakfast. Whether it's toast alone, or with guac, eggs, fruit, or bacon. Toast is one of the staples of the American breakfast. Mix it with some greek yogurt and orange juice or milk. Now you got yourself a solid meal. So with this being a major part of our breakfast production, we thought about building something around it for our senior design project. We researched past projects and ended up deciding that a smart toaster oven would be our best bet. So with that in mind, we decided to do this project.

Almost every household has a toaster oven, so this can have a major impact on an industry that is stuck in the past. Building the first affordable smart toaster oven is an opportunity to hit an open market. Research on Amazon and Ebay shows that there aren't any advanced toaster ovens in the market that are reasonably priced. In an age where almost every product has a smart option, it's a shame there isn't a smart toaster oven. So to capitalize on it, we built the

affordable budget option for the toaster industry. Everyone should have access to this technology. Someone shouldn't have to spend almost $400 to own a smart toaster oven.

In addition to the love of toast and the opportunity to change a market, we also wanted to create a product that would be fun yet challenging and innovative. Our group is full of electrical engineering students. Our background is in hardware rather than software. Being a group full of EEs, we don't have anyone that completed CS1 or CS2. We wanted to learn a lot about coding on the spot. We had to research the different development languages to determine what's best with the board, lcd display and sensors. We also had to figure out how to set up a bluetooth connection and to notify a users phone when the toast or other food is done cooking. We all love challenges (why we all ended up being EE majors instead of business), so we were prepared to spend sleepless nights grinding away at this project (EE majors don't have lives outside of school anyways).

The last major motivation on why we decided to go for this project is the creative freedom involved with it. We didn't want any non EE majors or companies to tell us what we had to do for the project. In a similar sense to how musicians don't want record labels to influence or push them into a different direction for the music. We thought it was best that we communicate our ideas between all of us. We've all known each other since freshman year, so we know our strengths and weaknesses. An outside person or company wouldn't know. It's the reason for our 3 person team and the lack of a sponsored project. We didn't want to work with a Boeing or Lockheed. On top of that, none of us are going to be working there after graduation anyways. We all have other jobs not associated with engineering. It would make no sense to work with a company.

2.2. Goals & Objectives:

A standard toaster oven has a dial on it to control how close the metal prongs are to the burners. The common misconception is that that dial is a timer. Toaster ovens have timers and temperature gauges but are much bigger, pricier, and usually require a preheat. For our toaster oven we had to implement a digital timer that is controlled by a number pad as well as a gauge to control the temperature. As electrical engineers, we designed our own PCB, DC to AC power converter, and sensors in order to make the toaster oven more efficient and innovative.

As some extra stretch goals, we wanted to have the sides of the toaster oven to easily be removed in order for the toaster oven to be easily cleaned. The problem with some toaster ovens nowadays is that they only have removable tray at the bottom but nothing to clean in-between the sides. In addition, we wanted to put a

sensor inside to be able to detect whether or not the toast is being overcooked. If the toast is being overcooked, it will automatically shut down the burners.

As an extra design innovation we also wanted to implement a smartphone application for the taster. This app is able to control certain aspects of the toaster oven such as: powering on or off, temperature readings, and time left on the toast. In case a user steps away to do another task, he or she will have a safety kill switch on their phone.

Pros/ Cons on the Smart Toaster Oven:

Pros :

1. Fun and interesting Senior Design project.
2. Involves multiple concepts in electrical engineering
3. No sponsorship required, cost is covered by group members.
4. Technology is fairly inexpensive and easy to obtain
5. Groups members are very familiar with the technology behind toaster ovens
6. Can provide an innovative product available to the common consumer.
7. Challenges the group with design constraints.
8. Project can alleviate certain safety concerns

Cons:

1. Each member is an EE student, programming is on the group's weaker side.
2. Requires a bit mechanical design work

2.3. Function of the Project:

The project would function as follows:

1. Set the temperature of the toaster oven using either a dial or numberpad

2. Set the timer of the toaster oven using a dial or numberpad

3. Place toast in the toaster oven and pull spring loaded prongs down.

4. Monitor the toast through visual or through the smartphone app.

5. If the toast is ready either hit the eject button on the taster, the button on the smartphone app, or simply wait until the timer runs out.

2.4. Engineering Design Specifications:

Engineering Design Specifications are a documented requirement, or set of documented requirements, to be satisfied by a given material, design, product, or service. In this section we discuss some of requirements that we put to the test with our Smart Toaster Oven Design.

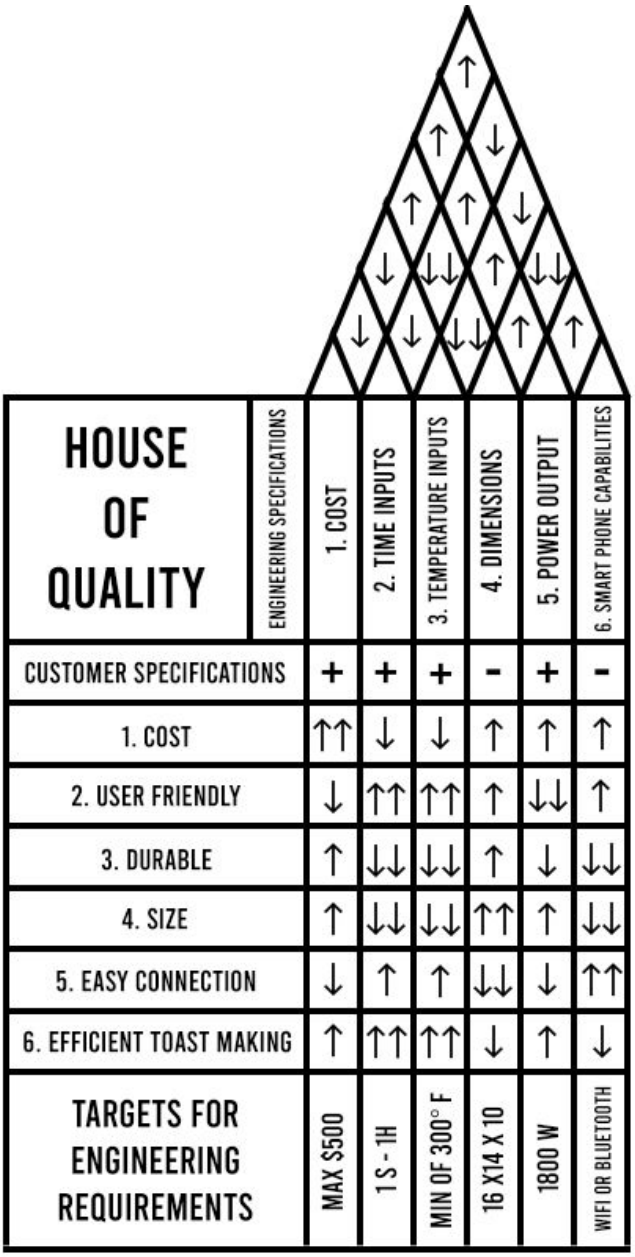
Table 1: Engineering Design Specifications

Specification	Justification
1. The toaster oven should be able to operate with a desired time between 1 second and 1 hour.	This spec shows that the user has a wide range of time selection when using the toaster oven
2. The toaster oven needs to be able to heat/ preheat to a minimum of 300 degrees.	This spec shows that the toaster oven can heat up to as viable temperature for multipurpose cooking
3. The toaster oven will need to be able to be turned off by a smartphone device within 5 seconds of issuing the command from the smartphone.	This spec shows the convenience of having access to the toaster oven with the use of your smartphone device
4. The user will receive a notification from the toaster oven to their smartphone device within 30 seconds of completed tasks.	The notification updates will let the user know when certain tasks have been completed such as preheating or the timer running out/

2.5. House of Quality

The house of quality in figure 1 shows the mixture of customer and engineering specifications that we aimed for in this project. Along with it, we have targets for engineering requirements.

Figure 1: House of Quality Table



One of the best tools for various professions to have access to would be the house of quality. It is broken up into consumer specifications, as well as engineering specifications, and the correlations between each variable. When it comes to the toaster oven, we have decided on six various aspects that could affect if a customer would buy this product or not. The first and foremost thing people look at first is the price. It obviously takes a good deal of money to prototype and create these devices, so the price to build must be lower than the selling price in order to make a profit. Next is how user friendly the device is, which is a big focus for us since we wanted to make it as interactive and smart as possible. The connection of the device would fall in this category as well. After that are some physical components such as size and durability. This is important in deciding if we want to build a toaster or a toaster oven. Lastly is the efficiency of the device and if a common user is able to access it with accuracy every time.

When it comes to engineering specifications, we also choose six as to balance out the tables. Firstly, as previously mentioned, the cost is one of the first things to account for. This would be the best example of positive correlation, since when the cost of making the device is higher, the consumer price for the device will also be higher. After that we have some of the inputs that are the main features of the toaster, mainly in the time and temperature domains. Following is the dimensions of the device, in which many forms of prototyping will take effect in order to balance out all the variables listed. Next is the power output of the device, which would control how fast and what quantity of food can be toasted. Lastly we would like to include some form of smart phone connection with the toaster, aiding to the smart nature of it.

The house of quality in figure 1 best demonstrates the relationship between the marketing and the engineering design side of things. The consumer of a smart toaster oven expects certain things. They expect it to be low cost, user friendly, durable, the right size, easy to connect, and efficient. But at the same time, the engineers need to make some compromises, or the final product will not be ideal. There has to be limits to the cost as parts, manufacturing, and research and development cost money. How user friendly the design can be depends on the engineering of the final product. The user comes first, but there are things that might not be able to be implemented. The durability might limit things such as the touch screen as it wears down over time. How efficient the product is depends on the parts used along with the engineering of the final product.

On the bottom is our targets per engineering specification. This gives us a goal to work towards. This must still fall within the customer specifications, however there must be achievable details mentioned or else the project planning stage would be too vague and a company looking to buy an idea would never buy into it. These precise achievements are the foundation of a great project

3. Design Constraints & Standards

In this section, we go over the design constraints and standards for the smart toaster oven. These include personal standards and economic, time, environment, social, political, ethical, safety, manufacturing and sustainability constraints. All of these are based in different subsections and written in great detail so that they are laid out properly for the project. For the safety of ourselves and all others who are to come in contact with the project, it is important for us to both identify and carry through with all the constraints and standards we have either made for ourselves, or have been laid out to us by a bigger company.

3.1. Design Standards (Personal):

From a design standpoint, one of the first things that we wanted to show off from the system is the LCD display. This display contains an easy to use interface on the front right part of the toaster oven. These contain multiple options so that various preferences can be accounted for when considering how to heat up something in the toaster oven. This part also connects with an app on a cellular device that is able to control the different settings of the toaster oven via wifi or bluetooth. This includes setting the initial temperature and timer, as well as alerting the user when the food is ready or if some abnormality has occurred and thus the toasting process has momentarily ceased. Another feature we wanted to add on the outside of the toaster oven would be how easy it is the clean it after any use. A removable tray would be useful in this situation for the food, however we need easy access to the entirety of the toaster in case any pieces of food fall below this removable tray.

Inside of the toaster oven, some of the key items include the burners, sensors, and timers. Firstly, the burners are optimal positioned, based on the dimensions of the toaster oven, to efficiently toast the item inside of it. There is room for multiple items, yet they should all toast evenly. That is why the sensors are very important in this case as well.

There are various ways the sensors can be used to determine when the food has reached a certain point. The most common thing would be temperature, to make sure it is toasting at the selected temperature. Another is the color of the toast, which would be the most user friendly option, since we are able to physically show how dark the toast will end up after a predetermined time under a certain temperature. Another is how dry or hard the toast is, since moisture disappears as the bread is toasted. We also had to look for the most optical location for these sensors, as to not disrupt their data collection, especially since they would be right next to a fairly concentrated heating surface.

Same would go for another irreplaceable aspect in design would be the timer. Once again, it had to be placed in a location where it can accept the user's input for a time, then continue through that time without being disrupted by the burners while they are active. However, they must also accept an immediate stop in case some error were to occur, or a safety hazard is imminent, or simply if the user wants to cancel the toasting earlier than initially expected.

3.2. Economic and Time Constraints

Monetary limitations can upset on production of a venture. We needed to limit as much as we can so every group for the venture gets an opportunity to arrange what they need for their needs. The financial limitations that are being forced are that the toaster must be an easy to use working framework fit for cooking an assortment of things. It likewise should have a creative method for controlling the gadget and not surpass a spending limit of 500 dollars. This information is stated in our House of Quality as an engineering requirement for the overall cost of our system. Therefore one can see how this can correlate with the other specifications and constraints laid out for us.

These monetary limitations influenced our budgetary circumstance since they constrain us to buy costly items conceivably leaving us with less cash expected to purchase different parts. Having more cash can enable us to sidestep effective structure and whenever thought cautiously may conceivably bring a superior and less expensive item relying upon the kind of parts one employs.

When staying aware of different items available we needed to figure out how to limit the expense of our undertaking. This helped guarantee that we have a working item at a low cost to utilize it along these lines expanding its prevalence. Alongside financial requirements there are time limitations. Because of the idea of this venture we are restricted with a 2 semester, around 8 to 9 months, to structure and manufacture this task. That time span isn't a time allotment where all undertaking individuals, especially with their current daily schedules, will have their complete consideration to the task due to scholastic obligations.

Alongside the info stated previously, different orders have an alternate calendar to maintain so the timetables for plan and requesting parts are out of match up which can cause issues with ease of structure and development of the toaster broiler. This blocks on the structure, testing and time to construct it, and can cause a "hurried" venture. Making items on the business sectors take extensively additional time and consideration so this would be one significant drawback if the task were to contend with items available.

3.3. Environment Constraints

The Toaster Oven is to NOT harm any environment including inside a home or outside area. This project goal was to make the difficulties of cooking easier and help improve day to day life. This toaster in most cases will be operating on a kitchen table plugged into a wall outlet. It will not be near water or other elements that can potentially cause harm. The toaster would also be able to operate outside if a wall outlet is available to provide power.

3.4. Social Constraints

Social imperatives in this task cover with different limitations for our venture. On the off chance that the smart toaster were to be sold available there are various safeguards it must take to work and have great social remaining among buyers. The smart toaster must not harm foundation, condition, or people. These are nearly "simple" understandings particularly with regards to the social part of the undertaking. On the off chance that the toaster were to harm any of the conditions recorded above there could be social kickback that could prompt a diminishing in prevalence also, thought to purchase and utilize our undertaking. Our objective for this task or any item is to have great social remaining among the clients that would utilize it. We would prefer not to utilize materials that are unsafe or can cause social kickback like utilizing a specific modest part from another nation that is under investigation.

3.5. Political Constraints

The political imperatives related with our undertaking cover with other imperatives yet at the same time have a colossal task to carry out. The requirement of the toaster oven must not harm framework, condition, or people is an extremely political limitation. Each of the three conditions particularly foundation and condition are politically persuaded now and again in this nation. On the off chance that the toaster oven were to harm open framework that can prompt individuals being retained from a specific utility or basic piece of working in this nation. For instance if the toaster oven were to harm someone holding a political position it will definitely hurt the reputation of the company that produced it.

There could be a tweet sent out by Donald J Trump. And we know how people react on Twitter to the tweets that the president sends out. There could be global implications over a toaster oven. Our government might create more standards and legislation based around the production of the smart toaster ovens which would cause more budget and time constraints for research & development along with manufacturing and marketing costs. This could also alienate half of our

target audience as the US is almost split 50-50 between Republicans and Democrats. The toaster must not harm a politician since they are in the protected class. They have their own healthcare anyways, so in the end it doesn’t even matter.

3.6. Ethical and Safety Constraints

The ethics of designing the toaster oven should have a high priority when designing. "Compromising" so the activity gets completed isn't an alternative with regards to the imperatives that the toaster oven must not harm framework, condition or people. An explanation of these conditions couldn't be met could be the as a result of absence of time to complete the task. Realizing that anything can turn out badly in any anomaly of a circumstance, we would firmly prompt that people be at a safe distance from the toaster.

3.6.1. Fire

With any electrical project, the risk of random sparks from overloaded or incorrectly placed wires is always something that could occur. This could lead to fire hazards in the home which is something that needs to be avoided. That is why we must be very knowledgeable in designing this project or else it could greatly injure ourselves or others in the process.Other than injuries, there is always the risk for lawsuits. This is why we have taken the fire safety of this project very seriously.

3.6.2 Overheating

Toaster ovens naturally get hot if not insulated correctly, and since we are adding various electrical components to make a more advanced toaster ovens, this risk increases significantly. In modern appliances, safety for use is an important factor. When building the toaster we have taken great strides in modern safety. Overheating of a household appliance can lead to larger issues than lawsuits. This is why safety is a number one concern of ours. To aid this we had to insulate the toaster oven to make sure it is safe to operate the touch pad even if the toaster oven is currently active. We had to make sure that the heat does not transfer into the touch panel. This could cause burns for the end user, which would not be good.

3.6.3 Overcooking

It is immensely possible one could forget that they are currently toasting bread in the toaster oven. If no timer is set, then the continuous toasting process could lead to not only potentially fire, but a complete waste of bread, thus a waste of

potential profit. To aid this we made a website that can go along with the toaster oven. In this case even the smell of burnt toast could alert a person and they can remotely eject the toast via the app to keep a safe distance from the toaster oven. Hopefully it never has to come to this though since we would like to include sensors as well to determine if the toast is overcooked. If this occurs, the sensors will let the toaster oven know and the burners will be shut down automatically.

3.6.4 Burns

As previously described, toaster ovens get extremely hot in order for the toasting process to occur. Not only can this heat damage the food and toaster, but it can also damage the user. The two most probable moments when one could burn themselves with the toaster oven would be when the toaster oven is finished and the user wishes to gather their food, or if the user chooses to preheat the toaster and they are about the place the food inside of the oven. The burners would be the main cause of this, and direct contact with them is highly not recommended, however there is another way this can occur. Since the heat is enclosed in a box has it toasts the food, depending on how the rest of the toaster oven is made, the sides of the oven could start reaching temperatures that could cause burns as well. This situation is a bit harder to move around, and varies between toaster based on the dimensions of the actual oven.

3.6.5 Electrocution

As with any electrical component the hazard of electrocution is always eminent. In this case, the cause of this is once again the burners since the heat is generated via high voltage electrical currents. Therefore, although it may not seem like it, one is at a higher risk in this case, as compared to burns, since the currents should always be flowing whenever the device is being powered. The easiest way to avoid this is to not allow the current to flow into anything you are holding, such as a piece of silverware made of metal.

The severity of the injury depends on the amount of materials used. A singular piece of metal would short circuit the device, more so causing a burn, but the real damage comes if two metal appliances are used. For example, using a pair of metal tongs or chopsticks. If both are attached to the circuit, then the current could potentially go up the utensil, through your body, past your heart, and out the other end. This is potentially fatal as a small shock to the heart can lead to death. Therefore it is undeniably safer to gather the toasted food with some non conductive material, such as rubber gloves.

3.7. Manufacturing and Sustainability constraints

Manufacturability limitations confine the parts of a plan to something that can be fabricated. For our situation the assembling will be restricted to administrations that are accessible to us. Maintainability limitations are particularly imperative to our plan in light of the fact that the smart toaster is intended to be used in regular home environments, which opens it to the components. Manufacturability and manageability requirements may either supplement or restrict one another. For a situation where assembling of a chosen part improves the supportability would be viewed as a positive correspondence. Be that as it may, in numerous applications the inverse is valid and manufacturability and maintainability imperatives restrict one another.

3.8. Applicable Standards

This sections all applicable standards that are to be considered in a toaster oven. We will discuss electrical, power, software and PCB standards that need to be addressed. Each are detrimental to the project design and they consist of the core aspects of the project. We will also be looking at pre existing standards for toaster ovens to see what is common place for them.

3.8.1. Electrical Standards

This area contains the use of electrical components for designs such as this determines how they should be used efficiently while thinking of the safety of those building the product, testing it, or using it in their everyday life. Electrocution is always a threat one faces when messing around with any electric component connected to a power source, especially one inducing a high voltage current The electrical standards are one of the most important being that they are the ones that physically go into the building and cause the device to operate as intended. Knowledge of these standards also aid if anything unexpected occurs and troubleshooting needs to occur.

3.8.1.1. Power Standard

Power is very risky being that too much could induce risk to the user, yet not enough power results in the product not working as intended or at all. This is why power standards in place it in order to place the well being of the user above all else, while still allowing for efficient usage of the devices that require the aid of some power source. We also have our engineering requirements from our house of quality that we can use as a foundation and safety net in determining how much power we should be using in an experiment such as this.

3.8.1.2. J-STD-001 F: PCB and Soldering Standard

The J-STD-001F is an industry standard that endorses rehearses and prerequisites for the production of bound electrical and electronic gear. The reason for this standard is to depict materials, strategies and acknowledgment of convention for the completionion of electrical patched hardware that will be both safe and of a high caliber. Through the utilization of this report it will give quality control to fabricated items that contain a patched electrical and electronic get together.

There are two different reports that might be utilized related to this standard that help give lucidity in its execution by giving both visual help and extra data. IPS-HDBK-001 is a handbook and guide intended to enhance J-STD-001F and gives extra data identifying with the procedures and "how and why" the current procedures are being utilized.

IPC-A-610 F is a standard that shows a gathering of visual quality for the acknowledgment of prerequisites for electronic Gatherings. This standard contains arrangement of electronic hardware that is resolved before the end-thing use. There are three general classes that are utilized to portray the last item and they are controlled by utilitarian, Performance, intricacy and different contemplations that identify with the nature of the item being delivered. It is conceivable that gear can have covers between classes.

Class one alludes to General Electronic parts and incorporates items where the significant necessity is the usefulness of the last get together. Class two alludes to Hard work Electronic Products and incorporates items that require long enduring execution and expanded life. Class three alludes to High execution Electronic Products and incorporates items that require a proceeded with high execution or elite on request.

3.8.1.3 IEEE 802.11

IEEE 802.11 is the standard related to WiFi. This standard has been refreshed various occasions throughout the years with the particular rendition assigned by postfix, for example 802.11n. This addition is utilized to recognize Wi-Fi gadget backing and abilities. The more typical forms being used today are appeared in Table 3.2.7.1-1. While there are other distributed adaptations, some prior and some later, they are not usually accessible and there I no push to help them. Data transfer capacity esteems are excluded from the table. Transmission capacity isn't of essential significance to the smart microwave since the real measure of information being traded ought to be little

Table 2 down below shows the different WiFi standards with the range & frequency for 802.11.

Table: 2 Wi-Fi standards (common)

802.11	Range (ft)	Frequency (GHz)
n	2.4	235
n	5	235
b	2.4	110
g	2.4	120
ac	5	110

Since 802.11b and 802.11g are more established norms going back to 1999 and 2003 separately, regardless they see some utilization in ease customer items and in more seasoned hardware that has not been supplanted because of cost. For instance, almost certainly, some Internet specialist organizations may even now supply remote passages that lone help the 802.11b/g models. IEEE 802.11n is exceptional among the form indicated on the grounds that it underpins both 2.4GHz and 5GHz frequencies.

This ability is called double band support. It additionally has twofold the usable scope of different renditions, even the more current 802.11ac. The most recent standard that is seeing expanding arrangement, 802.11ac, has the capacity for higher data transfer capacity contrasted with the prior forms, however transmission capacity is certainly not a significant thought for this undertaking. Luckily, 11ac gadgets regularly additionally bolster 11n Wi-Fi at the very least.

3.8.1.4 IEC 60335

Being that a lot of toaster ovens are produced in China, it is wise to do research on the standards looked there for these products. One of these standards is IEC 60335, which was developed in order to maintain a safe environment in the home or anywhere the designated product is used at. We specifically looked at IEC 60335-1 and IEC 60335-2-9. Firstly for IEC 60335-1, it is a standard that regulates the voltage of the device for safety reasons dependent on the user. It states that any form of toaster appliance shall not be allowed to go over two hundred and fifty volts worth of electricity within a single phase. This is then followed by another safety feature identified in IEC 60335-2-9. Any portable electrical product that is specifically able to roast, bake, or grill must be inspected

for safety purposes during said activities in order to prevent any damage to the user.

3.9. Software Standards

This area contains all standards relating to software related needs referring to our project. This is immensely important in order to absolutely define some syntax used in the coding language being performed. The C language will be the bassline of all of our research.

We wanted to start with the C language since that is the software language that all three of us are most familiar with. Other programs that we have learned so far that we could be using include Python, Assembly, and Java. Collectively though we all feel the most comfortable with C. Being that we all are electrical engineers, this area is one of the weakest for us. That is why this area is so important so that we may familiarize ourselves with the standards of the languages before diving headfirst into it.

3.9.1. C Language Standard

ISO/IEC 9899 is an International Standard which discusses the various ways furthermore, strategies you can utilize the C language and how to actualize it. The standard discussions around a few distinct segments about C: Scope,Terms and definitions, conformance, condition, language, and library. The Standard's degree goes over the themes like the portrayal of C programs, the sentence structure, and semantic guidelines for interfering with programs. The standard beginnings off characterizing watchwords that are utilized inside C program.

This standard applies to programming structure which will be utilized in the product part of our task. There are a rundown of definitions and decides that have been given in the standard that will help comprehend the standard completely. In the standard there are various situations that are characterized. An unattached condition is the place a program execution can work "with no advantage of a working framework."

The standard has a segment in it that clarifies the language, subjects like documentation, ideas, and changes. The standard clarifies various sorts that can have qualities to them. The sorts run from whole number, character, drifting, exhibit, structure, boolean, and pointer types. These all have their own qualities and can be utilized in explicit sorts of executions.

4.0. Project Constraints:

- Budget - Having a larger budget allows for more testing
- Time - This was researched and built under a year. Some products take years to develop and perfect
- Availability - Each member is busy with school, work, clubs, and hobbies. This restricted meeting times and amount of time spent on the project.
- Manufacturing ability - We do not have access to industrial equipment like larger companies do
- Power - Must be able to toast bread to desired crispiness while still allowing the toaster oven itself to be safe to touch.
- Dial/Numpad - Must be user friendly and allow to user to utilize all aspects of the toaster oven.
- Sensors - Must be allowed to take a specific input, either time or crispiness, and eject the toast once the user inputted desired goal is met.

4.1 Budget

As a budget, we were looking to spend around $500 for the project. This can get us most of the standard parts and the shell of a toaster oven, but it stifles innovation. If we had more of a budget, we might be able to test different parts and add additional features to the project. The problem is though that we are 3 college students with little funding. So we have to keep costs low so that the project can be affordable for all of us. It's not worth taking out a loan for a project prototype.

4.2 Time

Time wise for the project, we had about 9 months to research and develop the project. Half of the time was spent towards researching and writing a paper(this one) while the other half was spent towards building the smart toaster. In a real world application, there would be more time dedicated to the project. Especially if its purpose is to sell at the retail market. Multiple prototypes will be created, different parts tested, and the project would be optimized for both cost and the overall user satisfaction.

4.3 Availability

Availability wise we have constraints for both how much time can be put into the project and how long the project is. All 3 of us have really busy schedules outside of school so planning out meetings, researching, and building can be a hassle.

Alex works full time, is part of the ROTC, and is taking 4 classes. James is taking 5 classes, is in the marching knights, and competes on UCFs esports team. Ryan works full time, is taking 4 classes, and is training for ultramarathons. Each individual has to plan out when others are free, and with work schedules and limited time during the day it can sometimes cause conflicts.

4.4 Manufacturing ability

While we have access to the tools UCF offers, we do not have the capabilities of large companies. The manufacturing ability is thus limited compared to what our market competitors have. Since this is a prototype, it shouldn't be too much of an issue. But if the product is to be brought to market or sold, problems would arise as production time will be involved and at the current moment is an unknown variable.

4.5 Power

We have to strike a balance when giving the toaster oven power. Sure we have to make sure the toast is crispy, but we cannot supply too much power so that it possibly endangers a user. This is something that is researched and tested so that its safe for everyone to use.

4.6 Dial/Numpad

We need to make sure that our dial & or numpad is user friendly. It can't be too complicated as people wont read the instructions and become confused. At the same time, if it's really scaled back, it might lack a lot of features that we would want to implement into this project. Finding that competitive balance is key. And when we researched similar products on the market, decisions were made on what to use.

4.7 Sensors

We needed to find the sensors with the most appropriate thresholds. Some might not measure correctly in extreme heat, while others might report wrong. This also comes back to budget as we needed to find ones that are affordable so that we don't end up going over our final budget. This is something that is carefully researched under part selection to ensure the project runs smoothly.

5. Operation Manual

In this section, we go over the operation manual. This is how we intend a user will operate our smart toaster oven. We go over the process from plugging in the unit to producing the final toast or cooked food in vivid detail. There is a section about how the user uses the LCD display, creating a profile, and getting notified when the final product is ready.

Using the smart toaster oven should be easy for each user. So to do that, we really dumbed down the design of a traditional toaster oven. Before we get started though, it has to be plugged in so that the unit is powered on. Surprisingly people forget to plug in electronics and complain when they don't power on.

First, a user has to open the door to the oven. Next they put whatever they want to toast or cook inside the toaster oven. After that they close the door of the oven and they are all set to start cooking. To cook with the toaster oven, a user will have multiple options available to them on the LCD display. The first setting allows the user to either select a saved profile or create a new one. If they have to create a new profile, they first input their name and then go to the next screen which is where they establish a bluetooth connection. The user then goes and connects their phone to the toaster via a bluetooth connection. This will now allow for notifications for when the food is done. Now the user is brought to the begin toasting screen. A user now goes to a screen where they select the desired temperature for cooking. Next they go to a screen where they select how long they want to wait for their food to be done.

The user can now do whatever he or she wants for the duration of the time. When the timer ends up hitting 0, the user receives a notification that the toast or other food is now complete. The toaster starts beeping as well so the user knows it's done just in case they aren't near their phone or forget to check. When they get back to the toaster, they open the unit and can grab the food. The unit stops beeping and can now be turned off. The user in this instance can now sit down and eat the toast or other food that was cooked. If they want more food, they can continue to repeat the process until full.

Cleaning the unit is also easy for the user. They first have to make sure that the unit is unplugged. After that they can open up the smart toaster oven and remove the tray in the center of the unit. They can hand wash this or put it in the dishwasher. After that they can use a household cleaning product and scrub both the inside and outside of the oven and remove the crumbs. It's suggested that a user goes through and cleans the smart toaster oven at least once a month. This ensures that the product is clean and safe to use. Now that the unit has been scrubbed down, the user can now put back the tray table. Close the oven door and the unit is ready to go once again

6. Demo walkthrough

In this section, we go over the demo walkthrough. Through this we explain the components,user perspective, different mobile interactions, and the wordpress website. The demo walkthrough is taken directly from the demo video which we created. The full demo video is avaialble on the Senior Design website or https://www.youtube.com/watch?v=kMSAq4fz-uk

6.1. Explanation of components

The first thing shown is our board, the Arduino mega, it uses the 2560. Next shown is the original PCB. We designed this PCB and ordered it online with the task to mimic the original. This has the 2560 soldered onto it, but due to virus delaying everything when we found out there was a slight error, we were unable to get any new parts in time. We were able to flash the lights on the board but couldn't get code onto it. Therefore, we finished the project on the Arduino. There's a lot of wires connecting our project together so next we have some connections to go through. Firstly, the way this is connected we have a power coming into the toaster connected to the wall outlet. It starts by connecting to one end of the solid-state relay (which controls the AC flow). The next line shown (white and red) are the heating elements. Then there are two ends that are connected to the Arduino mega. The program on the board sends a 5v dc signal to open and close the relay to control the power. We power the Arduino via a 12v dc adapter. The thermocouple is connected against the toaster oven's wall to promote accuracy for temperature. The Wi-Fi chip is connected through wires some wires as well, so we set it up against the wall alongside the thermocouple to get the best signal. All these components are inside of the toaster oven, however for the purposes of the demo everything was taken out so that it is easier to follow how everything is connected and be shown on camera. There is a shell that goes over all these components so nothing electrical is shown to the user which could greatly degrade the quality of our oven. Without the shell the wires would be lose which would make them more easily breakable, as well as having various safety hazards present.

6.2. User perspective start

From the user's standpoint, looking at the front of our toaster while it is plugged in shows the LED display. It defaults to welcome page which welcomes you and askes the user to press pound to continue the toasting process. After you press pound, it asks for a preheat temp and to once again press pound to proceed. It Should take 10-15 seconds to turn on the heating elements and preheat. The bars inside the toaster oven will begin glowing red to prove this is occurring. The

next step the user must input on the pad is the time. The led display asks for the time and the user must press their desired time and press pound. Then the countdown begins. When it finishes, it says done and enjoy. You can always enter more time by pressing star (which acts as the back button). If not, the toaster will automatically turn off slowly for safety reasons after about 30 seconds.

6.3. Mobile Interactions

If one uses the make toast using our website we have created, the first step would be to make sure the ESP module is on and connected to the device that will access the website. Move over to the website, it has various toast profiles to choose from. This demo uses the lightly cooked one. Pressing it opens a new prompt saying the light toast is cooking, it will be ready in 3 minutes, and enjoy! Pressing it also sends the signal to the toaster to begin the preheating process as well as stating the timer countdown. As shown in the demo, the bars are heating up since they are slightly red and the timer has already begun counting down from the three-minute mark mentioned in the website, so we know the toast profiles are working. One can also change the time of the toaster oven. Again, by hitting star (back) we can change the time left for the toast. In this example we change it to ten seconds. Therefore, it counts down from 10, says the done enjoy message, and then it's the same deal as before with adding more time or waiting 30 seconds for the toaster to rest automatically.

6.4. Website Breakdown

There is a break in the video where we go over the different labels on the led screen, since the video might not have captured the glowing screen clearly. Various messages from the screen are shown in picture form to ensure it working capabilities. Now for our website we used WordPress with Elementor. If you go under plugins in WordPress, you can see how Elementor is connected to it. To check out the actual site one must go to our link. There are 5 main sections: home, toast profiles, about the toaster, the committee, and results. First the home page is simple and sweet. It contains a nice picture of our toaster oven with a little intro of who we are and a nice quote the get people in the toasting mood. Next is the profiles which include light, medium, and heavy cooked toast. Each has the info pertaining to each profile regarding time and temperature and even a picture of how the resulting toast will end up as. These buttons will also start up the toaster oven assuming you are connected to our Wi-Fi chip. Next there's a section about the toaster. There are some skills we learned invested in

it as well as other topics of interest concerning our journey of building this device. Then we have a thank you to our review committee showing what professors are helping us out and going to be our judges. Lastly, we have our results which shows some pictures and diagrams of our story from the beginning of our project up until now. The demo ends alerting people that food cooked via our toaster oven through this video is in fact some great toast. One might even say “Nice” after a very satisfactory crunch occurs in the first bite followed by some chewing.

Figure 2 is an image of the different sections of the toaster website: theacreport.com. Home, Toast Profiles, About The Toaster, The Committee, and The Results. Each section was made with elementor in WordPress.

Figure 2: theacreport.com

7. Research

For this section of the project, we researched everything we need to know about the smart toaster oven. From the current competition on the market to the different parts that we would like to use on the project. Each is outlined and identified down below.

For the competition, we mainly looked at products on Amazon. This is due to the nature of e commerce in todays online world. Amazon sells pretty much every product, and any company can sell on Amazon (Amazon does have some restrictions, but not for our industry). Therefore, any company that has a quality smart toaster oven should be on Amazon.

For the parts, we took a look at a few different models for each individual part. We outlined the cost and specs for each one and weighing in on the pros and cons before deciding what is used for the final project. If there is a toss up on parts, we might order both (depending on the cost) and test them out to see what ends up working best in this situation.

7.0.1. Technology Investigation:

As a group considered of all Electrical Engineers we are dedicated to make this toaster oven as innovative as possible by revamping the control aspect of it. A typical toaster oven will require the use of knobs to control both temperature and time as well as no alternative way to control the device. The smart toaster oven device features a new way to control the device, give notifications to the user of completed tasks, as well as control from your smartphone device. More detail and different ways to implement this will be discussed in the following sections.

7.0.2. Previous Senior Design Projects

In our research we didn't see anyone do a smart toaster oven before in a senior design project. The closest project that kind of gave us inspiration was a project done back in spring 20915 called the Memrowave. The principle reason for this task was to make a more astute and increasingly self-sufficient microwave fit for cooking different nourishments effortlessly and constrained client input.The Memrowave was intended to be a microwave that is increasingly associated and self-governing. Using scanner tag checking, cooking arrangements dependent on the code of the nourishment bundle is sent straightforwardly to the Memrowave, enabling it to start the cooking procedure once the entryway is shut. Also, epstien didn't kill himself. Alongside standardized identification checking, a nourishment item database was arranged to log all the particular data expected to cook food sources. The Memrowave additionally can send notices to the client's telephone

or cell phone, which enables the client to meander as the nourishment is being readied.

After explaining the smart microwave it is clear are project does offer some similarities as well as some differences. Both of the projects have a revamped interface in this case being a touch screen display. In addition both projects will offer an sms text message or email to their device. As for the differences the microwave has a barcode reader to scan food projects and have a way of quickly setting the time for those cooks. Our project does not have this feature however it does have smartphone control so tasks can be carried out such as turning off the toaster oven.

Figure 3 is an image of a past senior design project that we wanted to take inspiration from. It shows a microwave that has smart capabilities added to it.

Figure 3: Previous Senior Design Project

7.1 Analysis of Competitive Products:

Checking Amazon, there is clearly an open market for a real smart toaster oven. Most of the smart toaster ovens on the ecommerce store lack smart features that consumers acquire today. Most do not have apps, none have advanced LCD displays, none have specific temperature dials.

The most advanced feature these toaster ovens offer is an LCD display which shows different browning levels. On top of that, most of the smart toaster ovens are expensive. Most start around $100 for a typical toaster oven. One article was

found however where someone created an app that allows a user toast his or her from their smartphone. The project appeared to be in development but nothing has really come out of it.

Figure 4 shows the Tovala Gen 2 Smart Steam Oven. It's one of the comparable ovens on the market.

Figure 4: Tovala Gen 2 Smart Steam Oven

7.1.1 Tovala Gen 2 Smart Steam Oven

The Tovala Gen 2 Smart Steam Oven is the most complete smart toaster oven on the market. It has the capabilities of scanning items, multiple heating options, and even connects to WiFi.The problem with it though is that there are multiple displays and the cost. Instead of having one LCD display with either a touch screen or buttons, it has multiple. On top of it, the cost of the oven is $300. This isn't affordable and is way out of the price range for most people wanting a toaster oven. The unit also weighs just over 20lb which is heavy for a toaster oven. While toaster ovens aren't supposed to be moved around often, 20 lbs is a lot of weight. A lot of the technology of the toaster is innovative and will help us when building our smart toaster oven.

7.1.2 Breville BOV900BSS Convection and Air Fry Smart Oven

The Breville BOV900BSS has the best LCD display on the market for a toaster oven, but the problem is that it's expensive. The oven is $400. It's much more than a toaster oven though as it has many more options built into it. The unit also has multiple nobs, lacks a phone app, and has no wifi or bluetooth built into it.

It’s only considered a smart unit due to the LCD display and the multiple cooking options.

7.1.3 hOmeLabs Digital Countertop Convection Oven

The Panasonic NB-G110P Toaster Oven is the closest thing that we wanted to replicate from a cost perspective. The base unit is around $100 and features a large LCD display for the users. We believed this is a good basis for us to determine our cost from. This is a good model for us to compare our project to, for referencing. What it still needs though is phone capabilities, easier to use display instead of all the nobs and a way to connect to WiFi or Bluetooth. This creates a better result for the end user, since they have better control over the device, with their smartphones.

Table 3 shows a comparison of the 3 most popular toaster ovens on Amazon. Everything was compared from Smartphone controlled to price.

Table 3: Amazon Comparison

Feature	Tovala Gen 2	Breville BOV900BSS	hOmeLabs Digital Countertop
Smartphone Controlled	Yes	No	No
Recipe Scan	Yes	No	No
LCD Display	No	Yes	Yes
Weight	20.9 Lbs	39 lbs	17.9 Lbs
Dimensions	18. 5"" x 12. 32"" x 11. 75””	21.4”” x 17.2”” x 12.8””	19”” x 15.6”” x 10.8””
Price	$300	$400	$100

7.2. Power

The principal center for fueling our venture is what will be used, how much burden is required, and what will be the wellspring of intensity. Seeing how much power is required for every part alongside the most proficient method for arranging a battery(s) to segments to limit misfortune. Showing power will be no doubt as a Printed Circuit Board or PCB.

7.2.1. Power Requirements and System Viewpoint

Toaster Ovens likewise fall in the area of 1,200 watts, despite the fact that there are a few models out there that utilization up to 1,700 watts. The recipe for figuring the power utilization is actually equivalent to for a bread toaster: watts times hours isolated by 1,000.We are going to utilize the toaster stove for a more extensive scope of dinners, in any case, so we should place it into utilization for 30 minutes, or .5 hours, consistently: 1,200 watts X .5 hours = 600 watt-hours/1,000 = .6 kWh every day. At 10 pennies for each kWh, you're burning through $.06 every day, $1.83 every month and $21.90 yearly for the comfort of your toaster stove.

7.2.1.1. Thermocouple

A thermocouple is a kind of temperature test that can withstand the very high temperatures (>100C) of the toaster broiler. There are a variety of thermo-watts out there. The sort K thermocouple is the most widely recognized (in any event as I would like to think). Type-K alludes to the two sorts of metals that are joined to make the thermocouple sensor. The precarious part is taking the voltage change appropriated by the physical idea of the thermocouple and transforming that into a temperature. This over the top expensive DIP bundle was worked for a wonder such as this. Append a K-type thermocouple, control the thing at 5V, and you have a 10mV/C yield. There are numerous different approaches to skin this feline, many are less expensive, however all are unquestionably progressively complex then this tight bundle.

We were searching for +/ - 1 or 2 degree C precision over the stove. So we can take the 10mV/C voltage levels straightforwardly into the 10-piece ADC found on most 16F PIC microcontrollers. We have the microcontroller to pursue temp information, presently we have to kill on and the broiler. With a 1500W broiler on 120VAC, 12.5A that should be turned on and off. Any typical transfer would presumably dissolve or flop after a couple hundred cycles.

7.2.2. Voltage Regulators

There are numerous circuits that we needed to use to control the board , one of which is a voltage controller. A voltage regulator directs and deals with the input voltage and yield voltage of a circuit to deal with the power. A voltage regulator circuit is involved operational intensifier, transistors, capacitors and inductors. There various designs expected to make a fixed, or persistently evolving yield. Rather than utilizing every one of the segments referenced to make a controlling

circuit, a coordinated circuit can be used to keep impression on printed circuit sheets negligible. Rather than having a more convoluted association conspire on a PCB we can utilize a coordinated circuit that uses 4 or 5 sticks that can do practically everything required for wanted activity. Two kinds of coordinated circuits we can utilize are an exchanging controller, and a direct regulator.

A linear regulator can be utilized when gadgets need low power and the distinction between the info and yield is little. The more distinction among input and yield more power scattering ought to be envisioned. Power dissemination can be determined by the distinction of info and yield increased by the heap current. A linear regulator is generally utilized for venturing down a voltage , and its unpredictability is generally low. The utilitarian model of a direct voltage controller is comprised of an operational speaker, a transistor, painstakingly chose opposition dividers plans and capacitors for sifting information and yield.

A switching regulator is an increasingly confounded gadget that can be utilized in numerous more applications, for example, venturing down and venturing up voltages. Switching regulator have a bigger scope of information voltages so they are increasingly adaptable. The utilitarian model of an exchanging controller, has a lot more segments to help make a controlled and stable yield. The additional cost for exchanging controllers are commonly the outer parts to make an increasingly steady yield, they are generally capacitors, inductors and diodes.

7.2.3. Battery

When dealing with batteries, many things must be taken into consideration. Even though this is a very vital piece of our product, and really any project requiring power, there is some safety features we needed to implement and always be aware of. Without a battery or any kind of source of power, there would be no way our project would be able to function at all. Since we are dealing with batteries that contain various currents, we must be aware of them so that, even with various other currents going around, the toaster oven still operates as it should. Since the toaster heats up to a fairly high temperature as well, we should always be monitoring the battery to make sure it doesn’t have any issues concerning overheating and possibly exploding. Therefore, the standards put into place by IEEE and various other standard developers were taken into account to aid in the safety of both building and operation something of this caliber.

7.3. Sensor Information

The sensors or undoubtedly a very important aspect when it comes to the design of this project. Due to this, the following research about these sensors have been very thorough in order to ensure we have both a safe, yet super efficient toaster oven.

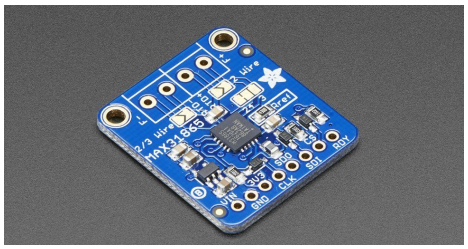
7.3.1 Temperature Sensors

Temperature is a very important aspect for this product being that we would be unaware of the toasting status without the use of these temperature sensors. Therefore research must be done on these sensors in the aspects of their range, price, dimensions, source, and other potentially useful specs.

7.3.1.1. Adafruit PT100 RTD Temperature Sensor Amplifier - MAX31865

Figure 5 shows an image of the Adafruit PT100 RTD Temperature Sensor.

Figure 5: Adafruit PT100 RTD Temperature Sensor



We took a look at the four different types of temperature sensors. Negative Temperature Coefficient, Resistance Temperature Detector, Thermocouple, and Semiconductor-based sensors. After analyzing the pros and cons for each of them, it was decided that we would use a Resistance Temperature Detector. The reason for this was it's accurate linear in its operating range of -200 to 600 °C. The only issue is it can be more expensive.

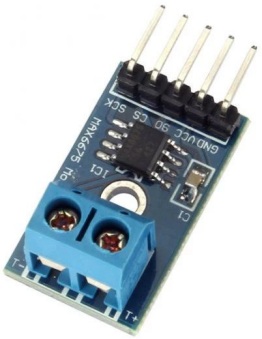
We found that the Adafruit PT100 RTD Temperature Sensor fit our needs. It's a RTD that's compatible with Aurdalino. The recommended conditions for this are -40 to 125°C. The price is around $15 on most websites.

The only issue with this sensor is that it's too small of a range. Toaster ovens tend to be warmer than 125°C. So unless we keep the temperature low, this is most likely not our best choice.

7.3.1.2. SainSmart MAX6675 Module + K Type TThermocouple Sensor

Figure 6 shows an image of the SainSmart MAX6675 Module.

Figure 6: SainSmart MAX6675 Module



This is the widest range of temperature, not as accurate at the RTD, but it has a much bigger range. We thought the RTD would be best, but the thermocouple allows for higher temperature ranges than the RTD. For some reason the Aurdalino's RTDs highest temperature is 125°C even though research shows other RTDs go up to 600°C. The range for the SainSmart MAX6675 Module + K Type Thermocouple Thermocouple Sensor is 0 to 1024 °C. It can be found on a few websites for around $15. This is what we will most likely be what we will be using for the smart toaster oven.

Table 4 shows a comparison of two different temperature sensors. We are comparing the Adafruit PT100 Vs SainSmart MAX6675

Table 4: Adafruit PT100 Vs SainSmart MAX6675

Feature	Adafruit PT100	SainSmart MAX6675
Temperature Range	40 to 125°C	0 to 1024 °C
Avg. Price	$15	$15
Size	28.0mm x 25.5mm x 3.0mm	25.0mm x 15.0mm x 13.0mm
Weight	2.7g	4g
Type of Sensor	RTD	Thermocouple

7.3.2 Timers

Arduino has three built in timers on the board. They are the following: timer0, timer1, and timer2. We can set each of them to do different tasks if needed. For the timer to work properly, the counter increments with each tick of the built in clock. Timer interrupts can be built into the code so that it triggers when the counter hits a set number. This is key for us when we have to set up a timer to cook the food. We get the user input of time and figure out how to code it so we can start and turn off the toaster oven along adding a delay if needed and alerting the user that the food is done.

7.3.3 Smoke Detector Sensors

The two most normally utilized kinds of sensors for use in household and business smoke alarms are Ionization Detection Sensors and Photoelectric Smoke Detection Sensors. These sensors might be utilized independently in industrially sold smoke alarms, utilized in mix with one another, and furthermore in blend with Heat Sensors or Gas Sensors. The importance of these sensors is so the toaster oven doesn't catch on fire and burn the house down.

7.3.3.1 Ionization Smoke Detection Sensor

The Ionization Sensor is viewed as a less expensive option in contrast to utilizing a Photoelectric Sensor. Like a Photoelectric Sensor it can likewise detect smoke particles noticeable all around that are commonly not large enough to see with the unaided eye. This sensor is contained two ionization chambers that make a present utilizing the potential contrast crosswise over two terminals contained inside. A reference chamber has no molecule section while the other chamber is available to the air and would possibly take into consideration smoke particles to enter. The two chambers contain a little measure of Americium-241, a radioactive material that discharges "alpha particles" which bring about emphatically charged particles and adversely charged electrons when they crash into air particles. The electric charge of the particles makes a potential distinction over the pair of cathodes and enables a current to stream over the sensor. The normal current ought to be the equivalent in the two chambers, as they are both confronting indistinguishable conditions including pneumatic force, temperature and maturing of Americium.

In the event that any smoke particles enter the test chamber, particles will start connecting to those particles and the present won't be conveyed over the chamber. In this way, the circuit connected will recognize the present distinction between the test and reference chambers and initiate the alert. When the smoke clears, the particles will start to stream between the terminals again and current should come back to the reference level. The present draw of an Ionization Sensor is low, consequently a little battery is adequate for controlling this circuit

long haul. Ionization Sensors are known to rapidly recognize limited quantities of smoke, for the most part delivered by flaring fires filled by paper and combustible fluids and in this way is inclined to bogus cautions.

7.3.3.2. Photoelectric Smoke Detection Sensor

The Photoelectric Sensor, is frequently considered to fill in as an "eye" due to the idea of how it identifies smoke. The sensor regularly comprises utilizing a light source that produces infra-red light, an LED is usually utilized, a focal point for coordinating the light and a photoelectric collector, for example, a photodiode, that is the objective of the infra-red light. These are set in a chamber that is available to the air, and when smoke is available, will be loaded up with smoke particles. Smoke particles will cause the light to dissipate and influence the measure of light that interacts with the photoelectric collector.

This will at that point bring about a drop in current over this sensor, which is detected by the circuit joined and the alert is enacted in like manner. This kind of sensor is regularly put on or close to the roof of a room, as smoke tends to rise and this takes into account a superior response time if there should arise an occurrence of a fire. This alert is moreover less delicate to bogus alerts that outcome from minor smoke from candles, steam or cooking. This sort of sensor is additionally known to respond more rapidly to seething fires, as these flames will in general produce bigger burning particles that collaborate well with the sensor, anyway regardless of whether it possesses a decent location energy for blazing flames.

7.4. Communications

This is the main source of either how the user gets connected with the toaster oven. This includes aspects of anything referring to wifi or bluetooth, as well as other forms of communication such as texting or email alerts. This is extremely important when it comes to the implementation of a phone app that must have the user communicate with the toaster oven from a distance.

7.4.1. Bluetooth

Bluetooth is a fairly big competitor when it comes to selecting a form of communication for our project. One of the big pluses going for it is that it doesn’t consume much power and it doesn’t interfere with other wireless electronics or vice versa. The following research dives into specific models we’ve researched.

Bluetooth is recognized from Wi-Fi with the end goal that it works on a lot of lower removes and isn't centered around giving correspondence to gadgets through a passageway. Rather, Bluetooth stressing direct correspondence

between gadgets through an ace and slave correspondence plan and convey ability as a wire-substitution innovation.

Associated Bluetooth gadgets may swap jobs; for instance, a vehicle may start an association with a telephone as an ace yet may then turn into a slave while working. Bosses can speak with slaves, be that as it may, slaves cannot speak with one another. A Bluetooth arrange is known as a piconet, though a scatter net is a more elevated level topology that comprises of various piconets. Gadgets in the scatter net may work as an ace in one piconet, while at the same time working as a slave in another piconet.

The tickers of the slave gadgets are synchronized with the clock of the ace gadget. In even schedule openings, information bundles are transmitted by the ace and got by the slave, while in odd availabilities, the complementary is valid. Bluetooth associations brag a hypothetical separation of 100 meters, contingent upon the Bluetooth variant.

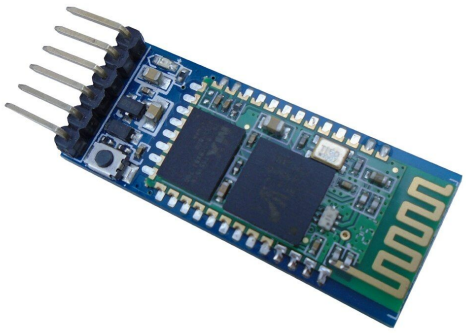
Exemplary Bluetooth uses a tweak strategy called Frequency Hopping Spread Spectrum (FHSS) to transmit signals. FHSS is cultivated by quickly "jumping" a sign between channels. The sign is part into a few parcels, which are bounced 800 times each second more than 79 distinctive 1 MHz channels, which might be adaptively chosen by keeping away from the channels at intensely dealt frequencies. In Classic Bluetooth, an ace may speak with up to seven slaves, the limit of which may vary between gadgets. Great Bluetooth has a most extreme throughput going from 0.7 to 2.1 Mbps.

Bluetooth is another marked innovation that enables gadgets to remotely convey crosswise over short separations utilizing ultra-high recurrence (UHF) radio waves in the 2.4 GHz ISM recurrence band. Bluetooth was once in the past institutionalized as the IEEE 802.15.1, yet has since been kept up by the Bluetooth Special Interest Group (SIG). This standard encourages the making of low-fueled and compact remote individual territory systems (PAN), which let gadgets speak with one another in an impromptu way; despite the fact that uplinked correspondence of gadgets in an infrastructural way is conceivable.

7.4.1.1. DSD TECH HC-05 Wireless bluetooth Serial Transceiver Module Slave And Master

Figure 7 shows an image of the DSD TECH HC-05

Figure 7: DSD TECH HC-05



Since we decided to go the route of Arduino, we had to find a module that works with the board. Upon research we found that the HC-05 Wireless bluetooth Serial Transceiver Module would be our best bet. It's found on numerous websites under $5 and offers us the bluetooth capability that we desire. Some of its features include: RX to RXD / TX to TXD / GND to GND / 3.6V to 6V & Power: 3.3V.

The biggest drawback of this component is though that it's not compatible with IOS. Since we believe that about half of our target market might be using IOS devices, it's probably in our best interest to find a part that can deliver to IOS users as well as android users.

7.4.1.2. DSD TECH SH-HC-08 Bluetooth 4.0 BLE Slave Module to UART Transceiver for Arduino

This Arduino bluetooth module is a better fit for our project. Looking at the specs, it's compatible with both Android and IOS devices. This will allow us to hit most of our target market compared to the HC-05 Version. This version is a bit more pricier ranging from the $8 - $10 range on numerous sites, but it's an expense that we must have. Some of the features for the unit include: Default rate : 9600, Working voltage 3.3V to 6V, 6 PIN baseboard and leads interface including: VCC, GND, txd, rxd , status, EN

Table 5 represents a comparison between the latest two models of the DSD Tech HC

Table 5: DSD TECH HC-05 Vs DSD TECH SH-HC-08

Feature	DSD TECH HC-05	DSD TECH SH-HC-08
Android	Yes	Yes
IOS	No	Yes
Avg. Price	$5	$10
Default rate	9600	9600
Working Voltage	3.6 V to 6V	3.3V to 6V
Bluetooth module	2.0	4.0
Dimensions	1.1 x 0.6 x 0.1 inches	1.4 x 0.6 x 0.1 inches
Weight	0.32 ounces	0.16 ounces
Temperature range	-25 to 75°C	-40 to 80°C

7.4.2. WiFi

This section dives deep into the benefits of using wifi as our communication methods for our smart toaster oven. Wi-Fi systems have no physical wired association among sender and recipient by utilizing radio recurrence (RF) innovation - a recurrence inside the electromagnetic range related with radio wave proliferation. At the point when an RF current is provided to a radio wire, an electromagnetic field is made that at that point can proliferate through space.

7.4.2.1. 802.11

Wi-Fi is a brand created by the charitable association known as the Wi-Fi Alliance, which envelops the innovation that gives gadgets a chance to interface with a Wireless Local Area Network (WLAN) to speak with one another. It has risen as a predominant remote correspondence standard present in numerous electronic gadgets available, and because of its pervasiveness, it is broadly bolstered. Wi-Fi gadgets are ensured by the Wi-Fi Alliance for similarity and utilization with other Wi-Fi gadgets. Items with Wi-Fi depend on the IEEE 802.11

standard, a progression of conventions that portrays the qualities of the physical layer and media get to control sub layer of a remote system.

Together, the physical and media get to control layers structure the foundation of the 802.11 convention. The media get to control (MAC) sub layer of the 802.11 is contained inside the second most reduced layer of the Open Systems Interconnection (OSI) model, a top-level portrayal of a media transmission framework made out of seven diverse reflection layers. The MAC sub layer adds strategies to address gadgets and access channels, which enables different gadgets to associate with a mutual system. It has support for both full and half-duplex correspondence and furthermore gives a few extra capacities, for example, blunder checking. Because of the MAC sub layer, gadgets associated with a system are allotted one of a kind MAC delivers which enable them to dependably send and get information bundles.

A decent relationship is the manner in which that homes with addresses may send and get mail to different homes. The MAC sub layer basically associates the physical layer with the consistent connection control (LLC) sub layer, which is another layer that permits significant level coherent structures, for example, the Internet Protocol (IP) to work with one another over systems

Because of security vulnerabilities in certain Wi-Fi systems, an enemy could access a system and exploit gadgets on them. Systems with powerless passwords could be effectively gotten to by a pariah to access the brilliant table and adventure it. The malware Mirai is only one late case of an infection that has been intended to contaminate buyer Wi-Fi switches with frail passphrases. Once undermined, the malware assumes responsibility for IoT gadgets on the system, for example, DVRs, TVs, or even the savvy table and uses them in a huge scale botnet. The gadgets are told to flood parcels to an objective system, called a conveyed disavowal of-administration (DDoS) assault, which viably takes them disconnected for the span of the assault.

Another drawback of using Wi-Fi is that remote systems today are as of now immersed by a heap of other Wi-Fi proficient gadgets. Since data transfer capacity on a remote system is limited, extra gadgets could contrarily affect the nature of administration on the system. System execution measures, for example, the transfer and download speeds, are delicate to the quantity of gadgets at the same time utilizing the system. During a time of expanding web use for sight and sound downloading and spilling, it is perfect to maintain a strategic distance from this circumstance totally by using another similarly proficient remote correspondence innovation.

7.4.2.2. ESP8266 WiFi Module

The ESP8266 WiFi Module is affordable and easy to set up to the Arduino board. Some of the features included in the WiFi module are: Working voltage: 3V, integrated with a TCP/IP protocol stack, sensor interaction, flash disk size: 1mb, 8 pins, and a max voltage of 3.6V. The ESP8266 WiFi Module can also be picked up on multiple websites for around $8. So it's very budget friendly for the project.

7.4.3. SMS Text Notification

This section will discuss the different parts we can use when receiving an SMS text notification for the toaster oven. SMS means "Short Message Service." SMS warnings are sent a similar route as some other instant message. As a rule, they're constrained to 160 characters. With our extended informing highlight, in any case, you can send SMS notices that are up to 306 characters in length.

7.4.3.1. ARDUINO MKR GSM 1400

Figure 8 shows an image of the ARDUINO MKR GSM 1400

Figure 8: ARDUINO MKR GSM 1400

For an Arduino board, this is the best available option for GSM connectivity. While it is quite pricey at a cost of around $70 (found on Amazon and Arduino's website), it has all the options needed so that a user can receive text messages from the smart toaster oven. Including secure crypto & ultra low power consumption. The GSM 1400 runs at 3.3 V, uses a micro sim, has an antenna power of 2dB, is 67 mm in length while 25 mm in width and has a weight of approximetly 32 grams. The MKR GSM 1400 also provides global 3G/2G connectivity while also supporting HSPA/GSM for global coverage.

7.4.3.2. Makerfocus A7 GSM GPRS GPS Module 3 in 1 Module

This is a more budget friendly version of the ARDUINO MKR GSM 1400. It's around $50 less retailing at $20 on Amazon. It features a 3 in 1 GSM GPRS GPS Module and Sim card support. The downside of being a budget friendly part is that corners are cut sometimes when educating the audience. The user manual for this (which was linked on Amazon) is in Chinese. I'm not too sure if this is an error or whether or not it was never translated. If we had ended up going the SMS text notification route, I will be emailing the manufacturer asking for an english description, so that I can make a more educated decision between the A7 and the MKR GSM 1400.

7.4.4. Email

Part of our project includes a feature for a user to receive an email or text notification to their phone letting them know when their toast or other meal is ready. This section will discuss both, yet mainly the benefits of email over texting and what parts can be used to implement this.

7.4.4.1. Email

Email is a free tool and very easy to work with. When you are on the web, there is no further cost that you have to spend on so as to send and get messages. Email is brisk. When you have wrapped up a message, sending it is as basic as clicking a catch. Email, particularly if an email ready framework is incorporated into the system, is sent, conveyed and read very quickly. Email is basic. It is anything but difficult to utilize. When your record is set up, forming, sending and accepting messages is basic. Likewise, email takes into account the simple and fast access of data and contacts. Email takes into account simple referencing. Messages that have been sent and gotten can put away, and looked through securely and effectively. It is significantly simpler to experience old email messages as opposed to old notes composed on paper.

7.4.4.2. 3G/GPRS Shield

The 3G shield for Arduino and Raspberry Pi empowers the availability to fast WCDMA cell organizes so as to make conceivable the making of the following degree of overall intelligence.Other fascinating embellishments which can be associated with the module are a 2MP high goals camera (1600 x 1200) UXGA which empowers take amazing photographs and recordings, a sound unit including amplifier, speaker, hands free and earphones sets and an SD attachment to spare legitimately every one of the information originating from the

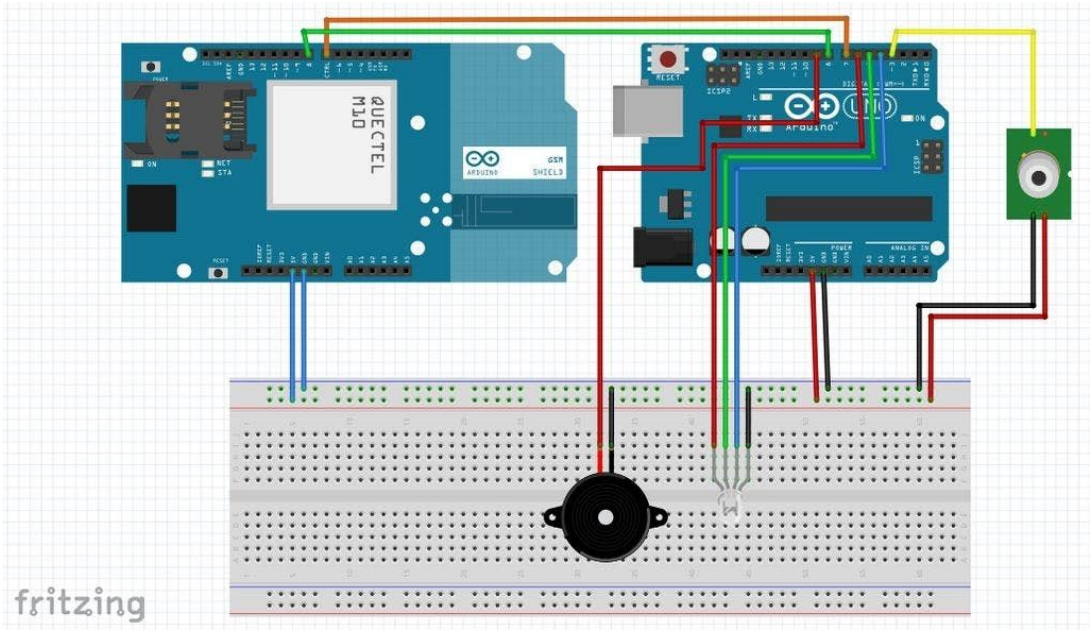
3G organize or recorded from the camcorder. You can even replicate sound documents put away in the SD card.
You can likewise utilize it as a standard 3G modem at max throttle simply associating it through its particular smaller than expected USB attachment to your PC (Linux, Windows, MacOS).

The new imparting module is exceptionally situated to work with Internet servers executing inside a few application layer conventions which make simpler to send the data to the cloud. We could make HTTP and HTTPS route, downloading and transferring substance to a web server. Similarly FTP and FTPS (secure mode) conventions are likewise accessible which is extremely valuable when your application requires dealing with documents. You can even send and get sends legitimately from Arduino utilizing the SMTP and POP3 customers executed inside.

7.4.4.3. Circuit Diagram

The following image shows an example of a arduino circuit diagram connected to a breadboard and a Quectel M10 which is a Quad-band GSM/GPRS module. The module allows for a wireless communication with the arduino board. The M10 is a LCC type which can be implanted in client applications, offering the most elevated dependability and heartiness. It receives the laestest MTK chipset and highlights com-settlement size of 29× 29 × 3.6mm, ultra low power utilization and extended temperature go.

Figure 9: Circuit Diagram



7.4.5. Smartphone Control

To truly make this toaster a smart toaster oven our group implemented a way to control the device from your smartphone device. We explored both bluetooth and wifi as a means of wireless communication. When it comes to the software involved, we looked into developing our own smartphone application as well as controlling the phone from a circuit board's software such as Ardunio. Our own application may pose as a challenge developing a cell phone app however it will still be looked into. A circuit board software would be much simpler to use however it will not be intuitive as the cell phone application. Other methods of controlling the device from your amarthopione will also be explored.

7.4.6. Serial Communication Technologies

Wired correspondences describe any innovation or convention used to build up correspondence between segments inside the equipment structure of the item, for example, information move between a microcontroller and LEDs. Sequential correspondences include transmitting a solitary bits of information through a channel consecutively, rather than parallel interchanges, which include sending numerous bits of information over various channels at the same time. A few institutionalized sequential specialized techniques exist that characterize strategies for sending and getting information synchronously or non concurrently, a little bit at a time.

Synchronous sequential specialized strategies, for example, I2C and SPI could be helpful for interfacing the microcontroller with other equipment subsystems such the Bluetooth module or the LED grid, while nonconcurrent techniques, for example, UART are valuable for transmitting and receiving information between the keen table and outer gadgets. It is perfect to fuse equipment with local usefulness for these specialized techniques, however bitbanging, a strategy to help a correspondence convention inside the product, is another choice that could give adaptability and a more noteworthy equipment choice. Because of the idea of the savvy table, which requires several LEDs to have a decent goals, utilizing an entrenched sequential correspondence convention is totally basic.

Numerous microcontrollers don't have countless pins, so a working the shrewd table would be unimaginable with a sequential correspondence convention because of the sheer number of wires that would be required for a LED framework. The shrewd table needs an approach to speak with and drive the RGB LEDs quickly, which is vigorously reliant on the convention utilized and the equipment capacities of the chosen microcontroller. The significance of these correspondence conventions to a task consolidating such countless associations

turns out to be increasingly clear when examining transports, which viably consider less pins to be used on the microcontroller.

7.4.6.1. I2C Communication

I2C, likewise called Inter-Integrated Circuit, is a sequential correspondence convention initially structured in 1982 by Philips Semiconductor, presently known as NXP Semiconductors. I2C has experienced various significant modifications since its commencement, starting with Version 1 and landing at the present Version 6. These adaptations have been for the most part worried about speeding up signal transmission through the offering of high recurrence modes for the information and clock signals. Starting in 2006gt, the convention is accessible for use by the overall population, sovereignty free and without the requirement for a permit, in spite of the fact that NXP charges clients to acquire slave addresses. I2C stays a famous convention and is bolstered by countless gadgets. It is typically utilized at low speeds and for correspondence between coordinated circuits.

I2C utilizes a sequential transport to encourage correspondence between gadgets, enabling various experts to speak with numerous slaves. The convention is essentially expected for use over short separations, for example, correspondence inside the equivalent printed circuit board. Ordinary I2C has both a 10 Kbps moderate mode, a 100 Kpbs standard mode, a 400 Kbps quick mode, and a 3.4 Mbps fast mode. An I2C transport uses 7-piece addresses and contains two sign, known as the two-wire interface.

I2C signal transmission is administered by a particular piece control plot. Messages, signified in every capital letter, are encoded in the sign, for example, START, STOP, and ACK (recognize). Information is sent in one-byte fragments. At the point when the ace starts transmitting, it utilizes a START bit alongside the ideal slave's 7-piece ADDRESS. The last piece decides whether information is being pursued or composed. At the point when a slave gets this message, it transmits an ACK bit, and the ace keeps on working in either the transmission or gathering mode depending if the beginning message encoded the last piece with a for compose, or for read. The slave at that point proceeds in the fitting mode; if the ace is transmitting, the slave must get, and if the ace is getting, the slave must transmit. When either the ace or the slave is getting information, they send an ACK bit after every byte that is gotten. At the point when the sign transmission is finished, the ace send a stop bit to end the transmission or starts another transmission with another START bit.

7.4.6.2 SPI Communication

The Serial Peripheral Interface Bus, also called SPI, is a strategy for sequential correspondence made by Motorola. It is indicated for use over little separations

and has been viewed as a standard implanted framework specialized strategy for quite a while because of its straightforwardness and flexibility. SPI is synchronous, which implies that the clock signal is utilized to synchronize information and transmission. Basic current advancements that use SPI are LCD screens and SD cards. SPI is amazingly basic at its center. Gadgets that use SPI transmit and get information simultaneously, additionally alluded to as full-duplex mode. Like I2C, SPI uses the ace and slave technique.

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Figure shows the round transmission of information between SPI move registers of the ace and slave. During signal transmission, 8-bits of information from a move enlists in the ace is swapped with information from a move register in the slave. The most critical piece from either the ace of slave is supplanted with the least noteworthy piece from its partner. This procedure is proceeded for the same number of clock cycles as it takes until the move registers have totally swapped qualities. From that point onward, the move registers are reset to get ready for another transmission. At the point when transmission is finished, the slave is discharged from the SS line.

7.4.6.3 UART Communication

A UART, in a sense is the general nonconcurrent beneficiary/transmitter, which is an equipment gadget that successfully empowers sequential correspondence. It is an interface utilized and bolstered by numerous microcontrollers as an interface among parallel and sequential associations. At its center, one side of the UART has a parallel transport with various information lines, and different has two simple sequential lines: the beneficiary (RX) and the transmitter (TX). It is executed by different understood correspondence measures..

Sequential and parallel information is changed over using shift enrolls inside the UART. Since UART underpins simplex, half-duplex, and full-duplex activity, this decides the quantity of move registers. For full-duplex activity, two move registers are required for both transmitted and got information. Bytes of information from the microcontroller are gone through the move register and transmitted through the sequential lines by-by-bit and the other way around. Information controlled by some UART interfaces might be put away in cushion on

a first-in-first-out way. Information might be added to the support by the microcontroller and transmitted in a solitary burst, or put away in the cushion by the sequential RX until the microcontroller can acquire the information.
UART gathering is accomplished utilizing a clock signal that is a different of the baud rate, normally 8. While getting a sign, the RX line searches for the beginning piece by checking if the bit is gotten into equal parts or a greater amount of the clock signal time various. On the off chance that the sign is acknowledged, it is tested, gone through the move register, and got by the microcontroller. The UART sets a banner that the information has been gotten and starts a hinder so the information can be used by the microcontroller The clock of the UART is information needy and synchronized with each new sign gathering.

7.4.6.4. Infrared

Buyer Infrared (IR) alludes to various norms that use light inside the non visible infrared range to encourage remote correspondence. It is a proposed correspondence component because of the moderate idea of IR transmitters and collectors. Gadgets that normally utilize IR incorporate TV just as remote controls that work a wide scope of gadgets. Despite the fact that there are various usage, IR transmitters regularly work by sending balanced IR signals encoded with an order to an IR beneficiary by means of an IR LED.

The IR collector utilizes an IR photosensor to identify the sign which is then demodulated and translated, which varies by gadget. The Infrared Data Association (IrDA) is an association that deals with the conventions and guidelines for items that use IR. Shopper IR has a few confinements that may not be appropriate to the savvy table. Because of the idea of IR light, can't enter most misty physical substrates such as dividers. As an outcome, the transmitter requires an immediate viewable pathway (LOS) to the recipient. This impediment might be a reason for worry in a business space or abiding that may contain numerous hindrances that would hinder transmission, for example, people or furniture. The shrewd table would require an omnidirectional IR recipient that would should be set in a subtle way, so it could be worked without hindrance.

7.5. Computational Hardware

This section will discuss the computational hardware we will consider for our project. This will include comparison of microprocessors, microcontrollers, LCD Displays and other parts.

7.5.1. Microcontroller/ Microprocessor

The job of the microcontroller is part into two significant errands. to quantify the time the wheel takes to pivot one full revolution, using an attractive reed sensor,

and convert that into a speed estimated in the units miles every hour (MPH). This speed would then be yield onto an LCD. In our decision for a microcontroller, we remembered this errand of what processor would be the best decision for this undertaking. Another however considered would be the language that the processor would comprehend, and that we would take a stab at a language that is natural to our software engineer.

Moreover, the MCU will take in throttle input that will be utilized to alter the created a high recurrence PWM signal for engine control. We would require an MCU with a high handling pace that is fit for creating such a sign. We additionally would need to discover a microcontroller that is amazing enough to take on the assignment while keeping the expense sensibly speaking.

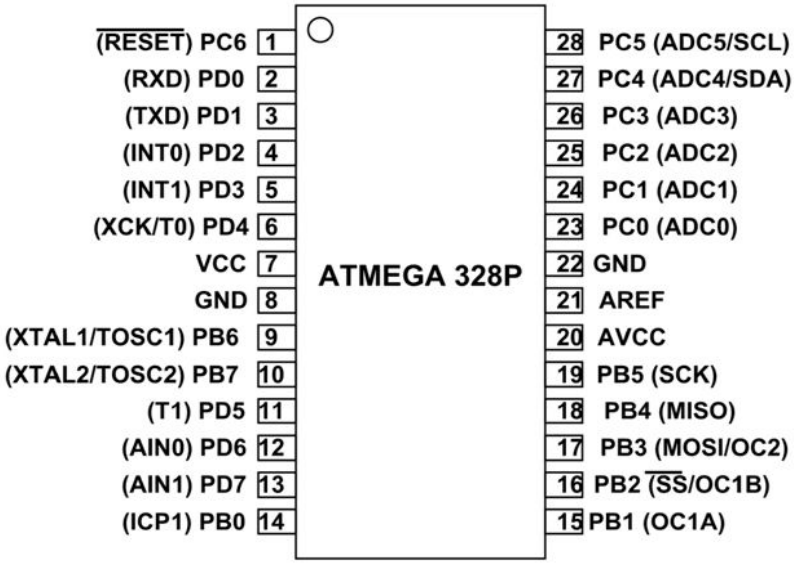
7.5.1.1. ATMEL ATmega328

For our project we considered two microcontrollers which include the Atmel ATmega328 and the Texas Instruments MSP430G2x53 arrangement. The ATmega328 is an ordinary and well known decision in microcontroller for most undertakings since they are, generally, easy to understand. The positives about the Arduino is that there's not a substantial arrangement for the processor, code-wise, and that taking simple sources of info is a lot simpler to program than most different sheets. The ATmega328 runs on a preparing rate of 16MHz and has a working voltage of 5V which is a low voltage that the sunlight based board can supply.

The ATmega328 additionally has an increasingly reasonable rationale while interfacing with an LCD screen for UI yield. The expense of the ATmega328 doesn't delve deep into our spending limit since most sites sell it for a minimal effort of just $16. The negative to the Arduino is that for a software engineer, the language isn't as recognizable contrasted with the language instructed on the MSP430, which should be a deterrent to defeat with more understanding. On a side note, we considered getting a starter unit for the Arduino to approach different sensors and exploit the included LCD that we would require. We ruled against this since we felt that it would be a misuse of accounts to our support. At last, we picked the Arduino UNO as our microcontroller of decision.

Figure 10 shows the Pin layout for the ATMEGA328 microcontroller.

Figure 10: ATMEGA328 Pin Layout



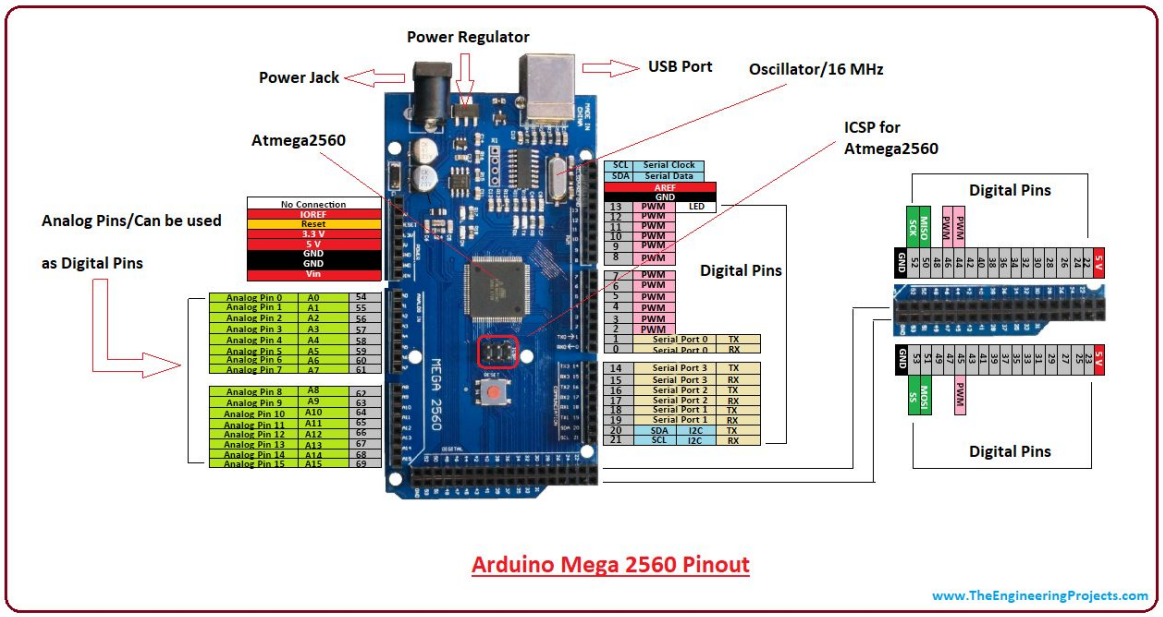
7.5.1.2. ATmega2560

The Atmega2560 is very similar to the 328 model with some key differences however. This microprocessor has many more pins to be utilized for more features. The elite, low-control Microchip 8-piece AVR RISC-based microcontroller consolidates 256KB ISP streak memory, 8KB SRAM, 4KB EEPROM, 86 universally useful I/O lines, 32 broadly useful working registers, constant counter, six adaptable clock/counters with think about modes, PWM, 4 USARTs, byte situated 2-wire sequential interface, 16-channel 10-piece A/D converter, and a JTAG interface for on-chip investigating.

The gadget accomplishes a throughput of 16 MIPS at 16 MHz and works between 4.5-5.5 volts. By executing amazing directions in a solitary clock cycle, the gadget accomplishes a throughput moving toward 1 MIPS for every MHz, adjusting power utilization and preparing speed. It is unsure as of now if we will be using this microprocessor as we will most likely not need its extra pins.

Figure 11 shows the layout for the ATMEGA2560 Microcontroller

Figure: 11 Arduino and ATMEGA2560 Layout



7.5.1.3. Broadcom BCM2837 SoC

The third MCU in thought would be the Broadcom BCM2837 SoC. This MCU is commonly utilized in different kinds of ventures in networks from training, home mechanization, and in business items from advanced media players, candy machines, and remote handsets. This MCU is normally on the Raspberry Pi 3 sheets, which is utilized in such undertakings.

The BCM2837 is an ARM Cortex-A53 processor that has a handling pace of 1.2GHz. The design of this MCU is a quad-center 64-piece with 512 KB L2 Cache memory. This chip has PWM support using pwmWrite(,) capacity and simple contribution for control. These specs for this task are a route over need and unreasonably incredible for what is required.

7.5.1.4. MSP430G2553

The other decision for a microcontroller is the MSP430G2553. This is a natural microcontroller that we have utilized in the classes. The positives for this processor is that it has a well-known language that our software engineer knows well, low costing (generally $10), runs at 16MHz with 16 kB of glimmer, a 5V

input. The negatives for this board are that it requires all the more coding to appropriately utilize a LCD, take in simple sources of info, and for the underlying arrangement than the Arduino, and furthermore that the IDE for the MSP430G2553 isn't bolstered for Mac or Linux situations.

Table 6 shows the comparison of multiple MCUs. We took a look at everything from the voltage range to the average price of the board.

Table 6: MCU Comparison

Feature	Atmega328	ATmega2560	MSP430G2553	BCM2837
Voltage Range	1.7- 5.4 V	1.8 - 5.5 V	1.7 - 3.5 V	2.5 - 6.1 V
Temperature Range (Celcius)	-40° - 86°	-40° - 85°	-40° - 85°	-25° - 80°
Low Power	Yes	Yes	Yes	Yes
Power Consumption	200uA at 1MHz	500 uA at 1MHz	330uA at 1 MHz	3500 mW
Clock frequency	20 MHz	16 MHz	16 MHz	1.2 GHz
Analog I/O	Input	Input	Input/Output	Input/Output
Digital I/O	Input/Output	Input/Output	Input/Output	Input/Output
Memory	32 KB Flash	64 KB Flash	16 KB Flash	512 KB Cache
GPIO Pin Count	20	100	24	40
Avg. Board Price	$16.72	$40.40	$18.94	$34.98

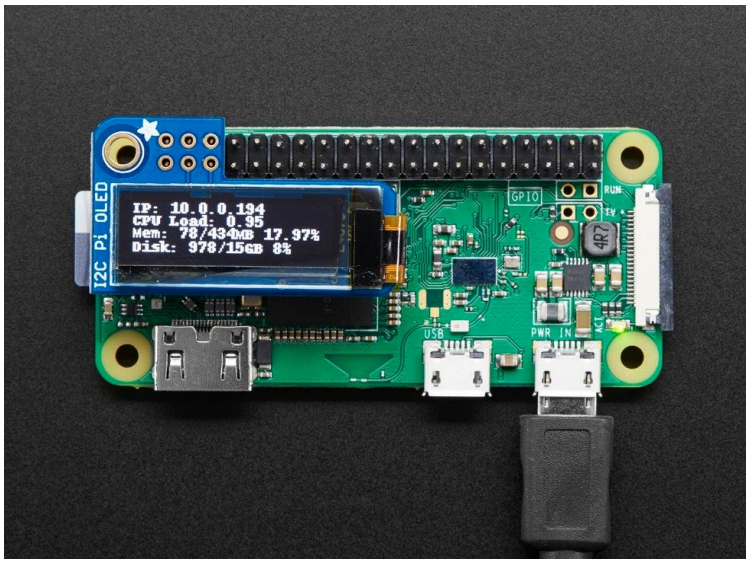
7.5.2 Displays

This sections discussing different types of LCD displays we could potentially use with our smart toaster oven. As part of the improvised interface, the smart toaster oven will definitely need and LCD display to fully engage in the new experience.

7.5.2.1 Adafruit PiOLED - 128x32 Monochrome OLED

The Adafruit 128x32 PiOLED is your little OLED buddy, prepared to snap onto any Raspberry Pi PCs, to give you a little show. The PiOLED accompanies a monochrome 128x32 OLED, with sharp white pixels. The OLED utilizes just the I2C sticks so you have a lot of GPIO associations accessible for catches, LEDs, sensors, and so forth. It's likewise decent and conservative so it will fit into any case. These presentations are little, just around 1" slanting, however entirely comprehensible because of the high complexity of an OLED show. This screen is made of 128x32 individual white OLED pixels and in light of the fact that the presentation makes its very own light, no backdrop illumination is required. This diminishes the power required to run the OLED and is the reason the presentation has such high complexity; we truly like this smaller than usual showcase for its freshness. Utilizing the presentation is extremely simple, there is a Python library for the SSD1306 chipset. The model code enables you to draw pictures, message, whatever you like, utilizing the Python imaging library.

Figure 12: Adafruit PiOLED



7.5.2.2 Infrared LED

Infrared radiation is a kind of electromagnetic radiation that is frequently alluded to as infrared light. Found in 1800 by Sir William Herschel, infrared radiation is undetectable to the human eye anyway heat coming from infrared can in any case be felt by contact, expanding simply past the red edge on the obvious range. Infrared radiation is named falling between the wavelengths of 0.75 um to 1mm. The IR LED utilized for estimating smoke nearness in the Smoke Chamber fills in as a low power alternative for transmitting the IR light intended to be gotten by the photodiode. This segment should likewise give the capacity to radiate the light ordinary to sensor, to maintain a strategic distance from mileage that is related with twisting the leads of the part. The wavelength of the light transmitted ought to likewise coordinate the wavelength of pinnacle affectability for the photodiode, to guarantee that the sensor will work.

7.5.2.3 Photodiode

A photodiode is a semiconductor segment intended to work backward inclination, that creates current when light is detected and its photons are retained. Be that as it may, it might likewise create modest quantities of current while there are no photons present. For the most part, the reaction time of a photodiode diminishes as the surface zone increments in size. The most widely recognized photodiode is the sun based cell, which utilizes its properties to change over daylight into electric flow for regular use. Photodiodes are very little not quite the same as standard semiconductor diodes, beside being presented to distinguish light or being structured with an optical fiber so light to arrives at the touchy piece of the segment. The photodiode is a p-n intersection, and when a photon with enough vitality arrives at the diode, an electron-opening pair is made, this is frequently alluded to as the inward photoelectric impact. In the event that that the retention happens in the consumption locale of the intersection, the inherent electric field of the consumption locale clears the transporters from the intersection, and the electron-gaps push toward the anode while the electrons advance toward the cathode, making a photocurrent. The all out current of the photodiode is comprised of the total of the photocurrent and the dim current, the current that is created when the photodiode isn't presented to light. In this manner, to boost the affectability of the gadget, the dull current must be limited.

Photodiodes are frequently worked in photoconductive mode, in which the diode will be turn around one-sided, bringing about a decreased reaction time as the width of the exhaustion layer is expanded by the extra turn around inclination, accordingly diminishing the capacitance of the p-n intersections. The turn around predisposition will likewise expand dull current while insignificantly influencing the adjustment in the photocurrent. Be that as it may, while breaking down the feasibility of testing our framework utilizing a photoelectric sensor in a shut

domain, we would need to make enough smoke each time we need to test the framework. While this is conceivable, we might want to evade the danger of making a real fire by consuming segments that would produce smoke just as abstaining from setting off the real smoke and alarms in the structure we are trying.

Performing tests outside isn't truly reasonable as there will be little command over climate and wind conditions, just as constrained access to lab materials for rolling out any improvements or fixing segments of the framework. Another conceivable detour is the weight of making a working smoke recognizing sensor, as this may detract from the genuine reason for the undertaking whenever actualized inaccurately or then again with mistake. This reason for the task being making a framework for improved departure in case of a fire, not making a smoke alarm. A carbon monoxide finder gives the most dependable sensor without making a real fire with smoke in a lab setting.

7.5.3. Organic Light Emitting Diode Display Overview

Most emissive presentation innovations don't have the capacity to show an agreeable interface for the smart toaster oven to absence of hues or pixel thickness. This isn't the situation for OLED shows which have as of late observed expanding use in numerous applications, for example, cell phones and TVs. As an emissive presentation innovation, OLED showcases don't require outer/backdrop illumination so as to be seen. Absence of backdrop illumination ordinarily brings about a more slender showcase and more vitality effectiveness. The survey plot for OLED showcases is very wide with the goal that a toaster oven user could be remaining to the side of the gadget and still have the option to unmistakably see the presentation.

Reaction time is extraordinary in the sub-millisecond extend. Differentiation and shading show capacity are both amazing which would upgrade the showcase of nourishment item photographs utilized by the toaster oven. Some OLED negatives incorporate varieties in the maturing of the various hues Unfortunately OLED showcases will in general be progressively costly and accessibility is constrained at this time.

7.5.4. Liquid Crystal Display Overview

The liquid crystal display is a full grown innovation that is at present pervasive in the shrewd gadget showcase just as different markets. As a non-emissive innovation, LCD must use an outer light source so as to see the presentation. This backdrop illumination adds some extra thickness and weight to the equipment, however this shouldn't be an issue since the toaster is not a handheld gadget. The backdrop illumination likewise lessens dark level portrayal and can

make hues look more cleaned out. Numerous illuminated screens can likewise be difficult to see in brilliant lights, and kitchens are generally splendidly lit, so perceivability could be an issue.

Some lucidity issues can be countered by utilizing thin-film transistor innovation, a 31active-grid innovation, which gives a more splendid and more honed showcase and would be desirable at little display sizes, for example, utilized in the smart toaster oven. Another issue with LCD perceivability can be to some degree constrained review point. This can be exceptionally reliant on the nature of the LCD. The quantity of hues that can be spoken to is very great and ought to be more than satisfactory to show the photos utilized by the toaster. Reaction time is reasonable and ought to be satisfactory since the toaster oven will not be using moving pictures like a TV.

7.5.5 Touch Screens

Potential contribution for the smart toaster oven will be cultivated with a touch screen gadget. These information gadgets are typically coordinated with a showcase, for example, a fluid gem show, however the innovation is unmistakable from the presentation innovation that it might be utilized with. It is even conceivable to include a touch screen input gadget to a presentation that doesn't have coordinated touch input. The two significant touch screen innovations that could be utilized for the smart toaster oven are resistive and capacitive.

7.5.5.1. Resistive Touch Screen

Touch resistive screens comprise of two slender layers of material, normally straightforward, that are isolated by a dainty hole so they are not contacting. The internal confronting surfaces of the two layers are electrically resistive. The idea is that when a client pushes on the top layer utilizing a finger or stylus, the two layers reach and the area of that contact can be resolved. This plan is a bit of leeway since the area of the press can be resolved paying little mind to the thing squeezing the layers together. A finger in a stove glove or shrouded in flour is similarly as equipped for being recognized as a spotless finger or a stylus. This would be alluring for the smart toaster oven since it is a kitchen apparatus. Resistive touch screens are additionally genuinely modest innovation and cost is a factor for this task. Weaknesses of resistive touch screens are that the two extra layers of material decreases the difference of whatever show they are put over and they can without much of a stretch be harmed by sharp articles.

7.5.5.2. Capacitive Touch Screen

Touch capacitive screens comprise of a hard protecting layer such a glass with a straightforward electrically conductive covering. The electrostatic field of the

touch screen twists when another electrical transmitter, for example, a human finger interacts with the surface covering. This twisting can be prepared to decide the area of the touch including the capacity to detect various concurrent contacts. Since the surface is certainly not a delicate, adaptable layer it is increasingly impervious to harm by sharp items. Complexity of a hidden showcase isn't adversely affected. Be that as it may, since the innovation requires a touch from an electrically conductive source, it would not distinguish a touch from a finger in a stove glove and probably won't identify a touch by a finger secured with flour. In spite of their commonness in the market, capacitive touch screens will in general be more costly than resistive touch screens.

7.5.6 Keypad Interface

As a way to improve the overall design of this toaster oven we will consider in revamping the user interface with a numerical keypad for the user to input the commands. One of the parts we look at was a 3 x 4 numerical keypad for arduino. With this keypad you're are able to punch in your mystery key into this numeric network keypad. This keypad has 12 catches, orchestrated in a phone line 3x4 network. It's made of a dainty, adaptable layer material with a glue backing so you can append it to about anything. The keys are associated into a network, so you just need 7 microcontroller pins (3-sections and 4-columns) to look over the cushion. This part on average would cost $3.95 and requires 1 V for power.

7.6. Solid State Relay

In this section, we go over the selection of our solid state relay. We added this part when we started to build the smart toaster oven. It was accidently excluded from our first iteration of the paper.

7.6.1. Opto 22 solid state relay 240D25-17

For the solid state relay, we went with the Opto 22 solid state relay 240D25-17. It features a turn-on/turn-off time of ½ Max Cycle, an operating frequency between 25 - 65 hz, and can be turned on and off with a 5V DC output from PCB. It was only $28 on Amazon so it fit in perfect within our final budget.

7.7. Software

This section will discuss the different types of software and boards to utilize said software available for us to utilize in this project. The project overall required a lot of programming. The toaster oven will need to be programming with the new user interface and be able to tell the user to input cook times and temperatures.

7.7.1. Arduino IDE & Language

The Arduino integrated development environment (IDE) is a product improvement stage with coordinated toolchain that is generally prevalent among specialists and experts the same. In view of its across the board prevalence in both model and item situations and the open source nature of its toolchain, it is broadly upheld by numerous microcontroller producers and incorporation libraries for countless different items.

The language of the Arduino IDE is basically a tongue of C/C++ expanded with a library with regular microcontroller usefulness and marginally extraordinary source code organizing rules. As opposed to a principle work as in standard C, and Arduino requires an arrangement and circle capacity to run which are then connected to a stub fundamental capacity at gather time. The connected code at that point is then incorporated with the standard GCC toolchain and the subsequent twofold is encoded as a hexadecimal portrayal inside a plaintext document that can be serialized into the microcontroller's memory. Inasmuch as the microcontroller underpins this strategy for assemblage, this permits engineers access to an amazingly rich, exceptionally cross-perfect library and simple establishment without losing the upsides of exposed metal programming.

7.7.1.1. Arduino UNO

The Arduino UNO is the first entry level product that we thought about for the use of this experiment. Since this product isn't very software intense, one the the entry level products is most likely where we should focus our attention when deciding on which device to use. The Arduino UNO really stands out is that the online Arduino store states that it is "The most used and documented board of the whole Arduino Family." This implies that it is very flexible in design, yet fairly specific so that we are able to accomplish whatever task may lay in front of us. It possesses 14 input and output pins, a 16 MHz quartz crystal, as well as the common place connections such as USB and a power jack.

This was the first in its series and was used originally with the first version of the IDE. Although it is the basis of all of their products, since it is the original there have been many updated versions of it made that likely contain more economic or technologically advanced parts than the UNO. A big advantage though is that, being the most popularly used device, if any errors occur in the process of it, then a solution can easily be found online or via customer service. The chip could even be replaced for a couple of bucks if that is the issue. Before tax, this product goes for twenty two dollars, which is actually one of the more expensive ones out of the entry level Arduinos. Some of the specs include an operating voltage of 5V, with a recommended input of 10V, and a DC current of 20 mA for

the input and output pins. The dimensions of it are 68.6 mm by 53.4 mm with a weight of 25 g.

7.7.1.2. Arduino Leonardo

The Arduino Leonardo is the next type of microcontroller board considered. The following other types of Arduino boards will be compared with the original (UNO) to show how Arduino as a whole as evolved or the age and to determine the advantages and disadvantages of this specific board compared to the original. The first noticeable difference is the price. The Arduino Leonardo goes for two dollars and twenty cents cheaper than the original, resulting in a total of $19.80. Furthermore, this device has an additional six input pins, making it twenty in total. The Leonardo has contains a 16 MHz crystal oscillator and, similar to the UNO, has a USB and power jack connection. Something that stands out for this board is that one of its main usages is to be recognized by the computer as a keyboard and mouse. Because of this, a second processor isn't necessary. This is a disadvantage as well though since it is very specific in the job that is designed to do. Spec wise, Leonardo is the same as the UNO when it comes to the operating voltage and input voltage of 5V and 10V respectively. It's also the same dimension wise being 68.6 mm by 53.4 mm, however the Leonardo is slightly lighter with a weight of 20g. Furthermore, the DC current of the Leonardo is twice as strong as the UNO with 40 mA. Another disadvantage to this board is since it is less common then the original Arduino UNO, if any kind of error were to occur, hardware or software wise, it would be more difficult for us to detect that error or reach out to others to seek a solution to the problem.

7.7.1.3 Arduino Micro

Since our product doesn't require much coding, we thought we'd do research on the smallest board Arduino has to offer from the original boards; the Micro. The sheer size of it is one of the most appealing factors as it can easily be attached to a device and go unnoticed to the untrained eye. It is a similar build to the Arduino Leonardo in that it can function as a keyboard or mouse. Once again because of this, there is no need for a second processor to be used. It has a surprising amount of input and out pins, tallying up to 20. It contains a 16 MHZ crystal oscillator and a USB connection port. Its operating voltage is 5V with an input voltage of 10V, as all the previous ones do. Also similarly the DC current is 20 mA. The size is the biggest plus with dimensions of 48 mm by 18mm. It also weighs only 13g. Going for a price of nineteen dollars and eighty cents, this device is looking fairly useful for our toaster oven.

7.7.1.4. Other Boards Compatible with Ardunino's IDE

In order to save money, there are cheaper versions of boards to are compatible with the Arduino software, however aren't made by Arduino. Two of these examples include the Freeduino and Netduino. Both of which are fine products that are able to perform their task efficiently, while being cheaper than most Arduino boards, however they are not as trusted as Arduino. In this case the parts is not what is being referred to, but the companies themselves. The reason these companies exist is because Arduino has an open PCB design, thus there is no legal issues into replicating a similar board based on the original and selling it. Both companies have great board, and through this open source they have made some great advancements in design and technology, however if something were to happen negatively and we were to use a lesser known brand such as the two mentioned above, it would not bode well for us. They are also similar in regards to all dimensions, including length, width, and weight. Furthermore, they can have similar amount of input and output pins. The similarities continue after viewing the operating voltage and input voltage, and even the DC current is similar. The main take from these other brands is if a bit of a discount on the price is worth not using a reliable brand like Ardunino.

7.7.1.5. Arduino Phone Apps

One idea we had for our project would be to include a phone app where you can remotely control all the main processes of the toaster oven at a far distance away from it. Through our research we have found that there are various phone apps already in existence that are able to remotely control an Arduino board, thus controlling our toaster oven, assuming we were to go with an Arduino product. Some of these apps include Blynk and ArduinoCode, just to name a few. These products can currently achieve milestones such as execute and edit actual code on an iphone or ipad. The drawback to these vary between the different apps, but on example for the ArduinoCode is that another app (which is free) relating to ArduinoCode must be actively running on a computer in order to freely exchange information and commands to the board via USB. On the other side, some apps are extremely user friendly and support designs that can't be utilized elsewhere, such as the advantage of possessing a touch screen.We have also done some research on making our own phone app in order to make it more personalized to our project's needs.

7.8. Safety

Safety is always one of the highest concerns when designing a project such as this, especially since our product is intended for use at an everyday home. Some of the biggest Safety concerns we must worry about involve if something goes astray with our electrical components. This includes things such as fire, overheating, and overcooking.

7.8.1 Fire

Fire being one of the biggest concerns if we have too much power from the source, or if some currents are out of place, or if something is too close to a heating source and explodes. Even in the building phase, if something is wired improperly that can result in disaster even within the prototype testing phase. This is why standards are in place in order to firstly prevent these occurrences from happening in the first place, but then to protect those if anything unexpected were to occur. This is also why we wanted to implement a kill switch to our design so that everything can turn off automatically if the system feels like something is wrong while the toasting process is occurred, or simply if the user wishes to cut the timer short. If these actions aren't taken into effect, lawsuits could be in place would could hurt multiple parties involved, even at a university level such as we are at ourselves

7.8.2 Overheating

Overheating is a big issue being that toasting an item requires a good amount of power which is then transferred into a large amount of concentrated heat. If one were to touch the touch as the toaster is operating and the system is not well insulated, then the user could induce multiple burns and once again. Standards are one of the biggest aids to help in the safety of those who built the system and those using it. Especially if we want to instal an LCD touch screen, overheating is a big issue we must overcome. Also since this is a smart toaster with multiple electronic devices there is bound to be more induced heat as a result.

7.8.3 Overcooking

Overcooking can not be overlooked as well, as simple as an idea it may be. If an object is placed inside of a container that constantly heats it at a high temperature, then so many things would go wrong. This leads to both previous health concerns, as well as burnt bread that would taste disgusting, if even edible at all. This leads to a lack of profit for both parties involved, since people would be less inclined to buy the product and the consumer who bought the bread just lost their edible object they spent a fair amount of money for.

7.8.4 Burns

Being how there are open burners right below your food, the chance of burning yourself while trying to either retrieve or place your food into a toaster oven is fairly high. The chance is lowly when initially placing the food since the toaster oven likely isn't heated up enough in order to cause any physical damage to the user. This is mainly true once getting the recently toasted food back for

consumption. Depending on how the toaster oven is designed, it is possible that other parts of the toaster oven could get hot enough to slightly burn human flesh other than just the burner. It's possible for the surrounding walls to also take in this heat, being that when the toast process is occuring the heat is trapped inside the box for a prolonged period of time. Although this is being used to actually toast the food, it can not be directly applied to the food, thus the excess energy must be given off as heat in the remaining sides of the inside of the toaster oven.

7.8.5 Electrocution

The energy for the burners must be coming from somewhere in order to heat up the food. This is due to the high voltage currents constantly traveling through. Although this advancement is great in terms of toasting various foods, it is a real danger that could potentially kill a user in the wrong situation. The burners continue to loop the current, so if one were to interrupt it in any manner, that energy would go either in or on the person. The main way this could happen would be via interaction with a conducting material, such as some form of metal. A singular form of interaction will result in a short circuit. Although this is still an electrocution issue, it will likely lead to a burn since the current has nowhere to go. The scary part appears when two conducting materials are in contact with the active circuit. This causes the circuit to go full circle between the two conducting materials. Assuming these devices are in both of the users hands, then the electricity will actually travel into the users body and make a potentially life threatening route through the heart.

8. System Design

For our system design we will reflect on the research that was explored in the previous section and select the best option for our senior design project. We will discuss which sensors, test boards, software, and PCB design we will be using and make any adjustments as needed along the way.

8.1. Hardware and Software Design Details

Design-wise, the operationally device that should stand out the most is theo LCD display. This display should contain an ease of access interface on the front right part of the toaster oven. These should allow for various user commands so that various preferences can displayed for when considering how to heat up something in the toaster oven, being that everyone will like desire a different outcome, even for a question as simple as ‘how do you like your toast?’. This part will also be intertwined with an app on a mobile device so that they can control the different settings of the toaster oven via wifi or bluetooth. This includes setting the beginning temperature and timer, as well as communicating with the user when the food is near completion or if something has gone astray and requires human assistant to get back on the proper track, else the entirety of the toasting process might have to drop everything at a moment’s notice in order to ensure the safety of those around it.

Another feature we would like to add on the outside of the toaster oven would be dividing the pieces of the toaster in such a way so that they can be removed easily, thus be able to be cleaned easily. A removable tray would be likely aid in this case for the food, however we need easy access to the entirety of the toaster in case any pieces of food fall below this removable tray, especially if they get remotely close to the burner and burn to a crisp. This process would make it even harder to get rid of all the food chunks below the tray.

Looking towards more of the software components of the toaster oven, some of the apex properties of the oven include the burners, sensors, LCD display, and timers. Firstly, the burners must be optimal positioned, based on the length and height of the toaster oven, in order to efficiently toast the items going through the toasting process. Though this toasting process is most efficient when everything is toasted evenly, we would like to design the oven so that it also offers a good amount of space inside of it so that many items may be placed inside. One design solution of this could be adding multiple layers. That is why the sensors are extremely vital for any project such as this.

There is a multitude of ways the sensors can be used to figure out when the food has reached a predetermined position. The most appropriate thing would be

temperature, to make sure it is toasting at the selected temperature. Another is color, the most user friendly option, since a variety of pictures can be shown to the user and they may select their preference of toast based on those images as opposed to picking random numbers temperature and time wise and just hoping for the best. Another is the dryness or hardness of the toast, since moisture leaves the bread as the toasting happens. The location for these sensors is extremely important, as to not disrupt their data collection, so they must be positioned in such a way so that nothing may alter any of the data they are collecting, especially since the concentrated heating source such as the burners would be located in very close proximity to it.

The timer also fits into this category. For safety reasons, it must be able to stop at the drop of a dime despite what the timer is currently reading. The previous statements involving how close the device is the the burners also occurs for the timer. The LCD display is plays into effect here, being that it is literally on the toaster. It must be safe for human interaction while the toaster is still functioning, thus will be designed to account for that.

8.1.1. Test Circuit Board Selection

Table 7 shows a comparison of the Arduino Uno and Raspberry Pi boards.

Table 7: Test Circuit Board

Board	Pros	Cons
Arduino Uno	Microprocessor Much simpler Does not require much processing power or layers of software to run Can control pins directly	Typically runs clocked between 8 to 16 MHz (much slower) Will require additional board attachments to implement certain features
Raspberry Pi	Microcontroller Runs similarly to a computer, has operating system Has both a CPU, GPU, and memory Typically clocked at 1.2 GHz (much faster)	Much more complex requires much more layers of software to get started

We investigated some different boards but we selected two of the most popular boards and compared them to see which would be the best fit for us. After looking at some of the differences, our group will likely go through the arduino or something similar root. Arudnio are known to be much simpler in use and more viable for projects that involve more hardware with sensors. Our group still explored alternative options acquire more specifications of each.

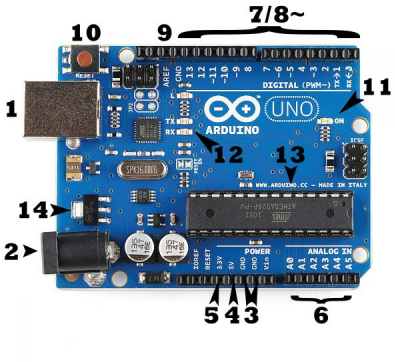
8.1.1.1 Arduino Uno Configuration

In this section we will discuss the layout of the Arduino Uno board we wanted to use and each feature it provides.Each Arduino board needs an approach to be associated with a power source. The Arduino UNO can be controlled from a USB link originating from your PC or a divider control supply that ended in a barrel jack. The Image shows which pins discussed. The pins on your Arduino are where you interface wires to develop a circuit. They generally have dark plastic 'headers' that enable you to simply connect a wire right to the board. The Arduino has a few various types of pins, every one of which is marked on the board and utilized for various capacities. GND (pin 3) There are a few GND sticks on the Arduino, any of which can be utilized to ground your circuit. 5V (pin 4) and 3.3V (pin 5): As you may figure, the 5V stick supplies 5 volts of intensity, and the 3.3V stick supplies 3.3 volts of intensity.

The majority of the basic segments utilized with the Arduino run joyfully off of 5 or 3.3 volts. Simple (pin 6): The territory of pins are analog In pins. These pins can peruse the sign from a simple sensor (like a temperature sensor) and convert it into an advanced worth that we can pursue. Computerized (pin 7): Across from the simple pins are the advanced pins. These pins can be utilized for both advanced info and computerized yield. PWM (pin 8): You may have seen the tilde beside a portion of the computerized pins. These pins go about as would be expected computerized pins, however can likewise be utilized for something many refer to as Pulse-Width Modulation . We have an instructional exercise on PWM, yet for the time being, think about these pins as having the option to reproduce simple yield . AREF (pin 9): Stands for Analog Reference, more often than not you can disregard this stick. It is in some cases used to set an outside reference voltage as far as possible for the simple info pins.

Figure 13 shows an image of the Arduino Uno with the configuration labeled.

Figure 13: Arduino Uno



8.1.2. Temperature Sensor Selection

This section will discuss the different types of temperature sensors could potentially use for our smart toaster oven. The temperature sensors is essentially so the correct temperature can be easily displayed at the users convenience.

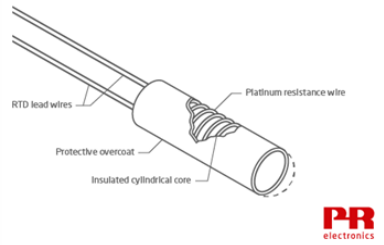
8.1.2.1 Negative Temperature Coefficient

If we were measuring the temperature of something in a lower temperature range, an NTC thermistor would be the perfect sensor. It's extremely accurate and measured linearly. Unfortunately, the maximum output of it's operating range is 250 °C. Toaster ovens can get warmer than this. Due to the limitation on the temperature range, we are going to have to pass on using this sensor.

8.1.2.2 Resistance Temperature Detector

Figure 14 shows an illustration of a RTD. Labeled are all the important parts of the device.

Figure 14: Resistance Temperature Detector



While the resistance temperature detector is expensive, it does fit our need for the desired operating range. On top of that it is accurate and is measured linear. If we can afford one with our budget, this looks like the sensor to go with.

8.1.2.3 Thermocouple

Just like the RTD, the thermocouple is in our range for the smart toaster oven. Out of the 4 sensors we researched, it has the widest temperature operating range. It's also not the most expensive which is great as it will save us some money. The drawbacks though are it's accuracy can be low and it's non linear. Based on everything presented, this is the clear 2nd choice if the RTD is too expensive.

8.1.2.4 Semiconductor-based sensors

The last type of temperature sensor we looked at were Semiconductor based sensors.

Table 8 shows the different types of temperature sensors and the pros and cons associated with them for this project.

Table 8: Smart Toaster Oven Temperature Sensors

Sensor	Pros	Cons
Negative Temperature Coefficient (NTC) thermistor	Price Accuracy Linear	Out of our temperature range. The Operating range is -50 to 250 °C
Resistance Temperature Detector (RTD)	Accuracy The Operating range is -200 to 600 ° Linear	Most Expensive
Thermocouple	Widest Temperature Operating Range	Accuracy Can Be Low Non Linear
Semiconductor-based sensors	Linear	Slow Responsiveness Not In Our Temperature Range

We are using a Resistance Temperature Detector (RTD). They are accurate, linear, and within our temperature range. The biggest downside though is the cost associated with them. They are the most expensive sensors out of the 4 listed.

A few of the sensors looked promising, but unfortunately, they are out of the temperature range or aren't linear. Due to these faults, we cannot use them in the project. Instead of the RTD, we ended up going with a thermocouple, which was our 2nd choice when researching. With our board it ended up being the best bet.

8.1.3. Timer Selection

Commonly, a toaster oven is really a simple circuit that begins as soon as you lower the bread into the toaster. This action starts up the power source for the circuit. The two main pieces of this circuit is a capacitor, and a resistor. When the "timer" starts, the capacitor begins charging through the resistor. Once the capacitor reaches a certain voltage, the springs launches the bread upwards out of the toaster. This also turns off the power source until more bread is pressed into the toaster. Thus, changing the resistance will change the speed in which the capacitor charges, and how long the bread remains in the toaster.

Instead we used a digital timer that is connected to a number pad on the surface of the toaster oven. There are also other sensors amidst the timer that could be used as a kill switch if anything goes astray. As electrical engineers, we designed our own PCB, DC to AC power converter, and sensors in order to make the toaster oven more efficient and innovative.

This timer also allows connection to the phone. This is especially important in order to aid in the customer service area. The ease of use should be simple enough to where the user can input a realistic time into their mobile device, and the timer should be able to automatically begin a countdown from an appropriate distance away from the source of the communication.

The kill switch mentioned is also tied into the phone. This way, a user will be able to safely disarm the toaster oven from a remote distance using the kill switch located on every screen of the app.

8.1.4. Improved Interface Selection

Table 9 shows the pros and cons of using a touch screen versus a keypad interface.

Table 9: Touch Screen Vs Keypad Interface

Screen Type	Pros	Cons
Touch Screen	Better User Experience Newer technology	More difficult to develop Can get scratched easier Can be difficult to use with dirty fingers
Keypad Interface	Easier to develop More durable over time Can still use with dirty fingers	Worse User Experience Slightly older technology

We used a keypad interface rather than a touch screen. Being a kitchen application, users are more likely to have dirty fingers. This is going to cause the screen to get dirty. On top of that, since a toaster oven is used almost daily, there is going to be wear and tear. Overtime this is going to scratch or wear down the display.The touch screen is the newer technology & it's technically better for the user experience, but we believe it's better to optimize the toaster for long term use. Figure 15 shows which keypad we will be using.

Figure 15 shows the keypad interface that we wanted to use for this project.

Figure 15: Keypad Interface

8.1.5. Communication Selection

The following section is used to help determine how the toaster oven will communicate with the user in order to promote the highest possible user satisfaction rating, while being efficient and easy to use.

8.1.5.1 Bluetooth vs Wifi

Table 10 shows both the pros and cons of using Bluetooth and WiFi.

Table 10: Bluetooth Vs WiFi

Connection	Pros	Cons
Bluetooth	Connects devices to each other	Does not connect to the internet Allows for 1 pair
WiFi	Connects to internet Allows multiple devices	Does not connect to other devices
Text Message (SMS)	No need for Wifi or bluetooth Easier to set up new numbers	Uses mobile data Expensive

We believe that the best option for connectivity is to use Bluetooth. We do not need the option to connect the toaster oven to the internet and we don't want to have the user to need mobile data to get text messages from the toaster. For this reason, bluetooth is the best option available. The use of a phone app will aid us in this case in order to use the bluetooth connection. It is possible to combine some of these though. For example, the toaster may be connected to a phone app via bluetooth, however once the food inside of the toaster oven is finished an SMS text message will be sent out in order to alert the user of their finished product.

8.1.5.2 Email vs Text

Table 11 outlines the pros and cons of text vs email notification.

Table 11: Email Vs Text Notification

Connection	Pros	Cons
Email	Free to send and receive Little training is needed	Requires Wifi Slower
Text Notification	Fastest growing form of mobile communication Commonly opened and read within the first few minutes	Requires signal Requires a cell phone carrier subscription

If it were simply between the user requiring mobile data compared to the user requiring to have internet, we decided the best possible option would be the use of the text notifications. One of the biggest factors being placed onto this is the development and utilization of a potentially cellular app that will be able to control the toaster. Once the items in the toaster are finished preparing, one is more likely to have their phones readily available as opposed to an email. Furthermore, emails are more so used for longer or more formal forms of communication. Something has simple as saying “your food is ready” would be better in the SMS environment.

8.2 Component Integration

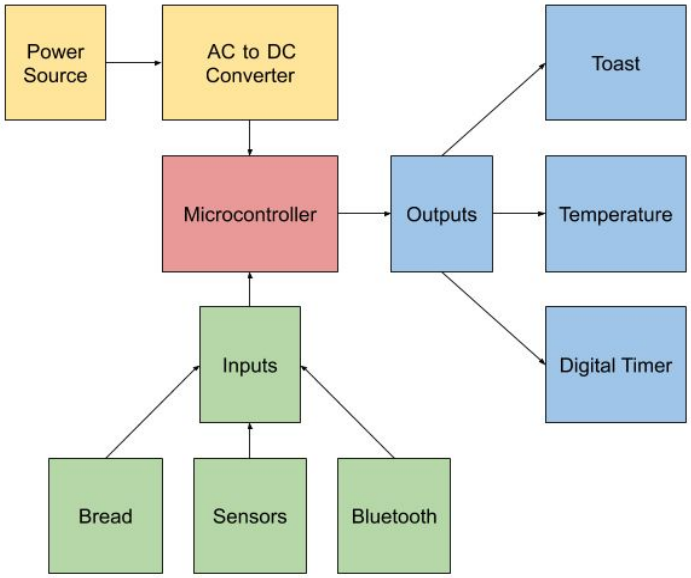
When it comes to component integration we can define it as the means by which to interface datelines and powerlines crosswise over frameworks with regards to electrical segments. In the product sense, the program joining is to a greater degree an exchange of data. Without emphasizing a lot on the power conveyance and the correspondence convention of this structures joining will be viewed on an all the more significant level view. The Block Diagram labeled figure 16 shows how this design will take forth. With the microcontroller at the center of it out, it takes in its inputs using the energy from the power source in order to achieve all the outputs listed adjacent to it.

8.2.1. Smart Toaster Oven Block Diagram

The following Diagram of Figure 16 is a **a high level Block diagram that displays the relevant inputs and outputs of the system that need to be added on to a toaster oven to make it a smart one. The power source shall come straight from an outlet which across the United States is mostly standardized as 110 V single phase at 60 Hz, however there are outlets meant for more higher duty task that use 220 V such as launching machines and ovens. The Toaster Oven though is being designed to take power from 110V outlet lines and outlets can be tested beforehand to make sure this applies through a simple multimeter test. Then an AC-DC conversion is needed which shall be accomplished on the PCB or through the use of a bought converter that shall be capable of taking 110 V AC to 5 V DC. 5 volts is needed to both run the Atmega328, the temperature sensor and numpad. All the sensors that are used for this project require 5 V. User will place Toast in the Oven set temperature on keypad and desired time. The microcontroller will be responsible for the control of the heating element and will work with the temperature sensor to verify that the set temperature is reached at that point a Led will display the temperature is reached. A digital Timer will display the amount of time left that is set by the keypad. The bluetooth component would be related if someone wants to be able to preheat their toaster before they see it to be able to save time by not having to be right there and enter the preheat stage. After the timer is finished a buzzer will go off to let the user know the oven has finished.

Figure 16 showcases the smart toaster block diagram for our smart toaster oven.

Figure 16: Smart Toaster Oven Block Diagram



8.2.2. PCB Fabrication

PCB or Printed Circuit Board we know as a procedure that has advanced throughout the years and now has many supporting projects to speed up the procedure. Commonly, in the past, PCBs could be handled in house by utilizing a photo etching substance process that would utilize synthetic concoctions to destroy the conductive layers. With new advances developing PCB structures would now be able to try and be printed by printers, or machined by boring machines in as short as a couple of hours. Notwithstanding the obstacles made in the ongoing decades a full scale configuration should at present be made by a producer since the recently referenced strategies are not as strong and don't keep going as long.

Numerous fabricates will take board structures and print them, for example, Advanced Circuits, APCircuit, E-TekNet, Olimex, or PCBart. These organizations will take your Gerber records which are the plan of the PCB and afterward thusly print the circuit board for an expense. The charge relies upon the intricacy and size of the plan and can run somewhere in the range of $20 to +$100, and these expanding costs have lead to the improvement of bunching makes which take enormous requests at that point make extremely 119 huge tiles of PCB in this way to diminish the expense of assembling. Organizations like BatchPCB, Oshpark, and SeeedFusion Studio utilize this strategy and along these lines can create your circuit board a brought down cost, however regularly take more time to fabricate. Another aspect that could bring costs down would be the use of a larger company with an open source.

Arduino is a great example of this since they make PCB and their IDE is open source. Because of this, many smaller companies take inspiration from the Arduino boards and develop their own. All of these boards are usable, efficient, and get the job done, yet they still don’t have that reliability factor when it comes to a bigger company.

Companies such as Freeduino for example are making very nice boards that use the Arduino IDE at a lesser cost than a normal PCB. They also make very new and interesting designs on said boards, so they were always an available option to us. However we choose Arduino for that reliability factor, even if it means spending a bit more money.

PCB configuration is an undertaking that has a wide range of programming situations to utilize. There is KiCAD, Altium, OrCAD, EagleCAD, and some more. EagleCAD is a free programming that anybody can approach, though Altium and Orcad are not free and require a permit. Fortunately, I approached the OrCAD programming and will in all likelihood do all the structure in that condition since it is significantly more competent free virtual products.

With these PC supported building devices clients can go from drawings, schematics, to examination and assembling. In the OrCAD suite Capture is the focal point, and it contains broad part libraries that can be utilized to produce schematics either with reproduction by PSpice, PCB editorial manager, or both. At the point when one is planning in Capture, there are three layers of structure that make up the schematic structure. The three layers are the model, Symbol, and the Footprint.

The model is where the part is recreated by PSpice and can be reenacted in setting, with AC reproductions, DC clear, Transient Response, and more sorts of various circuit reproductions. The images will speak to the schematic anyway it speaks to the pins of each part. The impression will speak to the size and design of every part on the schematic.

One example is an impression can speak to a soic, smd, plunge, or some other kind of segment impression. When these parts are planned the netlist will interface every one of the segments on the circuit board and move the record to the PCB proofreader. A PCB is reliable of two fundamental parts, the substrate and the copper follows. The substrate goes about as a structure to hold every one of the parts together and as a cover of power.

A circuit board comprises of PCB Cores, which are copper clad substrates. These layers can be stacked upon each other and make multilayer sheets. A PCB stack up can have vias that are plated, unplated, covered, and plated through gaps that are back penetrated in this way the plan can be very complex, or basically only one center that is twofold sided, and underneath is an image of a 6 layer center stack.

When the internal layers have been designed, the centers are adjusted and stuck together. Once everything is appropriately adjusted the pcb can be bored for its through openings. Not all layers will have follows and a few layers are planes which is a great idea to give low impedance associations with power and ground. Ground and power planes are frequently inward layers and sign layers will be above and beneath the planes.

A freedom can be utilized to give separation between plated opening and a plane. After the through openings are plated the top and base layers are designed utilizing a photolithography procedure. After this a slight polymer layer is applied to the top and base of the board called the solder mask and afterward utilizing photolithography to uncover the cushions and openings. The solder mask shields the top and base layers from oxidation and anticipates bind connects between firmly divided cushions.

PCB manager is utilized to plan the PCB by producing records that will portray the board layers for the photoplotter and CNC machines. Not these various layers are shown similarly. Thusly while structuring the PCB not these layers will be obvious. Frequently the work of art documents will create in excess of 25 distinct layers. Here is a rundown of these layers, their augmentations, and capacities.

Since the finished result is commonplace next is the way toward making a PCB begins with making the schematic in OrCAD Capture. In this progression you will include every one of the segments that is remembered for your structure. In the event that a segment doesn't exist in your library, you should discover it in an outside library or make the part. The subsequent stage is you will experience three unique advances, first which isn't essential however is to make the PSpice model.

This should be possible so utilizing PSpice and the datasheet to make an investigative model the part to be recreated. When you make the model you will make the image of the gadget with the goal that the pin number will be made. After this progression you make the impression by utilizing PCBeditor. This will be secured later. The entirety of our parts are fabricated and have comparing impressions. The following stage is to make the netlist for the PCB supervisor. This drove you to the PCB Editor program of the OrCAD suite. In this condition you will make the gerber work of art. First you start by making the board layout.

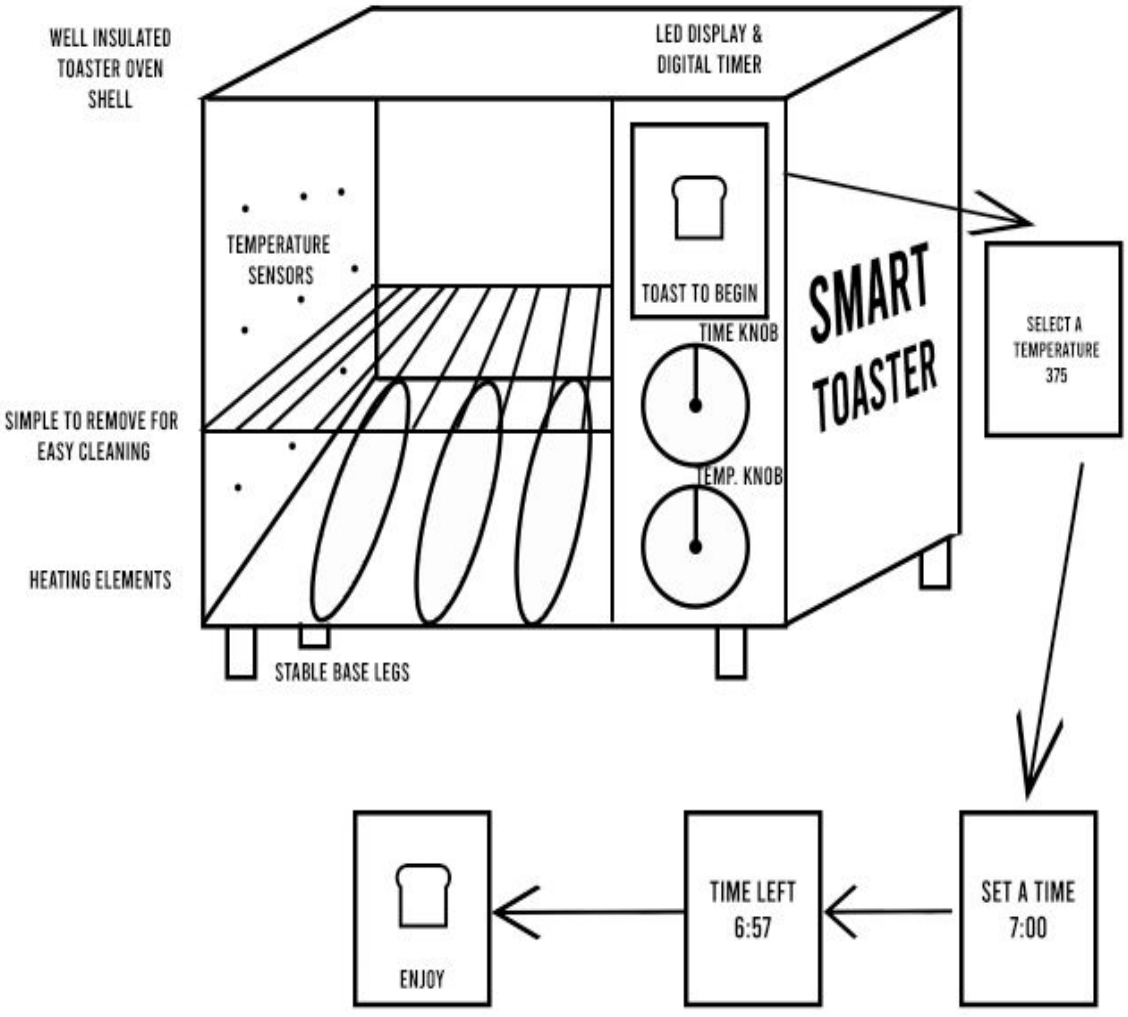
It is imperative to have configuration rule check while you make a PCB structure. These DRCs will inform you once a structure parameter is disregarded for example having parts to close, or having follows be excessively long. These physically dimensions can be overlooked when one is simply trying to think of the connections. One must realize that a manufacturer must have a very detailed explanation of what you are trying to send them, so the DRC is that physical step that shows them how to build it.

Also these boundaries laid out to us by the DRC is simply another constraint we must worry about, it is a must needed step into advancing to our final product. This helps in the safety of the product too as it determines the spacing between various parts, and takes into account how close various components can be without being a danger to the user. Overlapping is one of the most common mistakes the DRC error dialog will address to the one implementing the board. Another possible issue would be the angle in which some of the wires are placed. Forty five degree angles is the most optimal strategy whereas a ninety degree turns are frowned upon as they can cause a good deal of trouble.

8.2.3. Smart Toaster Oven Illustration

Figure 17 shows the initial Smart toaster oven illustration for the project.

Figure 17: Smart Toaster Oven Illustration



8.2.4 User Interface: Toaster oven

The toaster oven could work perfectly fine, but if the user interface of it isn't up to par then all the effort put into this project was for not. The very first thing we have selected to do regarding the interface is the buy a preexisting toaster oven and gut it out of all electrical components so that only the shell of the device remains. Well will then include all of our parts that we have handpicked to believe it will yield the best results.

The device we would like to jump out towards the user first would be the LCD screen. This screen should be appealing to the eye and promote the user to want to discover how it works. After turned on, the opening screen should read "touch to begin". This would then be followed by several prompts to determine how exactly the toaster should function. On all of these screens our icon for this project, a piece of toast, should always be visible. This is simply appealing to the user as its a continuous object that stays stationary and is always there.

Furthermore this may promote a hunger in the user so that they may want to use our product more. The first message that would show up would be concerning the temperature. Being that this is a touch screen, a temperature gauge appear on the screen and the user will be able to literally hand select their prefered option. However we are aware that a lot of people, especially those of the older generation, are still not entirely comfortable with this. Therefore we have decided to also include two knobs; one for temperature and one for the time. That way the consumer has multiple ways of inputting data into the toaster oven, thus vastly improving user friendliness.

The next prompt on the screen should read about the time. Similar to how the temperature aspect of our toaster oven worked, there will be a gauge on the touch screen the promotes the user to select their desired time throughout the touch pad. However this is not the only option. Directly below the touch pad is the time knob, which can be rotated in order to change the time without the use of the touchscreen.

After all the information has been properly added, a timer will trigger inside of the toaster to begin toasting the food. Simultaneously, a digital timer will be available for viewing on the LCD screen in order to remind the user of the countdown until the food is ready. Here, there will also be an option for a kill switch in cause something unexpected happens. This could be some form of error or safety hazard has occurred, but that should be rare. The likely case is that the user is able to peer inside of the toaster oven and they feel as though their original prediction was off and they actually wish to indulge in whatever food is currently being toasted at that moment.

Once this countdown hits zero from whatever the user inputted as the timer, then the toaster oven will ding to alert any surrounding people of the food that has finished being prepared. The screen will also change to the final screen available to been seen by the user, telling them to “Enjoy!”. After that the LCD screen will go back to the main menu once again so that the user may input some more data for a different type of food and toast that as well.

Another aspect of the toaster oven that is important to point out is the location of the objects on and in the device. First of these things is the user interface previously mentioned on the right side of the device. A majority of people are right handed, so we decided to place anything that requires interaction on that side of the toaster oven. Next, the location of the temperature sensors are immensely important. As seen in figure 16, there are multiple temperature sensors.

These sensors have been placed in this region of the toaster oven for a few reasons. First the obvious reason is to detect the temperature to make sure whatever the user inputted as their desired temperature is actually the temperature that the burners are supplying.

Another reason is its location in relationship to the burners. If the sensors were to be too close, then our data could be off big time. If the temperature is hot enough and there's little insulation, it would be possible to even break the sensors. This is why there are multiple sensors though. That way they can collectively have a reading and if one of the sensors is immensely off then the toaster would be able to realize this fact and adjust accordingly.

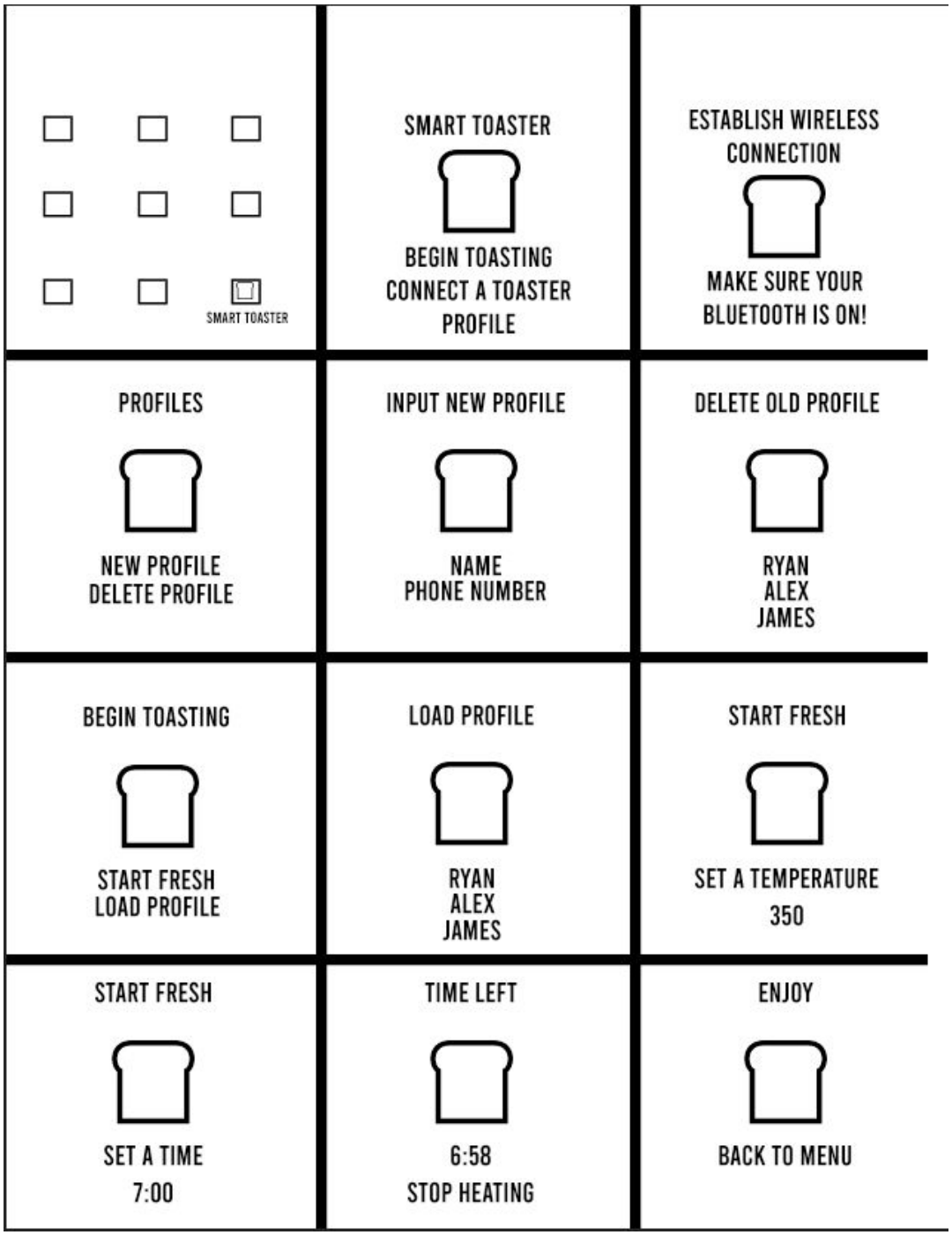
Lastly, their position in relation to the food is important, being that the temperature desired should be the temperature closest to the food being toasted. This shouldnt block space for the food though and promote user friendliness so that the consumer need not worry about placing their food too close to a device located in or on our toaster oven.

Above all, the user should not be inconvenienced or hurt due to the placement of any of the components of the toaster oven, or the dimensions of it compared to the other devices. This is one of the reasons we choose a toaster oven as opposed to a toaster; so that we may have more room to advance the toaster technologically wise while the user still has lots of space for food and moving around. The burners are the biggest factor to this as they can cause the most physical harm to a human body. The risk of some form of burn or electrical shock is greatest when coming in contact with them.

8.2.5 Smart Toaster Oven LCD Illustration

Figure 18 shows the concept for the LCD for the smart toaster oven.

Figure 18: Smart Toaster Oven LCD Illustration



8.2.6 User Interface: Phone App

User interface is very important to us and thus we have come up with a multitude of options one may used after downloading our software. Firstly being that we would like to design our own app, as denoted by the first box in the upper left of “figure 18: Smart ToasterOven LCD Illustration”. For future reference in this section, we will be referring to the boxes how one might access them in chronological order; going from left to right all the way to box 12 in the bottom right.

Therefore to rephrase, box 1 simply is a stereotypical phone screen containing various apps with our independent app to we shall be implementing in the bottom right labeled “SMART TOASTER”. Although there are other preexisting apps we have decided that it would be more suiting to our presenting and design if we were to make our own program and just draw inspiration from other apps instead of using them.

Box 2 will indicate our welcoming screen. For consistency sake, the picture of the app will be that of a piece of toast. This same piece of toast will be present on every screen from here on out to maintain that aestic feel while being user friendly. This same image appears as the image of the app from box 1, thus also maintaining that ease of familiarity. The options located on this screen that would lead you elsewhere on the phone app would be Begin Toasting, Connect a Toaster, and Profile. Debately one of the most important aspects of this app is the connect a toaster part. Using the touch screen to transfer to box 3 will automatically begin the search for a bluetooth device readily available.

After much research we have decided that the app would use this feature of bluetooth as opposed to wifi since, being this a fairly simple application, bluetooth should work more than enough that the internet need not have to be available to a consumer. After a device is found, the name of said device will appear to make sure this the proper device that needs to be connected. Once the toaster has properly been connected, the app will thank the user, then return to the home screen (box 2) and await the next input.

One of the most important aspects when it comes to making your product stand out and be welcoming to a consumer is the individually of it. The device should be a reflection of oneself, thus should be able to be personally designed the way the user wants. Therefore instead of tediously inputted your desired orders every time one wishes to use the toaster oven, a profile screen will be added as shown in box 4.

Boxes 5 and 6 would be the following options depending on if the user wishes to add a new profile or delete an old one. When first inputting a new profile, the app shall ask for a name to identify the profile with, as well as the number to contact

the user once the food is done heating up. We really enjoy this aspect, since a mother could throw in some toast in the morning, and their child would receive a text notification once the toast is ready, since the child in likely buried in their phone already. No need to go to another room to alert them of the food being ready since the notification of ready food should be more than enough to get most people out of their bed and ready to start the day. They'd be even more excited knowing that their food will always be exactly the way the want it to be as well since all of that information would be recorded onto the input new profile screen.

After the name and phone number is inputted into box 5, then the app will jump over to box 9 and 10 so that one can determine the perfect temperature and time that suits their needs. Another useful idea that can be applied is that instead of the name of the user, one could insert the type of food they want to be heated up. Even though the primary objective for this experiment is to successfully cook toast in the toaster oven, various other food may be used as well.

All food items that are to be toasted should be cooked at a different temperature for a different duration of time, depending on what is required for the food. The delete old profile screen on box 6 could then delete a profile not used fairly often anymore, such as if a guest was living with a consumer and they just recently left. There are currently three profiles underneath the image of the toast, but the app will allow for up to ten profiles to be saved at one time.

Finally, the last possible selection on the main menu of the app, which the user would be selecting most of the time, is the being toasting section. Here, the user is able to start fresh in order to choose the exact temperature and time they want for the toaster oven, or they can load a pre existing profile for a more ease of access. If one were to load a profile, then toasting will begin immediately with the selection of the profile. If start fresh is pressed though, the user will then be brought to box 9 and 10 to input their requirements for the toast. This data will be sent to the toaster via the bluetooth connection and start the timer in the toaster. This will also trigger the timer on the phone app to begin, as labeled in box 11.

After the timer has been set then hits zero, the user will be alerted that the food as finished heating up and emplores them to enjoy. This alert will happen in various ways to ensure the user knows the food is done. Firstly, the toaster oven itself will be able to making a dinging sound to alert the surrounding people that the food inside is finished toasting. Additionally, the phone app will also have an alert system that will make a similar noise and prompt a notification stating that the food that they have put in is now finished. After this the consumer can be put back to the main menu once again and start over if they so wish.

Furthermore the kill switch will always be active on the phone, thus can easily be located on every screen in the process of adventuring through the app. This

modulation allows the user to tell the toaster oven to immediately stop all action, including turning off the burners and the timer. This is simply for precautionary reasons and hopefully won't be used very often, if at all. It will only be used if something goes astray, however it could also be used as another user friendly element.

With this switch, one could change their mind with how long they want their food toasting for and just stop it in its tracks immediately. This way is a lot safer as opposed to other methods we have researched. This kill switch isn't labeled on the figure 16, however it will always be available to whoever is using the app. It will say "stop toasting" in the bottom right hand corner. We have used that specific phrasing as so not to alert anyone. If one were to open the app and see the word killswitch on the bottom, that doesn't seem like the most trusted device then.

8.3. Integrated Schematics

The integrated schematic shown below in figure 19 shows the layout and necessary components for the Atmega328p Au SMD chip. When first acquiring a Atmega328P au it will not have the boot loader already installed and will require to be installed through a arduino nano or an FTDI Connection which both are capable of being purchased from online retailers. The following schematic has been equipped so that it is possible to use either to upload it.

This design was chosen to give the design extra flexibility incase one method is not working properly or if you do not wish to use the arduino bootloader at all it is possible to load your own software interface through the FTDI connector.

Figure 20 then shows the microcontroller board's layout. This is especially useful in a production standpoint as a manufacturer would be able to understand the intricacies of building the device via this layout. This design was made especially well as all connections are direct straight lines from one part to the other. Overlapping also isn't a common issue in this case due to how smooth all the connections are, that is why we have determined this to be a very exceptional layout.

Figure 19 shows the schematic for the microcontroller.

Figure 19: Microcontroller Schematic

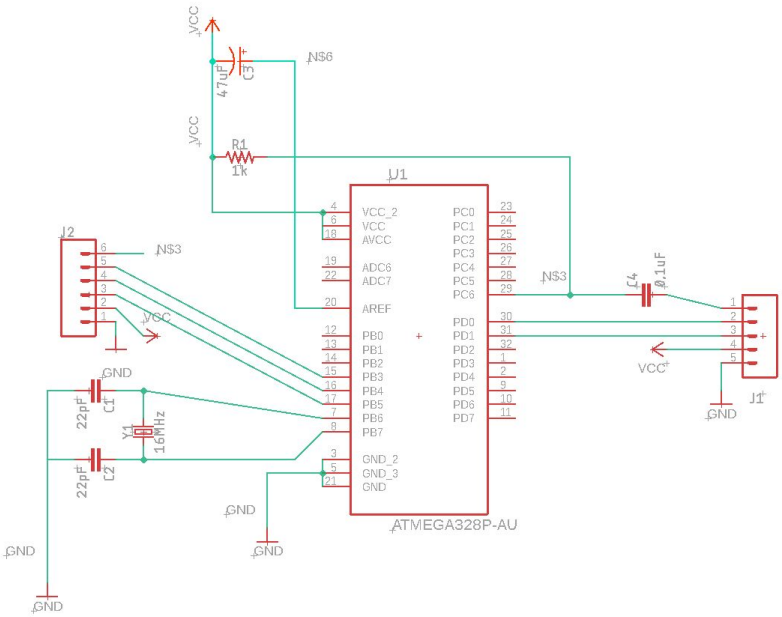
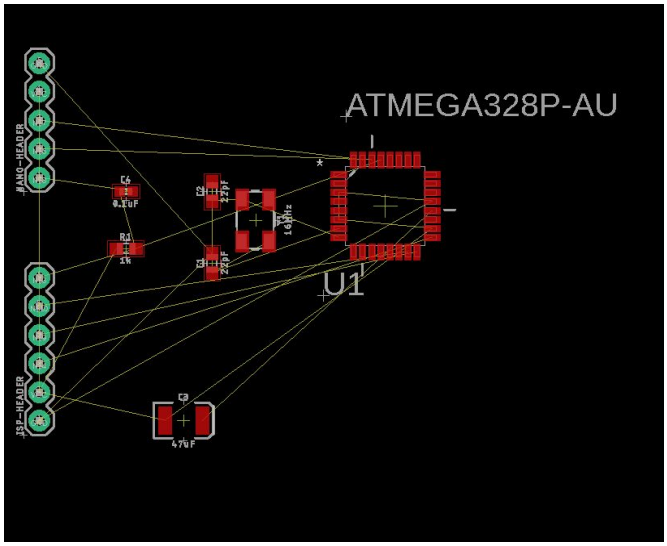


Figure 20 shows the microcontroller board layout.

Figure 20: Microcontroller Board Layout



9. System Demonstration and Testing

Concerning testing, it is basic in a framework configuration to have the option to approve that all the different areas and subsections are attempting to their normal standard. On the off chance that a solitary area isn't working, it is likewise fundamental that somebody can recognize the issue. So as to have a firm framework the reconciliation and testing must be set up plainly and be directed completely. Each and every segment must be tried so as to decide whether each part is working appropriately. That incorporates each resistor and capacitor up to the microchips. After every segment is tried exclusively then the finished subsystem must be tried so as to build up the plan was executed and made appropriately. At last, when each subsystem is considered then the framework in general will be tried and that eventually prompts the finished result. The real incorporation of framework is more in the extent of planning as opposed to quality checking. The test of reconciliation is the last advance in acquiring a concluded item. Interfacing every subsystem brings the inquiries of which correspondence convention to use just as how power will be conveyed. These issues will be investigated more in the accompanying areas.

9.1. Project Prototype Construction and Coding

When it finally comes to prototyping the device, we put all of our research collected in section 6 in order to implement our carefully selected plans described in section 7. Neither the construction nor the coding will likely be completely from scratch. The physical device will go off the basis of the shell of an already assembled toaster oven, and the code will contain some basic knowledge of coding, especially once referring to that of the phone app.

9.1.1 Project Prototype Construction

Both hardware and software are immensely important when it comes to any product being made. The part the consumer can visabilly see though is the harder, so it must look appealing to the eye and be user friendly. In order to achieve this outer look, we will be testing out the look with multiple toaster oven in order to discover what appears to be the best approach for what we are looking for. Once the testing is through, we disassembled the toaster oven we have selected so that it only remains a shell of what once was. This will be the basis of our hardware construction.

A major reason that we are only using the shell is because we wish to optimize the toaster oven so that it may have as much room as possible for all the advanced components going into it that actually make it smart. We must be careful with this though as another size situation that needs to be resolved is the amount of space allotted for food. It doesn't matter how advanced our toaster oven is if it doesn't have enough space for a multitude of food, such that is common for a regular toaster oven. Therefore testing must be done again in this aspect to best optimize the space permitted from the shells we determine meet our standards. This can be done, however we need to gather all the supplies that are to be embedded into the toaster oven so we can see what the ratio is between all the devices and the empty space for food.

Some parts could be moved around with ease, such as the timer, or board. Other objects need to be placed in a general location though. The one that may cause the most dismay on our end would be the temperature sensors. Firstly, these sensors must be remotely close to the food in order to find the temperature of the food and make sure it accidently doesn't overcook. This cannot impede on the customer rearranging the toaster oven however to place their food wherever they wish to. This also cannot come in close interaction with the burners, as first its a safety hazard, but second it can skew the results from the temperature sensors if they are in close proximity to the burners.

The location of the LCD screen would also fit under this category, as it must be placed in the foremost location so that the user has an ease of access to it. Depending on the shell of the toaster we have chosen through the experiments, we may have to modify the size of the user panel to match that of the chosen LCD screen. This is where the dimensions play a huge role in a deciding factor of where to place the screen, as well as how much room should be taken up by it.

9.1.2 Project Prototype Coding

Now leaning on more of the software aspect our own toaster oven, the code must be tested as well to ensure efficiency and safety for the user. This first begins by simply writing the code to make it as precise as possible. Long and drawn out code could cause slight delays which would hinder the process of toasting. Therefore we need to experiment to determine the optimal amount of code that is short and can be carried over easily, while still getting the entirety of the job done correctly.

With delays aside, the code must foremost actually work as intended. It wouldn't be the smartest thing to assemble to entirety of our toaster oven and test the code from there in case something goes astray. Therefore testing will be done simply through a USB connection to a computer or laptop, likely with a windows connection. Since it is away from all the other parts, we can assess for possible safety risks while it is isolated. One example would be how hot in might get. If its

overheating just by executing the code, then there is more than likely an issue somewhere, either in the hardware or software. This overheating aspect is very important being that this device will be located inside of the toaster oven, potentially next to the burners depending on the testing results found in the previous section. This actually stands true for all the smart devices, as well don't want to promote any form of skewed data results due to a device being located within close proximity of the active burners. We would most definitely be liable if something were to happen to the user due to a lack of coding performance on our end.

9.2. Project Prototype Testing Plan

The main components for the prototype that would need to be tested would be the sensors, timers, phone app, and LCD screen to ensure they all work properly. This is immensely important to the project has a whole so that if anything goes against our vision for this project we may correct it in the allotted time given to us. Being that power is needed for this project and we are dealing with objects being rapidly heated in a condensed space, safety precautions will be taken whenever readily available.

Testing for the efficiency of the sensors is arguably one of the most important aspects of this project. The sensors alert the user when toasting is complete or if something goes wrong and the toasting process needs to halt immediately. These sensors were the first be tested outside of the toaster oven without any of its forces acting upon it. This testing process can be as simple as attaching some probes and placing it on objects to check their temperature, or placing it in front of an image to determine the color currently in front of it. The feel of an object could be another test, such as dryness or hardness of an object as moisture as left it. Assuming these test results in a success, we would then try to initialize it into our design for the toaster oven. The sensors need take watch of the food inside of the toaster oven at all times in order to get these readings, but with variables such as being in close proximity to the burners, some of the data may be altered unexpectedly and thus unusable. A good way to test this would be to slowly crank up the temperature to see how much heat the sensors can withstand. As long as they are still able to function properly at the highest setting we are implementing into the toaster oven, then the test will be a success and the sensors will be fine.

In terms of the timer, the process will be fairly similar to that of the sensors. First they are tested outside of the oven to insure it properly counts down an inputed time. We would do this by comparing it to a real time clock to guarantee its accuracy is preferable. Once this is to our liking, it is transported and implemented into our toaster oven. First we would manually input a time while

the toaster is on to make sure it still works as it should, then we would do a combined test with some of the other features of our product, such as with the mobile app and the LCD screen. For the mobile app, we would input a time onto the device and check to determine if the connection is strong enough to keep an accurate measure of the timer. The same would be done for the LCD screen.

The last two objects that are tested is the mobile app as well as the LCD screen. The mobile app is basically an extension of the LCD screen so that you may place inputs to the toaster oven at a distance. Naturally, therefore, one trait to test would be the distance in which the phone could have a solid connection between itself and the toaster. We do this by repeatedly giving demands to the toaster oven to see if it reacts as it should until it is unable to accept our inputs properly due the the distance. We also know what other things could impose the connection, such as placing objects in the way, going through walls, or having other signals occurring simultaneously that could hinder the message trying to be delivered to the device. Once again, this is tested first with no burners, then with the burners on. Same goes for the LCD screen.

9.2.1. Power Testing

When testing the AC-DC change, the key qualities to gauge are voltage and current. For all the AC-DC changes, the voltages ought to be inside five percent of the normal yield since the Webench configuration records had a yield detail of keeping up inside five percent of the ideal yield voltage swell. It is essential to ensure gadget is completely utilitarian when all segments are turned on. This capacity will likewise be tried to ensure the gadget can run for at least thirty minutes. If we do not desired output then we are going to cross check multiple points in comparison to multisim.

In the table shown below the voltage and current tests are checked on that will be performed for the two phases of AC-DC transformation. The ideal opportunity for which the gadget ought to work for will likewise be audited. A rundown of steps will be taken while investigating the circuit on the breadboard and PCB also. First will check the circuit to guarantee that it has control being provided to it. This is effectively done utilizing a multimeter set to a voltage run.

Estimating the voltage utilizing a multimeter at the focuses where the inventory enters the circuit board will give an outcome. In the event that the multimeter shows that there is no stockpile voltage, at that point there can be various potential outcomes to examine. Normal blunders are that the battery could be level if the hardware is battery controlled. On-off switch broken is another mistake, which can be checked by detaching any power source and checking for congruity over the switch.

The PCB configuration will require having test focuses to decide whether each mounted piece is accepting the right voltage. Structuring the PCB test focuses will require putting an open connector gap with a positive and negative terminal. This can be structured in the PCB plan programming. The test focuses on the PCB would should be in any event 3.2 mm separated from board edges. This is done to forestall shorting any parts in the PCB. Normally embeddings the test focuses on the base of the board is a simpler plan technique. Test point destinations can be through-gap leads, devoted cushions or little width vias. Test focuses ought to be uniformly dispersed over the outside of the board. High worry in clogged zones can make board twist. Further clarification on how the PCB ought to be intended for testing is examined in the following areas.

Table 12 outlines our testing plan for AC-DC

Table 12: Testing Plan for AC-DC

#	Description	Conditions	Predicted Results
1	Input voltage to a desired voltage is ensured by all AC-DC components	The contribution of each supply is associated with a DC control supply set to the right voltage level and the yield voltage will be estimated utilizing an advanced multimeter	Each supply circuit ought to have and yield voltage that is 5% of the voltage level wanted from research
2	Input voltage to a desired voltage will be ensured by all AC-DC components	The heaps are tried on a breadboard to reenact what the last undertaking would resemble. Voltage would be applied and the present will be estimated at each heap.	Each supply ought to have a present that is inside 5% of the ideal esteem referenced from research
3	AC-DC conversion must be fully functional when in check by the electronics	All segments will be working at regular qualities once device is turned on.	Device ought to have the option to completely work for at any rate for 30 minutes.

Given the usage of numerous test focuses on the printed circuit load up, the capacity to diminish test time is accomplished. Furthermore, if explicit segments fall flat, it will set aside less effort to recognize the incorporated circuit or other part that has fizzled. Given the sharpness of test tips in the testing areas on the college grounds, test indicates give the capacity effectively associate with areas where different tests need to happen. Weld areas are not perfect because of their variable nature of shape and contact surface and along these lines a test point would be perfect.

To include extra simplicity of testing, breakout pins can be used to apply connectors or clasps to guarantee that the best possible waveform or recurrence is being delivered. Given the test style of oscilloscopes, it would be perfect if there were a breakout stick to associate with. With these extra testing areas with breakout pins, testing 131 time is decreased and consequently empowers the general testing grouping to be progressively intensive in less time and fruitful coordination can be accomplished.

With an assortment of test point areas, testing of resistors, capacitors, inductors, diodes, coordinated circuits, light transmitting diodes, and microcontrollers is conceivable. With the utilization of testing the numerous information and yield pins of the microcontroller, vigorous quality can be accomplished by guaranteeing that there is an approach to approve the product capacities.

9.2.2. LCD Testing

To test the LCD, we went through all of the different screens along with testing the timer. There are numerous iterations of the test as there is going to be a lot of different screens. From inputting the users name to selecting a user and the temperature, everything will have to be tested so that the smart toaster oven runs smoothly. This includes all interactions with the mobile app as well. Even though the user will mostly be looking at the app during this process, we would still like the proper images to appear on the LCD so that one may easily switch back and forth between the two devices.

9.2.3. Bluetooth Testing

For the Bluetooth testing, we tested on both an IOS and Android phone to see if they are able to pair correctly to the smart toaster oven. We tested them out by cooking toast and seeing if the phones get the notification that the food is done cooking. If it works, great, if not, there is more work to do

9.2.4. Microcontroller Testing

When it comes to a microcontroller, testing can be a very daunting task. In short, testing the microcontroller is an assignment that will incorporate both physically examining our planned circuit board with a rationale analyzer, and making programming for every module to test if every module is working appropriately. Testing the microcontroller will include every particular module that we plan on utilizing on the microchip.

For example the arrangement is to use the USCI module for I2C correspondence among microcontrollers, and with Bluetooth. Our test may work as a product in which we will check show the information of a register in the USCI module and contrast the aftereffects of the information with the normal information in the datasheet. This should be possible with both programming, and with equipment, since the USCI's module will cause its data to an outside module. Rationale analyzers can go somewhere in the range of $100 to over a thousand dollars in this way utilizing an oscilloscope may be the best alternative for equipment.

9.2.5. Heating Element Testing

This aspect of the toaster oven is one of the most dangerous to test, not only since it can injury the user while it’s on, but also any of the other devices inside of the toaster oven. The heating elements are essential though as they are the thing that actually toasts the food to the desired temperature. For testing purposes, this must be by itself first in order to promote the highest change of safety.

The temperature sensor is the next thing to test with it so we can get an accurate readout on how hot the burners can reach. The next thing we test is the burners with some food, such as toast, to see if it not only toasting, but how evenly the toasting process occurs in. After these few tests there are still a few dangerous that can occur, but it is likely safe to combine everything together.

After that we must test with actual food as well in order to be a hundred percent sure it is working as intended. White bread would be the optimal food item for this as it is easy to tell how far in the toasting process it is based on both the color and texture of it. We ran multiple runs of this to determine an accurate mean time based on a certain temperature. This will likely also be the timer and temperature used at our senior design showcase as we show off all we have learned through this project.

9.2.6. Phone App Testing

After the testing of the bluetooth as been complete, then the testing of the phone app begin. Being that we have selected for the phone app to use bluetooth in order to sync up with the toaster oven, it is a very important first step. A good way to test the phone app would be to start with comparing it to similar phone apps readily available on the app store for free. One of the first ones that should be compared is ArduinoCode that actually shows all the coding aspects gone into the product. This app also allows for executing these prompts directly from the phone that is being used.

Following the bluetooth and comparative testing, the test of our app should take place. To properly test this, we would have to go through every available option and much sure everything functions how it should. This can be seen by starting a toasting option, then seeing if the temperature sensors and timers on the toaster oven matches to those on the phone app.

Another important aspect to check is the kill switch. This is readily available to all users as it's the first thing one should do if something doesn’t go as planned. However, this is also being used as a turn of early switch. This way if a customer feels as if they accidently put the timer on too long, or changed their mind, or has to leave early, they can just end the toasting prematurely via the kill switch in order to safely remove their food from the toaster oven. Safety is of the utmost importance for this product specifically due to the open burners located directed inside the toaster, on top of the food.

Furthermore, this product must be tested with different users. If one person were to check all the devices by themselves, two errors are bound to occur. Firstly, they’re only human and likely will forget something, such as trying to toast a food at the highest temperature given with the longest time available or a similar extremity. Secondly, since user friendliness is also very important to this product, then we must have many different try it out in order to guarantee that it is as user friendly as we claim it is. This is also why the profile selection was added to the mobile app, so that everyone individually feels welcomed and that something remembers how they enjoy their food.

10. Administrative Content

10.1. Initial project milestone for both semesters

The following are the dates for milestones we wish to hit in both senior design 1 and 2. While nothing is set in stone, we needed to come close to hitting these so that our project is on track to be completed on time. It can be easy to get sidetracked with life and other senior level elective classes at times. Although this simply seems like a list of dates, it is very important for the completion of our project. If we were to wait until the day of to turn in the report, it would likely be a complete disaster with multiple spelling mistakes, repeated content, and vague paragraphs.

The most important parts of this project would be the first couple of days beginning the paper, as well as the last couple of days. The Beginning section is important because it starts out what we hope to achieve in our project. If we don't have a strong start there will be no motivation to continue with the rest of it, or it will be really lackluster. The last couple days are also extremely important due to the fact that we are able to review our work before the hard deadline. As much as we would like to take a break after typing up around one hundred pages, we must then be our own worst critic. We must dive into our work, even if a different group member wrote a specific section, and make sure everything is analytically correct, as well as worded properly. This time could also be used to have a professor check our our work and ask for suggestions as well. Ultimately it is up to us to write this paper to the best of our ability, and this milestone calendar is the first and last thing we should be looking at to make sure we stay on task.

10.1.1. Senior Design 1

Table 13 outlines the testing schedule for Senior Design 1.

Table 13: Senior Design 1 Schedule

Description	**Due Date**
Idea	August 28
Select Project & Figure Out Roles	August 31
Initial Project Standards	September 18
Initial Project Group Meeting	September 24
20 Page Project Standards	October 1
30 Page Project Standards	October 7
40 Page Project Standards	October 13
50 Page Project Standards	October 19
60 Page Project Standards	October 25
45 Page Group Meeting	November 5
75 Page Project Standards	November 3
90 Page Project Standards	November 15
Review The Final Project	November 18
Final Project Standards	November 24
Print The Final Project	November 30
Submit Final Project	December 2

10.1.2. Senior Design 2

Table 14 outlines the testing schedule for Senior Design 2.

Table 14: Senior Design 2 Schedule

Description	**Due Date**
Order Parts	December 6
Design Circuit Board	January 20
Solder Circuit Board	February 1
App UI/UX Designed	February 8
Toaster Oven Designed	February 25
Toaster Oven Skeleton Built	March 2
Phone Notification Developed	March 10
First Prototype Built	March 20
Start Testing	March 21
Form Faculty Committee	April 5
Final Prototype Built	April 8
Board & Presentation Created	April 12
Senior Design Showcase	April 17
Final Report	April 20
Senior Design Website	April 23

10.2. Estimated project budget and financing

The estimated budget for the smart toaster oven is approximately $500. We figure this is a good starting point for the project. We expected it to fluctuate a bit when ordering the parts and assembling everything. This is expected when prototyping any type of project.

Each member is going to pitch in ⅓ of the total cost for the project. So if the total does come out to $500, everyone will end up paying approximately $167.This is simply an estimate, and not our exact numbers.

We have no sponsors for the project and will be paying everything out of pocket. We do not want to work with a company. Since it's only $167, there will be no financing. Working with an outside source would cause extra issues with the project. We have decided not to look for a sponsor because we want to have full control of the direction the project is going to go.

Table 15 showcases what we want our projects budget to be.

Table 15: Project Budget

Item	Budgeted Cost
Arduino Board	$20
Toaster Oven	$200
LCD Display	$50
Sensors	$80
PCB	$20
Other Supplies	$125
Total	$495

10.3. Decision Matrix

The following is a list of other Projects/ Considerations:

1. **Padlock Mailbox**- the premise behind this design it to innovate another commonly used item. In the case of this mailbox it would be theft. The padlock mailbox would require a pin number to unlock a mailbox as well as have a smartphone application to be able to unlock the box. One major issue with this project is that the person deliver the mail may have issues putting in the mail. He or she would need some sort of special key to access the mailbox. Giving mail companies access to this would require a nationwide adaptation of the idea which can be difficult.

2. **Auto-targeting Nerf Gun**- the idea behind this project was to use a Nerf gun that would target and shoot certain targets it is programed to use. This project has been done by other groups in the past and shown to be a

very interesting project. The challenge this proposes is more complex programmer for our group. Our group consists of only electrical engineers in which can pose a problem with projects that are very heavy on programming.

3. **Smart drinking cup**- UCF is known for its tailgates and football games. When it comes to drinking, there is a responsible and irresponsible way of doing it. Doing it responsibly maintains that healthy balance of excitement and safety. One idea that our group had was to develop a smart drinking cup that would automatically close itself when the user had too much to drink. This would work by having a sensor that analyzes the breathe of a user and would shut down if it met a certain limit. We decided to do not move forth with this idea because it would require a large adaptation into society as it would essentially have to ban other ways of consuming alcohol.

4. **Smart Microwave** - This project was most similar to the smart toaster oven. A phone app and smart capabilities would have been built into a microwave. We decided to go with a toaster oven instead of a microwave due to the costs associated with the microwave and the size of a microwave. It's too much of a hassle carrying it around. A toaster oven on the other hand is quite easy to carry. Also, microwaves are much more expensive than toaster ovens. Since we are all college students on a limited budget, it was the best idea to work on the toaster oven.

5. **Laser harp** - Due to our love for music we did some research to combine that with our majors and decided on a Laser Harp for a possible project. This device would contain a laser shining at a mirror attached to a motor creating the illusion of multiple lasers. If one were to place their hand on top of one of the beams, a signal would be sent to a circuit board that's also connected to a computer with a synthesizer and plays a corresponding musical note. Once again this would take some coding and photonics knowledge, so it would be safer for us to work on something mainly electrical, such as a toaster.

10.3.1 Toaster Oven vs Toaster:

When initially coming up with the idea of this project idea we originally planned on building a smart toaster device. After careful consideration it was modified to be a toaster oven instead. When exploring the idea of a smart toaster we came up with obstacles mainly dealing with the amount of space we will be working with. A simple toaster is very limited in size and may be very difficult implementing all the engineering design specifications we have planned. A toaster oven has much more space to work with and still maintains the original idea we have.

10.4. Project Tools

10.4.1 Communication Tools

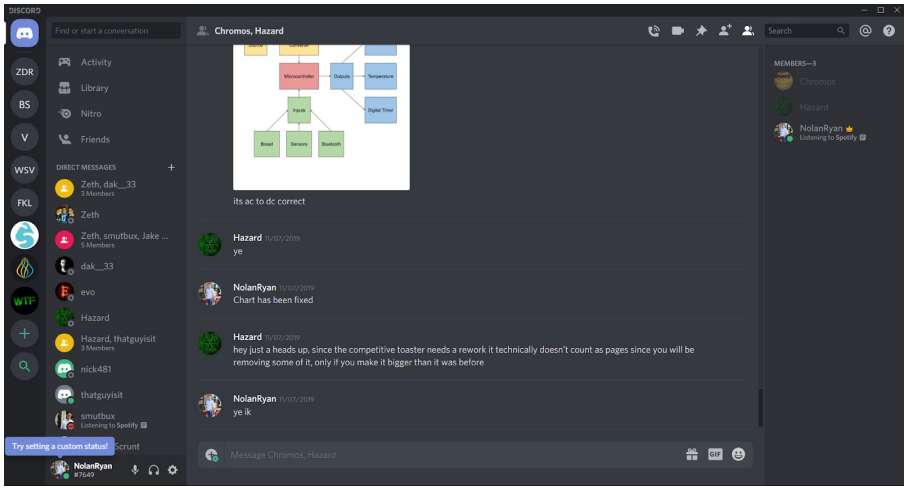
Communication tools are critical when working on a team project. That's why we decided to go with GroupMe and Discord. We had to have one that focused primarily on messaging while one that focused directly on calling. With both of these tools in our arsenal, we were able to stay on track and complete most of our goals on time for senior design 1 and hopefully will do the same when we build our smart toaster oven in the spring semester.

10.4.1.1 GroupMe

GroupMe is a messaging app that we use to share ideas and communicate updates. It has both a phone and desktop app. Since most of our classes have GroupMe groups, we thought this would be the best way to communicate. We created a group on there and use it daily. This will be our main source of communication because of how flexible it is, since we will get all notifications of the group either on our phones or on our laptops.

Figure 21 shows Discord which is our main source of communication when we need to jump on phone calls.

Figure 21: Discord



10.4.1.2 Discord

Discord is pretty much a higher quality version of skype. We use Discord when we need to jump on calls and discuss the project. Discord also offers messaging, but we tend to use GroupMe for that instead. Discord has both a phone and desktop app so it's available whenever.

10.4.2 Senior Design Paper Creation Tools

The creation of the paper for Senior Design 1 relied heavily on 3 tools: Microsoft Word, Google Docs, and Adobe Photoshop. Microsoft Word and Google Docs were used to write and format the paper properly. On the other hand, Adobe Photoshop was used to create the custom images for the paper. Images such as the house of quality, user interface design, and what the smart toaster will look like were all originally created on paper. From there we had to transfer them to the computer and make them look professional. So we ended up using Photoshop as our go to tool.

10.4.2.1 Google Docs

We used Google Docs as our main source for writing the report. Since multiple people can edit a document at once and we don't have to send files back and forth, it was the best option. We all have a link to our paper and can go and edit it whenever. It doesn't matter if it's during the middle of the day or middle of the night. All of the changes are saved automatically, and we don't have to worry about the file going missing if a computer crashes.

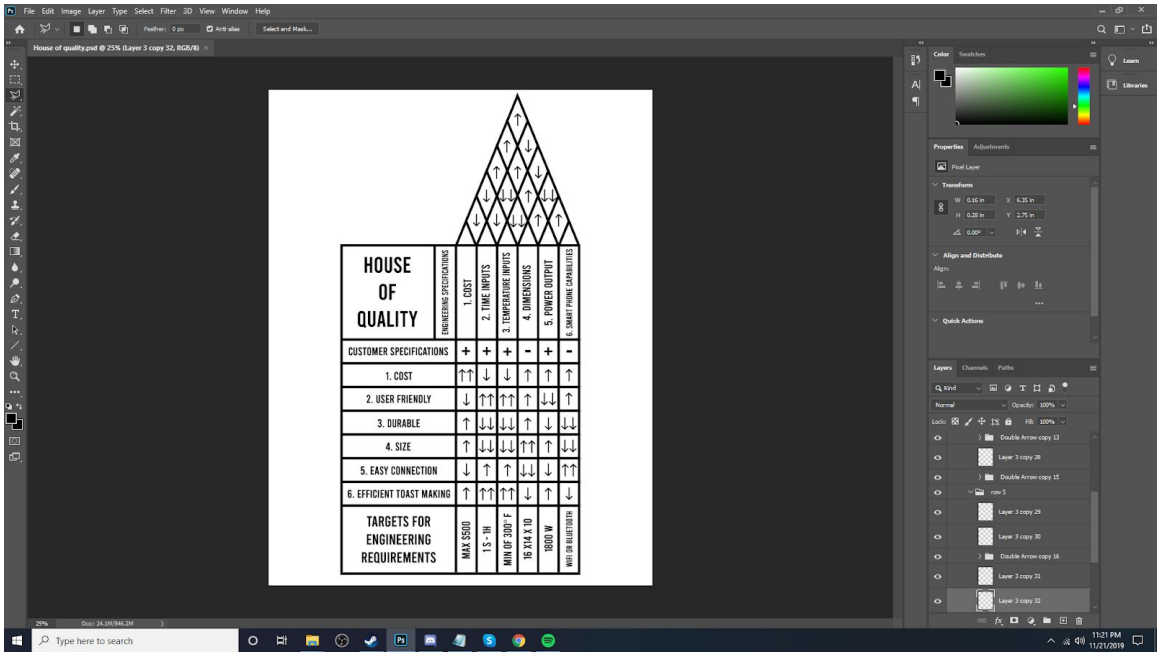
10.4.2.2 Microsoft Word

For formatting, we primarily used Microsoft Word. While Google Docs does have some formatting options, we found that they weren't as advanced as Microsoft Words. Especially when we had to number all of our pages. Google Docs doesn't have an option to start page numbers on a certain page. You would have to hand number all of them. Since our report is going to have over 90 pages on top of the extra sections, it was in our best interest to transfer it over to Word to save time and make things easier on the formatting side of things.

10.4.2.3 Photoshop

Figure 22 shows Adobe Photoshop. We used it to design images that were originally created on paper.

Figure 22: Photoshop



We used Photoshop to recreate paper drawings on the computer. Stuff like our house of quality and prototype illustration had to be translated to the computer to make them higher quality. Luckily Ryan has been using photoshop since middle school so we lucked out when translating all of the sketches.

10.4.3 File Storage

We each had our go to websites for storing and transferring files. Ryan preferred mediafire, Alex preferred Google Drive, and James preferred Dropbox. Each of these options have their own pros and cons, but they all got the job done at the end of the day. Being free to use was also nice as they didn't add to the budget of the project and it saved us money. These websites also stopped the hassle of sharing a flash drive or having to meet up when the need to move files was present.

10.4.4 Multisim

We will end up using multisim to test our circuit builds. We need to make sure we don't supply too much voltage or amps to different parts. If we do, there could be

issues as each have limits. This will also help us identify if we have a shorts or other issues with the designs. We all have used multisim in our lab classes the past few years so we have the skillset to use it properly. On top of that Alex has it on his computer so we don't have to go to campus to use it or purchase another copy.

10.4.5 Github

Github is a file storage site for software. It helps with code management, especially when there are tons of files being involved. There are even features built in where past versions of the code are saved. If there are any errors or bugs with the code, we can revert to a previous version that worked better. We can keep our code private or public on the platform depending on who we want to see it. For this project, it's in our best interest to keep it private so others don't steal it or use it in a different project.

10.5 Project Roles

Each of us have distinct project roles. This is ensures that the project runs smoothly. They can change when building the project in the spring, but this is what we think will work best.

10.5.1 Ryan Nolan - Electrical Engineering

Ryan focused primarily on developing the software for the LCD display. He's taken a few extra computer engineering courses as his senior electives so this will be the best task for him in this project

10.5.2 Alexander Tsangarakis - Electrical Engineering

Alex focus is on the PCB design and all of the wiring associated with the project. He's the best at the hardware side of things so he will be taking the lead in that side of things.

10.5.3 James Chroma - Electrical Engineering

James figured out how to connect the smart toaster oven to the phone. He's going to figure out the bluetooth connection and the best way to communicate the info over to the user that is using the smart toaster oven.

10.6. Difficulties

As with all projects, there were several difficulties encountered. Everyone has different backgrounds and schedules so everything didn't align up perfectly. We are also all Electrical Engineers so we don't have a large background in coding and development compared to our skills with hardware design.

10.6.1 PCB Design

None of us knew how to design a PCB. Unfortunately this is something that the Electrical Engineering curriculum at UCF skips over for some reason. We had to research what to do and ask a few friends who have had past experiences designing them.

10.6.2 Coding

We all have had some programming classes, but nothing to the extent this project will require. None of us have taken computer science 1 or 2, but Ryan has taken Object Oriented Programming. On top of that, we have all taken a few computer engineering courses as part of the EE curriculum. This is our weak point in the project, but we are excited to learn new skills.

10.6.3 Schedules

We all have varying schedules. Besides taking classes full time at school, we all have hobbies and jobs that take up a bunch of time. James plays on a esports team for UCF, Alex is in ROTC getting ready to join the AirForce, and Ryan is training for Ultramarathons. Each of these take up a good portion of time on a day to day basis. Job schedules can vary week to week, but a minimum of 20 hours is dedicated towards them. We had to plan accordingly week to week to ensure everything runs smoothly.

11. Appendices

This section we list the different resources used to create this research paper. We have linked all resources used to get the material for our paper. We will also show the permissions that we have currently received for the project

11.1 Permissions

1) 'Texas Instruments Terms of Use." Internet: http://www.ti.com/corp/docs/legal/termsofuse.shtml

2) "GNU GENERAL PUBLIC LICENSE." Internet: http://www.gnu.org/licenses/gpl-3.0.html

3) Images from Sparkfun Electronics are licensed under the CC BY-NC-SA 3.0 license. Internet: http://creativecommons.org/licenses/by-nc-sa/3.0/

11.2 Resources

1) Amazon - Product Page URL: https://www.amazon.com/Tovala-Gen-Multi-Mode-Programmable-Stainless/dp/B07K85LXBK

2) ADAFruit - Product Page URL: https://www.adafruit.com/product/3328

3) Sainsmart - Product Page URL: https://www.sainsmart.com/products/max6675-module-k-type-thermocouple-thermocouple-sensor-temperature-0-1024-for-arduino

4) Aliexpress - Product Page URL: https://www.aliexpress.com/item/32223740060.html

5) Arduino- Product Page URL: https://store.arduino.cc/usa/mkr-gsm-1400

6) Prelectronics. The Fundamentals of RTD temperature Sensors. Nov. 21. 2019 URL: https://www.prelectronics.com/the-fundamentals-of-rtd-temperature-sensors/

7) GPS Shield Arduino - Product Page URL: https://www.cooking-hacks.com/documentation/tutorials/4g-gps-lte-wcdma-hspa-3g-gprs-shield-arduino-raspberry-pi-waspmote-tutorial/

8) PCB Fabrication - Product Page URL: https://www.pcbcart.com/article/content/PCB-manufacturing-process.html

9) LCD and LED Displays - Product URL: https://www.mvps.net/docs/what-are-the-main-differences-between-lcd-or-oled/

10) ATmega2560 - Product URL: https://www.microchip.com/wwwproducts/en/ATmega2560

11) ATMega328 - Product URL: https://www.microchip.com/wwwproducts/en/ATmega328

12) Broadcom BCM2837- Product URL: https://www.cnx-software.com/2016/02/29/raspberry-pi-3-board-is-powered-by-broadcom-bcm2827-cortex-a53-processor-sells-for-35/

13) Photodiodes - Product URL: https://www.hamamatsu.com/jp/en/product/optical-sensors/photodiodes/index.html

14) MSP430G2553 - Product URL: http://www.ti.com/product/MSP430G2553

15) Eagle Software - Product URL: https://www.autodesk.com/products/eagle/overview

16) Multisim Software - Product URL: http://www.ni.com/tutorial/10710/en/

17) Toaster Oven Standards https://www.intouch-quality.com/blog/toaster-qc-inspection-standards

18) Arduino Boards https://www.arduino.cc/en/Main/Products

11.3 Datasheets

1) Adafruit MAX31865 RTD PT100 or PT1000 Amplifier Page URL: https://cdn-learn.adafruit.com/downloads/pdf/adafruit-max31865-rtd-pt100-amplifier.pdf

2) Cold-Junction-Compensated K-Thermocoupleto-Digital Converter Page URL:
https://cdn-shop.adafruit.com/datasheets/MAX6675.pdf

3) HC-05 Datasheet Page URL:
https://components101.com/sites/default/files/component_datasheet/HC-05%20Datasheet.pdf

4) MKR GSM 1400 Datasheet Page URL:
https://www.electronicsdatasheets.com/manufacturers/arduino/parts/mkr-gsm-1400

5) SH-HC-08 Datasheet Page URL:
https://drive.google.com/file/d/0B4urklB65vaCcEVyMm5haVVpMUk/view

6) ESP8266X Datasheet Page URL:
https://cdn-shop.adafruit.com/product-files/2471/0A-ESP8266__Datasheet__EN_v4.3.pdf

7) Maduino GPRS GPS A7 v1.5 User Manual Page URL:
https://www.robotshop.com/media/files/pdf/maduino-a7-gprs-gsm-module-datasheet.pdf

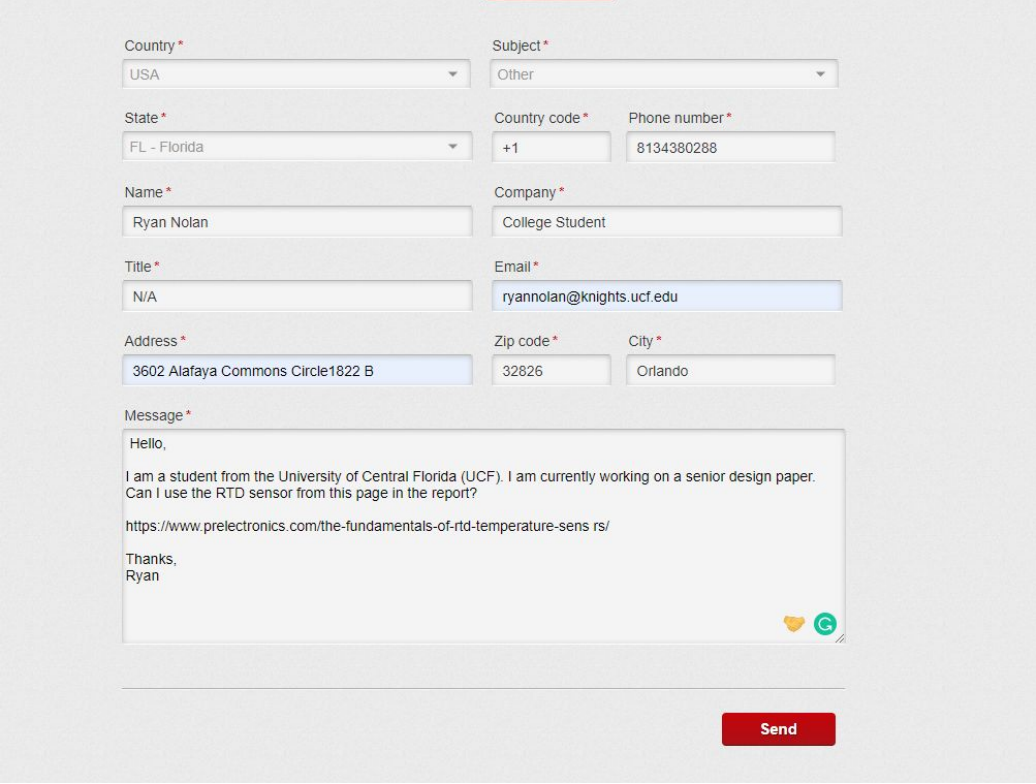
8) ATMega2560 User Manual URL:
http://ww1.microchip.com/downloads/en/DeviceDoc/Atmel-2549-8-bit-AVR-Microcontroller-ATmega640-1280-1281-2560-2561_datasheet.pdf

9) ATmega328 User Manual URL:
http://ww1.microchip.com/downloads/en/DeviceDoc/ATmega48A-PA-88A-PA-168A-PA-328-P-DS-DS40002061A.pdf

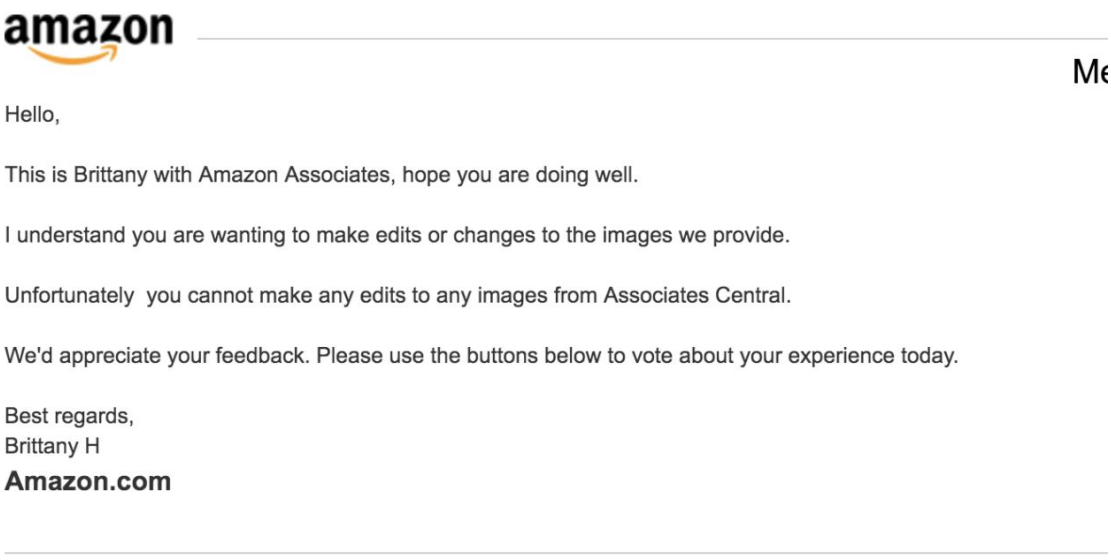
10) Broadcom BCM2837 User Manual URL:
https://cs140e.sergio.bz/docs/BCM2837-ARM-Peripherals.pdf

11) MSP430G2553 User Manual URL:
http://www.ti.com/lit/ds/symlink/msp430g2553.pdf

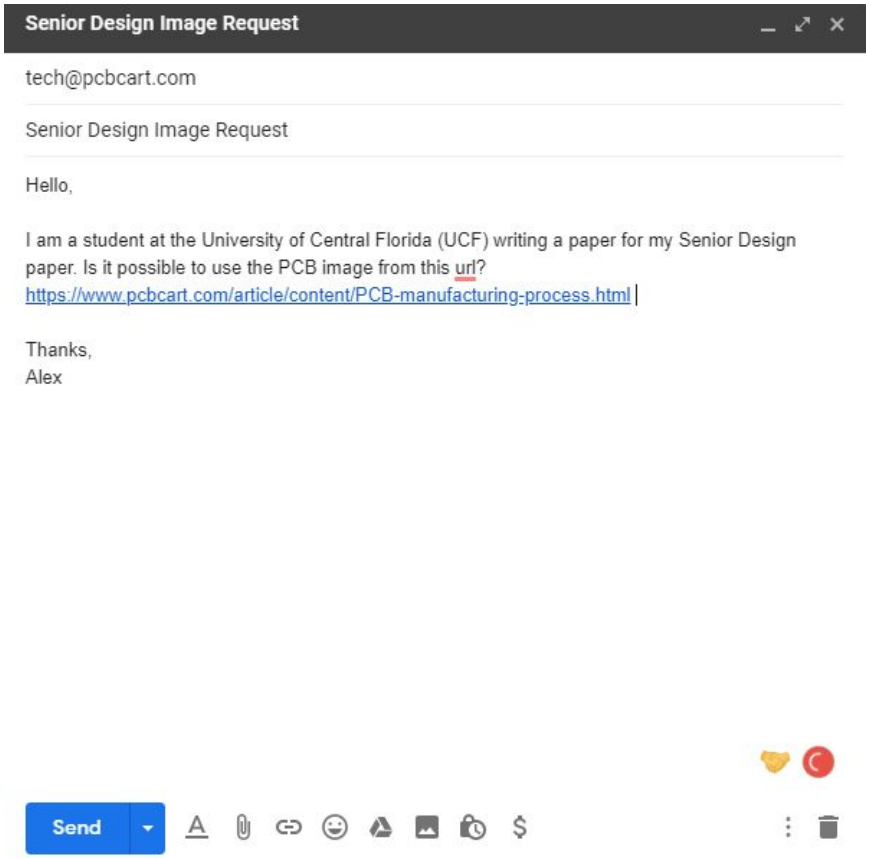
11.4 Email Permissions



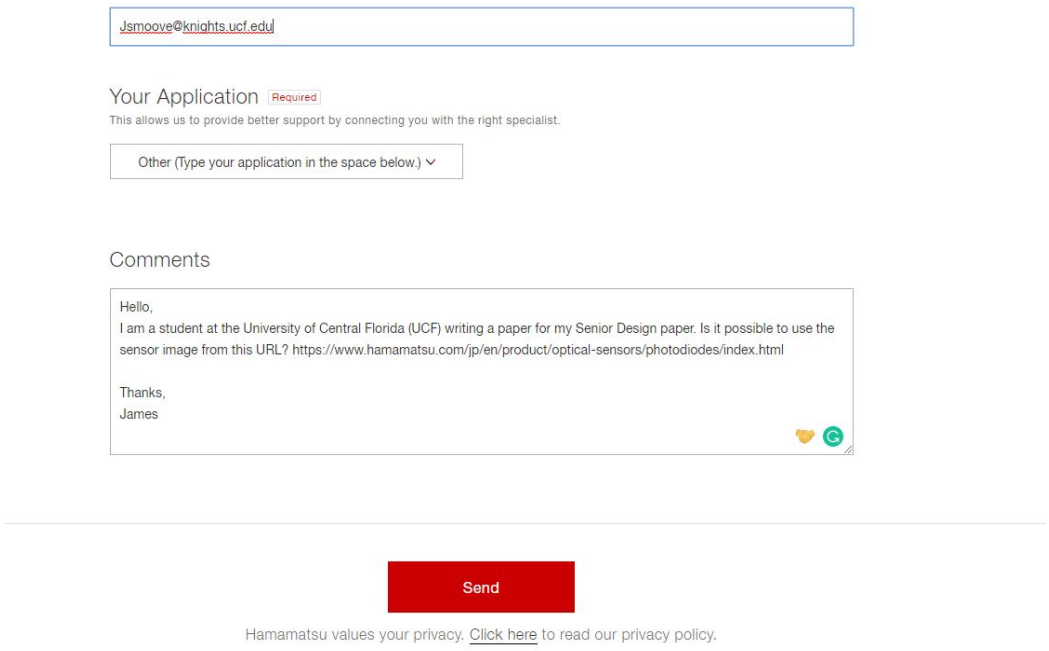
Request to use RTD Sensor



Allowed to use Amazon Images, but not allowed to modify them



Request for PCB image use



Request for use of Photodiode Sensor