Beyond Buttons & Beeps : Reverse Engineering the Casio fx-55 Plus

Team 97101W
American High School - Fremont, CA
By : Shriya Iyangar & Shriya Sreevathsa
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1. Introduction: Why Calculator?

Our robotics team, composed of six young women, is fueled by a shared passion for engineering and innovation. When presented with the reverse engineering challenge, we initially gravitated towards working with cutting-edge technology like computers. However, after much deliberation, we turned our attention to the fundamental device that is present at each of our team meetings.

Every line of code we meticulously write and every mechanical modification we make to our robot relies on the bedrock of precise calculations. For our reverse engineering challenge, we have decided to disassemble and delve into the different components of the Casio fx-55 PLUS, a seemingly modest calculator that has been a key tool throughout our team's robotics journey.

Figure 1 : This is our team at the 2023 VEX World Championships alongside our trusted calculator, the product which we will be reverse engineering.

2. A Brief Visual Analysis

Figure 2 : This is a front view of the Casio fx-55 and its case.

First, we decided to observe the Casio fx-55 Plus' exterior. Manufactured by Casio Inc, it has a smooth plastic frame with 48 buttons that cause corresponding symbols to appear on the display.

Additionally, there is a mini solar panel as a power source and a cover to protect the calculator while unused. The colors of the calculator are vibrant and the calculator's size is compact.

An improvement could be to make the screen have more contrast between the text and background to make the display more clear.

3. Innovations of the Calculator

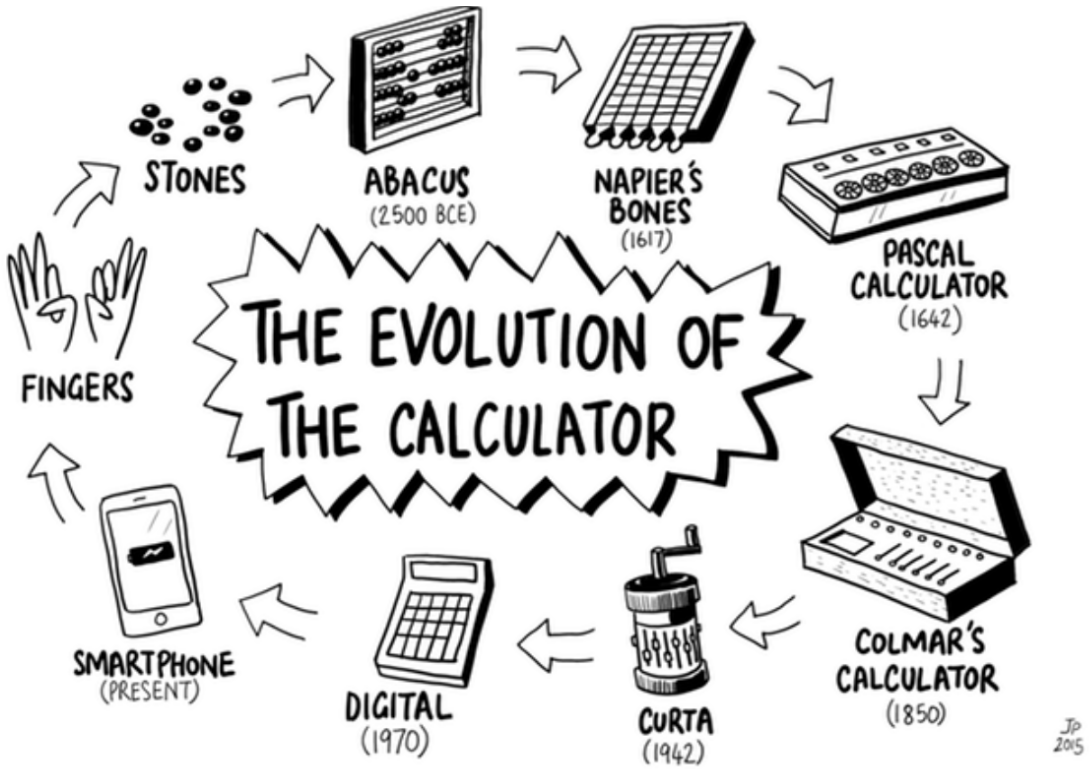


Figure 3 : This history of calculators demonstrates how calculators have evolved from the abacus in 2500 BCE, which manually solves problems by sliding counters along rods, to the digital & programmed calculators of today (Davis). These calculator designs continue to evolve in order to be able to perform more complex mathematical functions!

4. A Hypothesis

Before disassembling the product, we decided to hypothesize how it functions. After a discussion, our team reached a consensus that, powered by battery, a calculator receives inputs from its programmed buttons. This program causes the correct answer to be shown on the display.

However, this is a really abstract hypothesis. To better understand how the calculator works, we will be deconstructing it next!

5. The Disassembly Process

A. The Tools

Figure 4: These are the tools we used in our disassembly process. We used a screw driver, a wire cutter, a spudger to separate parts, and goggles for safety.

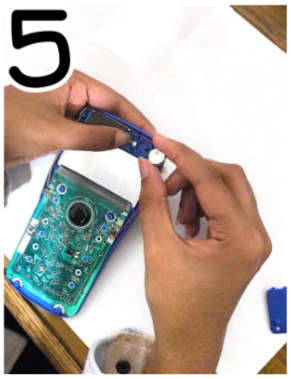
B. The Step-by-Step Process

1. We removed the 6 screws on the back of the calculator using a Phillips screw driver to separate the frame from the rest of the calculator. To the right is a zoomed in view of the screws we removed.

2. We removed the battery cover from the calculator.

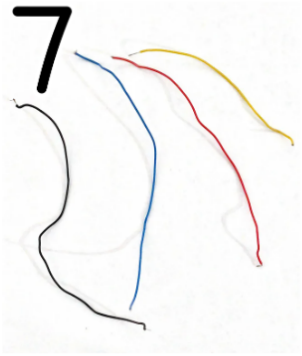
3. We separated the back cover from the rest of the calculator.

4. Next, we moved all the plastic frame pieces to the side.

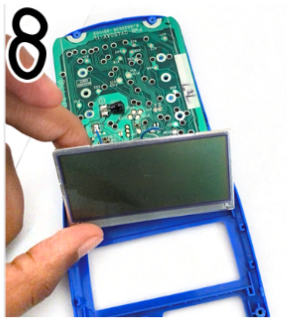


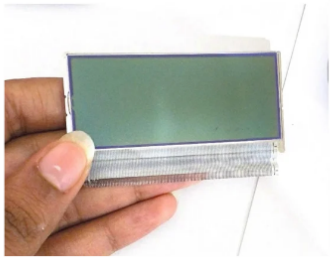
5. We then removed the lithium battery from the calculator for safety.

6. The solar panel is another source of power that we detached from its frame.

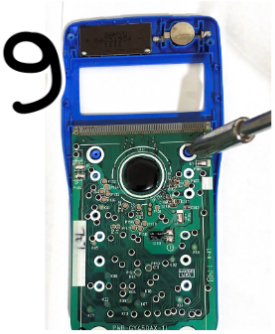


7. We used a wire cutter to safely separate the power sources from the calculator.

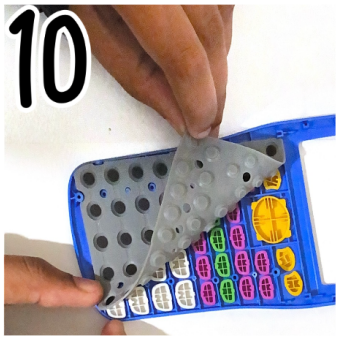




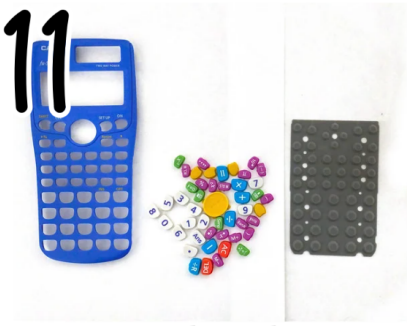
8. We flipped the display backwards and removed the adhesive that attached it to the frame. The image on the right shows the separated display, on which the remains of the adhesive can be seen at the bottom.



9. Next, we unscrewed the PCB screws using a Phillips screwdriver and inserted the spudger between the rubber keyboard membrane and the PCB to remove the PCB from the case.

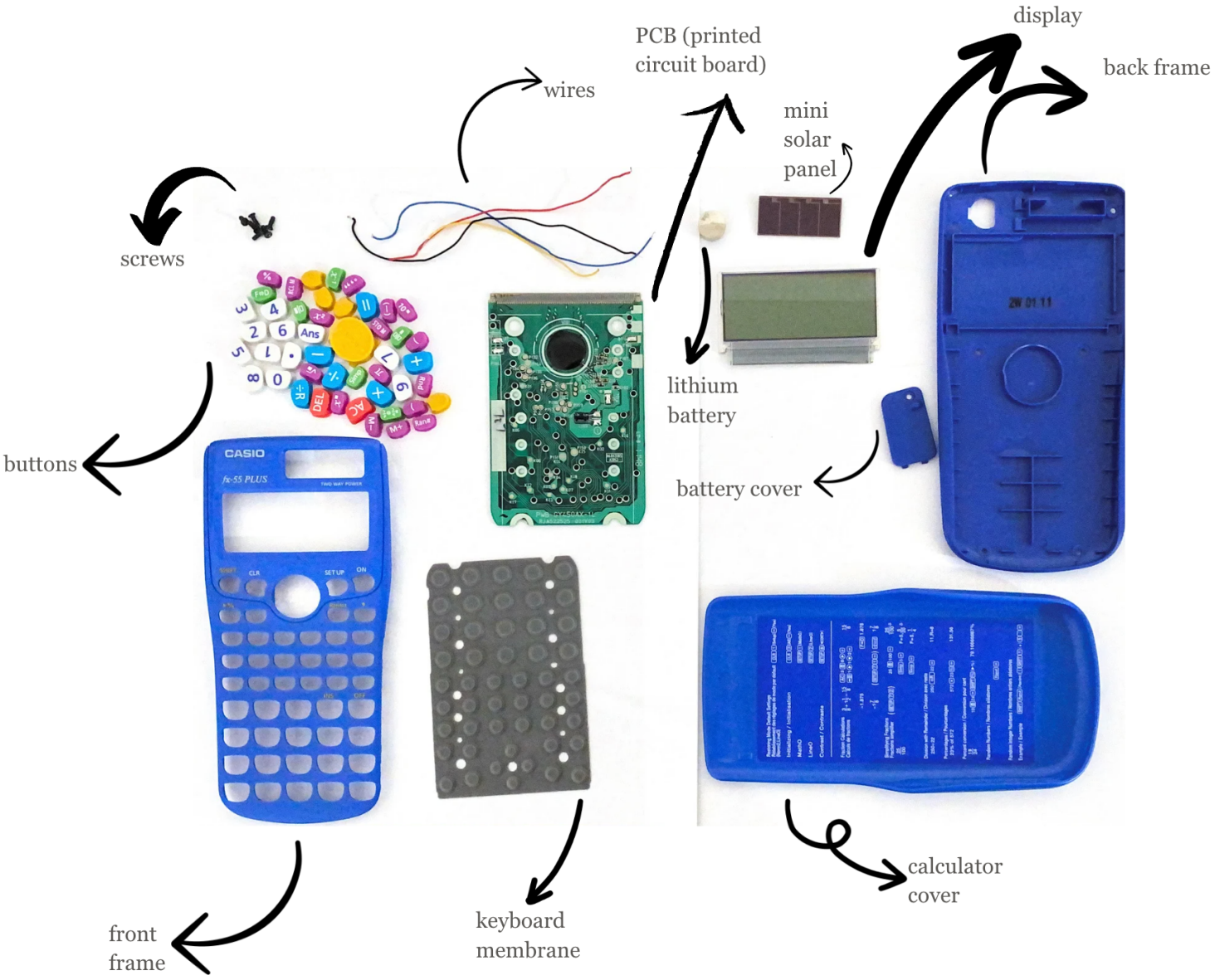


10. We peeled off the keyboard membrane to uncover the buttons.

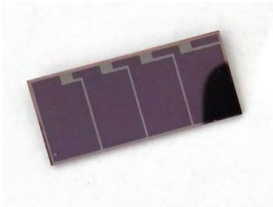


11. We turned over the calculator and separated the buttons from the front frame.

C. All Parts


screws
wires
PCB (printed circuit board)
mini solar panel
display
back frame
buttons
lithium battery
battery cover
front frame
keyboard membrane
calculator cover

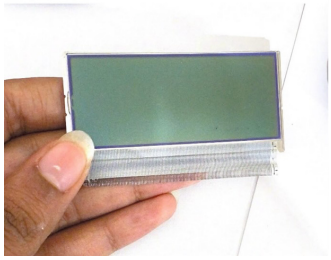
6. Functional Analysis : A Deep Dive into the Components

Component Name	Image	Description & Purpose
Solar panel		• Powers calculator • Made of a semiconductor material • Photovoltaic effect : photons from sunlight knock out electrons from atoms to form electricity
Lithium Battery		• Powers calculator & memory • Lithium ions travel between cathode and anode in battery, forming electricity
PCB		• Circuit with copper tracking • Allows the physical connection of electrical components • Black piece in the center, LSI, is the calculator brain
Buttons		• Receives human input • Binary component • Electrical signals are converted into a binary value, which is read by the calculator's code to display an output

Button Sensors (Back of PCB)

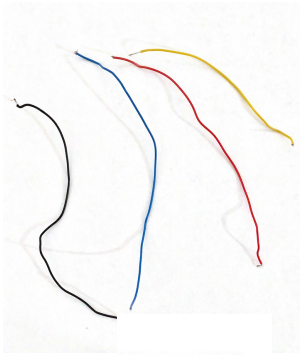
- Detects which button is pressed
- Conveys this to PCB to display/perform the function

Liquid Crystal Display (LCD)



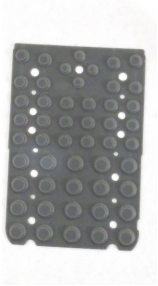
- Display uses backlight to print output
- Pixels on screen light up according to binary code

Wires



- Used to transmit electricity
- Transmits electricity from battery/solar panel to the PCB for powering calculator

Button Holder



- Made of rubber
- Gives buttons support

Frame

- Provides structural support
- Plastic pieces protect components from exterior damage

Screws

- Fastens components
- Secures front and back frames together

7. Conclusion

Through this reverse engineering project, our team learned that this calculator is dual-powered. Input from the plastic keys triggers the programmed sensors on the back of the PCB, which perform the calculator functions. The result is displayed on the LCD.

Not only did we learn about circuits and programming, but we also learned the value of safety tools like goggles and wire cutters. At one point in the disassembly process, a plastic piece flew up into the air, and the goggles protected our eyes. We could have been shocked without the wire cutter as the calculator was on while cutting once.

The complexity within the calculator was something none of us had expected to find. This journey leaves us wondering: what other hidden complexities are within everyday devices?

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