Fast, Portable Chlorine Generator Cell Tester

HAYWARD

hayward-pool.com

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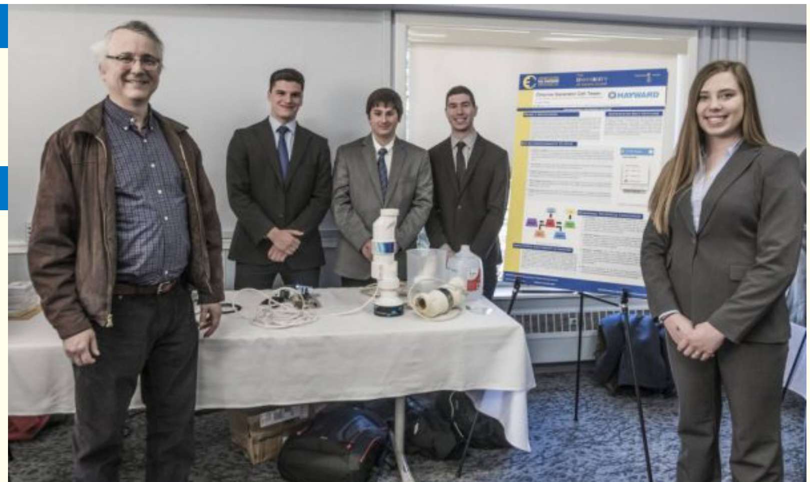

PROJECT MOTIVATION:

Currently, Hayward approved servicers of the AquaRite Salt Chlorine generation system use a storefront diagnostic tool to determine if the T-Cell chlorine generator has worn out. This involves connecting the warranty T-Cell to the tester's plumbing and generating measurable chlorine, the parts-per-million of which depend on the cell's age, as well as how dirty it is. The current tool is too expensive, too bulky, too easy to misinterpret, and thus is only used by a fraction of the servicers that diagnose and make warranty claims. As such, many cells are approved for warranty claims when they are in fact fully functional, or simply dirty.

Our capstone team will use water conductivity sensing, test signal generating circuits, impedance measurement, and software to produce a new testing method that is simple for any technician to comprehend, portable and less expensive. This innovation will allow Hayward to widely deploy thousands of T-Cell testers, saving possibly 15% of total warranty claims.

ANTICIPATED BEST OUTCOME:

Ideally, by the end of the project our team will have developed a fully functional T-Cell tester. The ideal test unit should be battery operated for portability, function at a wide range of temperatures and be compatible with all Hayward T-Cell models. The tester's interface will be simple and allow the user to initialize the test and clearly see if the cell passes or fails, as well as the cell's chlorine output and other parameters. Previous test results will be stored for ease of access, and be sent to a bluetooth-enabled app for simple warranty claims. Ideally, the total cost of the tester will be $30.

IMPLICATIONS FOR COMPANY AND INDUSTRY:

For Hayward this product will reduce illicit and costly warranty replacements of fully functional chlorine generator cells. Additionally, It could save Hayward up to $500k annually. From the end-user standpoint the new tester will assist Hayward technicians in troubleshooting faulty T-cell chlorine output, and simplify the warranty process for failed cells. By utilizing a simple yet comprehensive user interface there will be no confusion regarding whether or not a T-cell qualifies for a warranty replacement. If the cell qualifies, the warranty process will be streamlined via the tester's app. Overall, this will reduce bottom-line costs for Hayward and increase profits on T-Cell generators.

PROJECT OUTCOME:

The Anticipated Best Outcome was not achieved. The product schematic was successfully completed; the prototype remains to be produced.

KEY ACCOMPLISHMENTS:

Confirmed New Testing Method - After several rounds of testing on various T-Cells, we confirmed the initial assumption made by Hayward that we could determine the health of a T-Cell based solely on the voltage and current it generated when a square wave is applied.

Finalized Schematic - Using the Pulsonix platform, the final schematic of Cell tester was created. Such schematic included all aspects of the tester including sensing circuitry, user interface circuitry, MCU connections and power circuitry for each component.

Finalized Board Layout - From schematic we created in Pulsonix, Hayward completed board layout, a custom printed circuit board (PCB). This PCB (shown in figs 1 and 2), would be based on an existing board designed to fit inside the pre-made Hayward enclosure.

LTSpice Simulation of T-Cell Tester - Throughout the design of the sensing circuit, LTSpice simulations were utilized to verify certain outputs and improve upon the specifications of the designed circuit.

Designed "Sensing Circuit" - To verify if a cell is functional, "sensing" circuitry was required to test the impedance of cells. Good cells have low impedance, bad cells have high impedance. Updates and modifications were made to improve upon the circuit designed previously.

Wrote Firmware for "Sensing Circuit" - Wrote code to read from and control the sensing circuit that was designed by our team. This including outputting a 1kHz square wave and other control signals, as well as reading from the circuit at certain nodes using the onboard analog to digital converter.

Wrote Firmware for 2x20 Character Display - Wrote code to output content onto the character display given to us by Hayward (shown in fig 3). This included writing code to initialize the display, change the data memory address to write to, and write characters to the display.

Wrote Firmware for MSP430 - Wrote code to take advantage of the features made available by the microcontroller we decided to use for this project, the MSP430FR5994. This included utilizing the general purpose input/output (GPIO) pins, the various independent timers, the analog to digital converters (ADCs), and others. (Block diagram shown in fig. 4).

Designed Scheduler to Execute Tasks - Based on the design provided by our Technical Directors, we implemented a simple scheduler which allowed us to execute tasks on a given time interval. Since we are working with a microcontroller with no operating system, this involved setting up a timer to increment a count every 1 milliseconds so that there was a way to keep track of the amount of time passed.

Wrote Tasks in Software - Break our flowchart into separate tasks to be executed independently. This, along with a state machine created from flowchart as well, we identified several different tasks. Among the tasks implemented were reading the battery level, testing the T-Cell and reading from and writing to the user interface (UI).

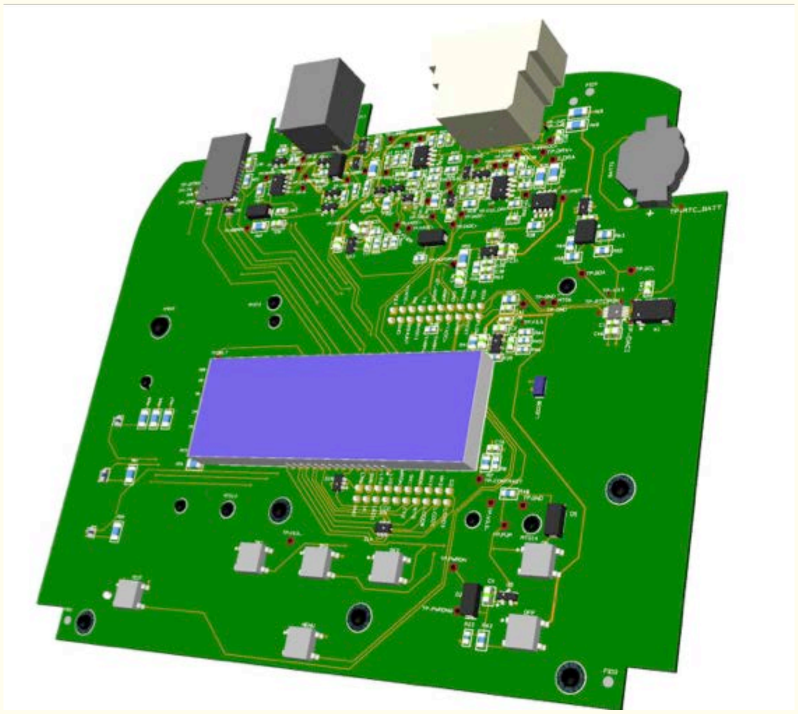

Fig 1: Shown above is the front of the custom printed circuit board (PCB).

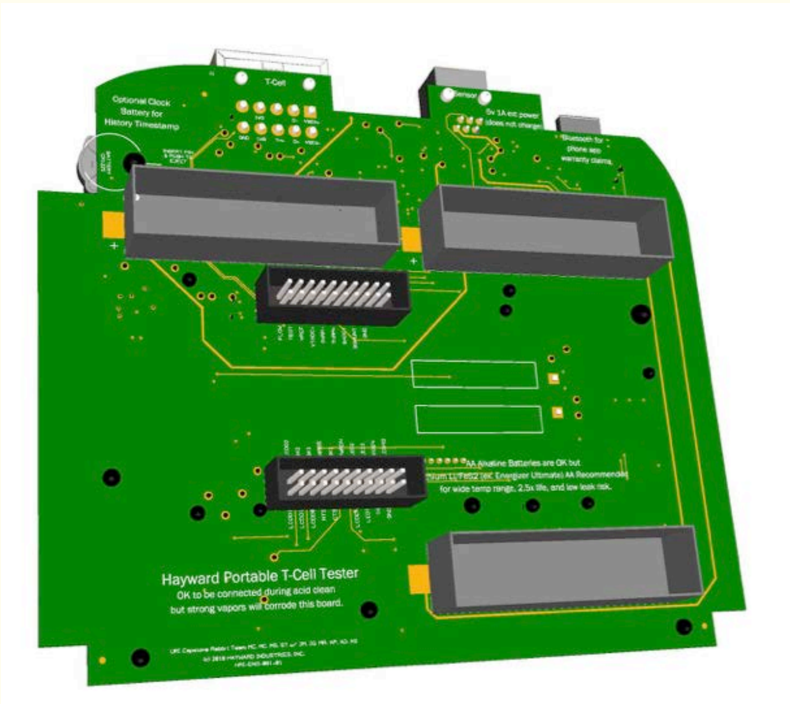

Fig 2: Shown above is the back of the custom printed circuit board (PCB).

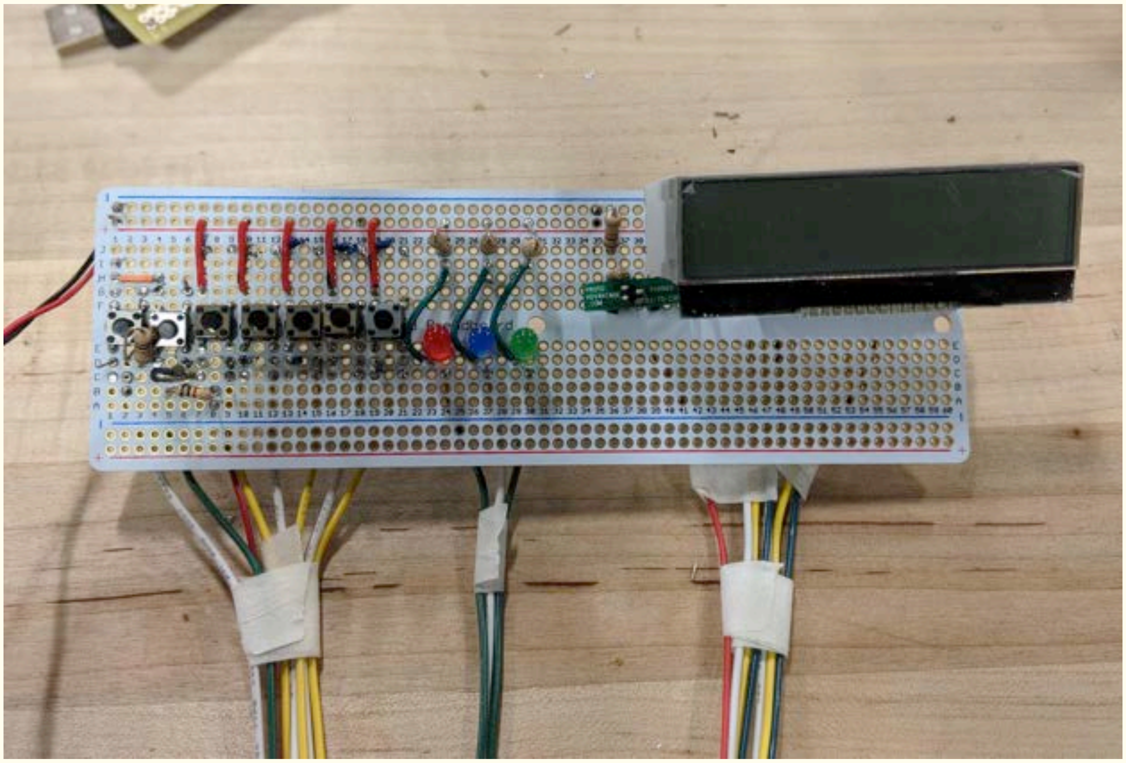

Fig 3: Current layout of our 2x20 character display, LEDs and buttons.

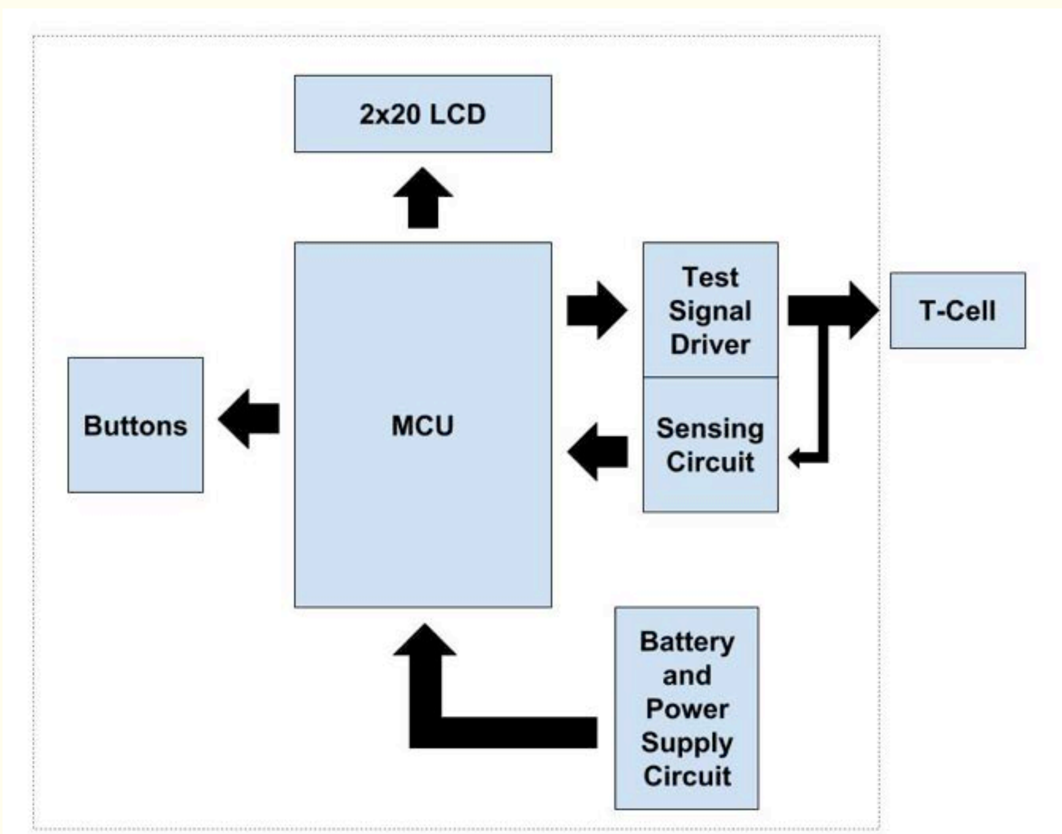

Fig 4: Shown above is the current block diagram for the design.