2020 Electronics Online Challenge

# Nest Protect Version 1 Combination Alarm

Team Number: 2496W

Team Name: Beckman RoboPatties

School: Arnold O. Beckman High School

Contributors:
Aayush Sehgal, 9th Grade
Andres Garcia, 10th Grade
Tyler Ogawa, 10th Grade
Conner Wallace, 11th Grade

# Table of Contents

# Final Report

After waking one of our teammates in the middle of the night to the fire alarm saying one of them was defective, his family knew it was time to replace the alarms after giving the teammate a near heart attack. With many of these fire alarms in the e-waste pile, the team decided it was an excellent electronic to disassemble because of its complexity and the sheer amount of alarms, which allowed each teammate to disassemble their alarm. In an age of social distancing, it was essential to making sure everyone was able to safely get involved. After getting the thumbs up from our coach and taking the necessary precautions, like wearing safety glasses and face masks, the disassembly started.

Luckily for us, we had a headstart on the disassembly due to our teammate having already removed the back cover when he took the batteries out of this aggressively beeping alarm. Next, the screws keeping the privacy cover, battery holder, motherboard, and power delivery board were removed to allow us to remove the cover and take out the boards. Then, we took the motherboard's privacy cover and removed the connectors keeping the board together. Afterwards, we removed the speaker, which made room for us to remove the battery holder. Finally, we removed the heatsinks to reveal the chips beneath.

To research these chips, we attempted to read the markings off of the chips, but that did not yield many results as the alarms were old and some chips were not listed on the internet, along with others having little identifying information on how and where to find them. Another hardship in researching the components was deciphering what all the writing on the chips meant. Once we figured out the important identifying characters, we were able to effectively collect data. It was really interesting to find out that a plethora of the many electronics inside were Texas Instruments components. Additionally, during this research, we also found that many sensors and integrated circuits work together to make functioning alarms function and how electrical engineers had to make sure these parts work together (More on the findings in section 4).

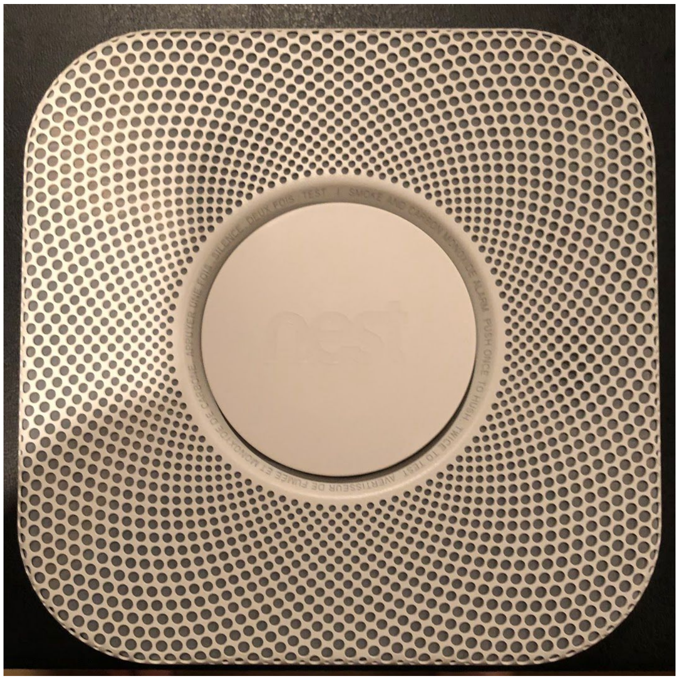
From this experiment, we learned how external, internal, and electrical parts all come together to make a product and how every design has its shortcomings. This experiment made us appreciate how electrical engineers had to think about using their product and how to adjust for optimal usability and effectiveness. Our favorite example of this was the heatsinks because although the chips underneath produced little heat, in a fire the heatsinks would need to spread heat away from the chips in order for the alarm to do its job and warn the consumer of the fire raging in their home.

Final Report Word Count -- 456 Words

## Section 1 - Introduction

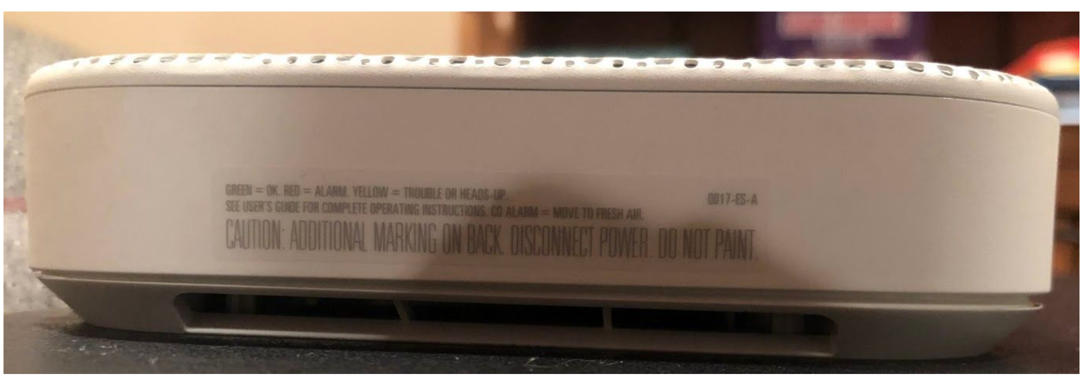
As many people have experienced in their lives, one of our teammates was woken up to the heart attack inducing sound of a broken fire alarm. This prompted his family to replace the alarms throughout the house. This resulted in many alarms that could be disassembled for this project, a very important factor. As with anything in life, safe precautions were taken, most notably wearing safety glasses when disassembling the alarm and giving alarms to each team member to disassemble in the safe of their house in order to combat the global situation. Before starting the disassembly it is important to familiarize yourself with the piece you will be disassembling. For us this was no exception. We did this by looking over the alarm before starting the process. Important to note, that we had no screws to unscrew on the backplate because in order to stop the incessant fire alarms from going off again because they had backup batteries in them in case of a power outage.

Top of Alarm



Bottom of Alarm

Sides of Alarm



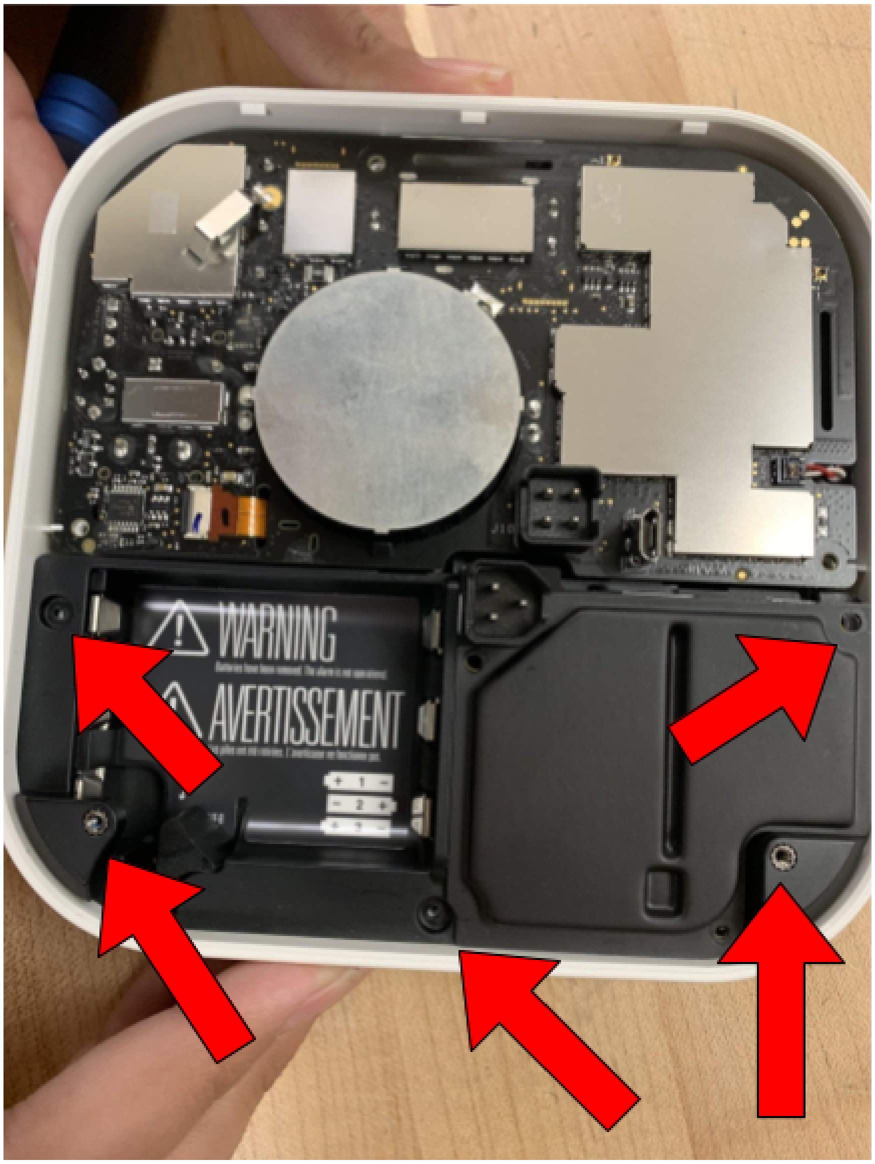
# Section 2 - Disassembly

Going on to the main event, the disassembly started by unscrewing the protective cover and removing it. The backplate removal was not done because of the lack of one on this alarm due to the note mentioned in section 1. After the protective cover was removed, the screws were unscrewed in order to remove the power delivery board from the battery holder. Next, the cables keeping the button, speaker, power delivery board, and battery holder to the motherboard were unplugged. This allowed us to remove the motherboard and power delivery from the unit completely. The speaker and battery holder were then removed from the unit by unscrewing some screws. Finally, the heat sinks were removed from the chips on the motherboard in order to display what was below and the privacy cover removed from the power delivery board. This completed the disassembly of the alarm and now it was time to look at the carnage.

Step 1 - Removed Backplate (no screws)

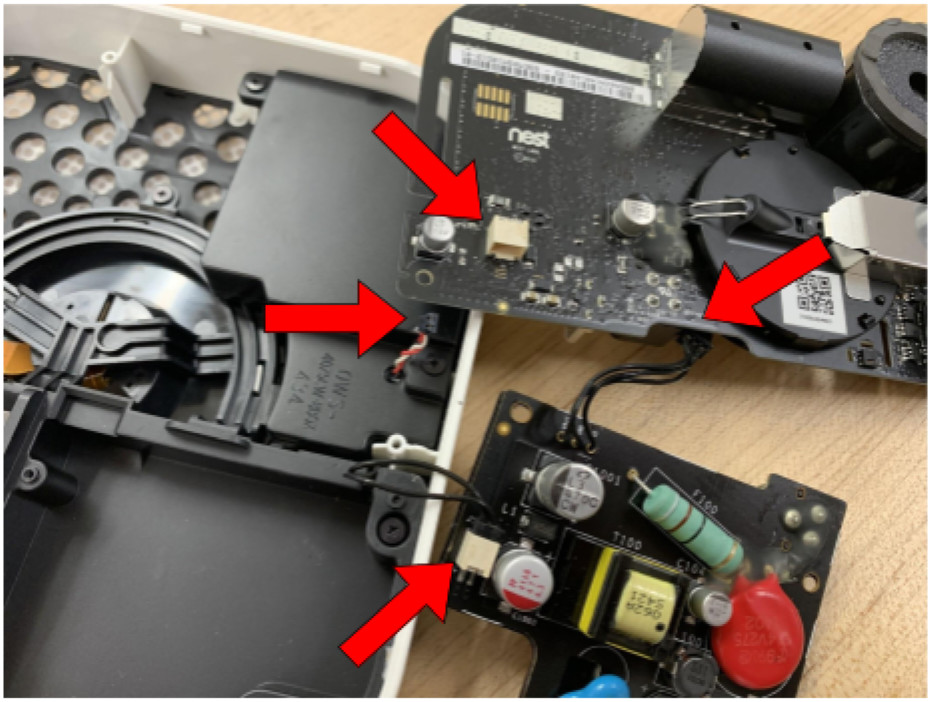
Step 2 - Remove Screws from Protective Covering and peel off from Heatsinks

Step 3 - Remove screws from power supply and carefully remove

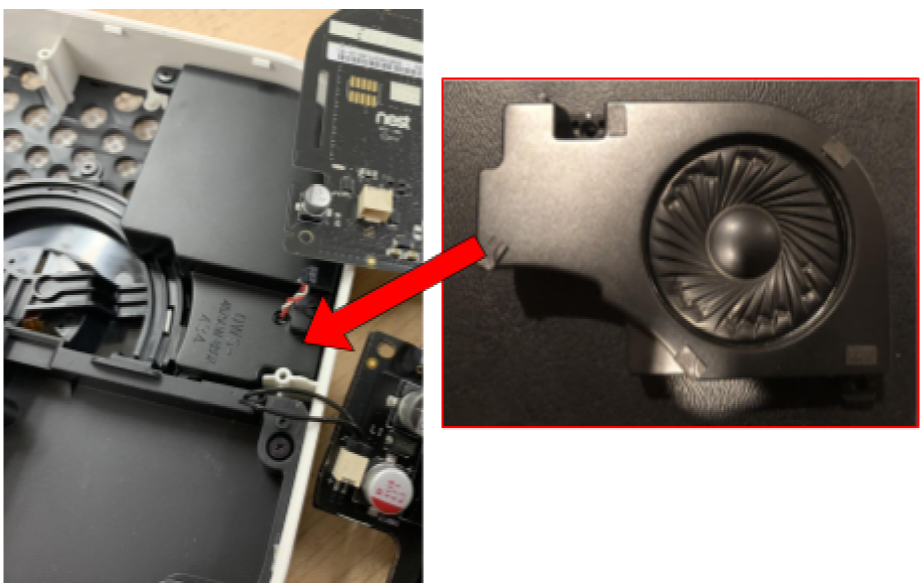


Step 4 - Unplug ribbon cable from button mechanism

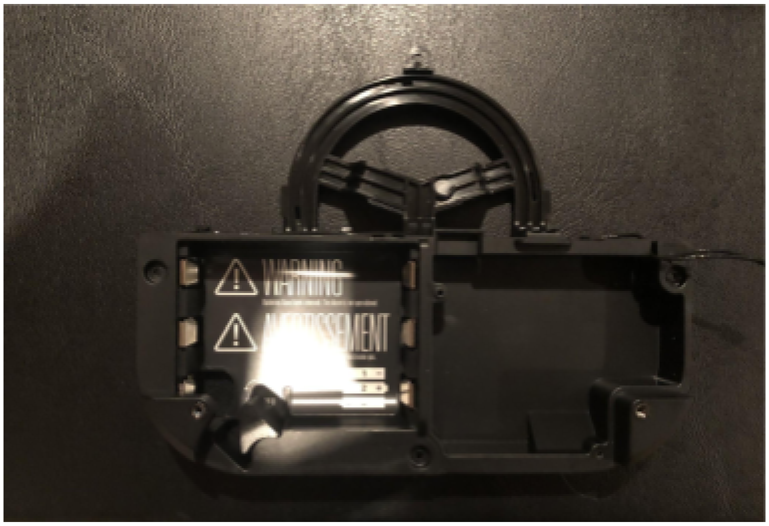
Step 5 - carefully remove wires connecting power supply to motherboard and alarm



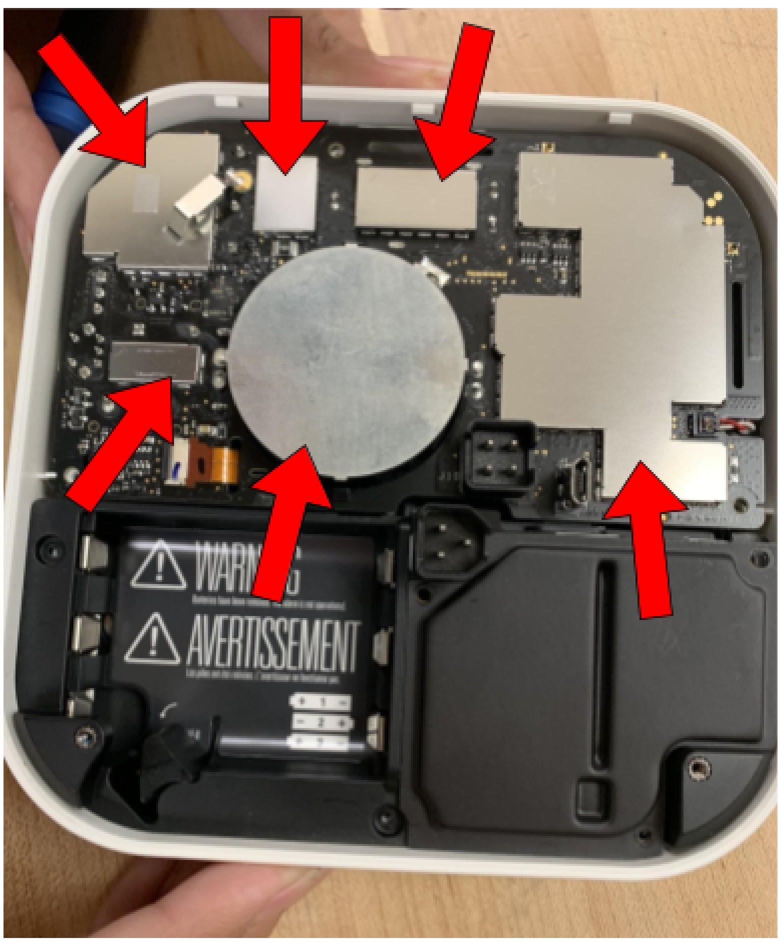
Step 6 - Remove the speaker



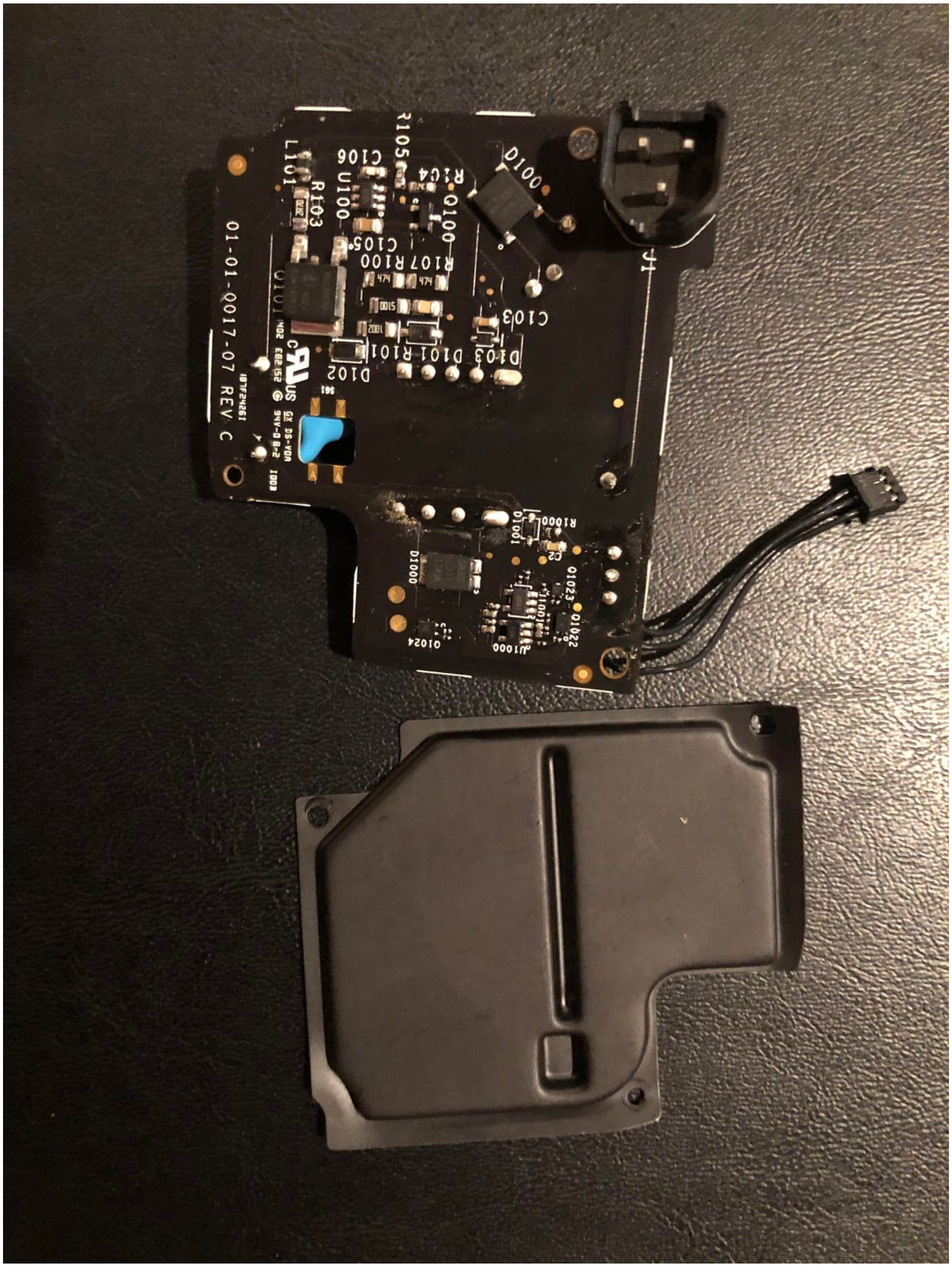
Step 7 - Remove enclosure for batteries




Step 8 - Remove heatsinks from motherboard chips to reveal inside chip structure



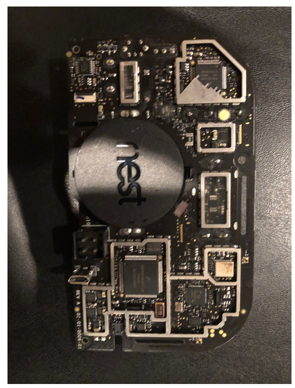
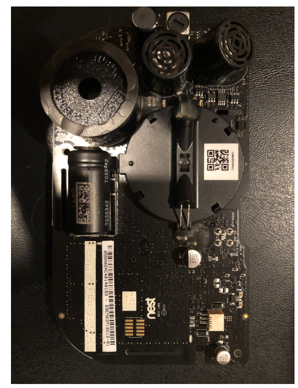
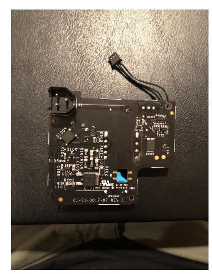
Step 9 - Remove Privacy Cover from Power Delivery Board

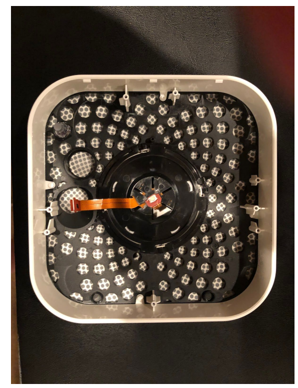


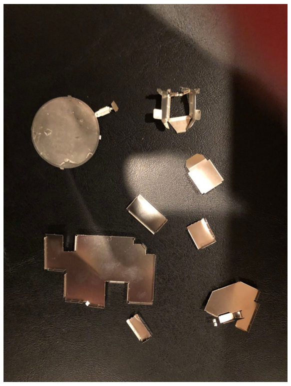
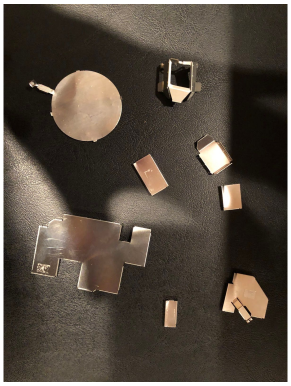
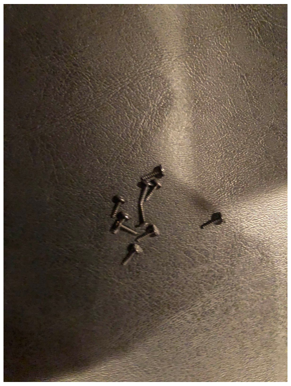
# Section 3 - Disassembled Alarm

With the alarm disassembled it was about time we took inventory of the different parts that made up the alarm. In the alarm the main electrical components were the motherboard, power delivery board, battery holder, and speaker. The main structure components were the button top cover combo and the back cover. There were other minor parts that are included in the table along with quantity.

Chart of Internal Components

| Name of Part | Quantity | Front | Back |
|---|---|---|---|
| Motherboard | 1 |  |  |
| Power Delivery Board | 1 |  |  |
| Speaker | 1 |  |  |

| | | | |
|---|---|---|---|
| Back Cover | 1 |  |  |
| Button and Top Cover | 1 |  |  |
| Battery Holder | 1 |  |  |
| Motherboard Privacy Cover | 1 |  |  |

| | | | |
|---|---|---|---|
| Power Delivery Board Privacy Cover | 1 |  |  |
| Electrochemical Sensor Cover | 1 |  |  |
| Heatsink | 8 |  |  |
| Screw | 12 |  | N/A |

# Design Flaws and Strengths:

Every product ever designed has had flaws and innovations. In recognition of this we added this section about what could be improved internally and externally. This can be best illustrated in how you could have the best computer in the world, but if the user experience is horrible no one will buy it, highlighting how product design and electrical engineering have to go hand and hand. Many of our issues could be ratified by either a design change to the physical part of the product or using higher quality materials.

# Flaws:

The button is not flush with the rest of the unit, leading to unintentional button actuations when replacing the batteries.

The wires are very tightly compacted together making it easy to break.

There are unnecessary ports in the back of the unit which are of no use and some are unable to be accessed.

The battery compartment is very finicky and difficult to work with; feels tough.

# Strengths:

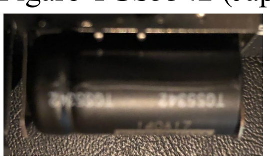
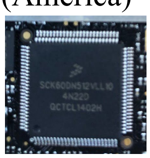
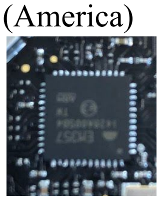
The unit was effectively able to use all available space and have a small size.

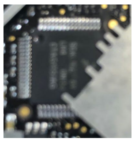
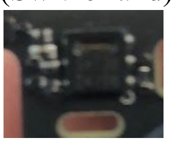
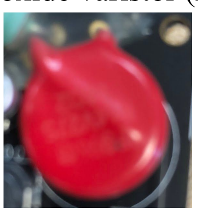
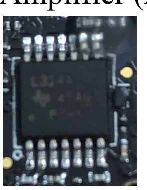
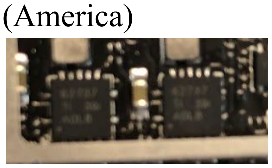

The mounts are easily accessible and straightforward. Very simple design.

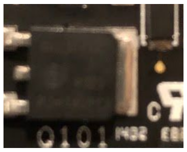
## Section 4 - Findings

Now onto the chips on the motherboard we found. There were many on this board that could not be located due to the lack of writing or clear product number. On top of all that, some of the chips had all the data one would think is needed for finding it, but alas the internet could not find a product listing or data sheet. This problem stems from some chips having too little space or being a custom chip just for that product. Below is a chart listing all of the chips and sensors we could find data on. We found this data by looking at the internet and seeing if the product information on the chip returned any results and then looked for data sheets or other pieces of information in order to surmise what the component did. Under the chart are annotated pictures of where they can be found on the board along with total for common component types, explanations of those component types, and a graph displaying the country of origin totals. By the end of all of this research, we gained a greater understanding of just how complex our electronics are and how electronics manufacturing is a global process.

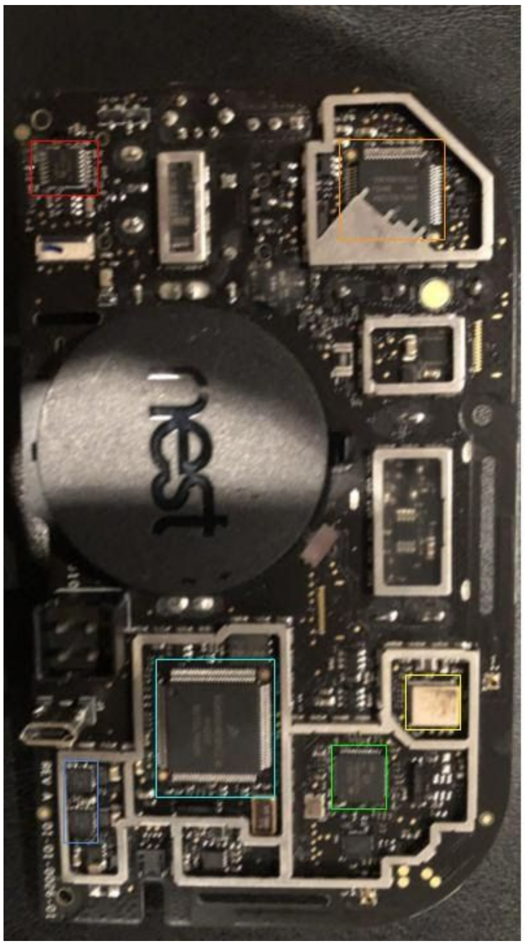
Chips we could find data on:

| Chip Manufacturer and Name | Quantity | What the Chip Does |
|---|---|---|
| Figaro TGS5342 (Japan)  | 1 | The chip is used to detect carbon monoxide and smoke in the air and when a certain threshold is reached it sends a signal to the motherboard |
| Freescale Kinetis K60 (America)  | 1 | Has peripherals with features such as USB and ethernet. This is also the microcontroller of the unit. |
| Silicon Labs EM357 (America)  | 1 | An RF connector designed to be a two separate radio system. One radio contains a 2.4 GHz transceiver and an alternate way to connect to WiFi. The other radio communicates with smart home products. |

| | | |
|---|---|---|
| muRata Type ZX WiFi module (Japan)<br> | 1 | The main radio allows for a connection to WiFi. |
| Freescale K16 (America)<br> | 1 | Another microcontroller; estimate use for handling critical functions. |
| Sensirion SHT20 (Switzerland)<br> | 1 | Contains a humidity and temperature sensor. |
| Littelfuse 14V275 metal oxide varistor (America)<br> | 1 | Used to protect against power surges and as an uninterrupted power supply |
| Texas Instruments L324A Amplifier (America)<br> | 1 | Used to amplify electrical signals in a circuit. |
| Texas Instruments TPS62737 Step Down Buck Converter (America)<br> | 2 | Used to lower voltage and increase current |

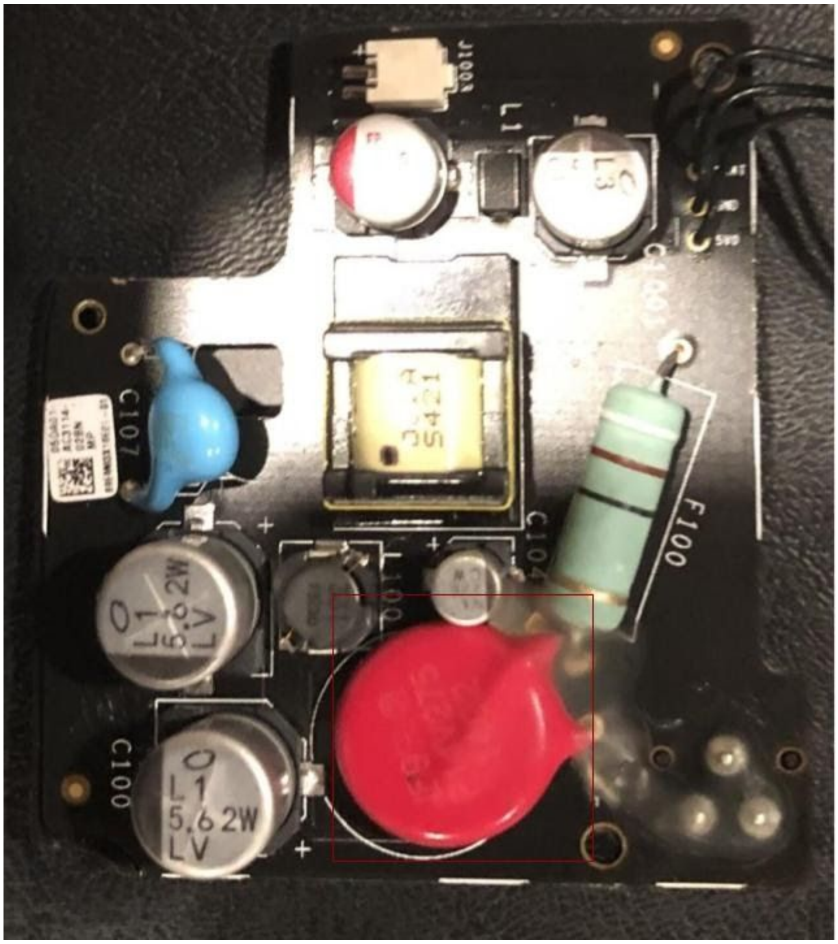
| | | |
|---|---|---|
| WeEn Semiconductors BUJ302AD NPN Power Transistor (China)  | 1 | Used for direct current to direct current conversions |

Components we Found Data on, on the Smoke Alarm




Red = Texas Instruments  L324A Amplifier
Orange = Freescale K16
Yellow = muRata Type ZX WiFi module
Green = Silicon Labs EM357
Turquoise = Freescale Kinetis K60
Blue = Texas Instruments TPS62737 Step Down Buck Converter

Pink = Sensirion SHT20
Purple = Figaro TGS5342

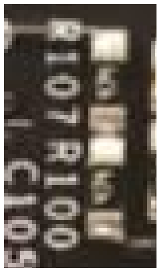
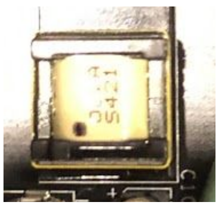
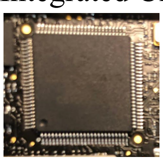


Maroon = Littelfuse 14V275 metal oxide varistor

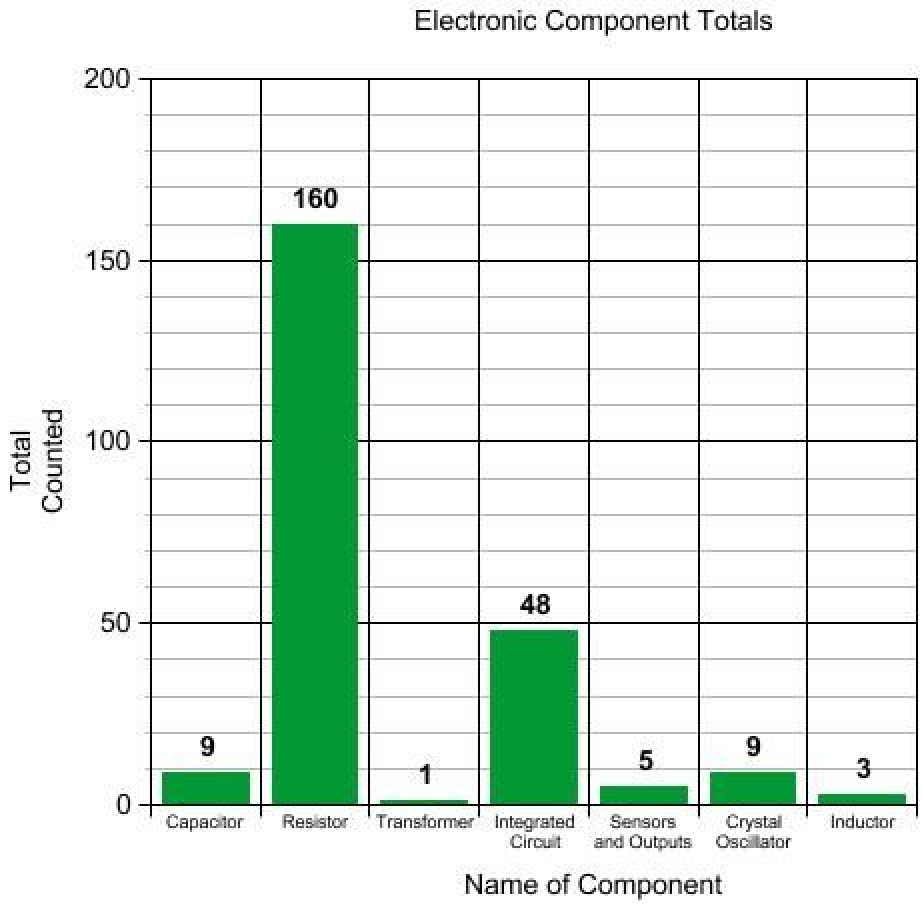
White = WeEn BUJ302AD

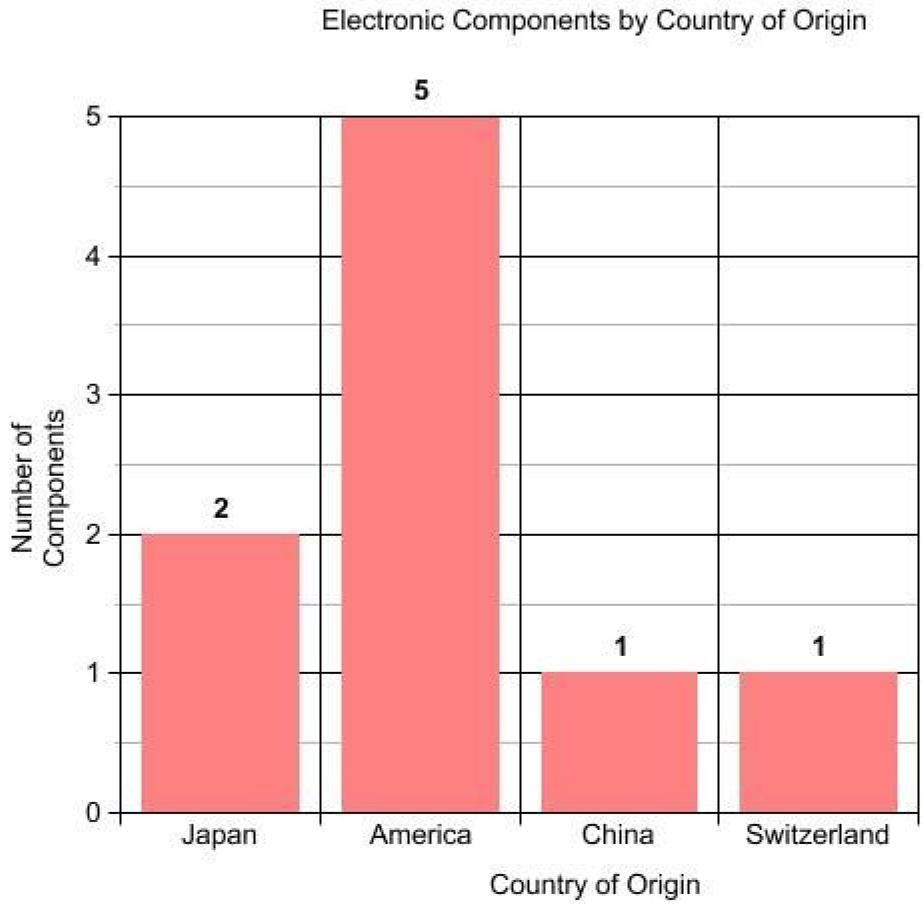
Types of Common Components and What They Do

| Type of Component | Quantity | What They Do |
|---|---|---|
| Capacitor  | 9 | A component that can block direct current (DC) and allow alternating current (AC) to pass through; smooth out the output of power supplies, so that they output a consistent current and voltage; and can stabilize voltage and power flow. These components like resistors are crucial to ensuring that integrated circuits run properly. |
| Resistor | 160 | An electrical component that changes resistance in a |

| | | |
|---|---|---|
|   | | circuit, and since voltage and current are tied to resistance it in turn changes voltage or resistance depending on the type of circuit. Resistors are used in order to make sure that chips have the right voltage and current to run because otherwise they would either not run or fry themselves. |
| Transformer  | 1 | A component that either increases voltage in AC low voltage high current circuit or decreases voltage in high voltage low current circuits. This, like a resistor is used to ensure that integrated circuits have the right voltage to function. |
| Integrated Circuit  | 48 | A chip that includes many circuits in a small space in order to perform a certain task. They are like organs to an electronic device. |
| Sensors and Outputs  | 5 | A component that either detects a stimulus and reports it to the device or outputs a stimulus using instructions from the device. This component is used to inform the device of internal and external changes or do something about said changes. |

| | | |
|---|---|---|
|   | | |
| Crystal Oscillator  | 9 | A chip that emits a constant frequency in order to provide a stable clock signal for digital integrated circuits (like how a metronome is to a musician)or to tell time. This chip works by putting a piezoelectric material, or a solid that produces electricity under mechanical stress, under a mechanical stress to create a clock frequency. |
| Inductor  | 3 | A component that allows for DC current to pass through and not AC current. This is used in order to make sure that integrated circuits have the right type of current flowing through them. |


Electronic Component Totals
200
150
100
50
0
Total Counted
160
48
9
1
5
9
3
Capacitor
Resistor
Transformer
Integrated Circuit
Sensors and Outputs
Crystal Oscillator
Inductor
Name of Component


Electronic Components by Country of Origin
Number of Components
5
4
3
2
1
0
5
2
1
1
Japan
America
China
Switzerland
Country of Origin

# Works Cited


"BUJ302AD Data Sheet." *WeEn Semiconductors*, WeEn Semiconductors, 28 Apr. 2018, www.ween-semi.com/sites/default/files/2018-10/buj302ad.pdf.

"EM357 Datasheet." *Silicon Labs*, Silicon Labs, silabs.com.

"Figaro TGS5342." *Figaro*, Figaro, www.figaro.co.jp.

"Freescale K16 Datasheet." *Spark Fun*, Spark Fun, sparkfun.com.

"K60_100: Kinetis® K60-100 MHz, Mixed-Signal Integration Microcontrollers Based on Arm® Cortex®-M4 Core." *NXP*, NXP Semiconductors, www.nxp.com/products/processors-and-microcontrollers/arm-microcontrollers/general-purpose-mcus/k-series-cortex-m4/k6x-ethernet/kinetis-k60-100-mhz-mixed-signal-integration-microcontrollers-based-on-arm-cortex-m4-core:K60_100.

"Littelfuse Metal Oxide Varistor Data Sheet." *Littelfuse*, Littelfuse, www.littelfuse.com.

"Sensirion SHT20 Datasheet." *Mouser Electronics*, Mouser Electronics, www.mouser.com/.

"Texas Instruments LM324A Spec Sheet." *Texas Instruments*, Texas Instruments, www.ti.com.

"TPS62737." *TPS62737 Data Sheet, Product Information and Support | TI.com*, Texas Instruments, www.ti.com/product/TPS62737.

"Wireless Connectivity." *Wireless.murata.com*, Murata Manufacturing, wireless.murata.com/?type=Type+ZX+2.4GHz+Wi-Fi+802.11b%2Fg%2Fn.