# Reverse Engineering Challenge

TEAM 1850A

NORTH LONDON COLLEGIATE SCHOOL


Kohana Pathak, Avika Sapra, Divya Ram, Athena Hu, Maia Svistula

Northern Lights 1850A


# What device did we choose?

We chose a Samsung smart remote, to reverse engineer.


# Why did we choose this?

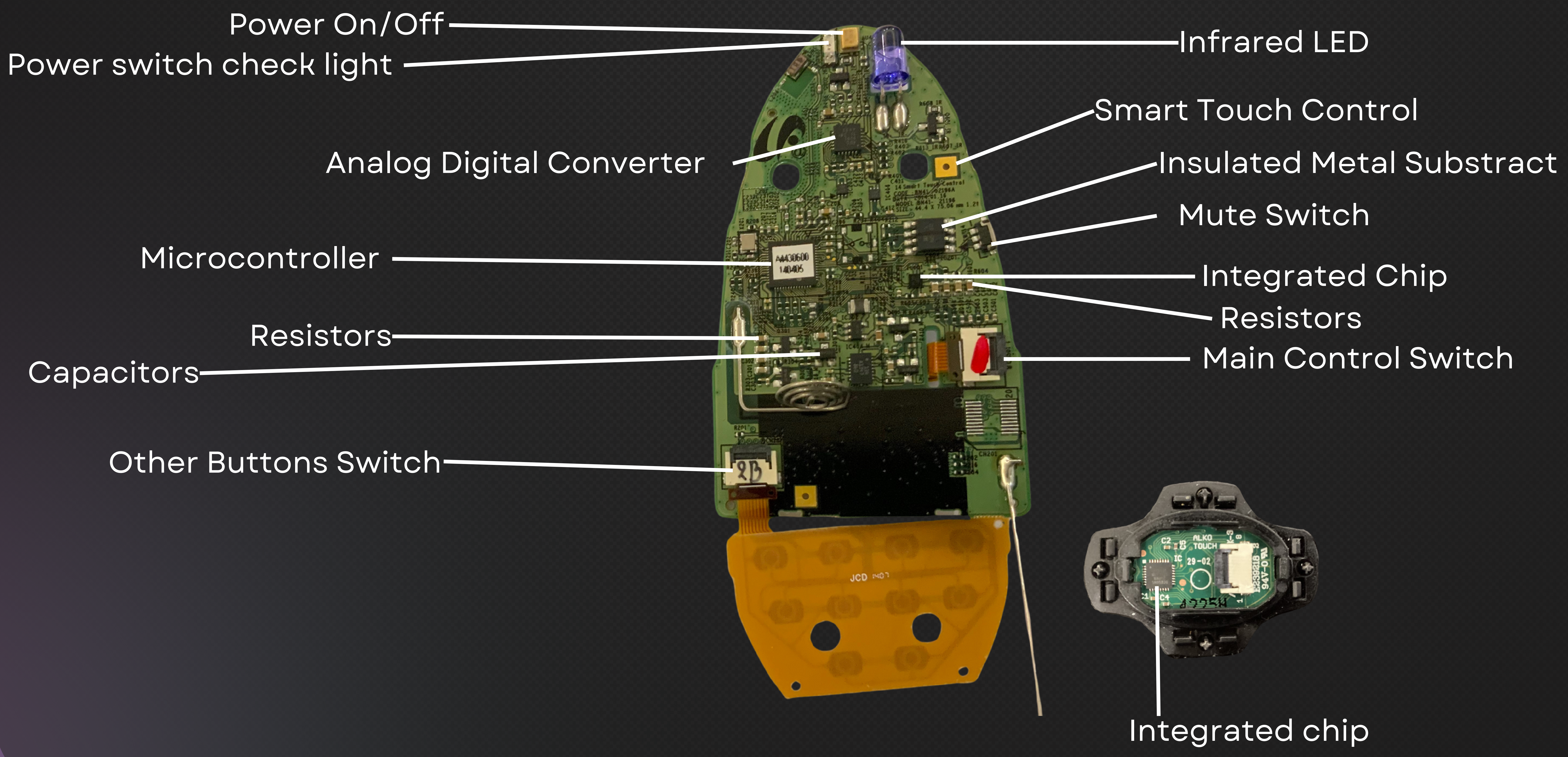
We chose to reverse engineer this remote, because it is an electronic device, and we thought that a device with a circuit board would be very interesting to study.

We were also quite curious, as to how companies like Samsung, Apple, and Microsoft, fit all that is needed, to make such sophisticated and refined products into such small spaces.

We also were wondering how the remote worked wirelessly, and we knew that this was a learning opportunity to find out about Bluetooth.

We also wanted to take a challenge, with what was available for us to use. Out of all the different things available for us to use, we settled on this, to test how we can handle reverse engineering the remote.

# Research


Power On/Off
Power switch check light
Infrared LED
Smart Touch Control
Analog Digital Converter
Insulated Metal Substract
Mute Switch
Microcontroller
Integrated Chip
Resistors
Resistors
Capacitors
Main Control Switch
Other Buttons Switch
Integrated chip

# Research

Before deconstructing we did some research to know more about the remote control, mainly its features, and electronic components. It is ergonomically designed so it is easy to hold and operate. The gyroscope pointing or Magic Mouse is a unique feature, and it also has a touchpad.
Infrared remotes are simple, low-cost and widely used, and it is voice enabled as well.

## Features

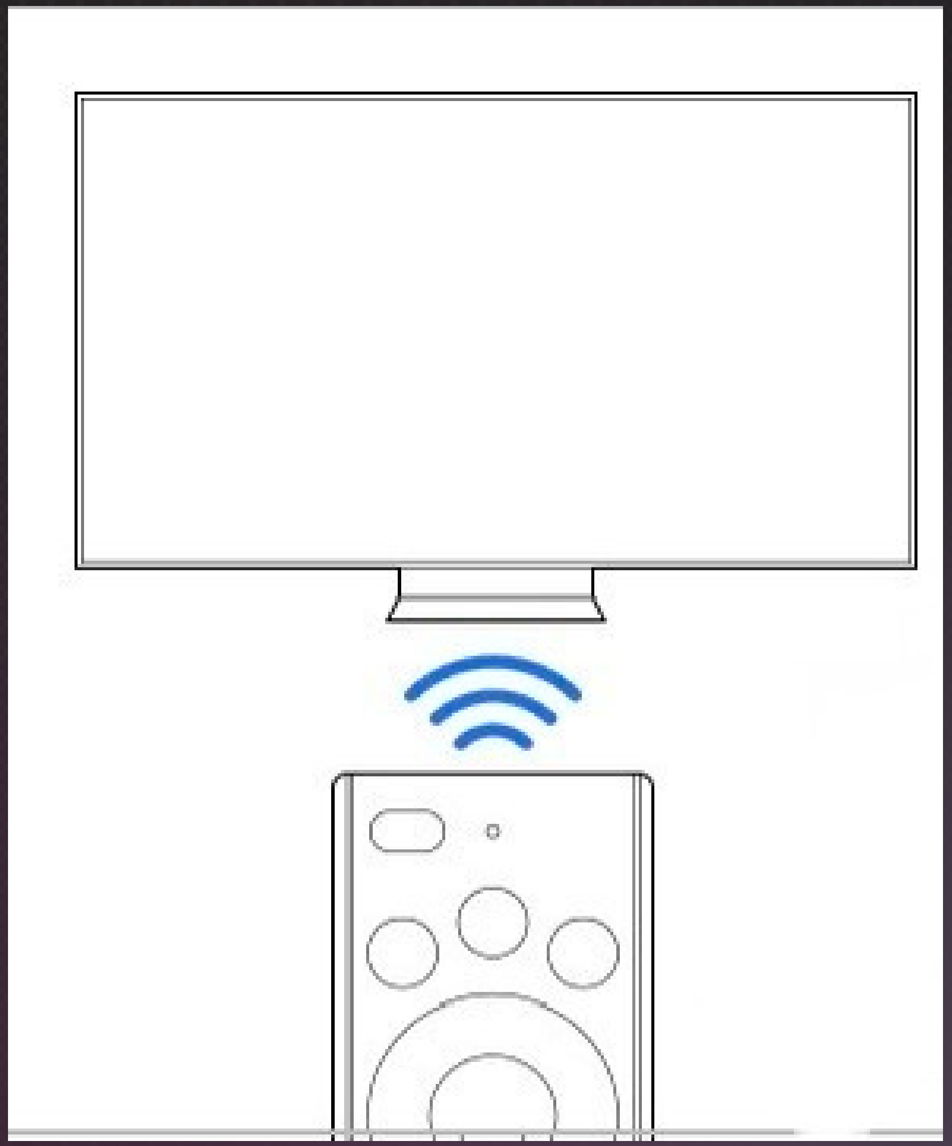
- TV Guide - This provides the information for TV programs.
- Smart Hub - This allows users to browse the apps on the TV.
- Internet Connection - This allows the TV to connect to the Internet, which allows it to run programs.
- Voice Recognition - This enables users to give a voice command, which is carried out by the TV.
- Menu - This shows the settings to the user.
- Source - This enables users to navigate between HDMI ports, USB Hubs, and the TV itself.
- Sports Mode - This activates/deactivates the sports mode, which lowers the volume of the commentary, and turns up the volume of the crowd.

# Research

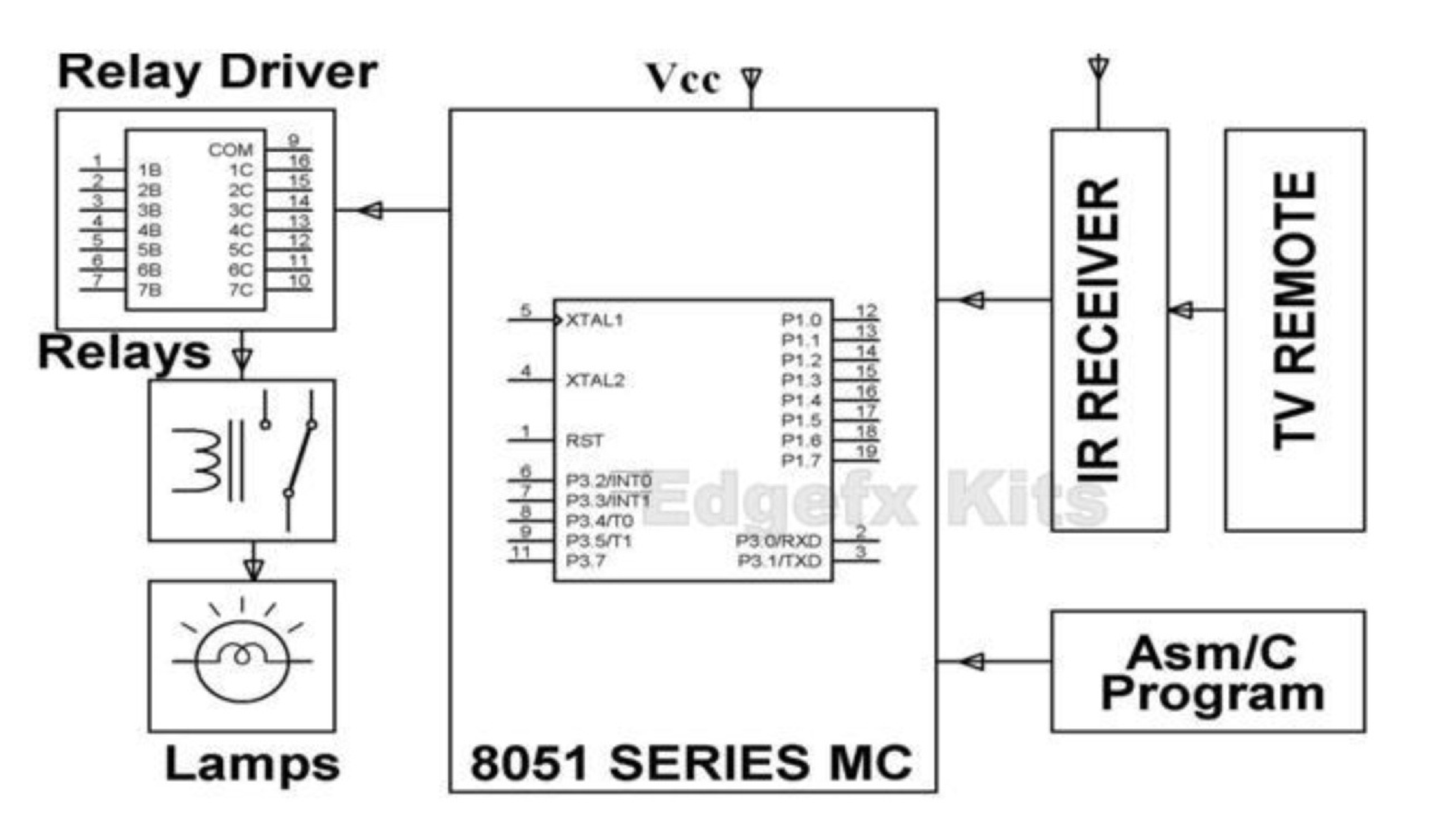
## Pairing the remote

It is important to pair the remote control with the TV.
Users have to:

- Have the TV powered on while attempting to pair the remote.
- Keep the remote within 1 foot of the TV.
- Have the IR emitter on the front of the remote aimed at the TVs IR receiver.
- All the buttons on the remote send Bluetooth commands except the POWER button. The power button send an IR command, if the remote is not in the line-of-sight with the TV, then the power command will not be received. This means that the power button will turn the TV on and off, even if the remote is not already paired with the TV.



# How do remotes work?

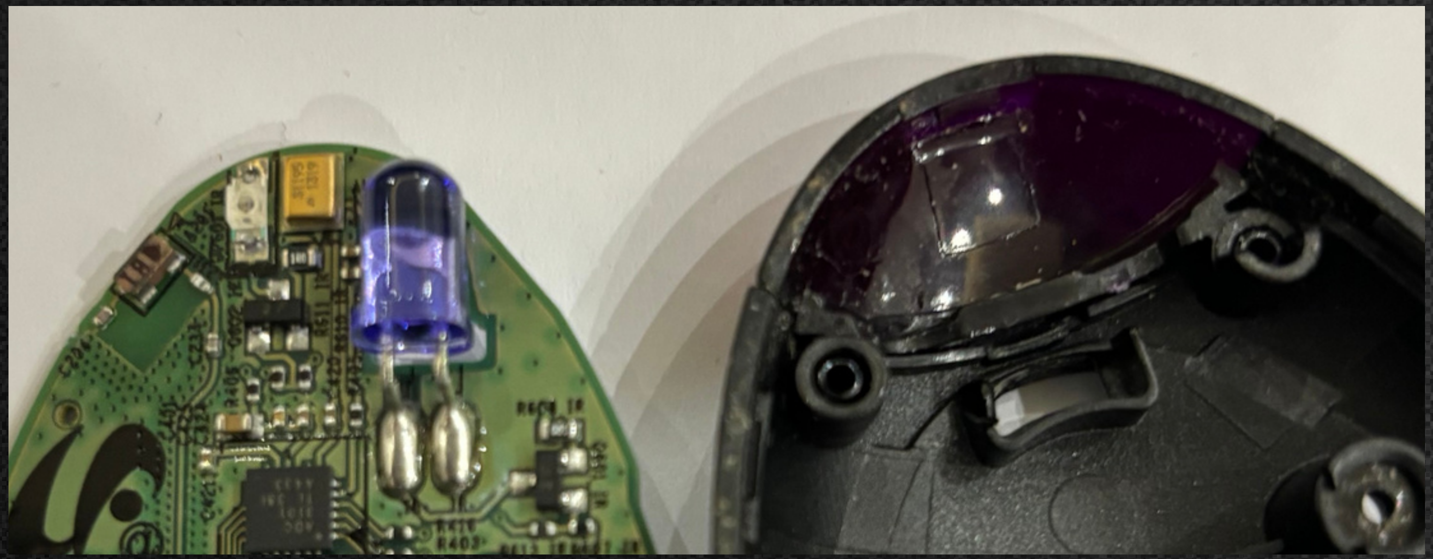



This diagram shows how the remote control and the TV connect with each other.

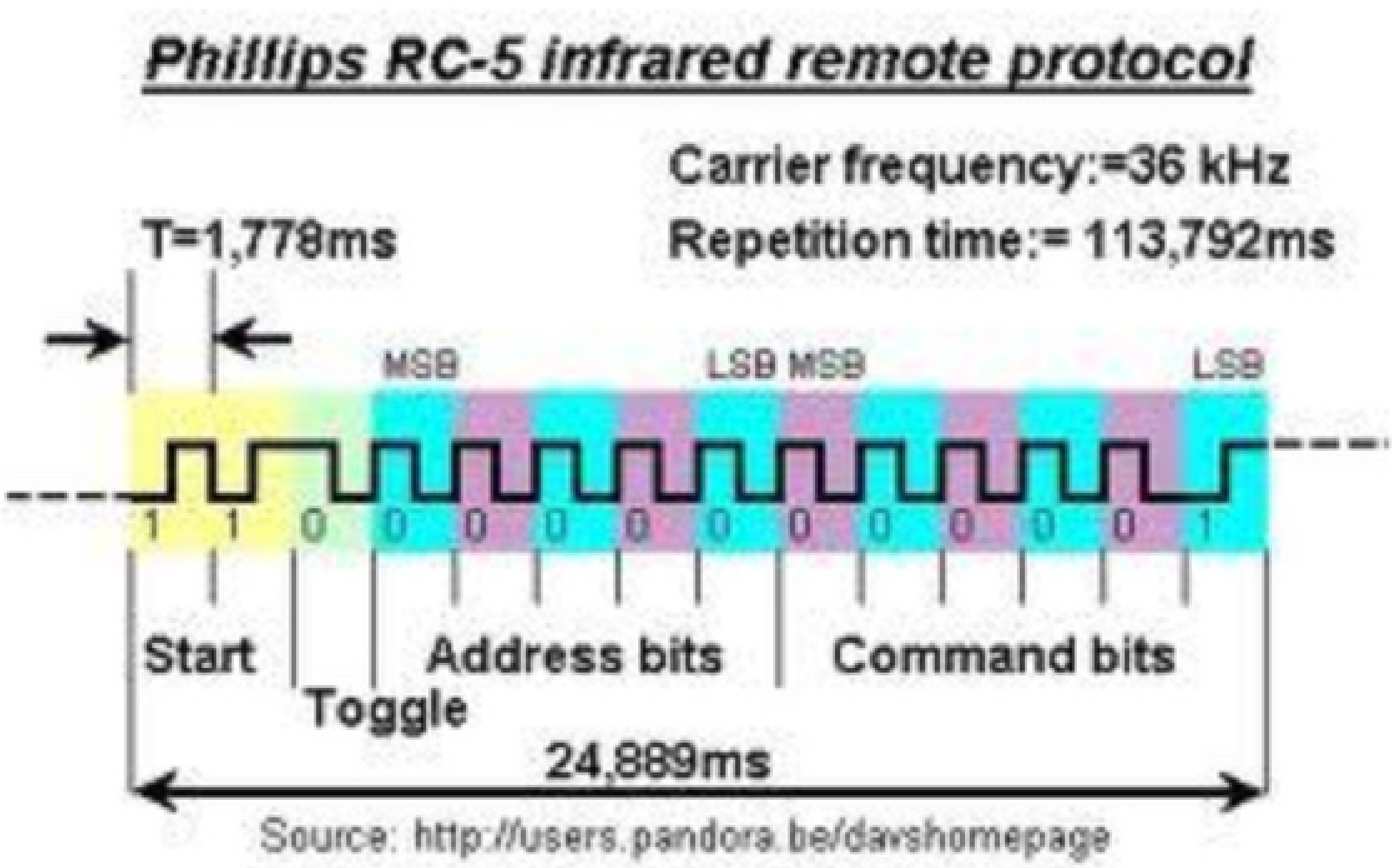
Even before disassembling, this gave us an idea of how the remote control works.

# How do remotes work?

## Transmitter



LED transmitter



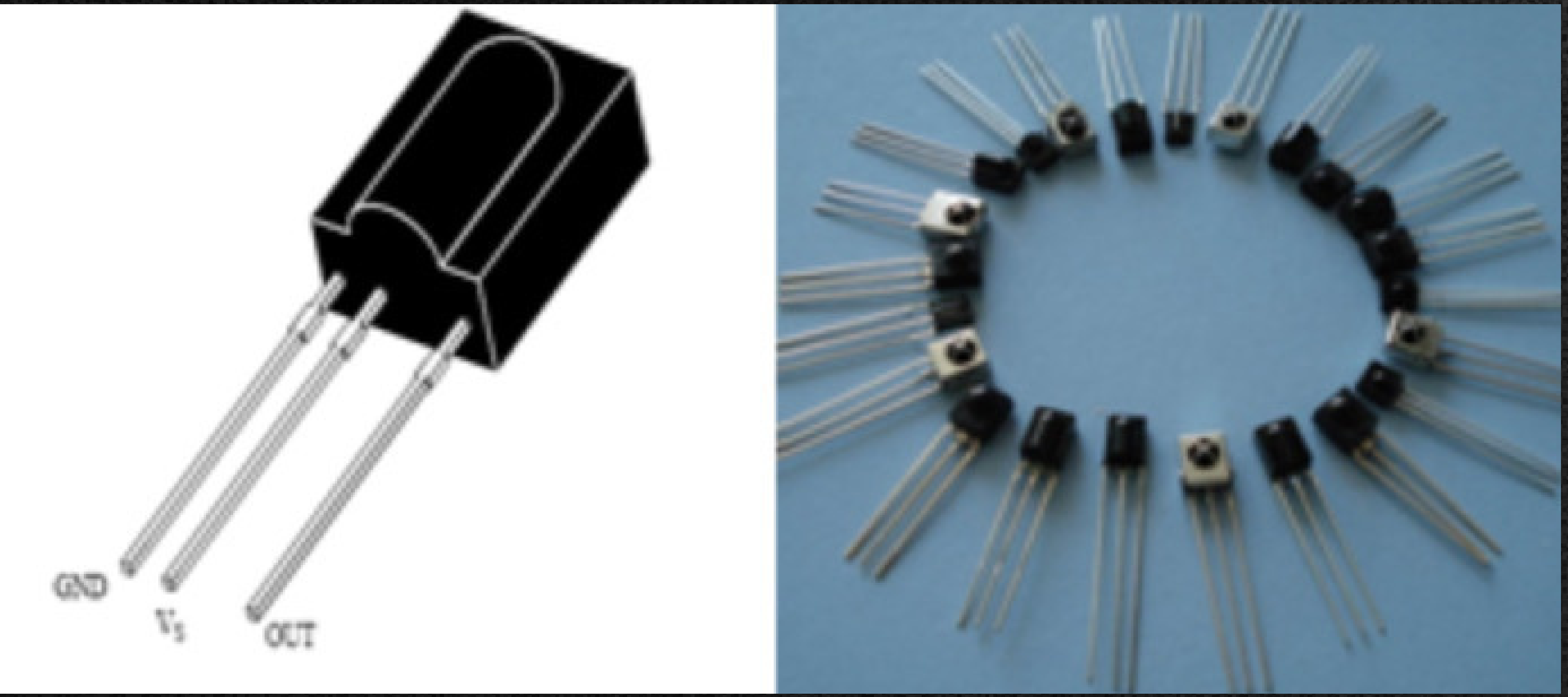

Transmitter sending signals

The process of sending a signal from the remote control, to the device, that is being controlled (normally a television), includes two major parts. These are the Transmitter, and the Receiver.
The remote is the Transmitter.

The process starts when the human presses a button on the remote. When it is pressed, a circuit is completed, and an electrical signal travels to the microchip.
The microchip transfers the signal, into binary, using bits. This is a series of 1s and 0s, that can make any number, that each represent different things, such as numbers, letters, and operations to carry out.
This is sent as rapid pulses of infrared light from a light emitting diode (LED), at the top of the remote. Infrared light is not in our light spectrum, so it is invisible to us.

However, in our modern world, they are everywhere, due to our devices, including mobile phones, computers, satellites, and, of course, remote controls.

Finished product of TV IR Receiver




TV IR Receiver

# How do remotes work?

## Receiver

The device being controlled is the receiver.
First, a sensor on the front of the device picks up infrared pulses, sent by the remote.  These pulses can be told apart from other infrared pulses.

Normally, the frequency of the pulses are modulated, so that each pulse is unique, and the wave lengths are different. The width variation also helps to make pulses unique, this means that the pulses happen with different timings. Filters can also block out any unwanted pulses, and a device address included in the signal helps greatly in ensuring that the correct signal has been picked up.

Then, the sensor converts these light pulses back into binary code. This is so the computer can understand it.

Finally, the binary is sent to the motherboard of the TV, where the code is understood, and correlated to a specific function, which the TV proceeds to carry out. These can be things as simple as increasing the volume or changing the channel.

# Steps of Deconstruction

## Dimensions

Before we deconstructed the remote, we thought that it would be beneficial to measure the remote. To do this, we brainstormed on what would be the most accurate measuring tool, and we picked a digital vernier calliper.
The readings that we got from this were:

- Length: 131.9mm
- Width: 25.5mm
- Depth: 50.3mm



# Steps of Deconstruction

The first thing that we did, was the simplest. We removed the batteries. This was because of safety considerations. We did not want to get electrocuted by operating on a circuit, that was connected to the power. We also wore safety goggles, to protect our eyes.
It also allowed us to have a view on the remote, from the back, since we deconstructed from the front to the back of the remote.

1

After this, we proceeded to the hardest step. This was removing the front case. It was hard, since it was attached to the back case, and we had great difficulty unattaching it.
Eventually, we managed to take it off, inside, we found a small circuit board on the back of the case, where the navigation controls were. This was attached to a wire, which went further down into the remote. There were some pieces supporting this.

2

# Steps of Deconstruction

3

Under the front casing, there was a layer of material, that felt like rubber. This rubber was limited to the size and shape of the component below it. We thought it was likely, that it was there to protect the component below.
The rubber had been designed to be thicker where the buttons were on the remote.

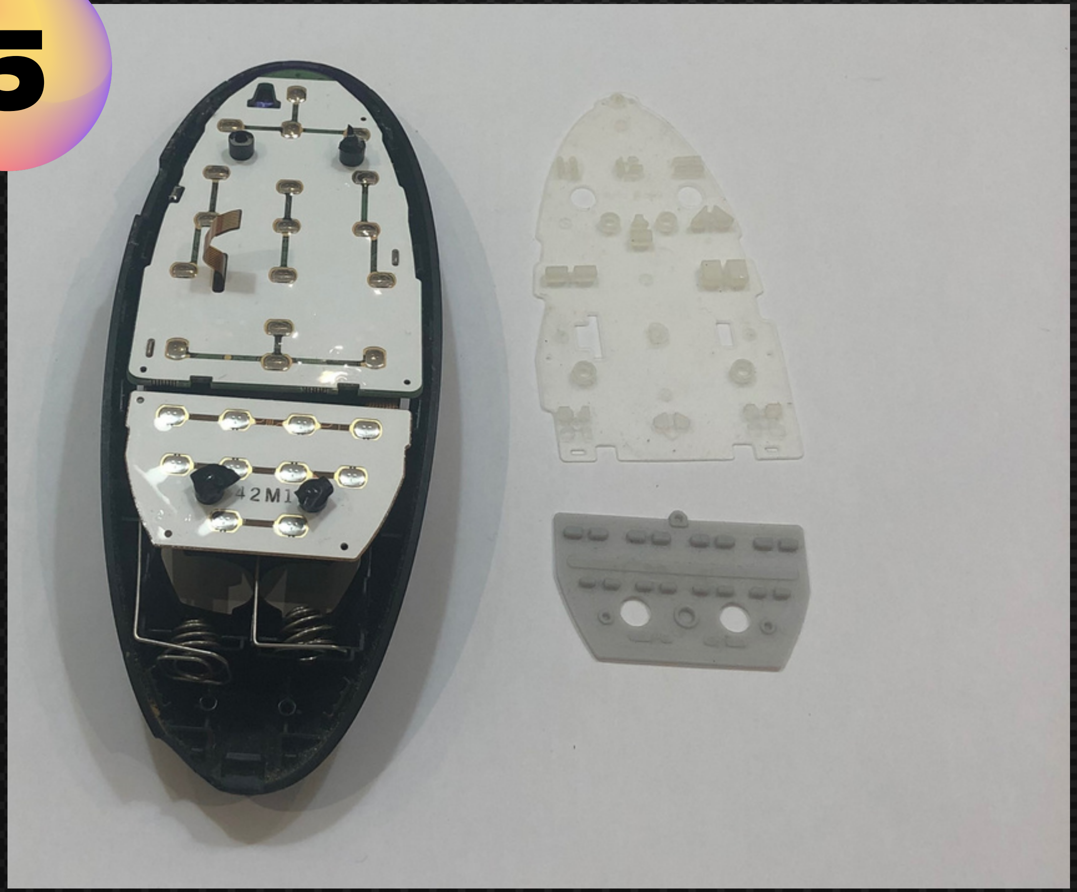
4

This is where we came to a small roadblock.
We could not take out the next component, since there were pins in the way. Eventually, we managed to see that there were screws underneath them, and by matching them up to where they were on the back case, we could see where the screws had been tightened. It took a lot of trial and error to unscrew these, since many of our screwdrivers were too big, or too small. Luckily, our school provided us with one small enough, and we managed to unscrew them.

# Steps of Deconstruction

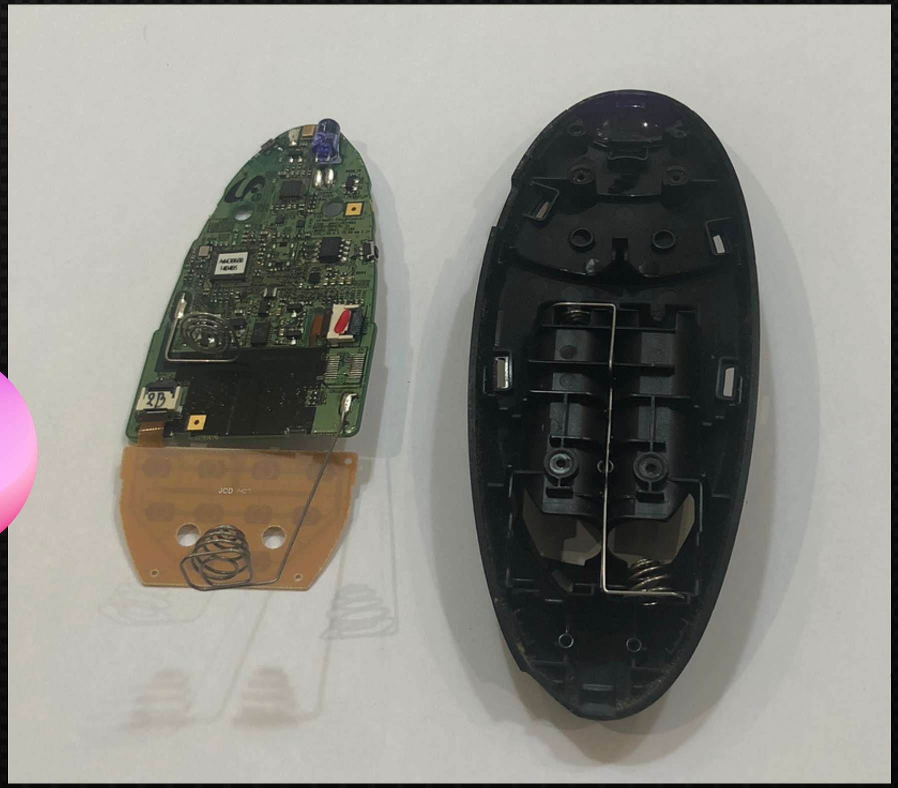
5

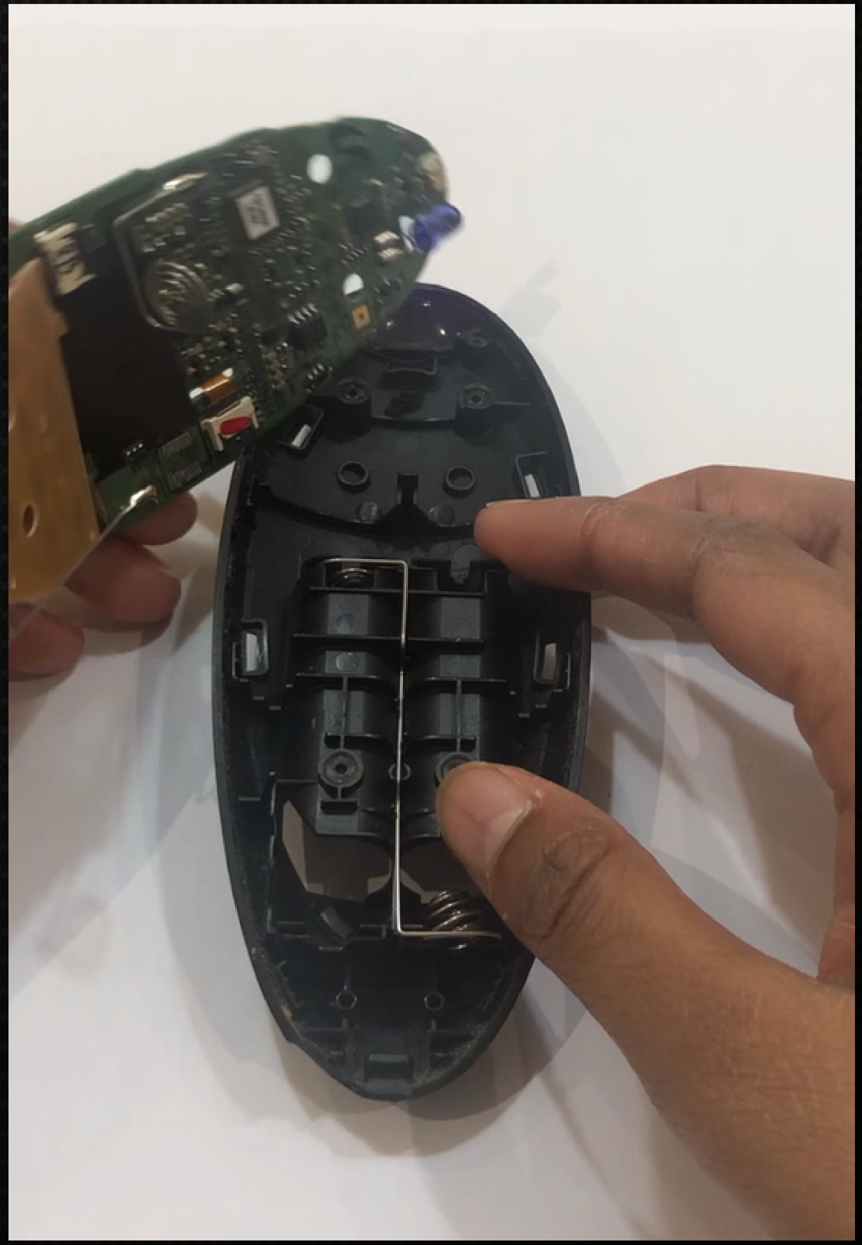
Once unscrewed, we still had to remove the pins and screws. This was slightly difficult, since some were stuck inside the case, but we managed to get them out, due to holes in the battery holder.



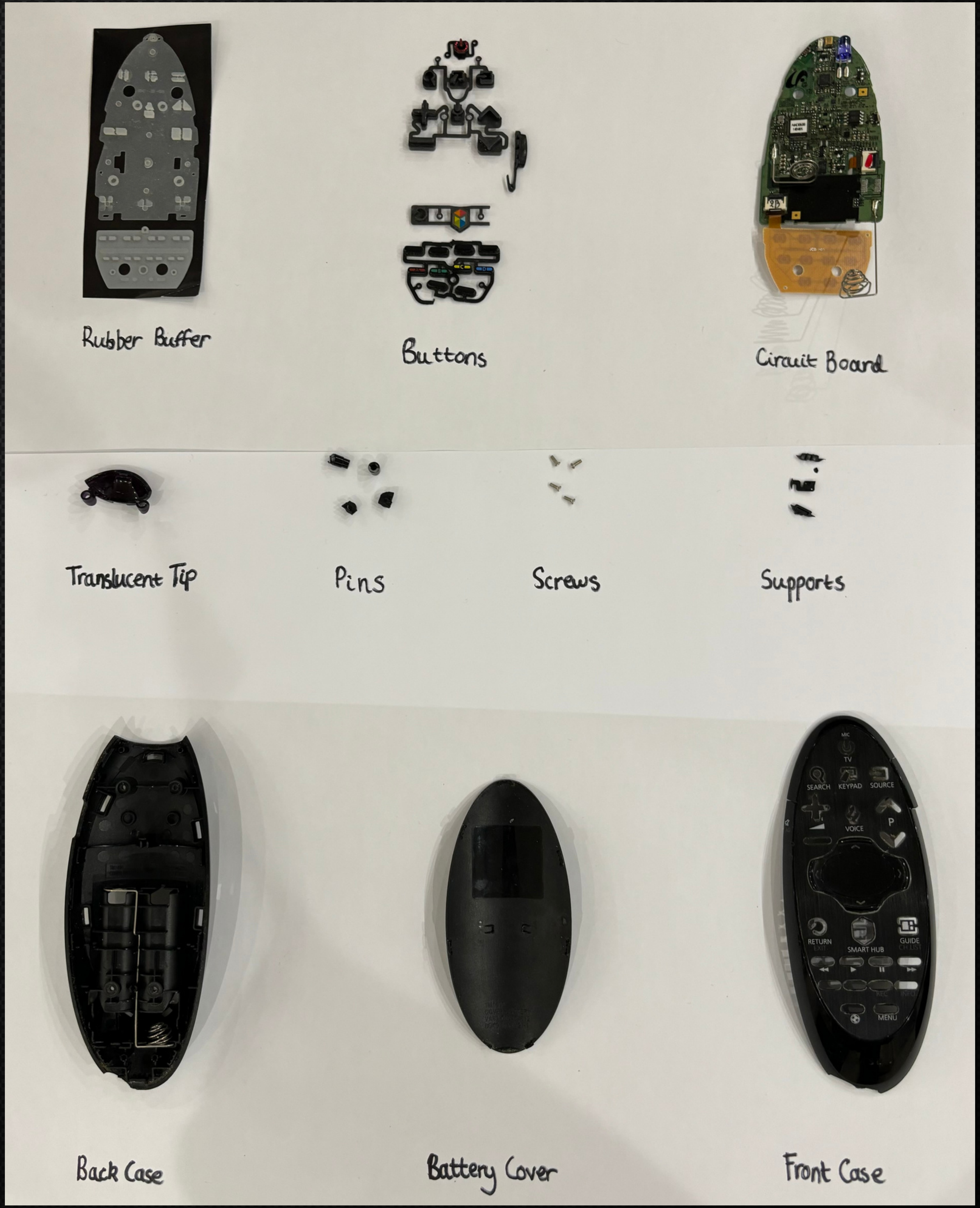
6

Finally, we could take off the component below. This turned out to be a circuit board, which was the place where all the main functions happened. Using a magnifying glass, we were able to identify major parts, such as the battery circuit, the LED for sending infrared signals, and the microcontroller, which controlled the entire system. Other parts took more time and research to identify.
We could also take off the tip of the back case, which was confusing, since it did not seem to have any function,





# Components List



# Analysing Important Components

## Microcontroller

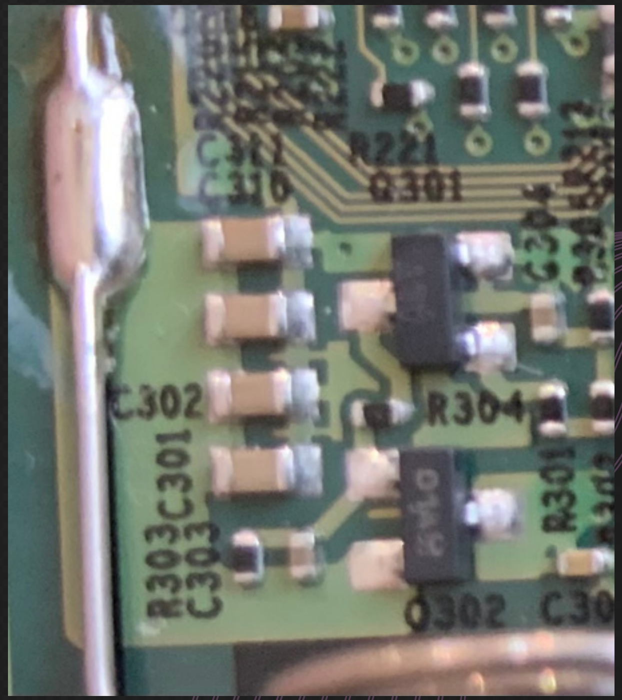
This is the central processing unit of the remote, responsible for interpreting user inputs, managing functions, and generating signals to control other electronic components.


## Buttons

These are the physical buttons on the remote's surface, each corresponding to a specific function. When pressed, these buttons complete circuits, sending signals to the microcontroller.

## Resistors & Capacitors

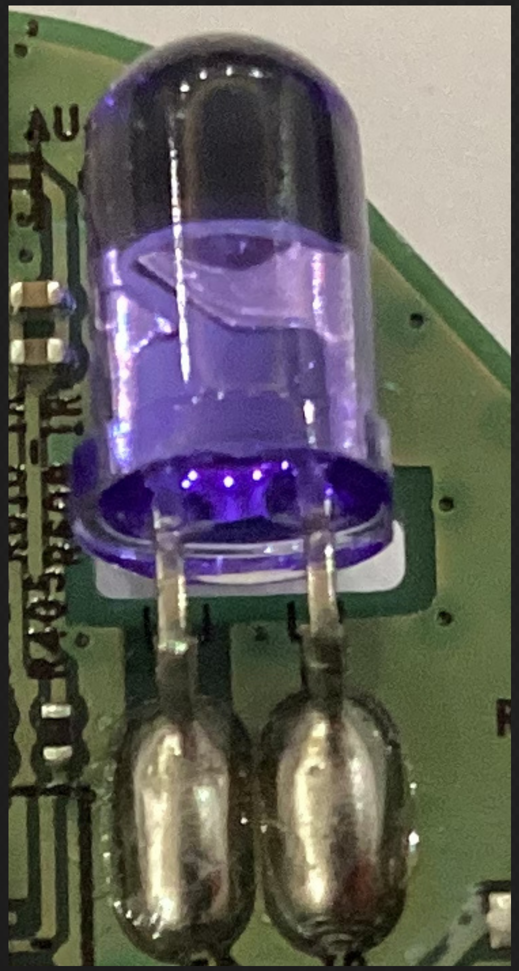
These electronic components help regulate and stabilize the electrical signals within the circuit.



# Analysing Important Components

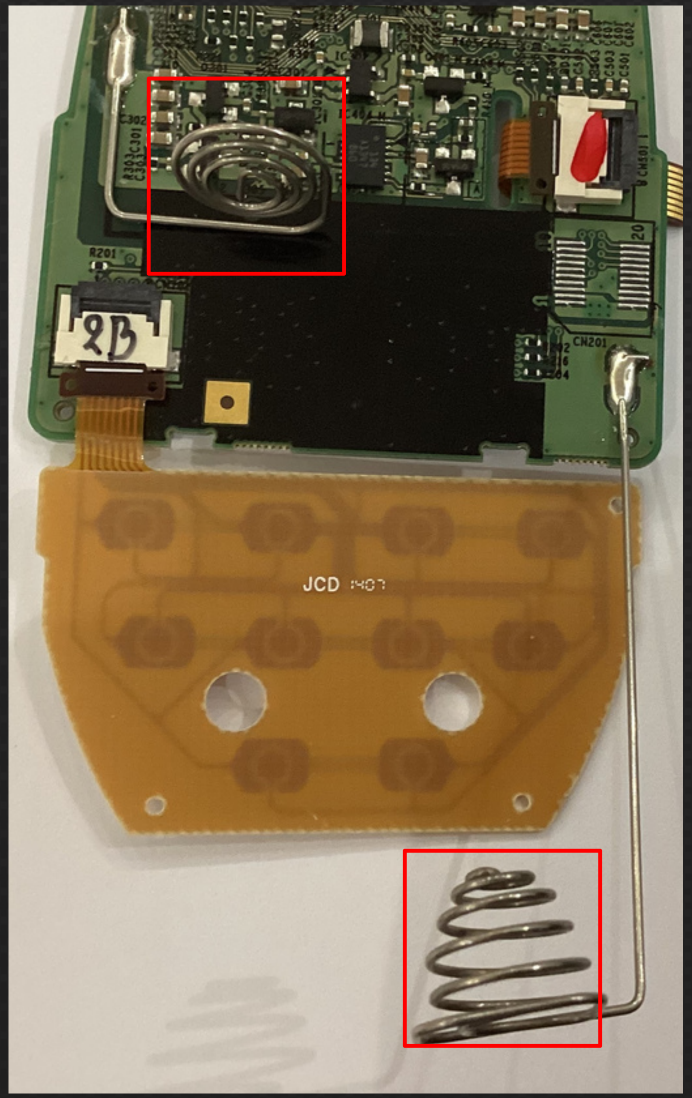
## Infrared LED

lo indicate when a button is pressed or when the remote is transmitting a signal. They are often connected to the microcontroller.



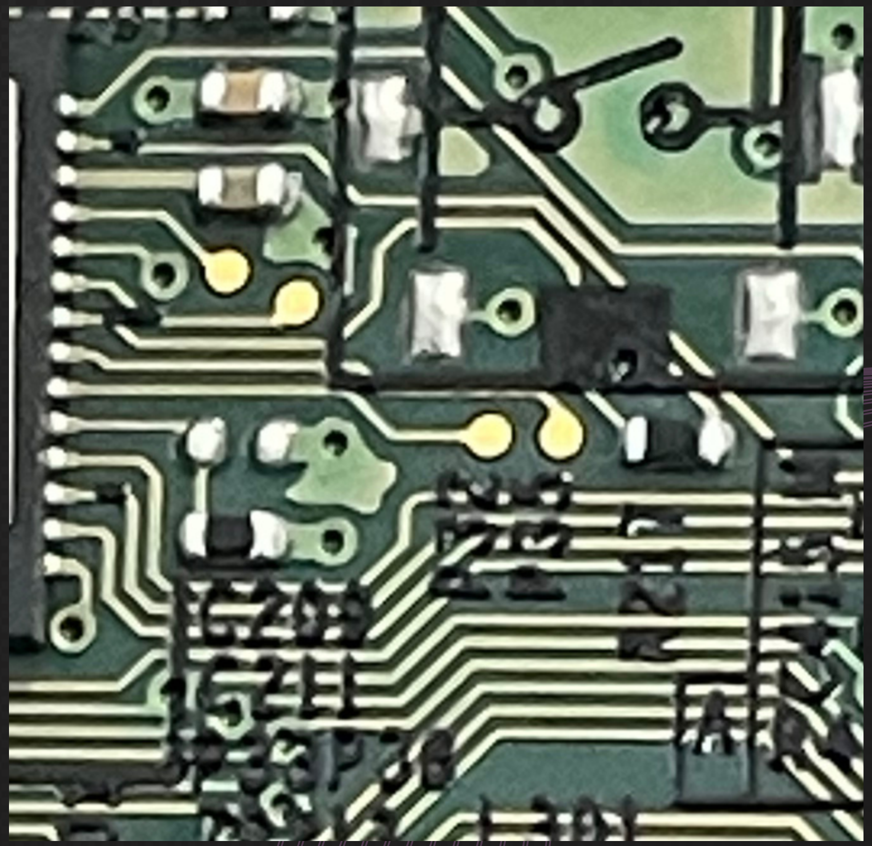
## Battery

The point where the remote connects to its power source, typically batteries.



## Connectors & Tracers

Conductive paths on the board that facilitate the flow of electrical signals between components.



# Analysing Important Components

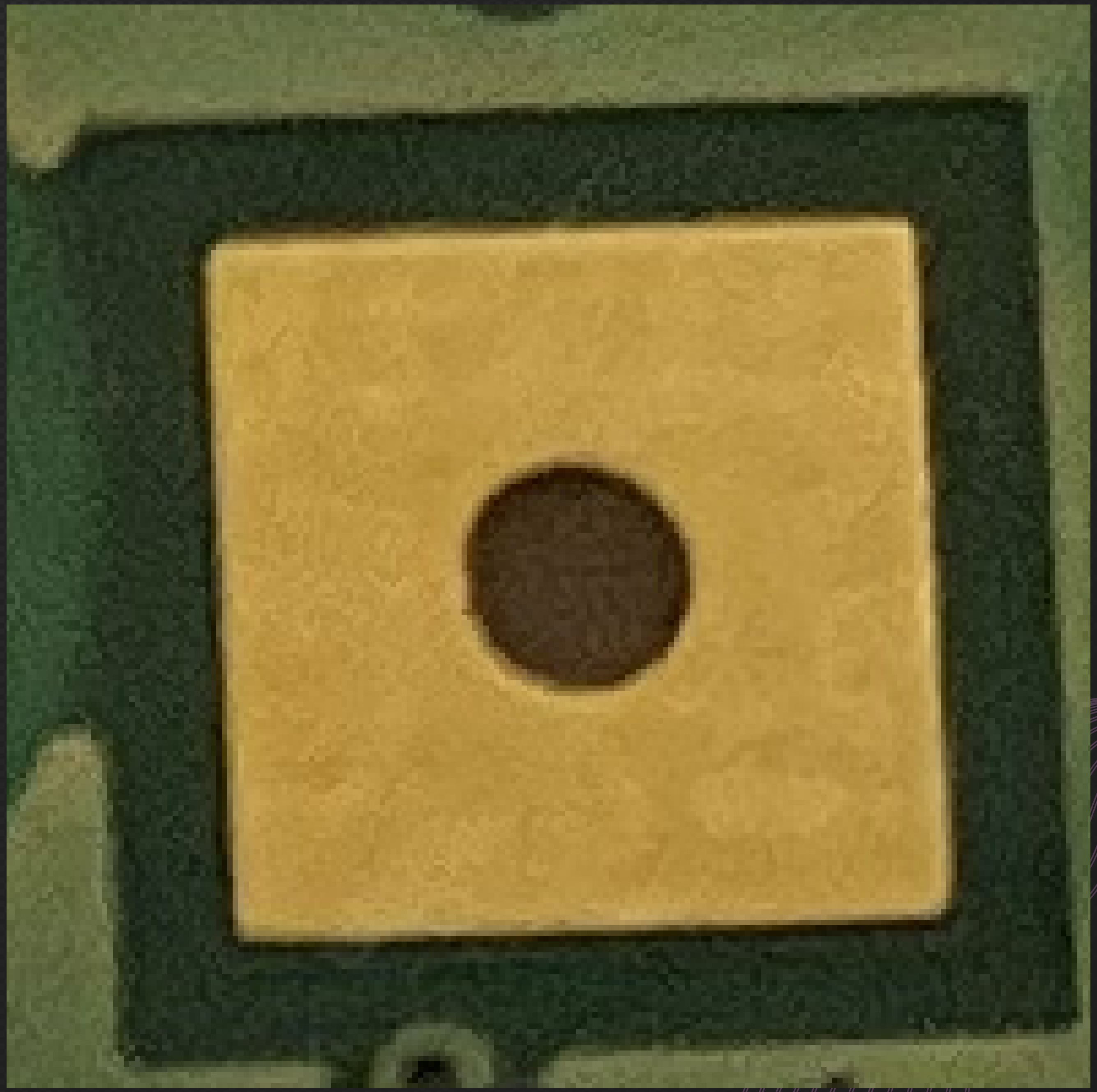
## Analog to Digital Convertor (ADC)

An Analog-to-Digital Converter (ADC) is a crucial component in electronic systems that convert analog signals into digital data. The ADC takes in an analog signal, which is a continuous and variable voltage or current signal. The ADC samples the continuous analog signal at discrete intervals. The sampled analog values are then quantized into digital values. The quantized values are encoded into a binary format. The final output is a digital representation of the original analog signal.

# Analysing Important Components

## Smart Touch Control

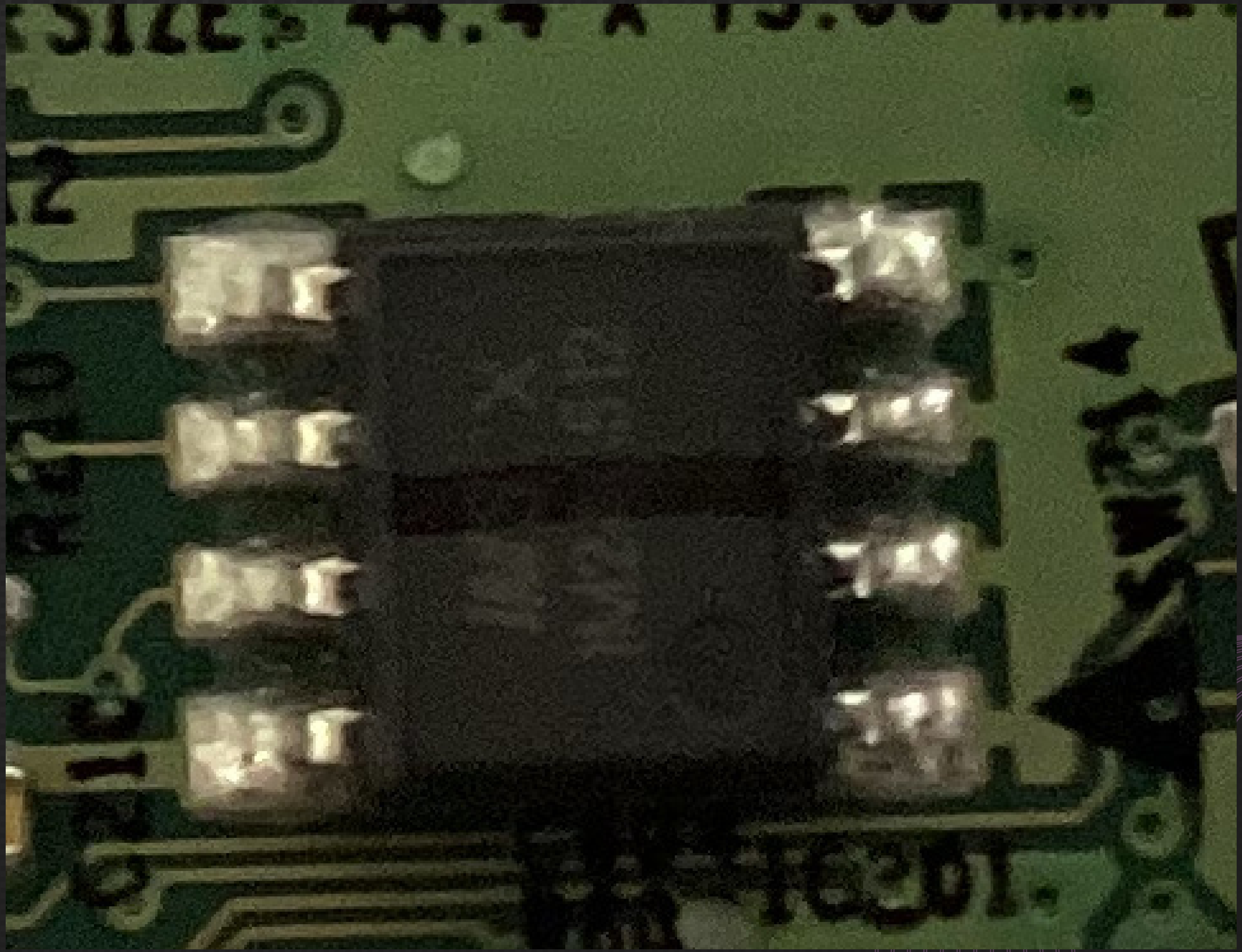
Smart touch control typically refers to a user interface technology that involves touch-sensitive surfaces and smart functionalities. Smart touch control systems use capacitive touch sensors to detect the touch of a finger or a stylus. Smart touch controls are often part of a broader ecosystem, connecting wirelessly to other devices.



# Analysing Important Components

## Insulated Metal Substrate (IMS)

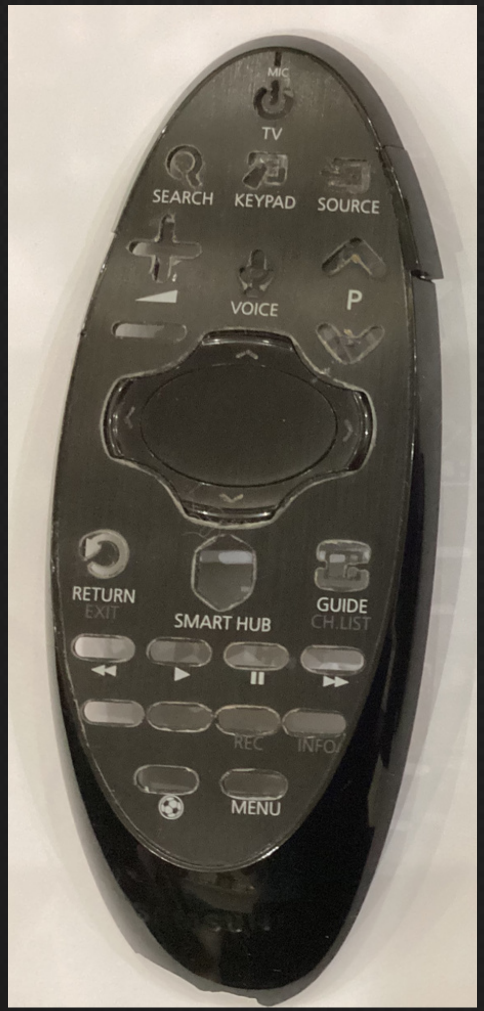
Insulated Metal Substrate (IMS) serves as a base material for electronic circuits, particularly in the manufacturing of printed circuit boards (PCBs). One of the primary functions of IMS is thermal management. The metal substrate, usually made of aluminum or copper, provides excellent heat dissipation. IMS has an insulating layer that isolates the conductive metal from the electronic components. IMS allows for a more compact and lightweight design.



# Analysing Important Components

## Front Case

This is where the user accesses the buttons of the remote. Behind this is where the circuit board is, so that it can carry out the functions of each button.




## Back Case

This is where the batteries can be placed to power the entire circuit. It also has a part on the top, which is translucent, meaning that the infrared LED can send signals, to the TV.

## Buffer

This can be found between the buttons and the circuit board. It is to protect the circuit board from damage, due to accidents.

# Conclusion

From reverse engineering this remote, we have learnt a lot about how remotes work and the physics put into the signals, as well as engineering skills. It showed us how important it is in out daily lives. By deconstructing the remote, we have gained the skills and knowledge on constructing.

We also learnt about circuits, and all of the different parts put into them, especially about resistors and capacitors, and their role in maintaining the circuit. This is the first time we have even seen a proper circuit from a finished product.

We found that, surprisingly, there was only four screws in the entire device, and that most things just slotted in. This showed us how designers for modern technology manage to fit all the parts into such a small space.

Most of all, we learnt how to improve working together as a team.

# Evaluation

What would we do differently next time?

If we were to do this again, we would handle it with slightly more care, since it was so hard to get the front case off, and it almost snapped. We also could pay more attention to the design choices of the parts of the remote, that were not electronic.
Another additional project that would complement this one, is if we were to take apart the receiver of the signals from the remote. This would give us a deeper look into the inner workings of the complete process.

# References


- https://www.elprocus.com/ir-remote-control-basics-operation-application/
- https://electronics.howstuffworks.com/inside-rc.htm
- https://www.allaboutcircuits.com/news/teardown-tuesday-tv-remotes/
- https://www.pbslearningmedia.org/resource/tips-for-distance-learning-with-pbs-learningmedia/virtual-professional-learning-series-video-gallery/
- https://en.wikipedia.org/wiki/Remote_control
- https://www.youtube.com/watch?v=-mfNR4GUNR4
- https://www.samsung.com/uk/support/tv-audio-video/how-to-pair-your-smart-control-remote-to-your-2014-model-tv/
- https://chat.openai.com/auth/login
- https://www.avforums.com/threads/brand-new-q65b-solarcell-remote-not-charging-with-usb-not-connecting-to-tv.2459432/
- https://bard.google.com/chat


Thank You