**Energy Efficient toaster**

**Thomas A. Britt and Juan D. Franco**

EDD 104 Section 60 **| Project 4 design 3**

Futuristic Classic Toaster

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# Design Statement

Design a 2-slice bread toaster that uses less energy than an average 1200W model.

# Introduction/Background

The toaster is such a common home appliance that it is difficult to imagine a household that does not have one in the kitchen. The use of toasters dates back as far as the 1890s. With every year since then trying to improve this kitchen appliance. The use of a toaster is a simple one. You plug the toaster in, add bread to the slots, set the timer, and lower the lever so the bread can begin to toast. You have to be there when the toast is done as some toasters do not have a pop out function or could get stuck because the toast was in for too long. The toaster can be seen to have different problems when it comes to energy efficiency, though not obvious. Toasters do not actually use that much energy on a regular day, even in a year. For a toaster like ours that uses 1200W for about 12 minutes a day if you are toasting multiple breads, it uses 240Wh a day. Looking at it yearly, the toaster on its own still does not add up to too much on its own. The issue can be seen through when you add up the yearly price for all the kitchen appliances in the household. Use of the toaster, the oven, the refrigerator, the blender, etc. To better the device in the field it lacks, energy efficiency, we will have to take a look at what energy is being wasted in the toaster and where else we could use that energy instead.

That leads to what our project is directed towards. Our aim is to create an energy efficient toaster. Following the requirements given to us by our CEO, we are aiming to create or modify a toaster so that it does not consume too much energy while also adding something new to make the device better. With the requirements given to us, we have made our Appendix A which has the minor requirements we need to accomplish the greater ones. With the requirements now set, we aim to accomplish this goal by coming up with different ways in which we can make an energy-efficient toaster without straying away from the requirements. With coming up with multiple ideas on how to accomplish making an energy-efficient toaster, we now narrow it down to three different options. Our group of six members now have split up into three pairs to work on each different design for the toaster and to find information on how to make it work and why it is the best option when it comes to making an energy-efficient toaster.

For design 1 of the energy-efficient toaster, we have come up with the Contact Heat model. This toaster aims to be energy efficient and to toast the bread by the bread coming into direct contact with the heating element being used. This would speed up the process making it take less time and energy to toast the bread. For design 2 of the energy-efficient toaster, we have come up with the Light as Heat model. This toaster aims to be energy efficient and to toast bread by using light to heat it up instead of using a heating element. This is for the heat emitted from a lamp to warm a slice of bread until toast is made. Design 2 also aims to have some glass cover so that the user can see how much their bread has been toasted so if they want to take it out or leave it in for longer time. For design 3 of the energy-efficient toaster, we have come up with the Futuristic Classic model. This toaster aims to be energy efficient but to also include some of the latest trends in technology of the last decade.

The toaster will be an interactable touchscreen that will include multiple settings so that the user can toast different types of bread and set the different levels of toast they would want. The touchscreen will also display the time on the screen and the cooking time remaining for the toast to be complete. With the touchscreen, we want the toaster to shut down on its own when it completes toasting the bread. As this design is more focused on the touchscreen aspect of the device, this toaster will still have the traditional heating style of using a heating element to toast the bread.  The toaster will also include a Bluetooth feature so that the user can connect to their cellular device or any other device of their choosing that has a Bluetooth feature. This is so that the user can see on their device how much time is left for their bread to finish toasting and to also add time or stop it completely. This will also allow for the toaster to alert the user when their toast is done.

# Viable Design Description:

Our alternative design is to incorporate a touchscreen feature and Bluetooth connection to a toaster. The touchscreen would be on the front of the toaster to make it easier for the user. The toaster shall give them the option of what type of bread they want to toast and also how much they want it to be toasted. The use of the Bluetooth would allow the user to set the toaster from wherever they are and also be able to shut it down. The toaster would also be able to send a message to the user’s device so that they know when their toast is done. The toaster will then also be able to shut down on its own when completing the job. The dimensions of the toaster would be small enough for it to fit on a standard countertop (Appendix

## Viable Design Solution, Touchscreen (Juan Franco)

To implement a touchscreen to the toaster, we have to decide which type of touchscreen we are looking for. There are two types of touchscreens that could be used, resistive and capacitive. The type of touchscreen that should be used is a capacitive touchscreen. A resistive touchscreen works with two layers that are thin and flexible with a small gap in between. There is an electric current running in this space. When someone presses on the screen, they disrupt the current when pushing the outer layer to press on the inner layer, allowing for the device to detect where exactly the pressing occurred and what button the user was aiming for. On the other hand, a capacitive touchscreen has an electrode layer which goes on top of a glass panel which is then covered by a protective layer. So, when a finger touches the screen, some of the electricity goes to the user and the sensor picks up the loss in the electric current. It then picks up where exactly the user touched the screen. That is the difference in how they both work, but the difference to user would be that “A resistive touchscreen requires the user to touch and actively press the screen; a capacitive touchscreen does not require a press action” (Burnett, G. E., Large, D. R., Lawson, G., De-Kremer, S., & Skrypchuk L., 2013, p6). This would allow for different gestures when using a capacitive touchscreen compared to a resistive touchscreen. Such as swiping to the sides to choose which bread you want to toast or how toasted you want it to be. A resistive touchscreen does not allow for swiping on the screen, it needs to have a full press to make sure the command goes through, and it tends to have a hazy viewing experience as the display is behind glass. This type of touchscreen can be seen used in an ATM. On the other hand, a capacitive touchscreen tends to have better image clarity allowing for a clearer view of the screen and what it is showing. The screen is durable and resistant to dust, grease and water, things that would be in a kitchen. Capacitive touchscreens tend to be used in the smartphones that most people own nowadays.

We want the touchscreen to be facing the user in a way to make it easier to use. For this to happen, the touchscreen would have to be facing the user at an inclined angle instead of how normally it would be just vertical and flat. This is so that the user does not have to lower themselves to make eye level with a vertical screen on a toaster. The toaster would normally be on a standard countertop (Appendix A). The majority of users would most likely be above this height, so to make it easier for the buyer to use the device it is best for the touchscreen to be inclined so that the screen faces up. As the toaster is not a device that is used in the hands of the buyer like a mobile device, we do not have to limit the size of the screen on the toaster. Unlike the size of a screen on a mobile device that affects the person's use of it based on their physiology, a toaster would be on a counter so the user would just be pressing the screen (Restyandito, Kurniawan, E., 2017, p354-p259). As a two slice bread toaster on average tends to be 12 inches in length and 7.5 inches in height, the touchscreen would have to be less than those dimensions (YLLUFAL, 2018, N/A).

Touchscreen

*Figure 1- Shows how the screen would be inclined on the toaster so that the user can see the screen from above without having to lower themselves to eye level.*

The output of using a touchscreen would either hit the requirement of the toaster having to use 200 Wh per use or be less than 200 Wh (Appendix A). “The power consumption of any laptop ranges from 20 watts to 100 watts”(Big, T., 2020, N/A). The use of energy on a laptop screen is a good comparison to that of the screen we are aiming for. A laptop is used for more intricate things than what we are asking for the toaster to do. The fact that a laptop also stays on longer adds to the fact that the screen would not use that much energy in a toaster. As a toaster would be on for about 4.5 minutes to toast bread, the screen would not even be on for that long (Appendix A). Also “the laptops whose screen sizes range from 12 to 15 inches consumes 60 watts on average” (Big, T., 2020, N/A). As a toaster on average has a length of 12 inches and 7.5 inches in height, the amount of watts the screen would consume would be around 60 watts (YLLUFAL, 2018, N/A).

For the touchscreen to work with the toaster, we need two things. We need a touch screen controller and system software for a touchscreen. “The touch-controller is generally a small microcontroller-based chip that sits between the touch sensor and the embedded system controller”(Kolokowsky, S., 2009, 1). This device can be put on a controller board in the system or on a flexible printed circuit on the glass touch sensor. This device is used to take “information from the touch sensor and translates it into information that the PC or embedded system controller can understand”(Kolokowsky, S., 2009, 1). The touchscreen driver software is a big part to making this work. “This software allows the touchscreen and system controller to work together and tells the product’s operating system how to interpret the touch event information that is sent from the controller”(Kolokowsky, S., 2009, 2). This works by the system registering the finger pressing the screen like the mouse clicking on the same spot. This process is what allows for the driver to compare the place you pressed to what is presented in the screen. Circuit boards will be needed of course so that the touchscreen driver software can be run in the toaster so that the touchscreen can work.

## Applying The Pahl & Beitz Criteria, Touchscreen:(Juan Franco)

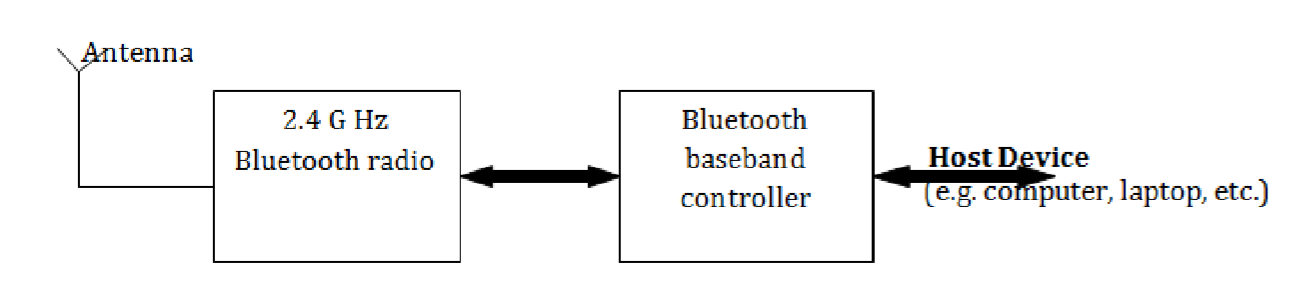
The touchscreen would apply to efficiency and durability. The aim of using the touchscreen is so that the user would not have to face the problems with using buttons, levers, or knobs. Those tend to get worn out and get stuck over time, leading to lower durability and efficiency with the toaster. With the touchscreen in use, the toaster will not have buttons, levers, or knobs. The user would just have to press on the screen without any issues.  Just like on any other device, as long as nothing is aiming to break the screen, touchscreens tend to last for long periods of time. The durability of the product would be high. It would also be higher if the touchscreen used is a capacitive as it is resistant to grease, water, and dust, which are all things that could be found in a kitchen. This type of touchscreen would also increase the efficiency of the device as the screen would be very clear and give good image clarity. It would allow the user to pick with more options in what bread they want to toast and how much they want to toast it. As it is a capacitive touchscreen and not a resistive, the screen will allow for more gestures when using the touchscreen. Such as lightly tapping the screen or swiping to choose the bread. The touchscreen has a high score in the criteria for the fact that it makes the overall use better for the user and allows the device to last longer without the worry of it getting worn out.

## Viable Design Solution, Bluetooth (Thomas Britt)

The Futuristic Classic model of the energy efficient toaster will have a Bluetooth implementation so that users can connect to the toaster using their phones. Upon the release of the toaster to the market, an app would be released to compliment the Bluetooth chip in the toaster, allowing for full control of the toaster. The Bluetooth chip that will be implemented is the CC2540/CC2541 BLE chip, which is known for its energy efficiency and cheap cost. The Bluetooth chip would work directly with the touchscreen, so that they would use the same system to control the toaster, as well as decrease the energy cost compared to if the chip was on its own power system. Users would be able to put bread inside the toaster, and then remotely activate it for a designated amount of time until the toast is made. Once the toaster has been active for the amount of time specified by the user, it would immediately shut off and cooldown so that the toast would be removable by the time the user is ready.

Bluetooth works as an energy wave that the toaster emits, searching for other Bluetooth devices to pair to. Modern Bluetooth technology is accepted to be two devices paired, both of which sending the same frequency waves back and forth, sending information to each other. The term ‘piconet’ is used to describe two devices connected via Bluetooth on the same network. “In piconet one of the communicating devices acts as the Master and the other devices act as slaves…”(Verma, M. 2015). In the case of the toaster, the toaster is the slave and the device that the user connects with is the master. This means that the user can send commands to the toaster, to which the toaster will comply.

Our Bluetooth chip would have a Scatternet Formation and Maintenance(SFM) scheme which would allow it to increase its speed and efficiency. An SFM scheme reduces the amount of waves that a Bluetooth device sends out, which streamlines sending and receiving waves between devices. It would also prevent random and unnecessary disconnections, which would be problematic for users in a hurry. “To avoid a link disconnection, Bluetooth devices in SFM continuously keep track of movement and residual energy”(Imran, M. 2018). This also includes a backup relay, so that once the user disconnects from the toaster after going to work, or just leaving the vicinity of the toaster, it will reconnect automatically once the user is in range. This would streamline the process of making toast for users, as there would be no need to repair the toaster and user device, which can sometimes take almost double the amount of time that it would take to make the toast itself. The selection of master or slave could also be completed through the scatternet, “Once the discovery process completes each node compares its weight with neighbor nodes to decide its role as a master/slave in the scatternet”(Imran, M. 2018). In the case of the toaster, its weight would always result in it being the slave, as it ethically should not be able to send commands to the user’s device. This means that the toaster would sit, idle, awaiting commands from the user. Once a command is received a signal would be sent back confirming that the toaster will now perform the function, and toasting would begin.



*Figure 2: Shows how Bluetooth would work inside the toaster to connect to a user’s phone, and how the Bluetooth itself works.*

The toaster would be the host device referenced in Figure 2, the chip would be the controller, and the radio would be implemented into the touchscreen. The toaster would emit energy waves that devices like phones, laptops, or tablets could receive, and then send back waves giving commands to the toaster. The app would include the option to turn your toaster on at any time, so that people in a rush could wake up, turn on the toaster, take a shower, and have toast ready for them once they’re ready. The toaster would also have timed toasting times, so that the amount of toasting the bread receives is fully customizable and changeable, based on the user’s preferences. This would comply with requirement [FUNC 2.1] found in Appendix A.

In terms of energy consumption, the Bluetooth chip will not be responsible for a large amount of the toaster’s total consumption. “Sending data at the same rate over Bluetooth consumes only 2 milliwatts”(Vogler, E.) Each data transmission between the user’s device and the toaster consumes only about 2 milliwatts, which is miniscule compared to the rest of the toaster. This complies with requirement [EEBT 1.1] found in Appendix A.

## Applying The Pahl and Beitz Criteria, Bluetooth:(Thomas Britt)

The areas that the Bluetooth aspect of the toaster applies to are efficiency and safety. The Bluetooth increases efficiency of both energy and time, as it facilitates the process of toasting, and the amount of energy that it uses is very small. The Bluetooth chip increases the energy efficiency of the toaster by automatically shutting off the toaster once the designated level of toasting was reached. The toasting time is shortened due to the chip as well due to the remote start option, as users can turn on the toaster and come back at any time to pick up the toast. The safety of our toaster is improved due to the automatic shutoff function as well. Since the toaster automatically shuts off, the bread/toaster won’t catch fire if the user leaves the bread in for too long. The toaster can also send alerts to the user’s device in the event that the automatic shutoff fails, which could prevent a house fire.

# Conclusion:

The Futuristic Classic design has two main additions to showcase, the Bluetooth chip and the touchscreen. The Bluetooth chip would allow for remote toasting while using minimal amounts of energy, as well as pairing with an app for possible alerts in the event that the toaster malfunctions. It would allow users to select the exact amount of toasting that they want on their bread, and then after toasting it would automatically turn off to prevent a fire. The touchscreen would function the same, allowing the user to scroll through multiple toasting options to select their preferred amount of toasting. It would also be the source of the Bluetooth chip, so that there would be an option on the touchscreen to look for devices to pair with to ease the pairing process. The toaster would conserve energy by having independently working compartments, so single slices of toast could be made without wasting the energy that the other compartment would use. The toaster would be made of stainless steel, which would give it a modern look, which goes perfectly with the Bluetooth and touchscreen features, as well as being very durable.

# Design Focus:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **Design Candidate 3** | | **…** | **Design Candidate n** | |
| **Criteria** | **Weighting Factor** | **Numerical Value** | **Weighted Value** | **…** | **Numerical Value** | **Weighted Value** |
| Efficiency | 0.30 | 2 | 0.60 | … |  |  |
| Safety | 0.30 | 3 | 0.90 | … |  |  |
| Durability | 0.15 | 3 | 0.45 | … |  |  |
| Environmental Impact | 0.15 | 1 | 0.15 | … |  |  |
| Cost | 0.10 | 1 | 0.10 | … |  |  |
| **Total** | 1.0 |  | 2.20 |  |  |  |

# Justifications for Evaluation Criteria:

* **Efficiency** has received a higher weighting factor of 0.3 since the purpose of the project is to create an energy efficient toaster. Efficiency also pertains to how time efficient the toaster is as well. The toaster must be both energy and time efficient in order to be successful.
* **Safety** received a higher weighing value of 0.3 since the device should be usable by anyone without putting them in danger. Furthermore, kitchen appliances need to follow safety regulations, otherwise the users could be victims of serious injury.
* **Durability** received a lower weighing value of 0.15 since there are other criteria that should be higher on the priority list. However, it wasn’t the lowest rating since the toaster should be durable and last a few years.
* The **environmental impact** was given an average- low weighting because while it is not the primary goal of our project, it is something we felt it was necessary to address when assessing the safety of our project.
* **Cost** received the lowest weight of 0.10 because the designing of an energy efficient toaster is the goal of the project, and there is no requirement for cost, so we deemed it unimportant in comparison to other criteria.

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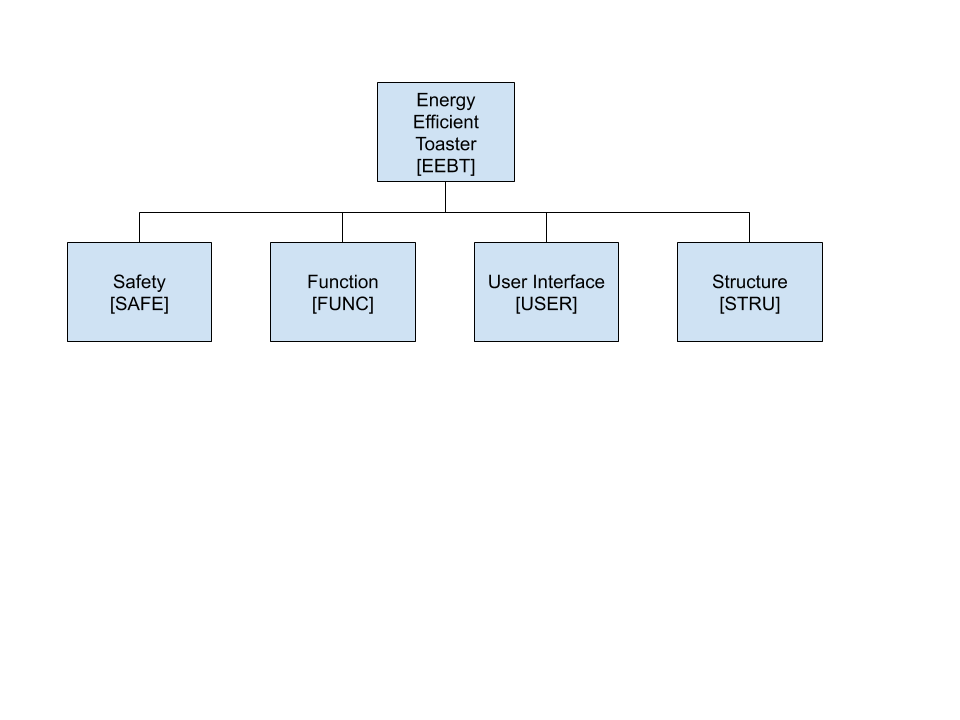
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# Appendix A:



**Definitions:**

**IEC:** International Electrotechnical Commission, an organization that standardizes electrical devices to ensure safety.

**Light material:** Any material with a density less than stainless steel (7.9 g/cm^3).

**Standard countertop:** 158” x 24” x 15” is the average American countertop.

**Standard cupboard:** 48” x 24” x 34” is the average kitchen cabinet size for below counter cabinets.

**Standard Bagel:** A standard bagel is 5.5” in diameter and 1” thick

**Environmentally hazardous material:** Any material that has a toxic byproduct

**Requirements:**

System Requirements

[EEBT 1.1] The toaster shall use less than 200 Wh per use.

[EEBT 1.2] The toaster shall house two regular cut bread slices.

[EEBT 1.3] The toaster shall not weigh more than 2.5 pounds.

[EEBT 1.4] The toaster shall not be more than 50% slower than usual brands.

[EEBT 1.5] The toaster shall abide by applicable safety standards.

Sub-system Requirements

[SAFE 2.1] The toaster shall have a casing that will protect the user from burns. {EEBT 1.5}

This is to reduce the most common source of injury from toaster use.

[SAFE 2.2] The toaster shall have a casing that will protect the user from electric shocks. {EEBT 1.5}

This is the second most common injury resulting from toaster use, and we want to mitigate as much as possible.

[SAFE 2.3] The toaster shall follow established safety standards from **IEC**, parts 2-9, as of 2020. {EEBT 1.5}

This is to ensure the device is as safe as possible.

[SAFE 2.4] The toaster shall have a mechanism for safe toast removal at any time. {EEBT 1.5}

This is because sometime people want to remove their toast before it’s done, and we want to make sure that they are as safe as possible.

[SAFE 2.5] Toaster shall have a mechanism to remove food waste. {EEBT 1.5}

Fires are very common with toasters as the insides get very hot and can burn the bread or any crumbs left inside

[FUNC 2.1] The toaster shall turn off after it finishes toasting{EEBT 1.1}

This is to ensure that the least amount of heat is used, and therefore wasted, as possible. This also helps the user accurately control the level of toastedness they want.

[FUNC 2.2] Each compartment shall operate independently.{EEBT 1.1}

With each compartment working separately, there will be significantly less unnecessary heating. No consensus of how many compartments, but every-one will operate independently.

[FUNC 2.3] The toaster shall have one heating element for each of the compartments. {EEBT 1.4}

This is to ensure that the bread is toasted as evenly as possible with a heating element in every compartment.

[FUNC 2.4] The toaster shall allow for multiple levels of toasting. {EEBT 1.1}

The users will be able to more accurately decide how toasted they want their bread.

[FUNC 2.5] Toaster shall toast bread in no longer than 4.5 minutes. {EEBT 1.4}

Most toasters toast bread within 3 minutes of reaching maximum heat, so ours must toast the bread within 4.5 minutes of reaching maximum heat

[USER 2.1] The toaster shall have compartments which can fit a **standard bagel**. {EEBT 1.2}

This is to allow for varying sizes of bread to be toasted, and modifying to the largest size will allow for more customization.

[USER 2.2] The toaster shall be able to fit on a **standard countertop** {EEBT 1.2}

The countertop is where most people keep their toasters, so it needs to fit there.

[USER 2.3] The toaster shall be able to fit in a **standard cupboard** {EEBT 1.2}

Many people also store their toasters in cupboards and cabinets when not in use as to not occupy counter space, so the toasters will also need to fit in there.

[STRU 2.1] The toaster shall be cased in a **light material**. {EEBT 1.3}

One of the requirements is that the toaster must be less than 2.5 lbs, so lighter materials are better for our designs

[STRU 2.2] The toaster shall not use any **environmentally hazardous materials**. {EEBT 1.5}

Part of energy efficiency is to make the toaster better for the environment, so keeping that theme with materials should be a priority.

# Appendix B: Cost Analysis

## Juan Franco

The touchscreen that we would be using is a capacitive touchscreen. It will allow for clear images on the screen and let the user have multiple ways to gesture their choices without having to directly press on the screen. The screen is also resistive towards water, dust, grease. The cost of the capacitive touchscreen would be around 30 dollars, maybe a little more or less (Capacitive Touchscreen). It may cost a good amount, but the end goal is for the toaster to be energy efficient so that over time you are saving money.

For the power cord we will continue to use copper. Copper is a great conductor for electricity and it shows no negative effects when in use in a power cord. The cost for copper is $2.45 for a pound in the United States (Copper Prices, 2020, N/A). The base of the toaster would be made with rubber. Rubber is a good insulator so in case of  any issues occurring, as long as the user holds it from the bottom. The cost for the rubber is $1.66 for a pound (Monthly price of rubber, 2019, N/A).

The touch screen controller ranges in price depending on which one we choose. It could end up costing less than a $1 to $17 dollars (Touch Screen Controllers, N/A). As we are trying to implement a touchscreen to a toaster, this is one of the most important parts to include. This is what allows for the information being received by the screen being pressed to be transferred into information that the software can understand.

## Thomas Britt

To use a stainless steel shell, the cost would be equal to about 3 dollars. Stainless steel is only about $3 per pound, and our toaster has to be less than 2.5 pounds, so it is safe to assume about one pound of stainless steel for the shell will be satisfactory. Stainless steel is a tough, durable, and heat resistant metal, so after years of use the shell will have no rust or other signs of perishing. As Wallace says, “Stainless alloys are highly nonreactive, so they are suitable for food and medical uses” (Wallace, 2018). Since stainless steel is a tough, safe, and cheap metal, we will be using it as the material of our outer shell of the toaster, costing roughly 3 dollars.

For a nichrome wire heating element, it would cost approximately $25. If we got the ideal nichrome wire, which is Nichrome 60, Catalog #16GA-NI60, 16 GA ALLOY 675 .050, 25 feet long, that would be enough nichrome for a single toaster. If we cut the wire in half so that we had two 12.5 foot long pieces for each compartment, and attach an electrical wire component to each one, each compartment will have an independently functioning heating element. Provided the voltage that the outlet will provide, this wire will make toast quickly and efficiently.

Another necessary heating element component is mica paper, which would cost about $2.50. Mica paper is shipped by the kilogram, so one kilogram on average costs around $2.50. This shipment of mica paper could be used for many toasters, since each toaster only needs about 4 sheets of paper. The amount of sheets of mica paper in a kilogram is unspecified, so multiple toasters could potentially be built using the same kilogram of mica paper.

The Bluetooth chip that will be implemented into our toaster and touch screen is the CC2540/CC2541 BLE chip. This chip costs about 5 dollars, is extremely energy efficient, provides easy connections, and is very cheap. This chip would connect to users’ phones, and would be able to tell the user when the toast is done, and would have a remote start option too so users could leave bread in the toaster and then remotely start it so the toast will be ready at the perfect time.

Overall the total price of this design would be $86.61. There is no restriction to cost in making the toaster, so we do not have to worry on that aspect as much.