Reverse Engineering Radioshack’s 2-in-1 eChess and eCheckers game

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Context

I chose to reverse engineer a Chess video game console I had as a child due to its age. Its model was planned and released in 2004[4] which made me wonder what differences I would find between a modern circuit board and a circuit board that was planned almost 18 years ago as of writing this.

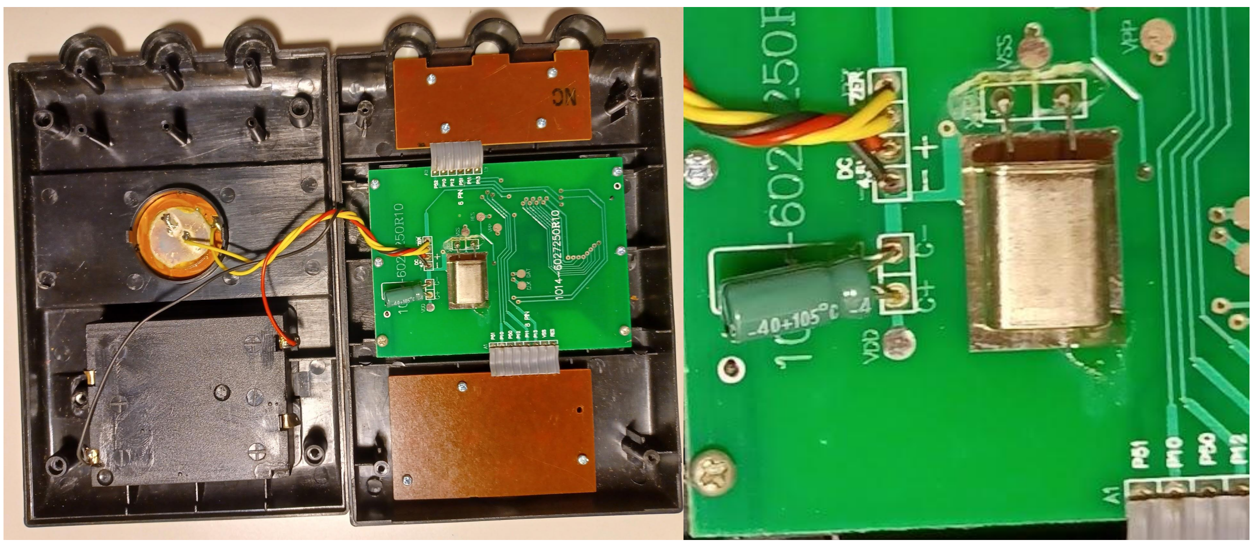
Expectations

There are buttons on the chess game that act as a user interface, hence I expect there to be button-specific paths to the microcontroller in order to process the moves for the player and the basic setup. I’m also expecting software to be present for the computer-based opponent and would like to look at the software as well. I couldn’t find any schematics of the device on the internet, so I expect to have to carefully document every part and not rip anything out.

Caption: Front and back of the Chess game pre-disassembly.

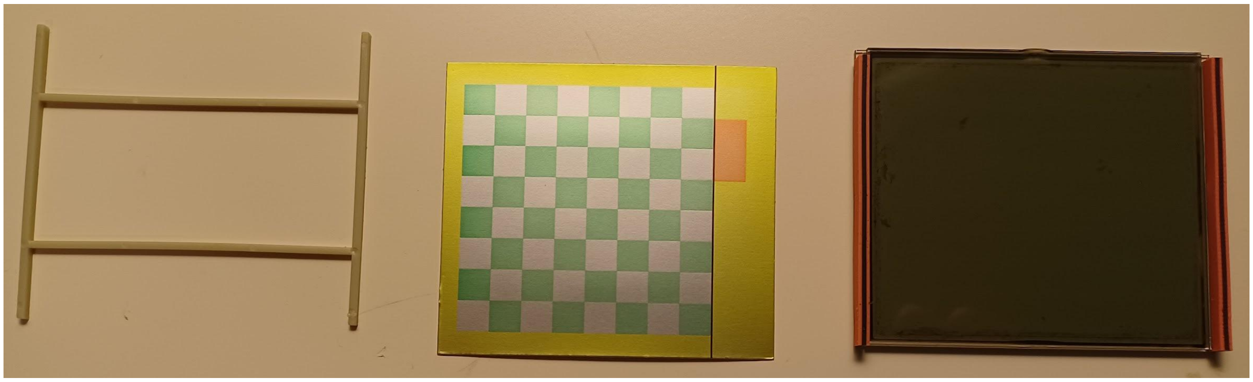
Disassembly

After opening the device, I saw 3 boards linked together with wiring, along with another set of wires connecting the batteries, speaker, and Integrated Circuit (IC). The two side boards are for the buttons on the front for user control, where the input would be carried out to the main circuit board to be processed by the IC. Near the battery is a capacitor, which acts as a temporary power source when the batteries for the game are being changed.[1] This is most likely so the RAM doesn't lose the data it is holding. There is also a crystal oscillator that connects to the IC. This is most likely used to provide a signal when a certain amount of time has passed so the IC knows when a certain action should be done, such as passing a second on it's timer.

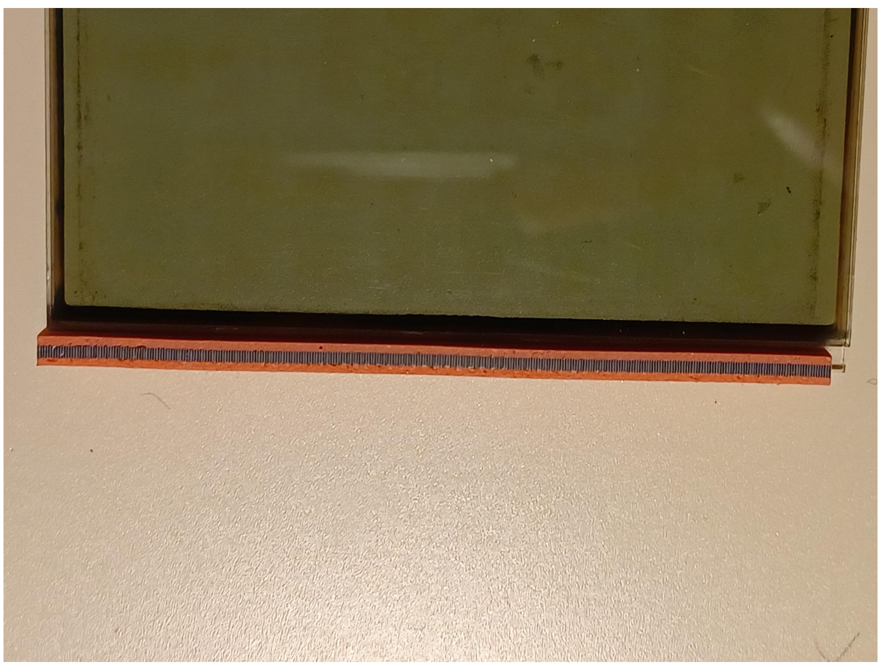


Caption: Image on the left is the device opened. The gray parts that connect the Circuit Boards are the wires for input. Image on the right is zoomed in on the silver Crystal Oscillator and dark green Capacitor.

The screen of the game was attached to the main circuit board. After carefully removing it, I found out that it was connected in a way where certain pin endpoints on the circuit board would connect to the ridges on the foam parts of the screen. This is so the IC can send signals to the LEDs inside of the screen. Taking the screen apart, the chess board appeared to be a paper printout.

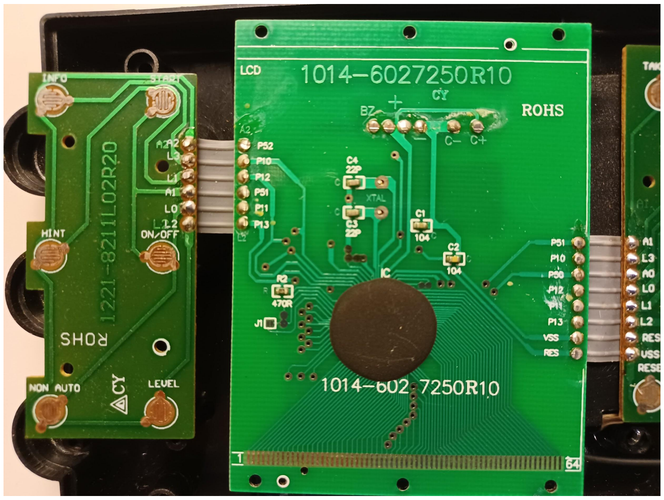


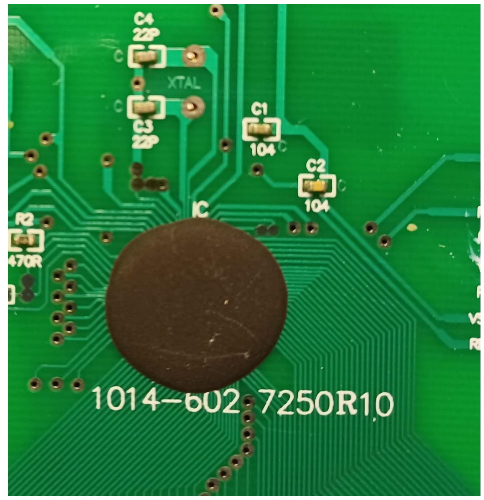
Caption: The image above shows the parts of the screen laid out. On the right is the screen that contains all of the LEDs. On the center is the paper that acts as a background for the game. To the left is a part that fills in the space between the screen and the circuit board, most likely so the paper isn't torn by the circuit board.



Caption: The image above is the first component zoomed in to show the rigid foam.

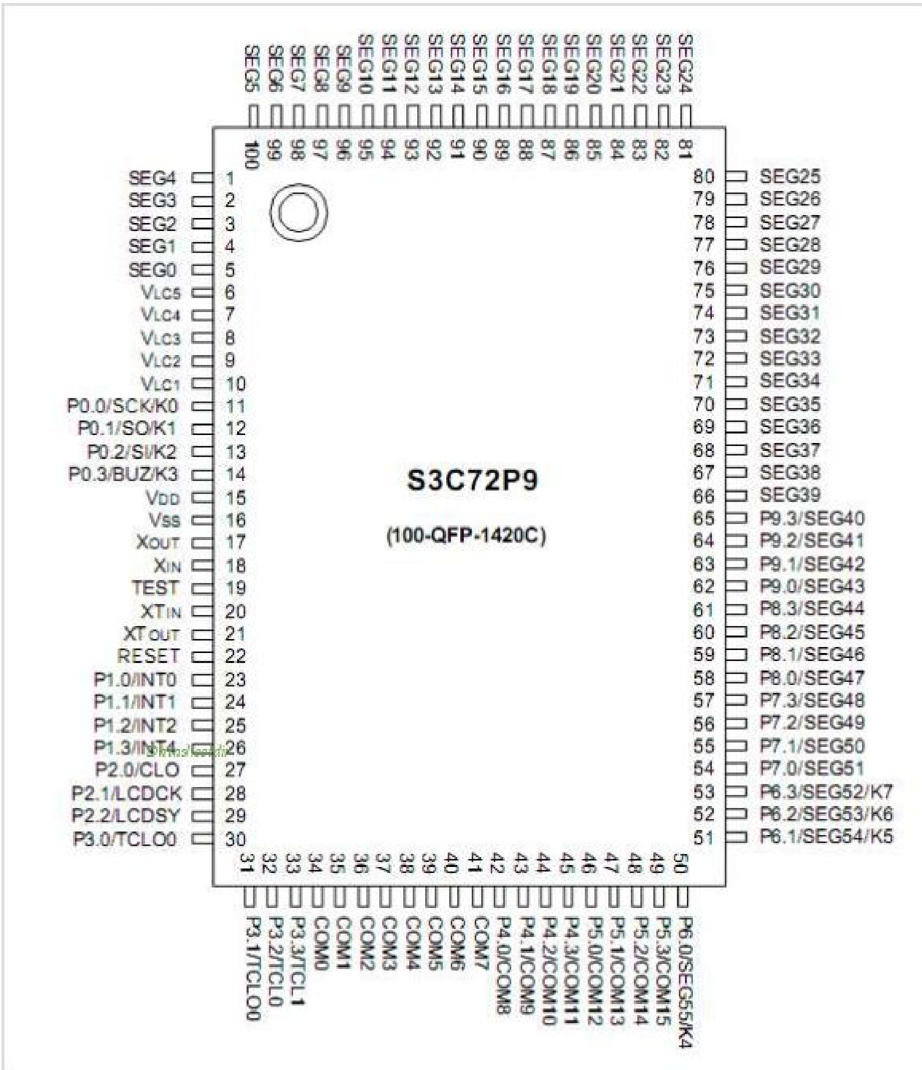
Turning the circuit board over, I found where the IC is kept and a few smaller scaled components, such as 4 capacitors and a resistor. Looking closely at the writing next to the capacitors, I determined that their outputs are either 104 microfarads or 22 picofarads.[2]





Caption: All of the components with “C” written near them are capacitors. The 22P and 104 are most likely numbers for their capacitance.[2] Off to the left is the resistor which offers 470 ohms of resistance. In the center is the IC, which is covered with epoxy to protect it from thermal and electrical damage.[3]

After doing more research, I found a website called “Spacious Mind” that documented the specific details of the chess game’s hardware and software.[4] Since I didn’t want to risk damaging my physical version of the IC, I instead searched up the schematic of the Processor listed.[5][6]

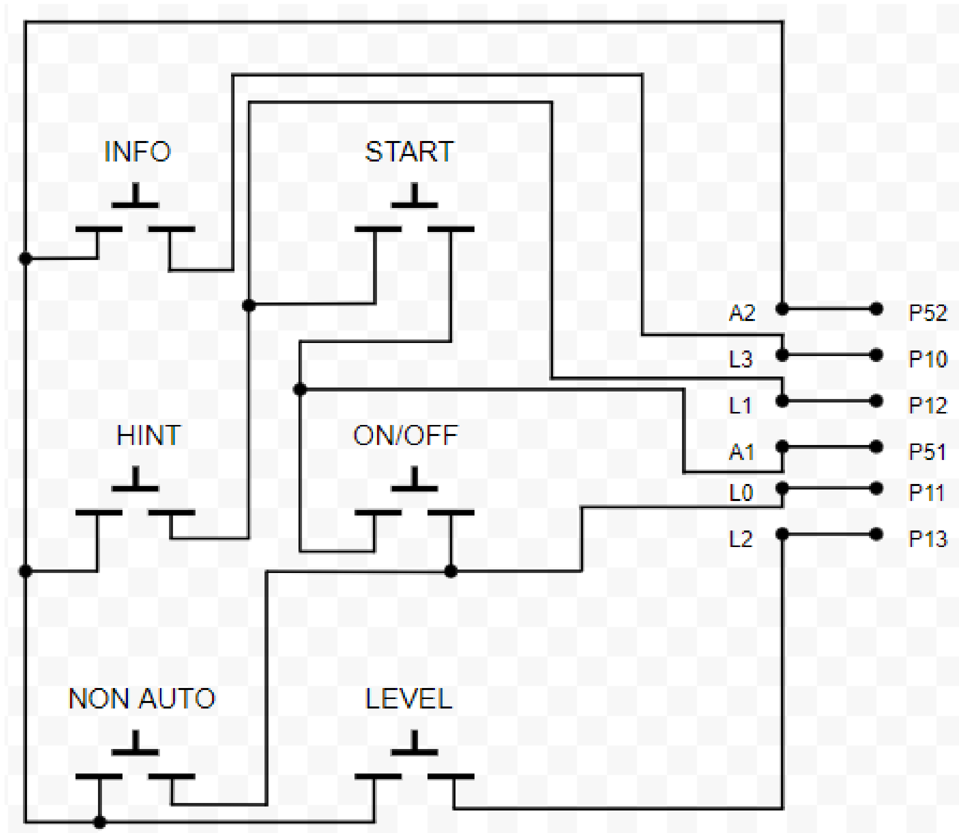


Caption: This is the schematic for the IC in the chess game. It consists of 100 pins which can all be verified from the main circuit board.

Reverse Engineering

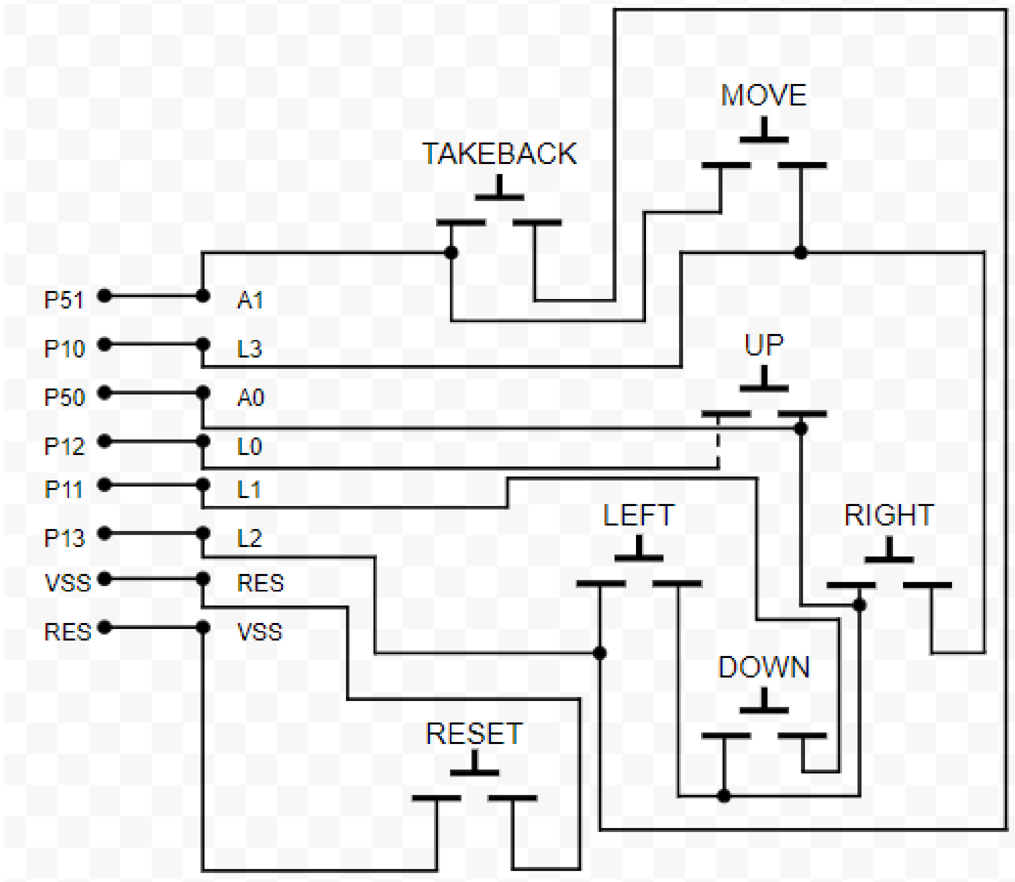
Since the schematics for the actual chess game aren't available publicly, I decided to create my own schematics from what I saw while disassembling.

Input Board 1 schematic



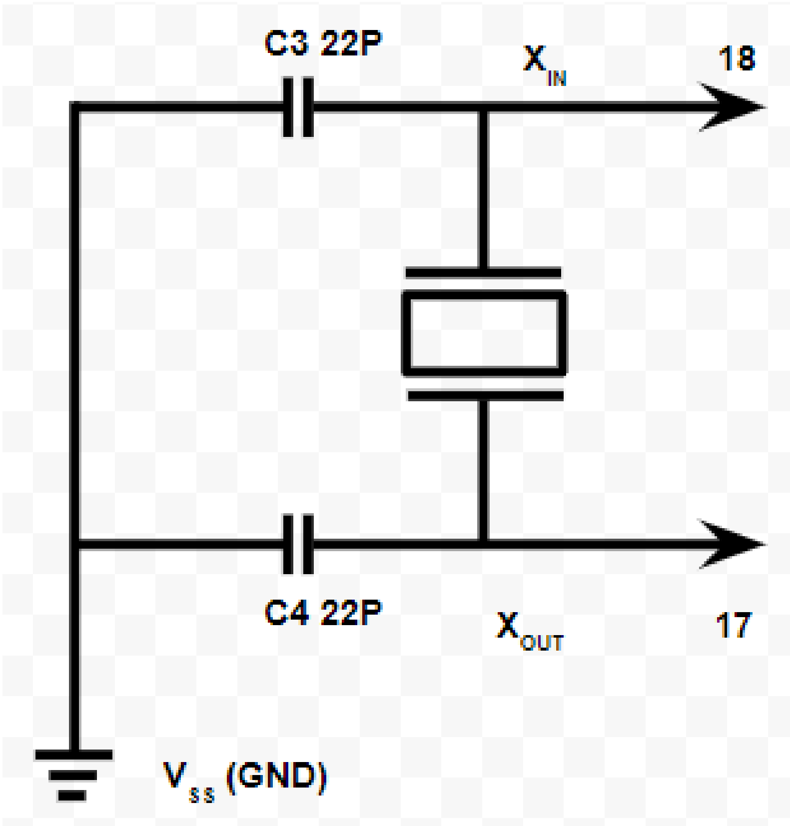
Caption: The push buttons and the endpoints are labeled. Each labeled endpoint correlates with the port and pin of the microcontroller it sends signals to. For example: P52 sends a signal to Port 5 Pin 2.

Input Board 2 schematic



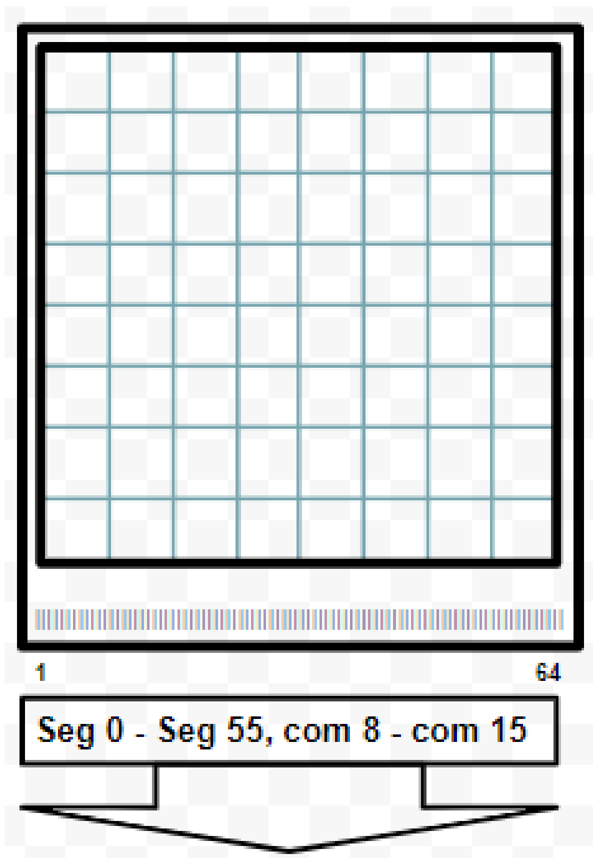
Caption: I speculate that these intersections imply a button combination that can be pressed. VSS leads to the ground. The input boards appear similar to modern day keyboards[8] with push buttons and endpoints.

Crystal Oscillator schematic



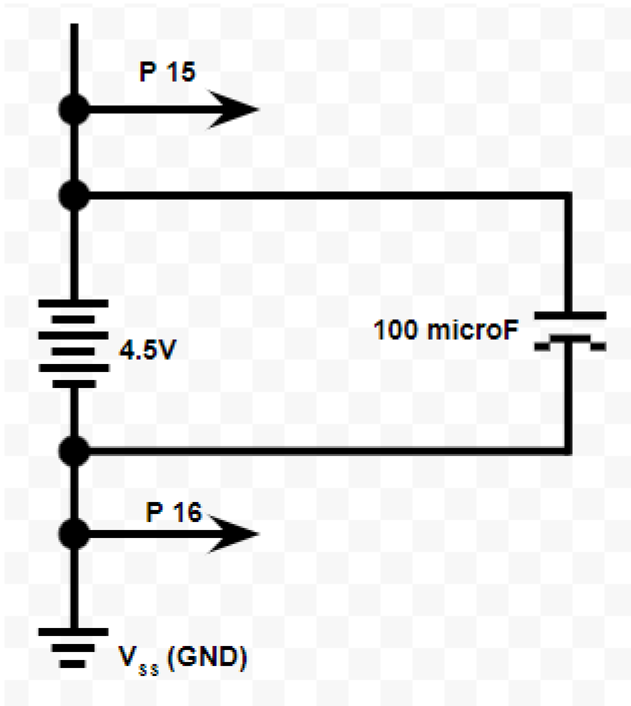
Caption: This is my drawn schematic of what the Crystal oscillator might look like. C3 and C4 denote capacitors which hold 22 picofarads. X_{IN} and X_{OUT} are pins 18 and 17, respectively, on the microcontroller. Likewise with the input boards, this simple crystal oscillator schematic is similar to modern crystal oscillators.[9]

LCD Screen schematic



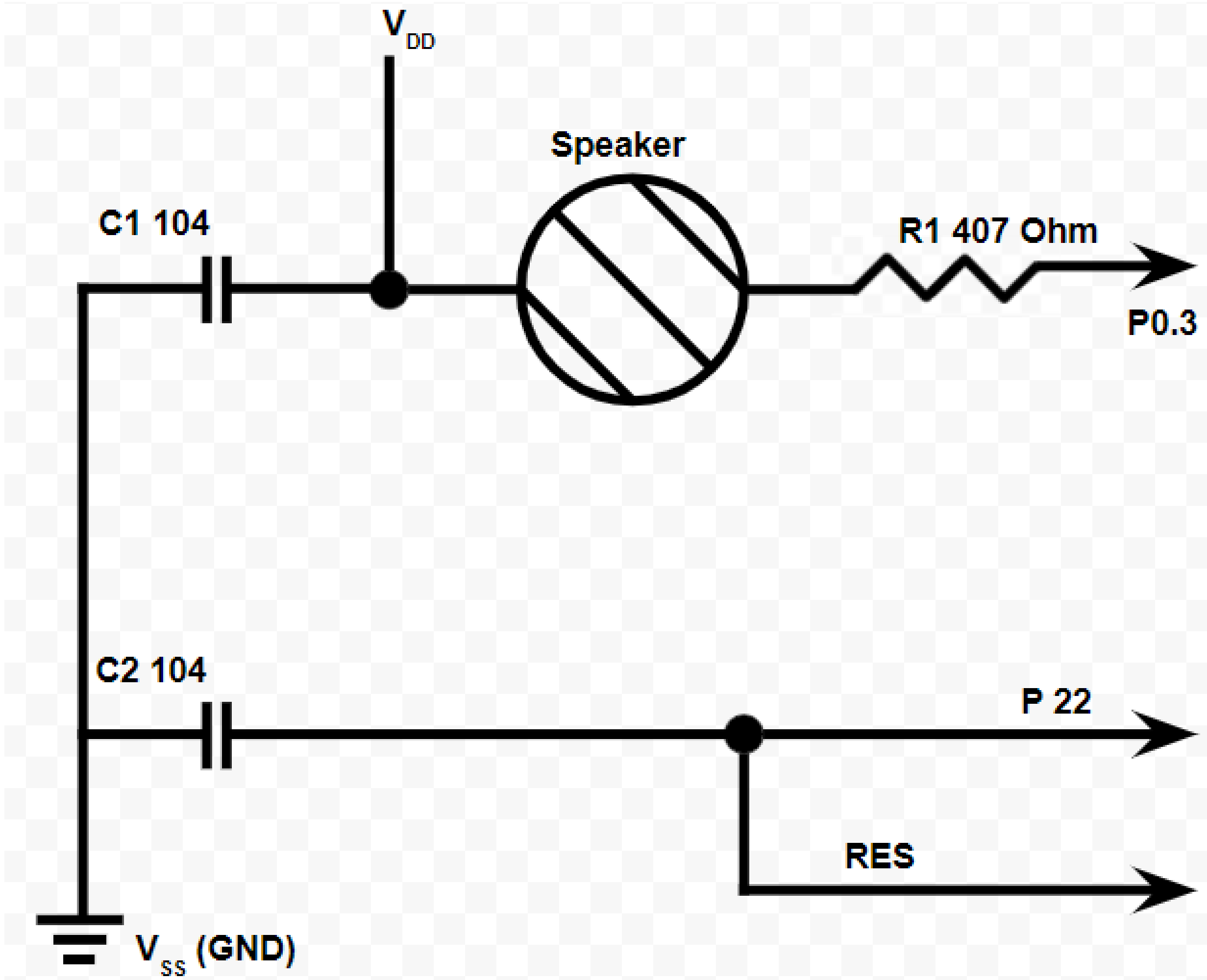
Caption: After counting, I found that it had 64 endpoints on the foam portion of it. They are connected with the outputs for Seg 0 - Seg 55 and com 8 - com 15 on the microcontroller. This screen actually differs from modern LCD screens which require pins for power in and power out.[10]

Battery schematic



Caption: Pins 15 and 16 give the microcontroller power, with pin 15 being V_{DD} and pin 16 being V_{SS}.

Speaker schematic



Caption: The other capacitors are featured here. They each hold 104 microfarads. A resistor is also shown here that adds a resistance of 407 Ohms to the circuit before sending the energy to Port 0 Pin 3 on the microcontroller. The speaker is self-explanatory as it emits a sound when the microcontroller sends a signal. Pin 22 is used for resetting as the wire below it, RES, connects to Input Board 2's RES endpoint. V_{SS} is shown again as the ground for the circuit, but V_{DD} is included in this schematic to signify power flowing into the circuit.

Parts list

- 5 Capacitors
- 1 Resistor
- 1 Speaker
- 1 Crystal oscillator
- 1 IC
- LCD Screen
- 3 Batteries
- 13 Push-Buttons

Conclusion

From this short Reverse Engineering journey, I learned more about how a circuit board functions, with double sided layers. I researched capacitors, chip-on-boards, and crystal oscillators to find out why they're included in the circuitry. I found out how programming is done on a microcontroller, and I also learned the importance of schematics and how to draw them in a way that makes sense.

In the real world, some modern circuit boards have multiple layers[7] which require more schematics that are all very carefully made. The capacitor and crystal oscillator in modern circuit boards is very similar to the capacitor and crystal oscillator that I observed during disassembly. I also learned about the usefulness of chip-on-boards when dealing with high temperatures and high amounts of electrical charge.

Works Cited

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