



VEX VRC 2022-2023
Reverse Engineering Online Challenge

Amazon Echo Dot



44777U – DiscoBotz
Redmond, WA

By: Mitra Junu, Nanda Junu, Varun Senthil, Sarvesh Senthil

Table of Contents

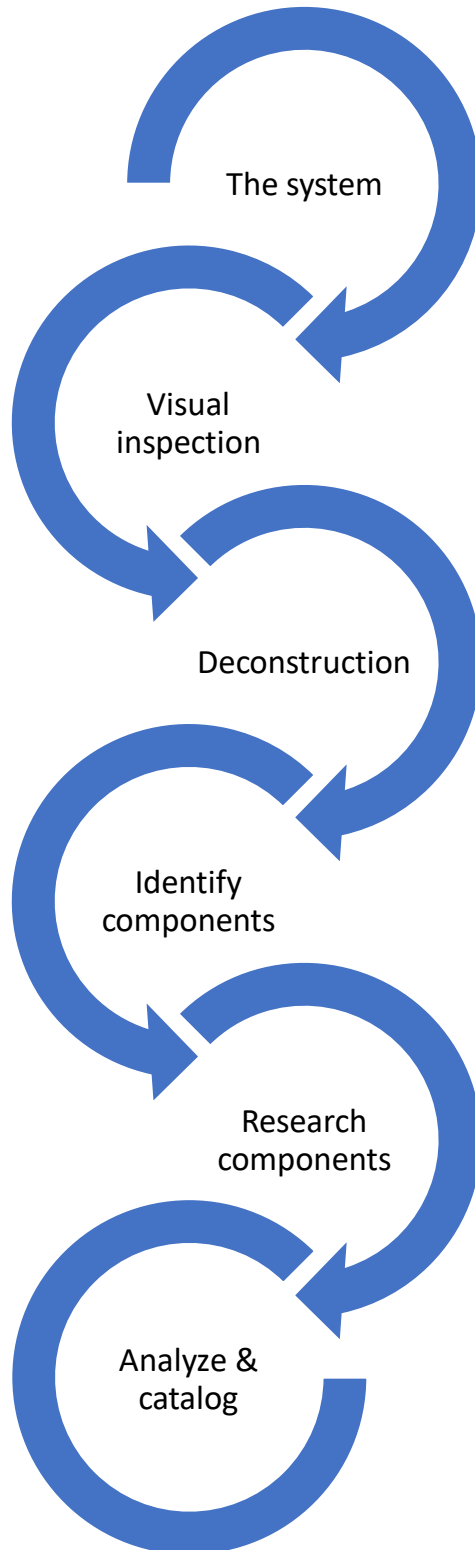
| | |
|------------------------|----|
| Introduction | 3 |
| Approach | 4 |
| Disassembly | 5 |
| Parts List | 6 |
| Circuit Boards | 12 |
| Component Analysis | 16 |
| Conclusion & Citations | 17 |

Introduction

We are the DiscoBotz of Redmond, Washington. This will be our 4th year participating in VRC and 6th year doing robotics. Our team consists of four members, all in high school. Our names are Sarvesh, Varun, Nanda, and Mitra. In our previous years of robotics, we have been very successful, climbing the global rankings throughout the season and participating in several events across the continent. Throughout the years, we have developed several hard skills, including programming, building, and designing. We have also developed many soft skills including teamwork, organization, and communication skills. Using these skills, we decided to reverse engineer an Amazon Alexa Dot because we use it every day and we wanted to see how it worked!



Approach





Disassembly

- 1) Wear safety goggles!!
- 2) Peel off the non-slip pad from the bottom of the Echo Dot
- 3) Remove the plastic circular piece under the non-slip pad
- 4) Remove the 4 screws at the bottom of the Echo Dot
- 5) Separate the bottom and top pieces, one piece should have the buttons on it
- 6) Disconnect the speaker from the top piece
- 7) Separate the metal piece from the Echo Dot
- 8) Remove the black rubber spacer and the white plastic spacer
- 9) Remove both circuit boards
- 10) Separate the boards, one is the microphone board and the other is processor board
- 11) Examine the parts of the boards



Parts List

| Photo | Description/Name |
|--|---|
|  | <p>Grey non-slip pad</p> <ul style="list-style-type: none">- Meant to prevent the Alexa Dot from slipping on a surface- Adds grip |
|  | <p>Bottom Plastic Casing</p> <ul style="list-style-type: none">- The bottom section of the Alexa Dot |



Top Plastic Cover

- The top cover of the Alexa Dot
- Has buttons to control volume, mute, and an action button

Top:

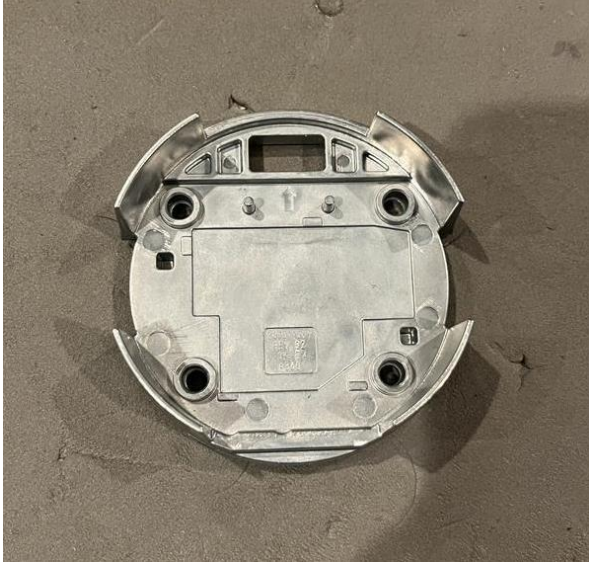


Speaker & Speaker Case

- This case holds the speaker
- The speaker is on the bottom side

Bottom:





Metal Weight

- This weight prevents audio vibrations and adds weight for higher quality



Black Rubber Spacer

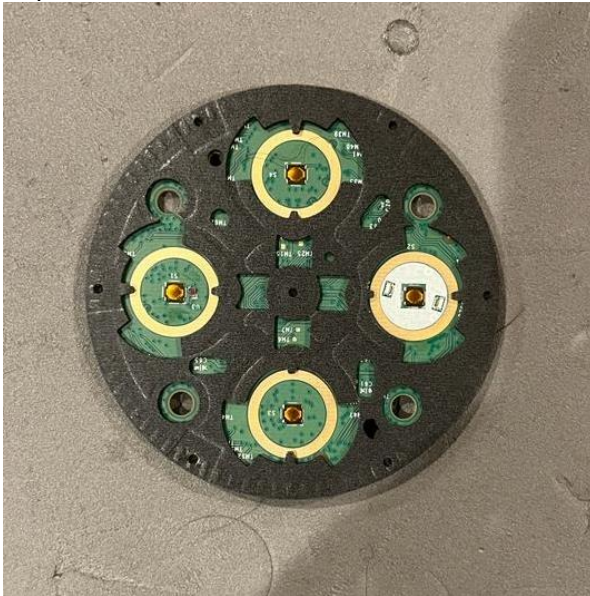
- Absorbs audio induced vibrations



White Plastic Spacer

- Separates both circuit boards

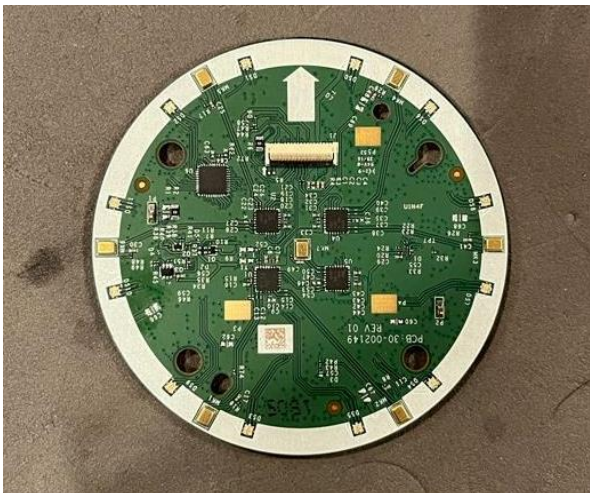
Top:



Microphone Board

- Hosts the 4 dome tactile switches, LEDs, light sensors, analog-to-digital converters, and LED driver

Bottom:



Top:



Processor Board

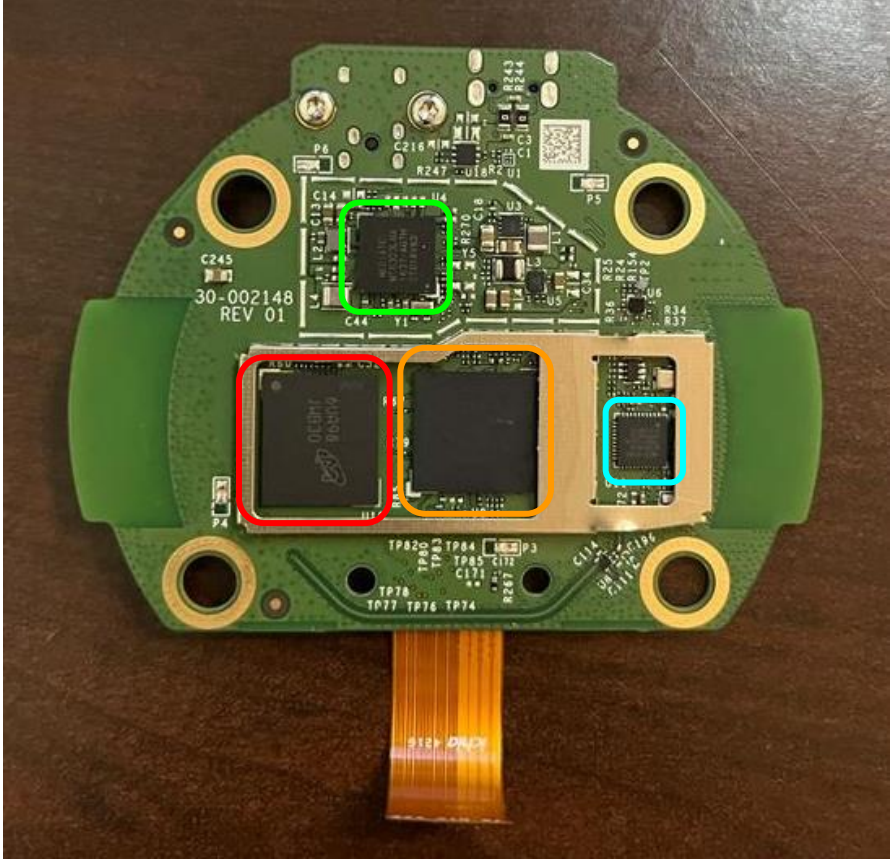
- Hosts the USB, audio output, digital-to-analog converter, processor, memory, and wireless chip

Bottom:



Circuit Boards

Processor Board (Top):



Memory card, stores 4GB of memory and used for firmware updates

Power-management IC, circuits used for power management

Wi-Fi/Bluetooth Chip, FM, and

Quad-core processor

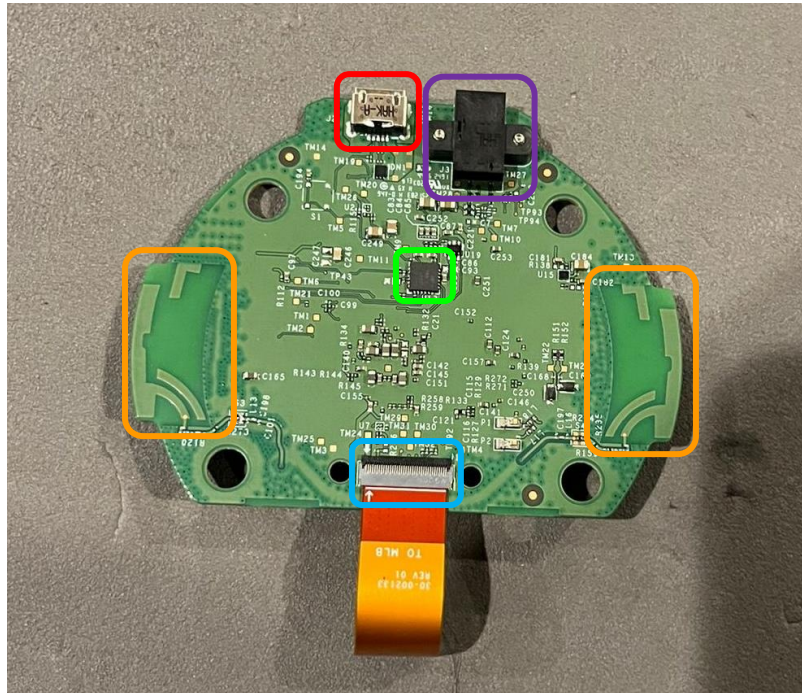
Processor Board (Bottom):

Micro USB port,
provides power
for the entire
system

Audio port, allows
you to connect an
external device to
play audio

DAC chip,
converts digital
audio into analog

Ribbon cable
connector, connects
the processor board
to the microphone
board

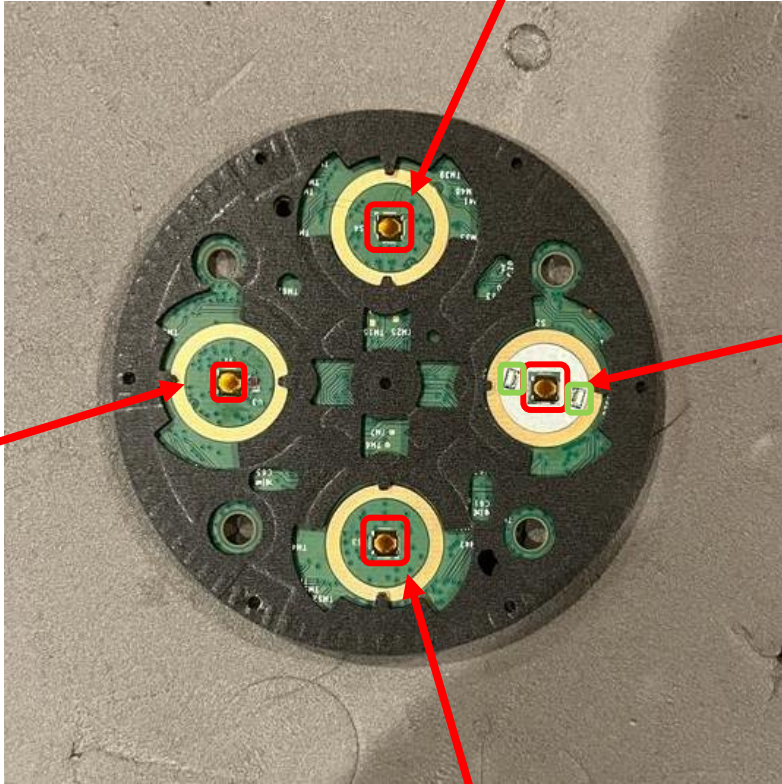


Antennas (2),
provides
connection to the
GPS, WIFI, and
Bluetooth

Microphone Board (Top):

Tactile switches
(4)

Volume Down



Action Button

Mute

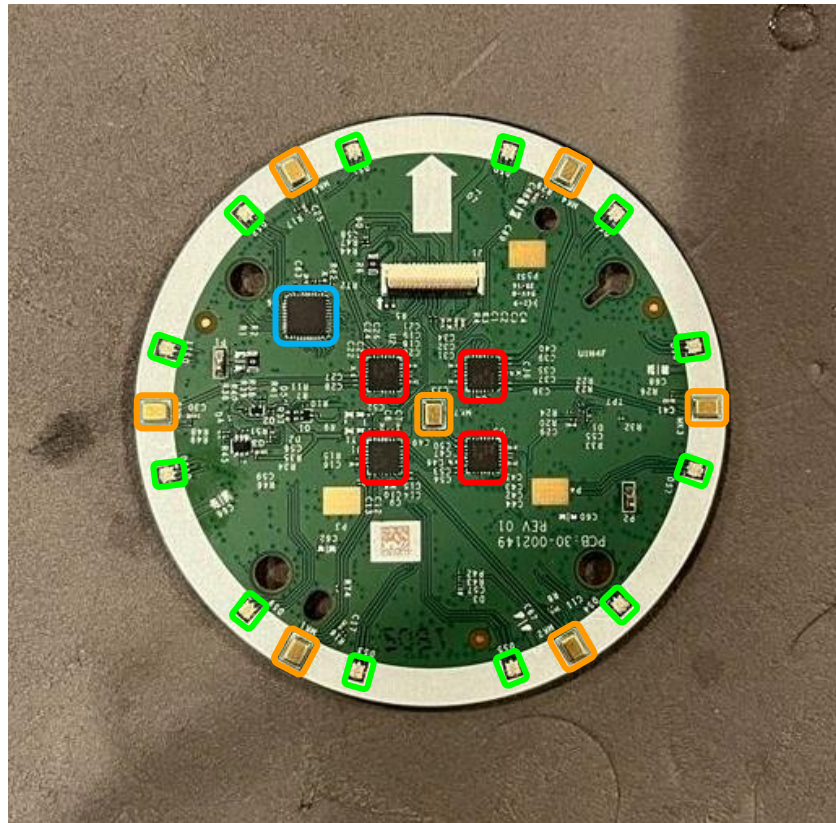
LED

Volume Up

Microphone Board (Bottom):

Analog-to-digital converters (4), converts microphone inputs to digital signals

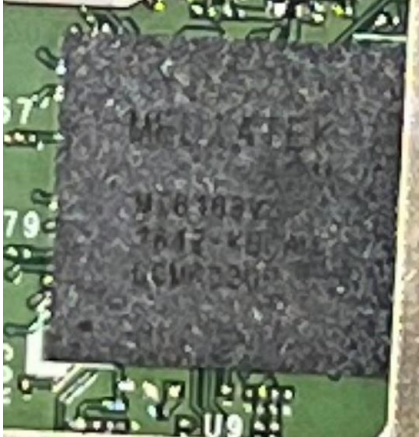
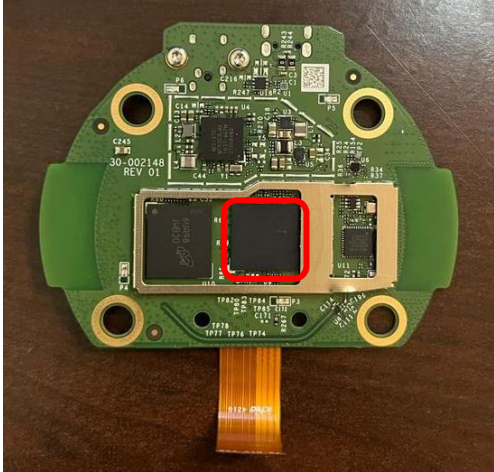

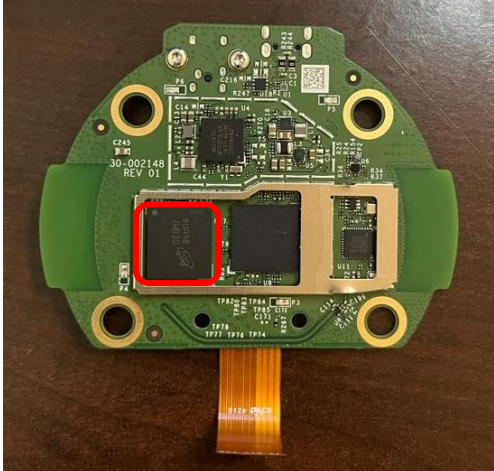

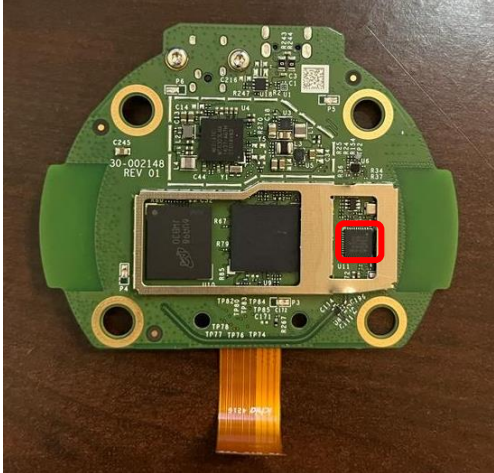
Surface-mount microphones (6)



Microcontroller, connects the switches to the LEDs

RGB LEDs (12), used to indicate the different buttons

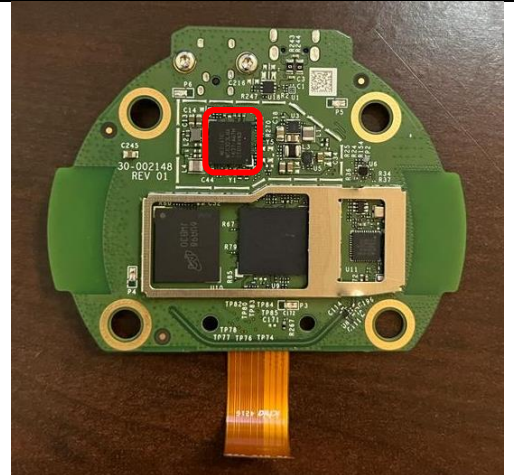
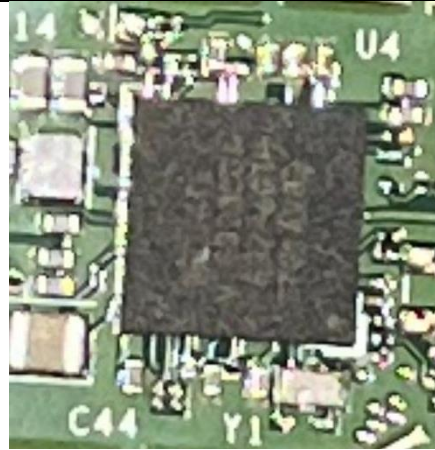
Circuit Board Components

| Info | Picture | Location |
|---|---|--|
| <p>Quad-core processor: This allows the echo dot to function; it runs all the code processes and works with the other components to run the echo dot.</p> <p>Data sheet: Quad-core processor</p> |  |  |
| <p>Memory card: The memory card stores the firmware for the echo dot. It sends firmware to the quad-core processor when the echo dot requires a firmware update.</p> |  |  |
| <p>Wi-Fi/Bluetooth chip, FM, GPS: This chip connects to the internet, Bluetooth and GPS and makes information you want available.</p> <p>Data sheet: Wi-Fi/Bluetooth chip, FM, GPS</p> |  |  |

Power management integrated circuit (IC):

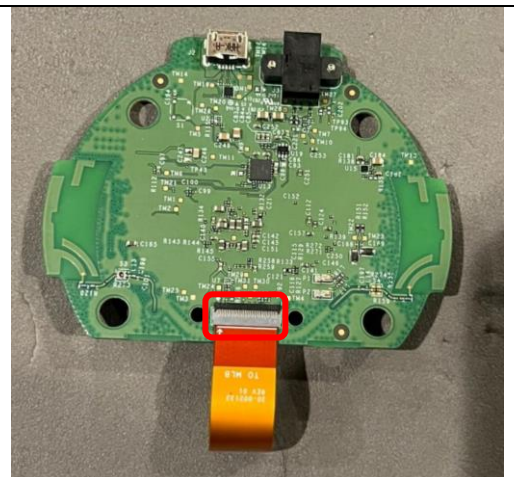
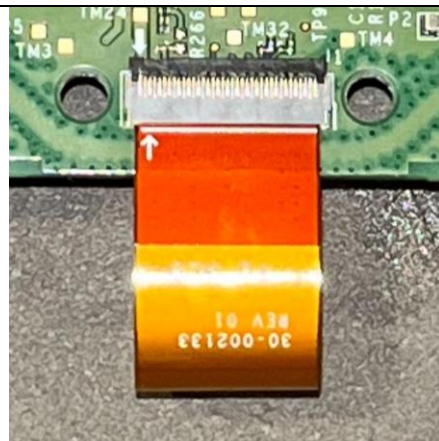
Sends current to different parts of the echo dot so it can function properly.

Data sheet: [Power management IC](#)



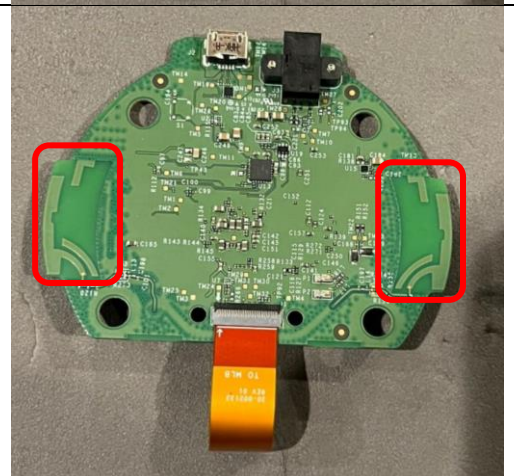
Ribbon cable connector:

This cable sends information from the Processor Board to the microphone board allowing them to work in unison.



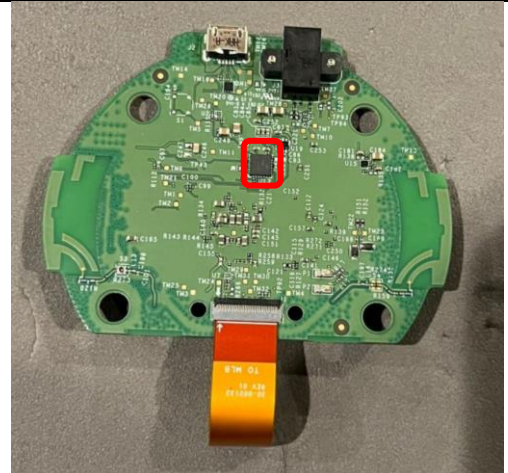
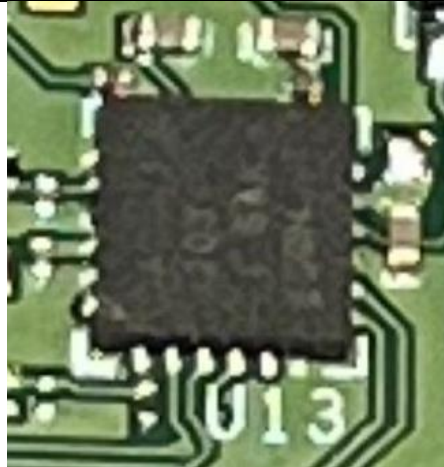
Antennas:

Catches connections from GPS WIFI and Bluetooth and sends that information to different parts of the processor board.



DAC chip:

This chip takes information from the Analog-to-digital chips (sent through the ribbon cable connector) and turns that into information that the processor board can understand.

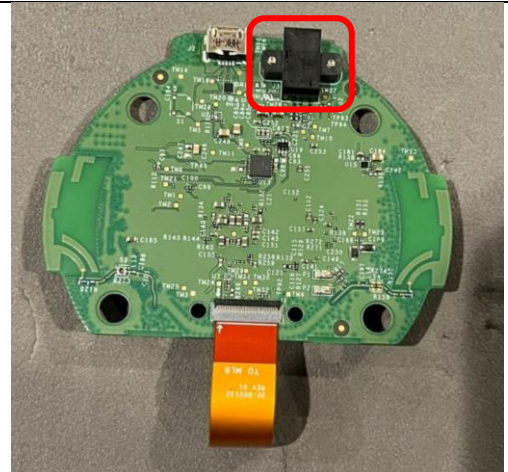


Data sheet:

[DAC chip](#)

Audio port:

Functions as an Aux input allowing you to plug in external device to play music from the echo dot.



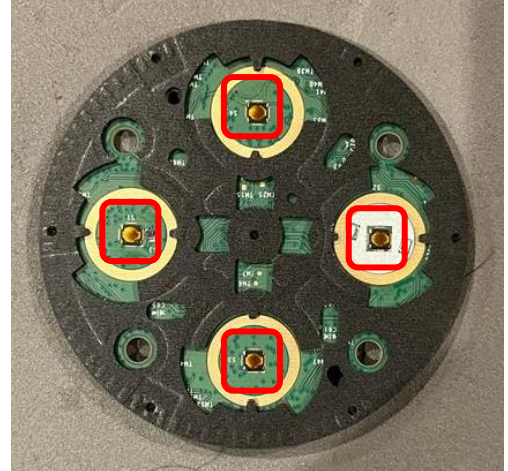
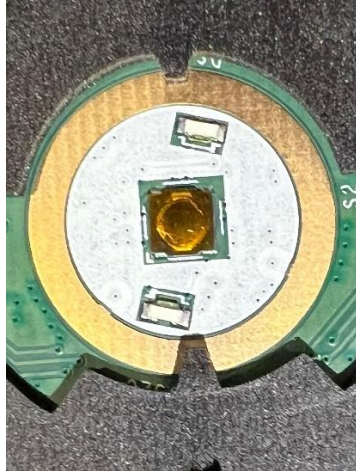
Micro USB port:

This is where the echo dot gets its power from.



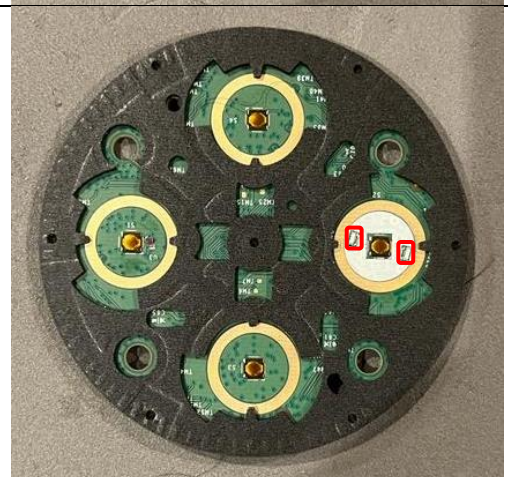
Tactile switches:

These tactile switches send inputs from the user through the circuit boards, so the echo dot knows when to raise/low the volume.



LEDs:

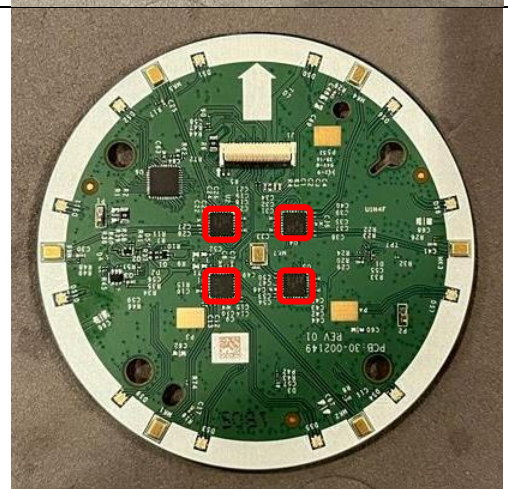
These LEDs indicate to the user when the echo dot is muted and can't hear their voices.



Analog-to-digital convertors:

Takes inputs from the microphone and turns it into digital information so the DAC chip can understand

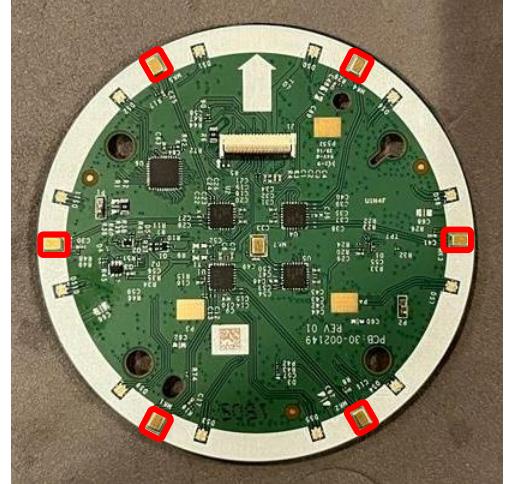
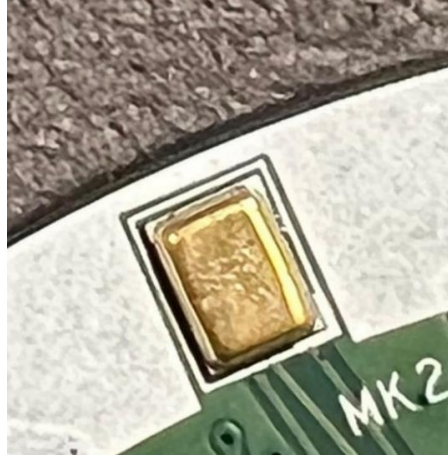
Data sheet: [Analog-to-digital convertors](#)



Surface-mount microphones:

Listens to your voice for any questions you have or whenever you are talking to the echo dot

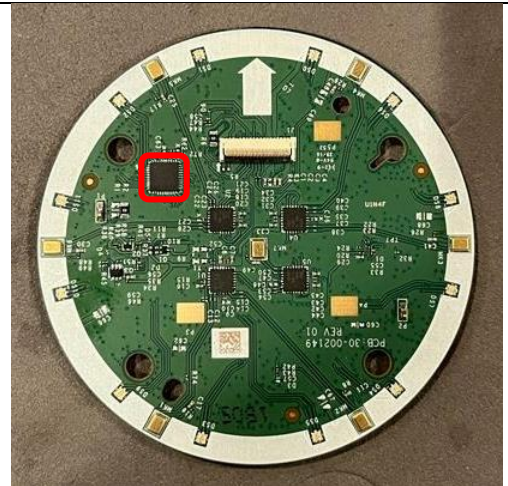
Data Sheet: [Surface-mount microphone](#)



Microcontroller:

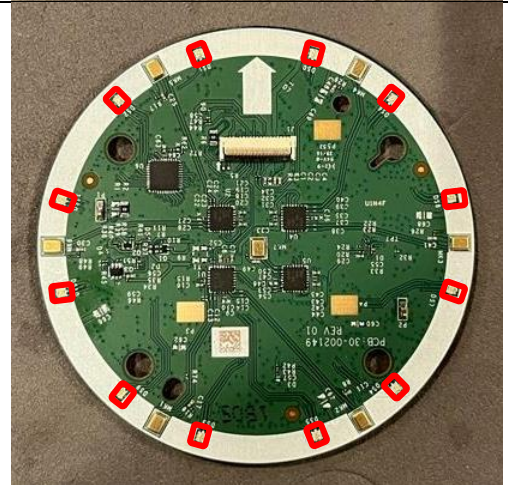
Connects the tactile switches on the other side of the microphone board to the LEDS

Data Sheet: Not found.



RGB LEDs:

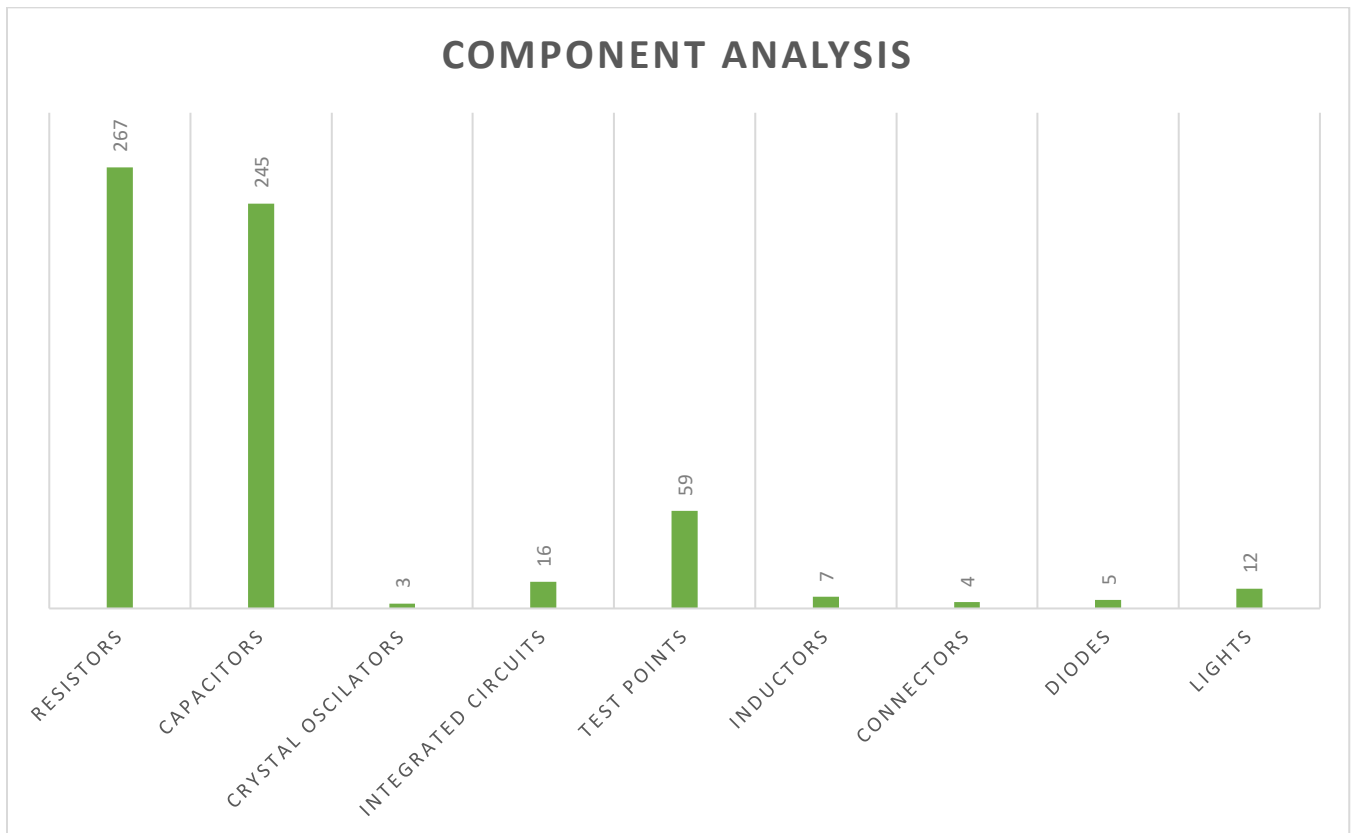
The LEDS serve as indicators to when the echo dot is listening to you, is changing volume or when it is muted



Component Analysis

We wanted to see how many parts are in both circuit boards combined so we counted all the components as shown below.

| Component | Amount |
|---------------------|--------|
| Resistors | 267 |
| Capacitors | 245 |
| Crystal Oscillator | 3 |
| Integrated Circuits | 16 |
| Test Points | 59 |
| Inductors | 7 |
| Connectors | 4 |
| Diode | 5 |
| Light | 12 |



Conclusion

After fully deconstructing the Alexa Dot and researching the parts, we learned a variety of things including the basics of how an Alexa Dot works, for example how it responds to our voices, lighting techniques and how the Alexa dot can answer any question that we have. Additionally, this thought us how to implement the engineering process in a real-world example and how the different components work in unison. We were able to learn about the functions of different parts of the Alexa Dot which broadened our overall knowledge of electronics and circuits.

Some overall lessons we learned were:

- Learned how valuable teamwork is
- Understanding different parts of a circuit and how they work
- Learned about different materials used for parts
- Implemented the engineering process

Citations

How to identify components on printed circuit boards. AX Control, Inc. Retrieved November 5, 2022, from <https://www.axcontrol.com/blog/2021/how-to-identify-components-on-printed-circuit-boards/06/07/>

88Deep Dive Teardown of the Amazon Echo Dot 2nd gen. RS03QR smart wireless speaker. TechInsights. (n.d.). Retrieved November 5, 2022, from <https://www.techinsights.com/products/ddt-1706-803>

**Online challenges.* (n.d.). Retrieved November 6, 2022, from https://challenges.robotevents.com/uploads/0019315_original.pdf

**Teardown Tuesday: Amazon Echo Dot V2 - News.* All About Circuits. (n.d.). Retrieved November 5, 2022, from <https://www.allaboutcircuits.com/news/teardown-tuesday-amazon-echo-dot-v2/>

**Teel, J. (2021, January 28). Teardown of an amazon echo dot.* PREDICTABLE DESIGNS. Retrieved November 5, 2022, from <https://predictabledesigns.com/product-development-teardown-of-an-amazon-echo-dot/>