Solar Powered Water Filter And Purifier

ECE 445

Group: 25

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Drinking Contaminated Water

- The World Health Organization estimates that 29% of the world's population does not have access to clean drinking water.

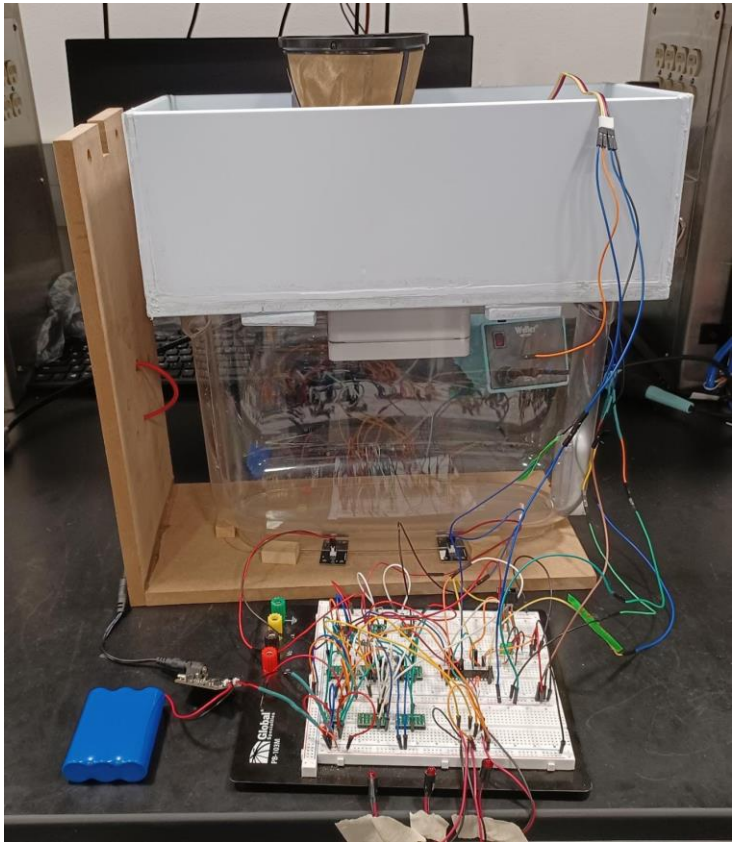
Not having access to electricity

- Many water disinfection techniques are limited without electricity.

Complete Water Filtration and Disinfection System

- **Process**

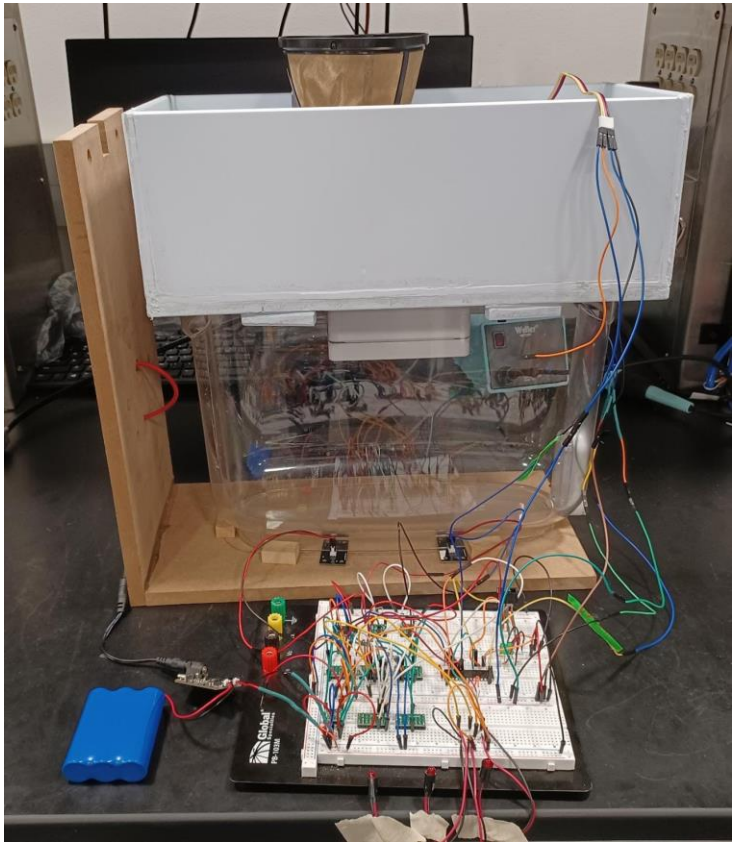
1. Filter the water (3 filters)
2. Check filters replacements
   - Microfilter Replacement
   - Carbon + Ion Filter
3. UV light Disinfection



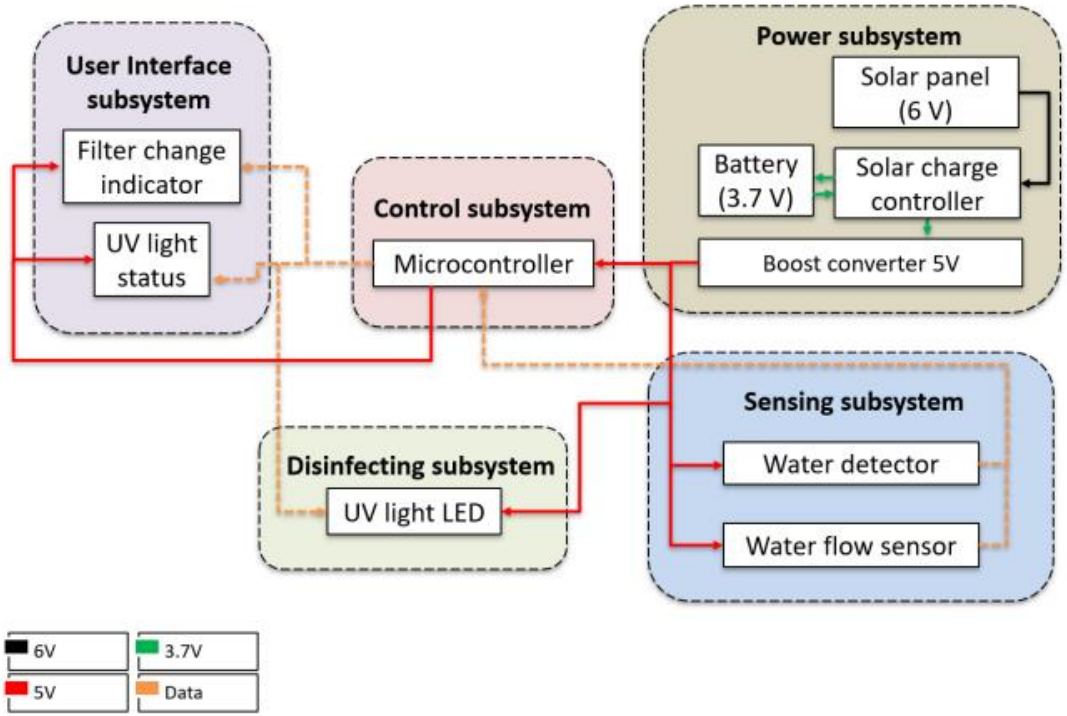
Solution

High-Level Requirements

1) The system must eliminate 99.99% of bacteria, and heavy metals present in water.
2) The LEDs must indicate if we should replace the micro filter or the carbon + ion filter correctly. They should also indicate when the UV lights are in use.
3) Our system should be able to operate using only solar energy.



Design - Block Diagram



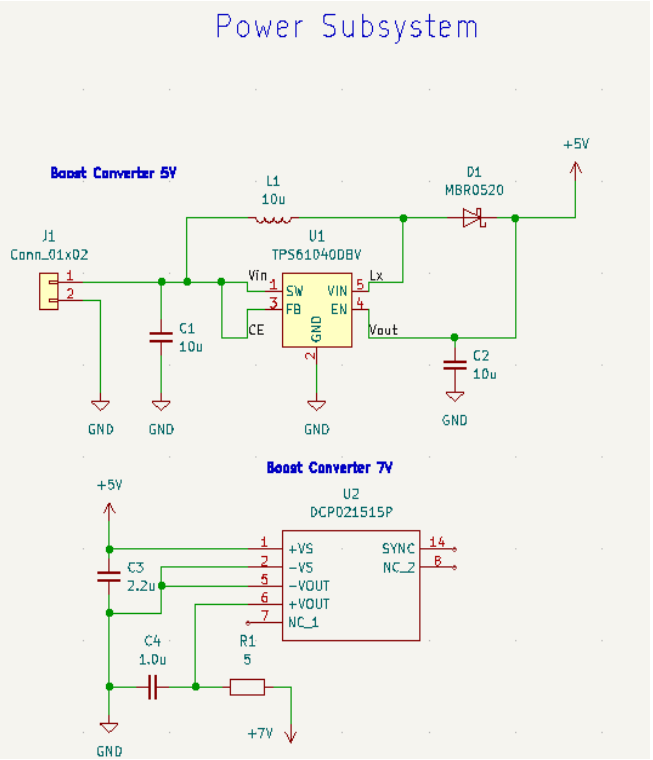
Block diagram of our product divided into subsystems

Power Subsystem

Solar panel, charge module and boost converts to 5V and 7V to power the circuit.

Requirements

- The power subsystem should provide 5.7 V to the UV lights.
- It should provide 5 V to the rest of the project.

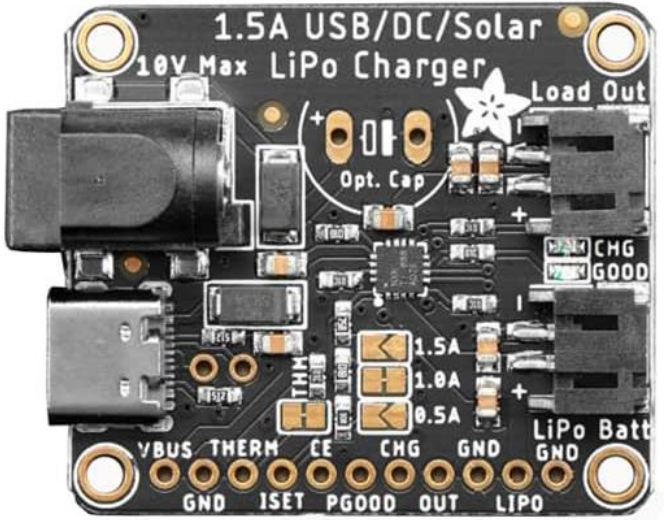


Solar Charger Output

In laboratory lighting conditions:

- Vout = 3.3V when battery low
- Vout = 4.3V when battery fully charged

- Typically:



Power Subsystem

5V Boost Converter

- Vin = 0.8V - 5.5V
- Vout = 4.83V

- Sensors work between 4.5V and 5.5V
- Microcontroller works between 2.7V and 5.5V

7V Boost Converter

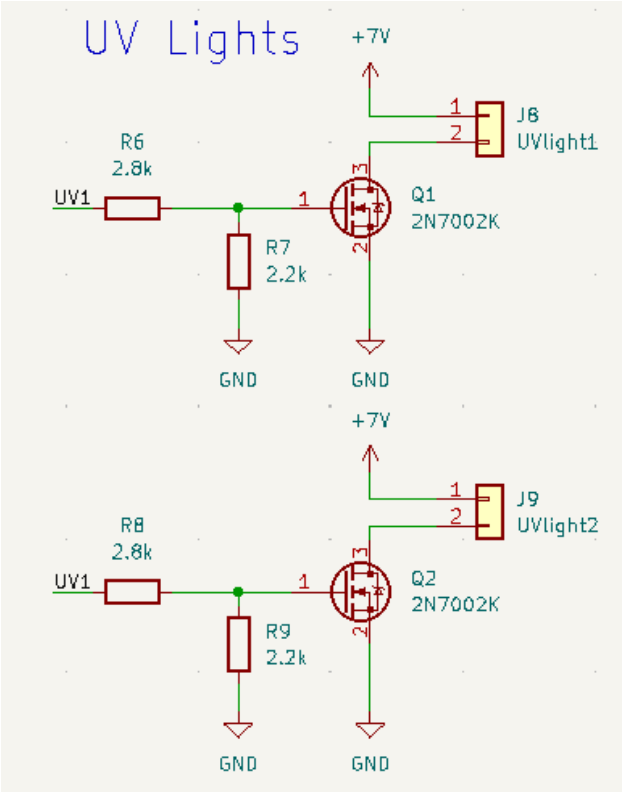
- Vin = 4.5V - 5.5V
- Vout = 7.20V

- UV lights work between 5V and 7V

UV lights Voltage

- UV Voltage = 5.77V

- 7.2V are dropped to 5.7V in the resistor connected in series to the UV light LED and the Vds of the Mosfet.

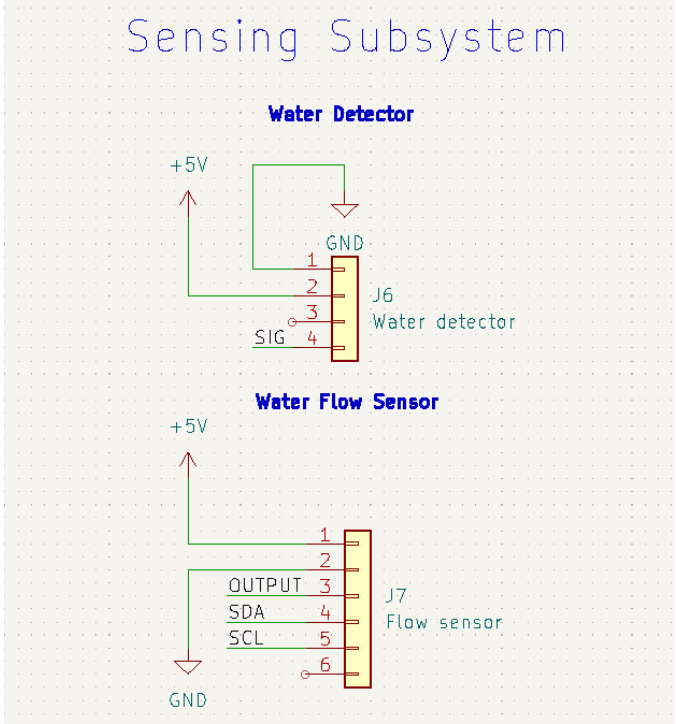


Sensing Subsystem

The water detector and water flow sensor send signals to the microcontroller, to control the user interface and the switching on of the ultraviolet lights.

Requirements

- It should sense if there is water present in the first tank.
- It should sense the different flow rates between the first and the second tank.



Water Detector

- Without water, Output SIG = HIGH (>3V)

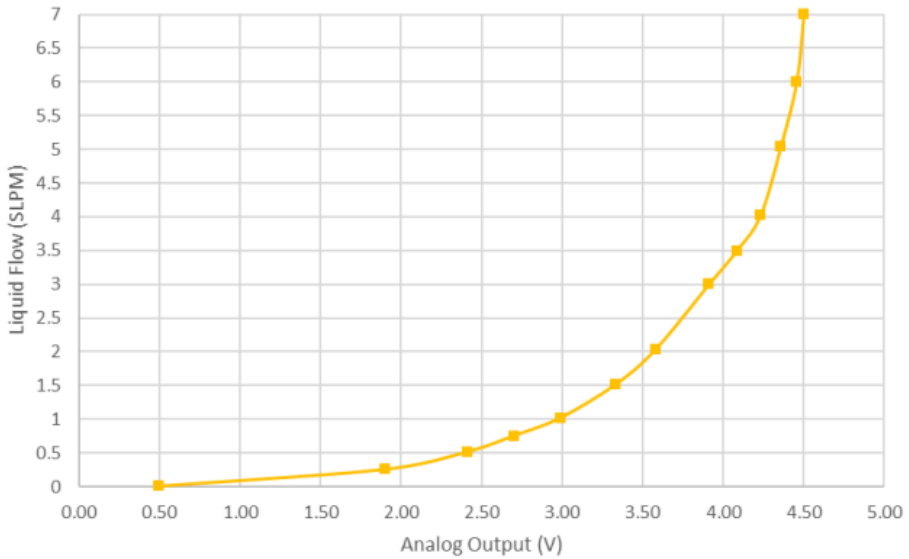
- When detecting water, Output SIG = LOW (<3V)

Water Flow Sensor

- Analog Output No water being filtered

- Typical analog Output when using the filter

Water Flow Sensor



Flow (Liters/min)	Analog Output (V)
0	0.50
0.251	1.90
0.513	2.41
0.752	2.70
1.016	2.99
1.515	3.33
2.033	3.58
2.997	3.91
3.494	4.08
4.015	4.23
5.045	4.36
6.000	4.46
7.000	4.50

Analog Output = 1.395V

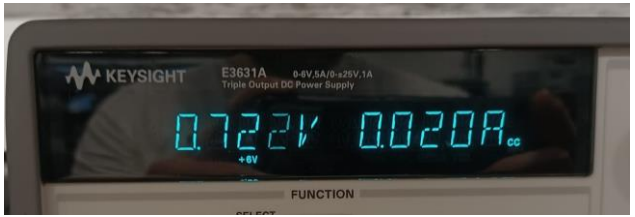
Flow = 0.251 * (1.395-0.5) / (1.90 – 0.50) = 0.160 L/min

0.16 L/min = 1L in 6.23 min

Water Flow Sensor Problem

- There is a short between signal and ground!

- Limiting the current to 20mA



- Limiting the current to 2A

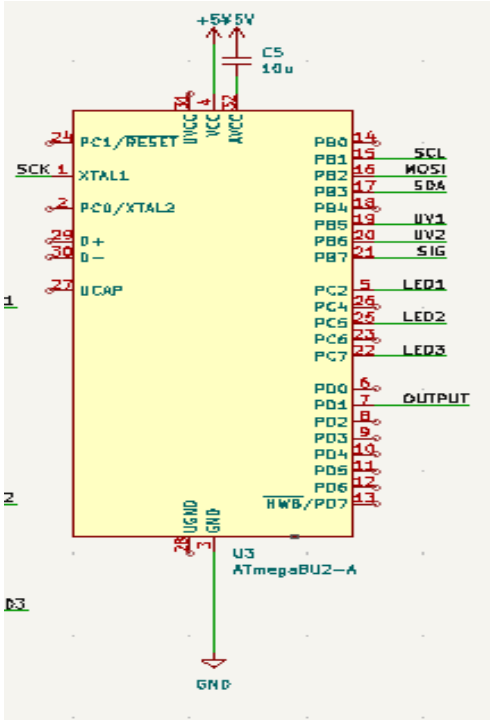
Control Subsystem

Microcontroller and programmer in charge of processing the input signals and controlling the user interface.

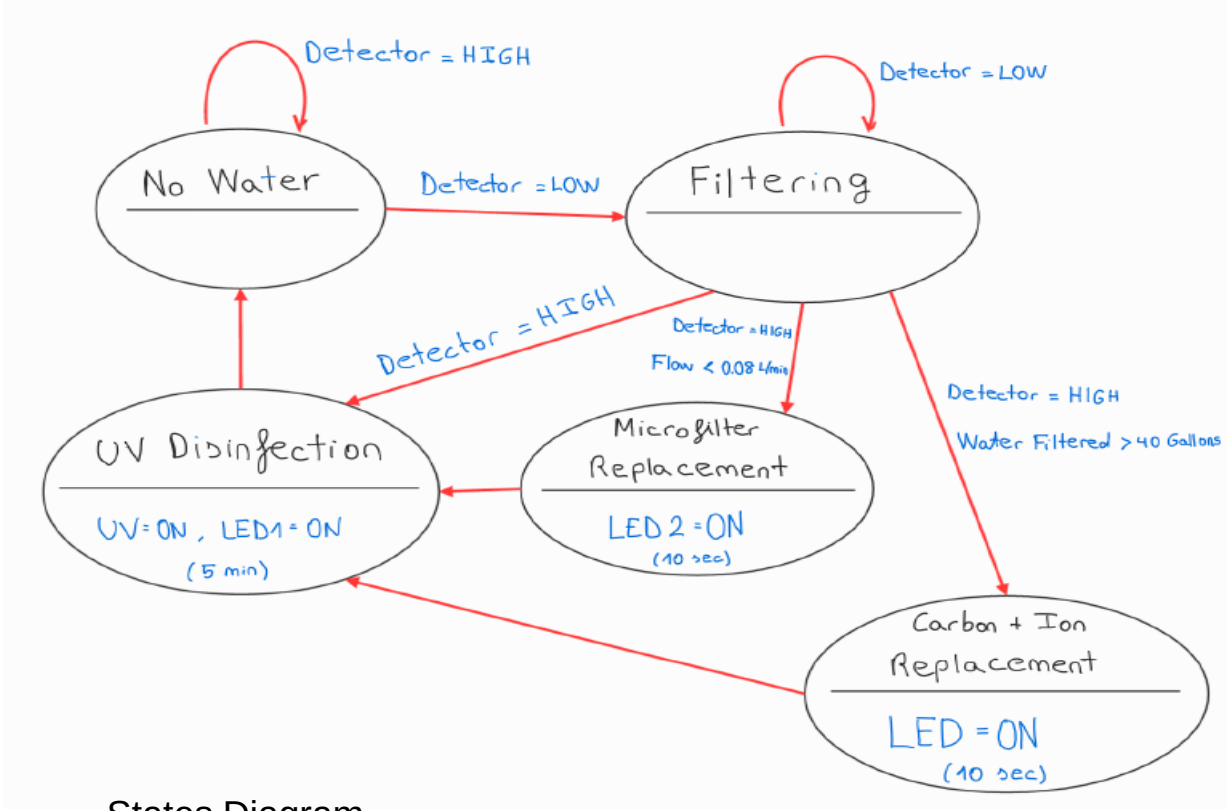
Control Subsystem

Requirement

- It should follow the FSM and be able to properly use the stimuli from the sensors to transition between the different states.



Control Subsystem



States Diagram

Control Subsystem

Microcontroller (T89LP828-20AU)

- Program memory size: 8KB
- Program memory type: Flash
- EEPROM size: 1K x 8
- RAM size: 768 x 8
- Oscillator Type: internal

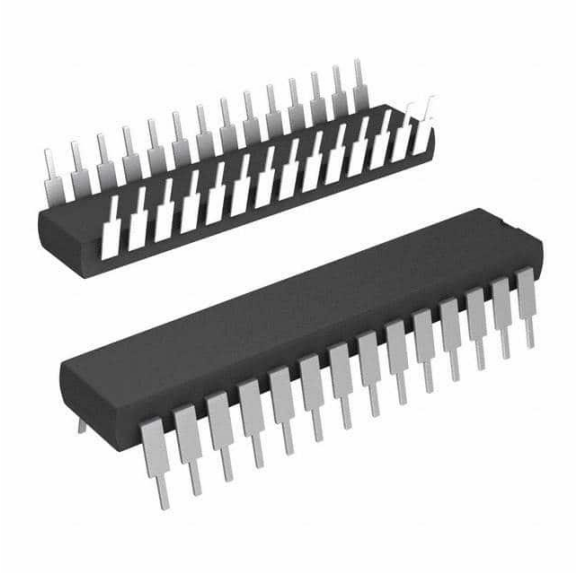
PROBLEM PROGRAMMING!

- WINDOWS VISTA

New Microcontroller (ATmega48)

- Program memory size: 4KB
- Program memory type: Flash
- EEPROM size: 256 x 8
- RAM size: 512 x 8
- Oscillator Type: internal

We chose that to use in a Breadboard



User Interface Subsystem

Set of 3 LEDs to indicate filter replacement and ultraviolet light on.

User Interface Subsystem

LEDs

LED1

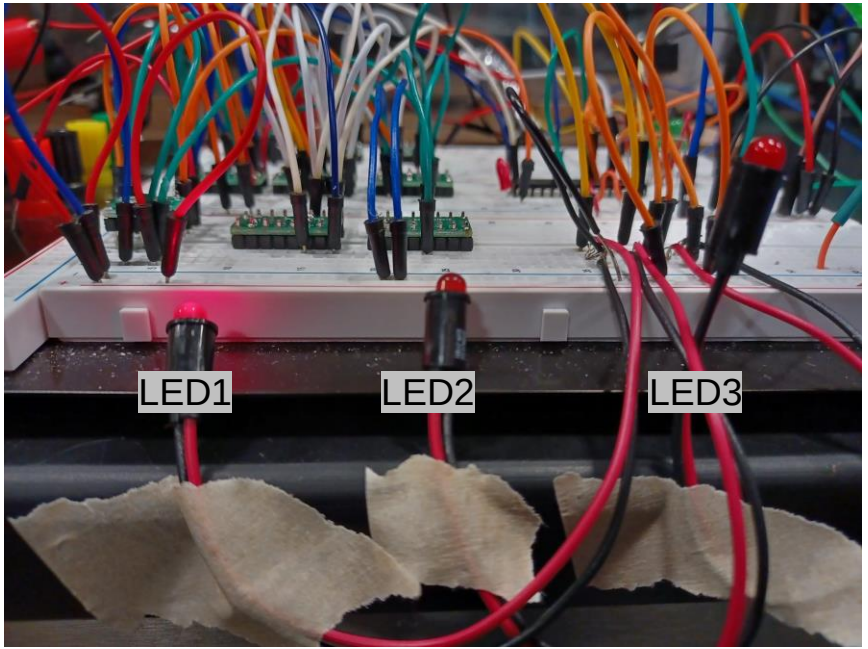
UV lights are ON is working

LED2

Replacement Microfilter

LED3

Replacement Carbon + Ion Filter



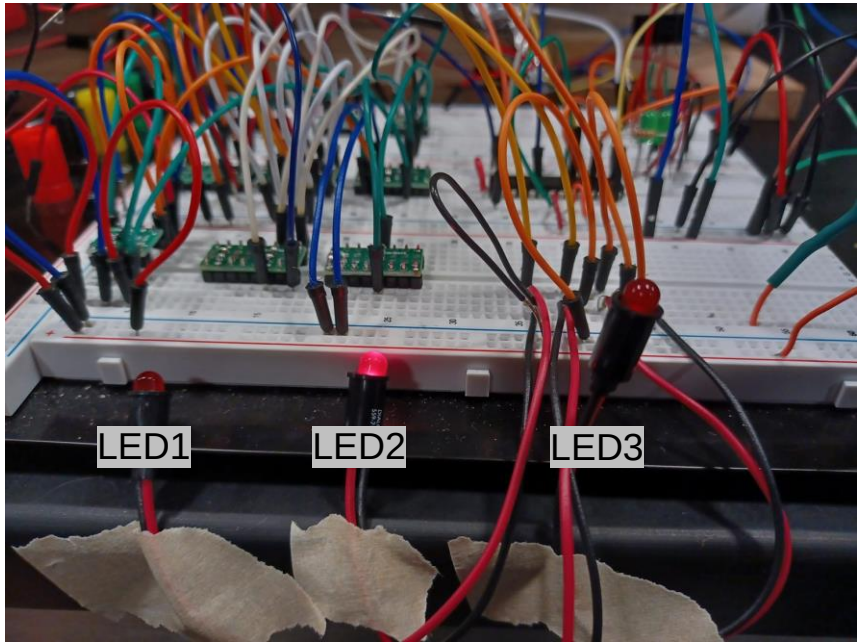
Microfilter Replacement Problem

Criteria

Maximum Flow Rate < (0.160 /2) L/min

New Criteria

Filtering time > 50 min

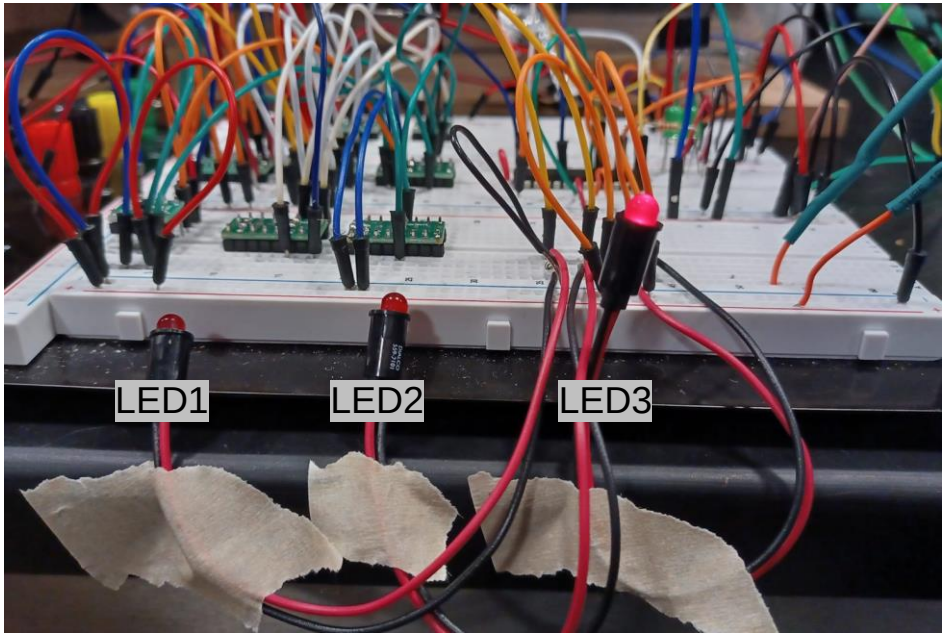


Carbon + Ion Filter Replacement Problem

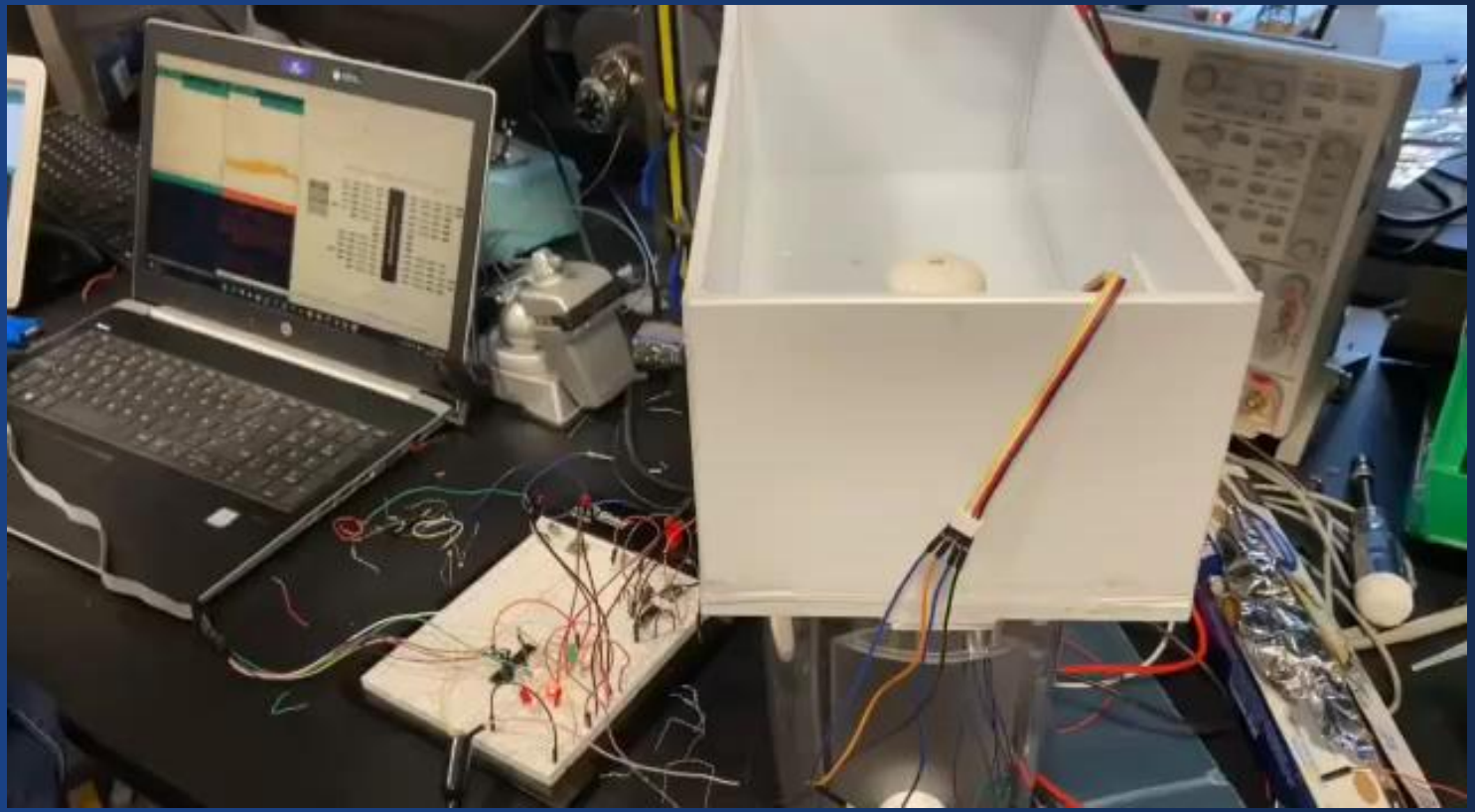
Criteria

Water Filtered > 40 Gallons

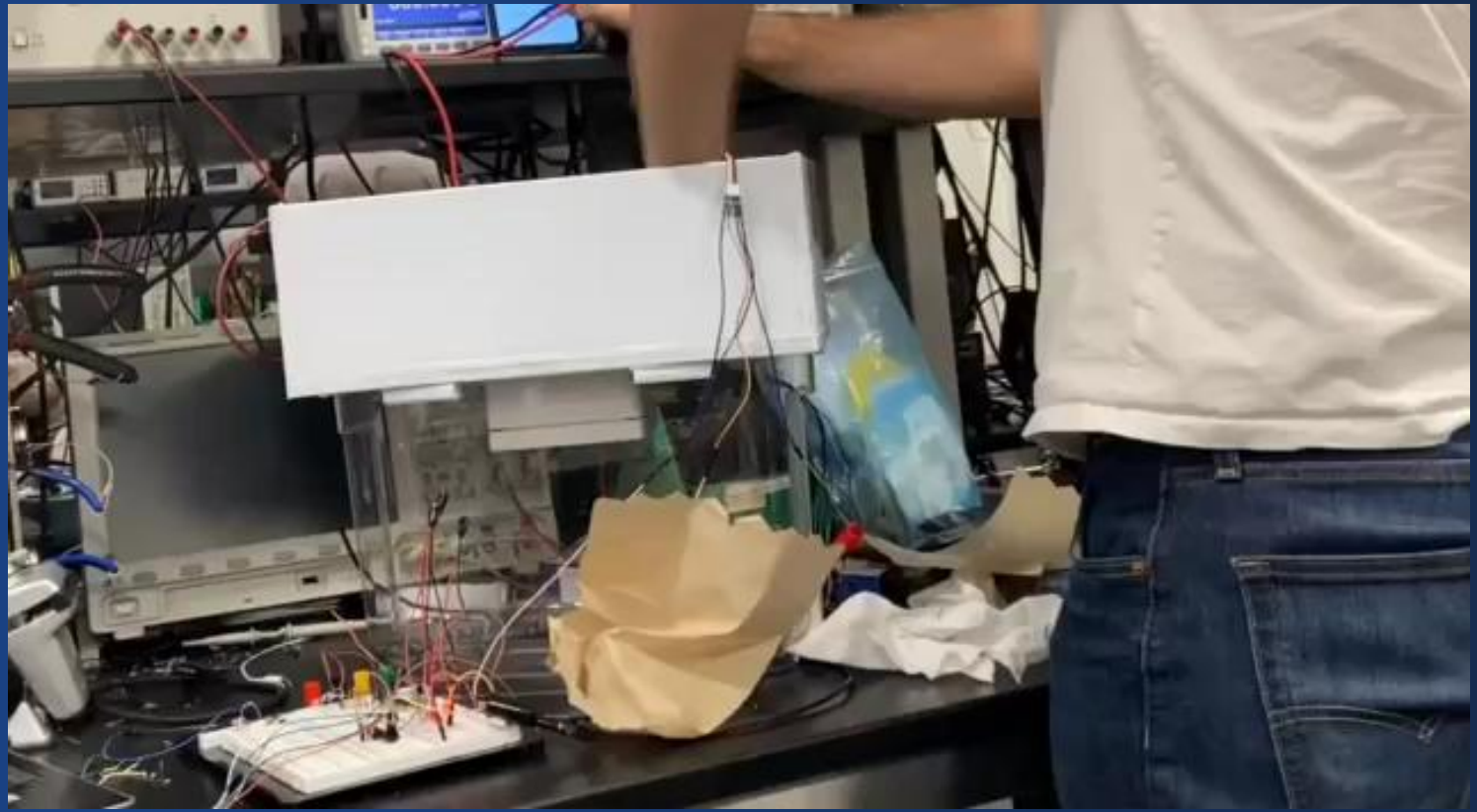
Water filtered = flow * time



User Interface Subsystem



User Interface Subsystem



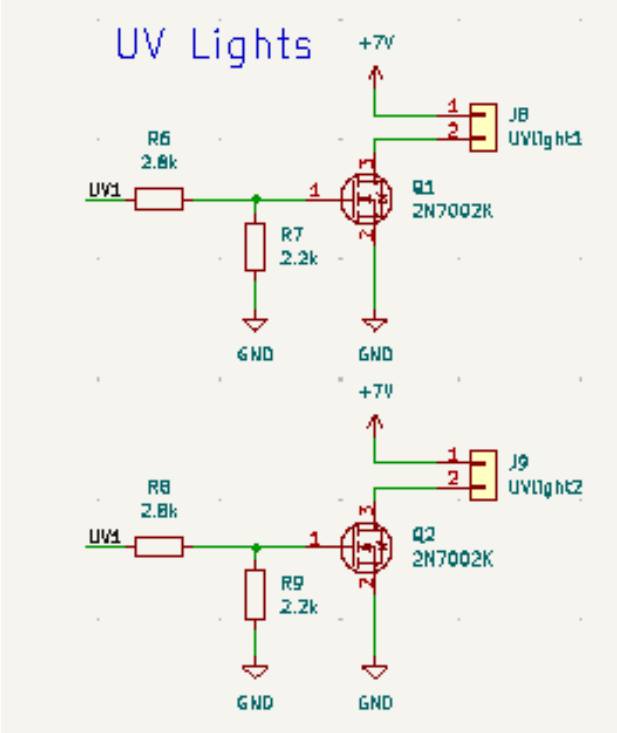
Disinfecting Subsystem

Microfilter and carbon + ion filter for water filtration. UVC lights for disinfection.

Disinfecting Subsystem

Requirements

- The filters should filter 99.99% of bacteria, and heavy metals present in water.
- The UV lights should be turned on for about 5 minutes to kill the bacteria and viruses.



Disinfecting Subsystem

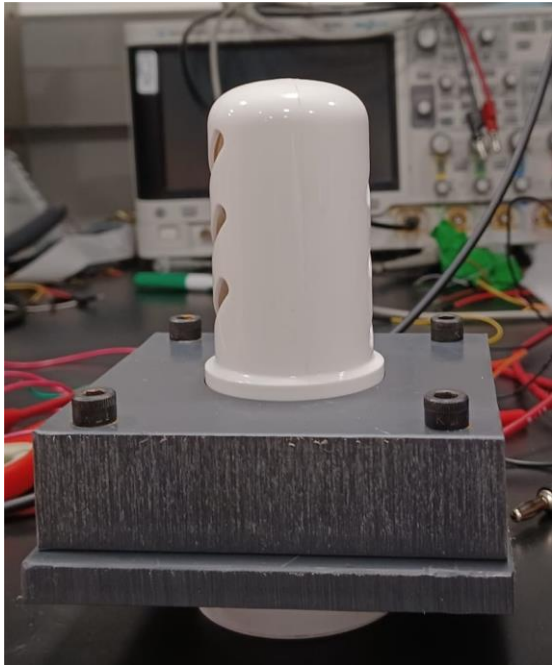
Filtering

Microfilter (0,2 um)

Remove bacteria, parasites and microplastics.

Carbon + Ion Filter

Remove heavy metals, chemical contaminants and chlorine.
It also improves the taste.



Disinfecting Subsystem

Filtering Problem

Remove Carbon + Ion filter

- Low pressure by the water
- Water Flow zero

Our Design

Manufacturer Design

UV Lights Disinfection

Bandwidth

UVC light = 200nm – 280nm
We are using = 275nm

Power

Minimum power needed = 16,000 μW*sec/cm^2

UV lights radiant flux = 2 x 10mW = 20mW
Second tank Base = 15cm x 25 cm = 375cm2

Time Calculation

20,000μW*sec/375cm^2 = 16,000 =>
=> 300 sec = **5min**

PCB Problem

PCB Problem

Microcontroller changed

- Problems programming it

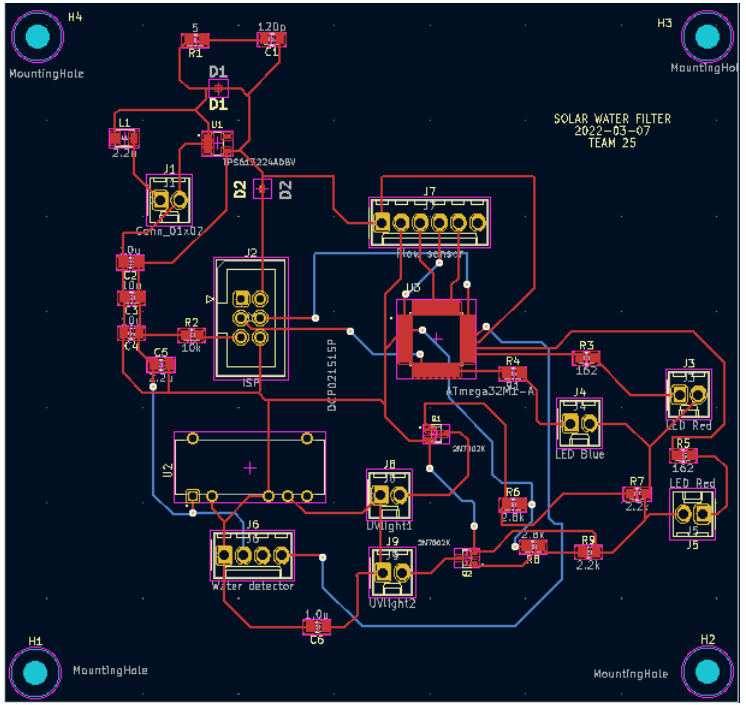
5V Boost converter changed

- Out of stock

Nano capacitors

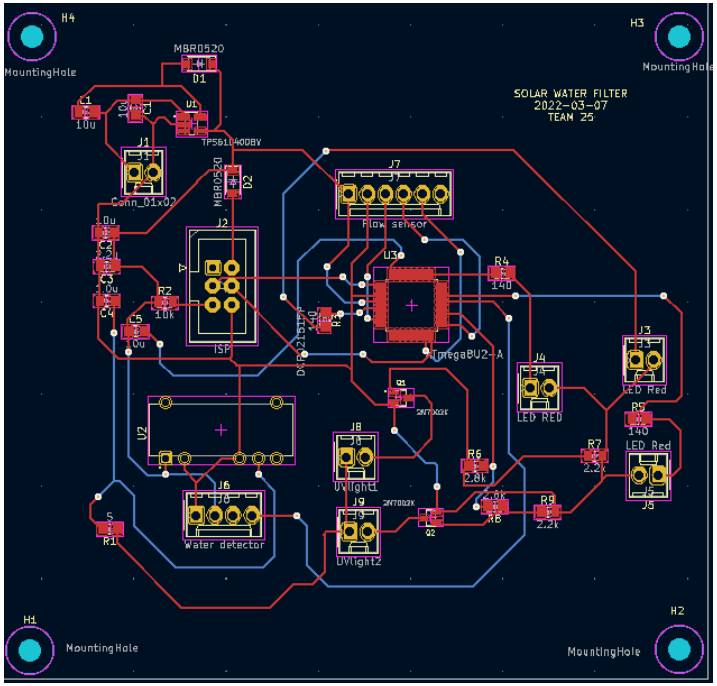
- Difficult to solder

UV light Resistor



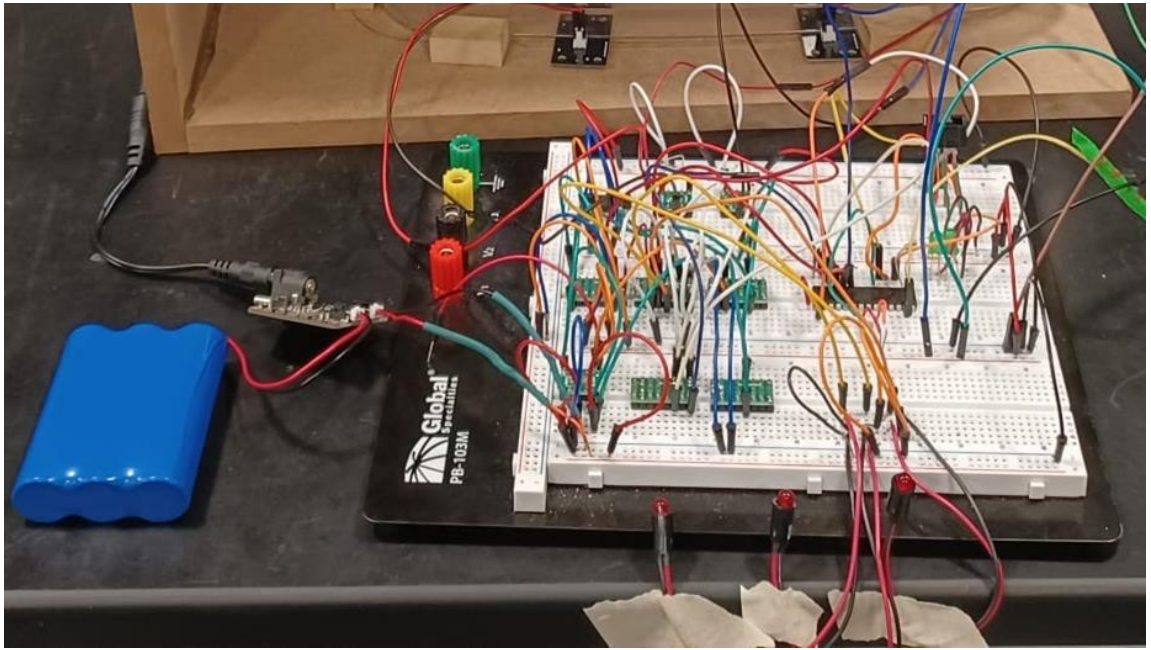
First PCB Design

PCB Problems



Second PCB Ordered

PCB Problems



Final “PCB” using BreadBoard

Conclusion

Lessons Learned

- Try to order more parts than you need to be prepared for emergencies.
- Getting familiar with different microcontroller programming environments is always a good idea.
- There can be problems such as lack of stock or unexpected unforeseeable delays. That is why it is important to make the best use of your resources to show what you have learned from the class and how you have implemented things in your project.
- Always be careful about how you operate certain sensors as they can be very delicate to changes in current/voltage.

Conclusion

Future Work

- Our new PCB arrives within the next two weeks. It would be a good idea to start working on it.
- Buy another water flow sensor and replace our current water flow sensor.

Once everything works

- Minimize the cost of manufacturing the physical product
- Create larger reservoirs, with larger solar panels to provide water for several people.

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Extra Slides

Requirements and Verifications

REQUIREMENTS	VERIFICATION	VERIFIED?
1. Provide a voltage of 5.7 V +/- 0.5% from the power subsystem to the UV lights. The UV lights should operate between 95-100 mA	Measure the output voltage using a multimeter to ensure it is within 5% of 5.7 V.	Yes
2. Provide a voltage of 5 V +/- 0.5% to all the parts of the device except the UV lights.	Measure the voltage of any subcircuit in operation using a voltmeter to ensure it is within 5% of 5 V.	Yes

Requirements and Verifications (1)

REQUIREMENTS	VERIFICATION	VERIFIED?
1. It should sense if there is water present in the first water tank.	This can be verified by checking what signal the water sensor sends to the microcontroller. If the sensor sends a HIGH (>) signal to the microcontroller, then there is no water present in the first tank. If there is water present, the signal is LOW. This can be verified using a multimeter in the circuit between the sensor and the microcontroller.	Yes
2. It should sense the different flow rates of the water from the first tank to the second tank.	We can access the different flow rates of the water from the microcontroller and check them manually for the microcontroller to see if the water flow rates are being measured or not.	Yes

Requirements and Verifications (2)

REQUIREMENTS	VERIFICATION	VERIFIED?
3. The water flow sub-subsystem should sense if the water membrane microfilter needs to be changed.	If the water flow levels are too low (50% of the initial flow rate), that means the filter needs to be changed. This data would be collected by the microcontroller. It would send a signal to the led to light up and it would light up outside the device	Yes
4. The water flow sub-subsystem should sense if the carbon filter needs to be changed.	If the filter has filtered 150L of water, the carbon filter should be changed. This information would be measured and stored by our microcontroller. When this threshold has been reached, it would send a signal to the led to light up outside the device	No

Requirements and Verifications

REQUIREMENTS	VERIFICATION	VERIFIED?
1. It would operate at about 5 V. That is the best voltage to operate for us as most of our other modules also operate at 5 V.	We measure the voltage provided to the microcontroller. If Vm is within 5% of 5 V, then it is working as planned.	Yes
2. Send signals to the LEDs to turn on and off depending on the signals received from the sensing subsystem. The LEDs indicate which part of the FSM we are operating on.	We can use visual stimuli to verify this. If the LEDs for a particular FSM state are turned on, we can clearly verify them using our eyes.	Yes

Requirements and Verifications

REQUIREMENTS	VERIFICATION	VERIFIED?
1. The UV lights should be turned on for about 10-15 s to kill the bacteria and viruses.	We can measure the time from when the UV light LED switches on and close to verify this. Also, the UV LED is on for the same amount of time so we can visually verify this as well.	Yes
2. The UV lights operate at 5.7 V each. This is the best option for our design.	We measure the voltage provided to the subsystem. If V is within 5% of 5.7 V, then it is working as planned.	Yes

Requirements and Verifications

REQUIREMENTS	VERIFICATION	VERIFIED?
1. The UV light LED should light up when the water is undergoing UV light treatment.	The LED should light up when the signal from the microcontroller is sent to it. We can verify this during UV light treatment by measuring the voltage between the microcontroller and UV light using a multimeter. If it is positive and the LED light is turned on, that means our LED is working properly.	Yes
2. The microfilter LED should light up when the water filter is worn out.	The LED should light up when the signal from the microcontroller is sent to it. It only lights up when the water is taking too long to filter. We verify this by simulating the water detector sensor. The rate of flow is halved or even more lowered when it needs to be replaced. The normal rate is 0.1614L/min.	Yes
3. The Carbon + Ion LED should light up when the membrane microfilter should be replaced.	The LED should light up when the signal from the microcontroller is sent to it. We can verify this by simulating the water detector sensor. This only lights up when the water has filtered 150 litres	No