Automated Home Hydroponics System (AHHS)

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***Abstract* — When people think of cultivating plants, most people would imagine the traditional method of seeds in water and soil. While this has been the norm throughout history for agriculture, there are better methods out there that can yield better results. Not only better results, but also make it easier to automate so that there are less mistakes and less labor by the grower. This is where hydroponics comes into the picture as it can grow a plant to its full potential and have the process automated for the user. The Automated Home Hydroponics System is an automated plant grower designed to create an environment suitable for any plant that the user may choose to grow.**

***Index Terms* — Automated, Hydroponics, WiFi Monitoring, Android, Relay Subsystem.**

I. Introduction

The Automated Home Hydroponics System was born with the goal of simplifying the process of growing plants within one's own home. The fundamentals of this project are based on the basic idea of hydroponics, which by definition, is the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil (oxford dictionary source). The Automated Home Hydroponics System was designed to be water based, with nutrients added in order to promote plant growth.

In order to create a hands-free hydroponics system, many sensors come into play to make sure the plants are receiving the nourishments they need. The most important factors are the sensors to monitor the water contents for proper nourishment and light sensors to monitor light intensity for plant growth. That said, pH sensors, CO2 sensors, water sensors and temperature sensors are included to ensure the most important components are met for plant growth. Since the purpose of our project is to make an automated hydroponics system that can adapt to different home environments, additional sensors and modules have been implemented to protect the growing process. Humidity sensors, fans, and heaters have been included to increase the survivability of the plants. All these components and sensors are monitored by a microcontroller that is programmed to keep the measurements in the desired ranges. Since the project design is modeled after the Nutrient Film Technique, pumps are used to propel the water around the system and administer pH fluid to balance the water contents. Therefore, the user doesn't have to do anything on their part.

II. Ease of Use

In order to prioritize making the system easy to use, the user interface was the main priority of the design. Control of the system is done via an Android Application on the user's mobile phone. This application has a variety of presets that can be used that have the ideal conditions for different plants, or a user may make a new preset of their own. This application then sets the limits on the microcontroller that will use the connected sensors and pumps to try to keep the environment within the set conditions. The status of the system is delivered back to the user both within the application and through the use of an LCD display that is mounted on the enclosure of the system.

Another aspect we found important for users ease of use was the portability of the hydroponic system. We designed a system to be able to fit through all types of doors and be mobile. However, we also made sure the enclosure would be able to fit a decent amount of plants in the hydroponic system so that the users can have the option of growing different kinds of plants that fit within the same environment criterion. The housing is able to hide most of the messy electronics of the Automated Home Hydroponics System away from the view of an everyday user. This means that the user is less likely to negatively affect the system's performance by mistake and also produces a cleaner design that would be suitable in one's living area.

III. System Design Overview

Although presented to users as an all-in-one inclusive system, the Automated Home Hydroponics System has a collection of subsystems that must all communicate and work together in order to properly achieve the goal of automated climate control. Included in these subsystems are: the Sensors, Wireless System, Power System, Printed Circuit Board, Liquid Pump System, Local Interface, and the Water Storage System.

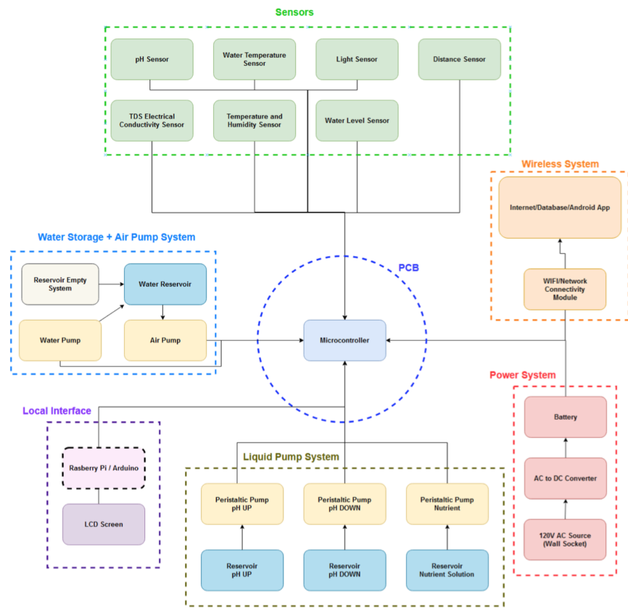

Fig. 1. System design overview displaying all the different systems that make up the Automated Home Hydroponics System.

A. Sensors

The sensors of the Automated Home Hydroponics System were chosen to monitor the pH levels of the system, water temperature, light levels, plant height, TDS (Total Dissolved Solids) levels, temperature/humidity, and the systems current water levels. For the sensors, we opted to choose sensors that would provide us with digital feedback when possible on our design. Sensor selection and a very brief summary of each will be discussed below.

pH sensor: For any hydroponics system, it is important to track the pH level of the nutrient solution for the relative health and speed of growth of the plants. The pH sensor used will be submersed so that real-time data can be collected. The pH sensor will be interfaced with the PCB and will connect to an analog pin. When the reading is taken by the pH sensor and sent back to the PCB, the PCB will decide if it falls within the preset value range. If the pH falls within the range, then the system will continue to take readings and do nothing. If the pH is outside the preset value range, the PCB will command the dosing pumps to appropriately distribute pH up or pH down until the pH falls between the preset range. The Atlas Scientific Gravity Analog pH sensor is an analog sensor in our design and provides a voltage that will be converted to a proper pH level using the formula below from the datasheet.

$$pH = (-5.6548 * voltage) + 15.509 \tag{1}$$

Air temperature and Humidity**:** The air temperature and humidity will be monitored to fully understand the current conditions of our hydroponics system. The SMAKN DHT22 / AM2303 Temperature and Humidity Sensor was a convenient choice as two readings were covered by one sensor. This is a sensor module made by SMAKN that incorporates the DHT22 sensor from adafruit. This sensor supports temperature readings within a range of -40 to 80 degrees Celsius with an accuracy of +/-0.4 degrees, which should be plenty of scope for the sake of this hydroponics system. The sensor also can take humidity readings between 0% up to 100% with a 2-5% accuracy. The circuit supports up to a 0.5Hz sampling rate which translates roughly to once every 2 seconds. The sensor output is digital and can be read from the 3 pins extending from the board.

Electrical Conductivity and Water temperature Sensor**:** The electrical conductivity(EC) sensor is used to measure the salinity of the nutrient solution for the purposes of water quality tracking. It is important to understand the current state of the nutrient solution provided to the plants to successfully grow the plants. The EC sensor determines whether the nutrient solution is too concentrated and if it needs to be diluted. The EC sensor operates at 5V. The EC sensor will be connected to the PCB, and when the conductivity reading falls out of the preset range value, the appropriate action will be needed. If the conductivity is too low, then the system will automatically add the appropriate nutrient solution through the dosage pumps. If the conductivity is too high, the user will need to manually add more water to the reservoir.

The DS18B20 Waterproof Temperature Sensor is pre-wired and waterproofed. The sensor is good up until 125 degrees but is best to be kept under 100 degrees as a result of the cable jacketed material. The signal output is digital and as a result there isn't any signal degradation over the long distance of the wire. The temperature precision is +/- 0.5 degrees and allows for up to 12 bits of precision.

Light Sensor**:** The light sensor is used to make sure the plants receive the correct amount of light to grow. The Adafruit TSL2591 High Dynamic Range Light Sensor is an advanced digital light sensor and supports a large range of light measurement applications. This sensor supports a large range with 188 uLux all the way up to 88,000 Lux and can be configured for different gain/timing ranges. This sensor features both infrared and full spectrum diodes. This allows the system to measure infrared, full-spectrum or human-visible light. This sensor has a large dynamic range of 600,000,000:1 and operates over I2C communication. There is even a built in ADC which allows this sensor to be used with digital inputs.

***Reservoir Water Level Sensor*:** The water level must be monitored to ensure the system is not operating at an insufficient amount of nutrient solution. The CQRobot Contact Water/Liquid Level Sensor was chosen to measure water level and is a photoelectric water/liquid sensor that operates based upon using optical principles. ***TDS Sensor**:* The DFRobot - Gravity: Analog TDS Sensor/Meter measures the TDS value of a liquid. This sensor supports input voltages between 3.3 volts and 5.5 volts and outputs between 0- and 2.3-volts analog voltage. This sensor reads TDS on a range of 0 to 1000ppm with an accuracy of +/-10%.

***Distance Sensor*:** The HC-SR04 Ultrasonic Module Distance Sensor is a popular low cost distance sensor. The module considers the speed of sound and the travel time it took for the emitted signal to bounce back and calculates the distance that object or obstacle is away from the sensor. The sensor requires a voltage of 5 volts and a current less than 2mA.

B. Wireless System

In order to connect our hydroponic system to our app, we needed a form of communication to deliver plant data and system information. After careful consideration, we decided to use Wi-Fi as our means of communication as it boats greater range and more versatility for plant monitoring. That said, we used a ESP8266 Wi-Fi module to connect our system to the internet.

The ESP8266 Wi-Fi module features two modes of operation: Access Point(AP) and Station(STA). The Access Point mode allows for the module to host its own network and allow other devices to connect to its network. The Station mode allows the Wi-Fi module to be connected to an already existing Wi-Fi network in range with SSID and password of the network.

The Wi-Fi module connected our system to the internet with UART communication through the serial pins on both the AtMega2560 and Wi-Fi module. These microcontrollers had to communicate through a logic level shifter as different voltage logic is used for each board. This is the primary way of sending plant data to the app and sending system monitoring settings to the hydroponic system. Due to UARTs limitations, message data structures and additional checks were used to limit message fragmentation. This allows for only correct frames of data to pass through to the user.

To have our hydroponic system communicate with our android app, we used a Wi-Fi library that connects our home Wi-Fi with standard user authentication. Then an asynchronous web server is created with 192.168.1.150 as the IP address that utilizes TCP connections for communication. This web server processes incoming commands from the android app and updates with plant data. This will also allow for the app to send system settings to the Wi-Fi module.

C. Power System

The Automated Home Hydroponics System has two sources of power. The microcontroller board that connects to the sensors is powered by a USB connection. For components that cannot be run from the Printed Circuit Board, we have created a relay power strip. Four of the outlets on the power strip are always on and the other four can be activated independently by relays that are triggered using the microcontroller board. The eight outlets are housed neatly in a box that hides and protects the relays while still allowing access to their terminals through the wires coming out of the box.

Components that will be utilizing the relay power strip include the lighting and some of the higher power drawing pumps in the system. The decision to not implement a battery in the design was influenced by the fact that this system would most times not be in a situation where power was unavailable for a long period of time. As it was designed to work indoors, it has been made to utilize standard wall power.

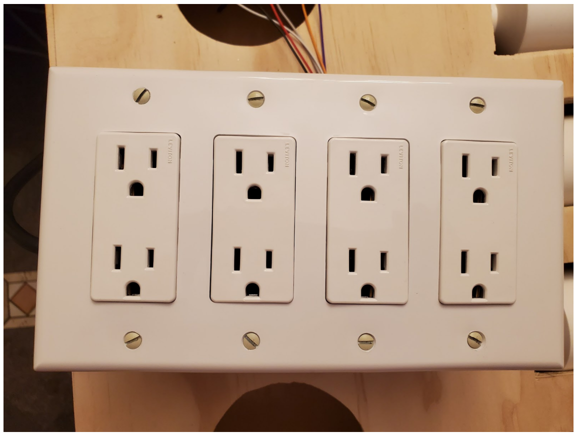

Fig. 2. The relay power strip that allows the Automated Home Hydroponics System to provide power to high power devices that the microcontroller otherwise could not. Four outlets are always on and four can be controlled through the use of the microcontroller.

D. Printed Circuit Board

The Printed Circuit Board of the Automated Home Hydroponics System is meant as the bridge between all the different systems. The design is meant to replicate the Arduino 2560 board that we prototyped our design with and acts in very much the same manor. Because the Arduino 2560 is open source hardware, we were able to use provided Eagle files to design a board with much of the same functionality and ensure portability from our prototype to final design.

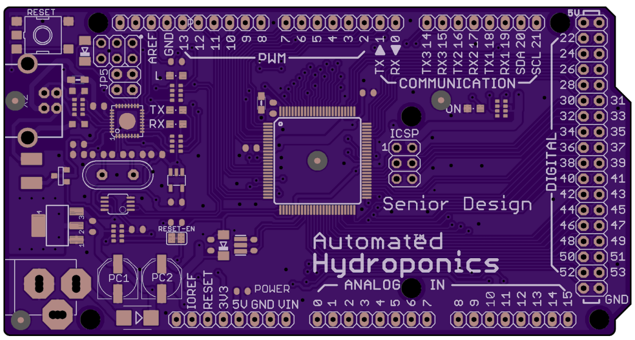

Fig. 3. The design for the fabricated Printed Circuit Board that is the bridge for everything in the Automated Home Hydroponics System.

The Atmel AtMega2560 microcontroller was chosen because of its extensive I/O lines that would allow us versatility in our design when it comes to how many sensors can monitor the environment and allow flexibility with future hardware revisions and feature expansion. The AtMega2560 also has plenty of memory for storing and uploading our code.

The Printed Circuit Board is provided power through the use of the USB port located on the upper left of the board. However, unlike a typical Arduino board we do not upload our code through USB serial. Instead we use what is known as a programmer to program the board through the use of the In-Circuit Serial Programmer (ICSP pins).

The whole process of loading the bootloader code and burning properly the fuses to make an ATmega microcontroller an "Arduino" is managed by the Arduino Software (IDE) [1]. Our original intent was to upload the Arduino bootloader through the In-Circuit Serial Programmer method, but ran into issues with getting the port of the board recognized by the Arduino IDE. Unfortunately for testing purposes this meant that we could not monitor the serial data of the board through USB. To work around this problem, we would monitor the status of the board through its connection to the LCD screen that would display the status of the system at a quick glance.

Instead of uploading our code through USB after installing the bootloader, we uploaded code to the Printed Circuit Board through the use of the ICSP header. To stay within our budget, we avoided purchasing a dedicated programmer device but instead used a method called Arduino as ISP. Using this method, another Arduino acts as a middleman between the computer and the target board. This “programmer” board is first flashed with software that enables it to act like a programmer board. Then, the two boards are connected through their ICSP pins and using the Arduino IDE we use the “Upload as Programmer” functionality as if we were using a normal programmer.

The In-Circuit Serial Programming functionality revolves around the use of six pins. These include: VCC, GND, and four data pins. Three digital pins connect MISO, MOSI and SCK between the programming micro and the target micro, the fourth pin from the programming micro goes to the reset pin of the target [1]. In our programming process we used two different boards as programmers (the Arduino Uno and Arduino AtMega2560) and were able to successfully program using both boards as programmers.

For the fabrication of the board we first downloaded the open source design of the board through the official Arduino website, Then, using Eagle we modified the design to meet our needs, edit the silkscreen layer to accurately describe the device and create a general build of materials to order parts that will fit within the design.

Once a design was agreed upon we went with OSH Park to fabricate the board. Overall fabrication of the board was under two weeks and to coincide with this time we ordered all the board components through Mouser to be soldered on. The purchasing portion of the board was anticipated to be delayed due to COVID-19 but we were able to receive our packages in a timely manner that met our general timeframe.

After the board and all its components were ordered and received, the main challenge came in how to properly solder the surface mount devices to the board. With no prior surface mounting experience the process of mounting the roughly forty components took approximately three weeks. The senior design laboratory was immensely helpful as soldering tables with irons, hot air guns, and hot plates were readily available along with microscopes and other helpful equipment for smaller components.

Solder paste was immensely helpful at soldering small connections, but came with the danger of possibly overheating components if exposed to hot air too long. For the difficult AtMega 2560 processor with Quad Flat Packaging (QFP) we used the method of flooding all the pins with solder then using desoldering wick to clean the excess solder and in the end the surface tension was able to allow the solder to make secure connections between the AtMega 2560 processor and the board.

Through the process of soldering and testing we had two components hold up our initial troubleshooting period that needed to be replaced. Whenever connected through the USB port, the AtMega 16U2 processor and the LMV358IDGKR operational amplifier had significant overheating. The AtMega 16U2 processor that is responsible for much of the USB processes of the device seemed to have burnt out and the LMV358IDGKR operational amplifier had a short between two pins that could not be seen until we removed the device and reinstalled a new one.

After fixing these problems and mounting all the components we were able to flash the board with our software for the Automated Home Hydroponics System through the use of ICSP and Arduino as ISP mentioned earlier. The downside to this method is that anytime we want to make any changes while testing the board, we have to wire a programmer board to the target board (our printed circuit board) and repeat the whole Arduino as ISP process. Outside this inconvenience, the printed circuit board has been able to meet all expectations for being the bridge of the system and has worked without any errors in its role.

E. Liquid Pump System

In our hydroponic system, there are many pumps that transfer liquid throughout the whole system. There are 3 main liquid pump systems which are enclosed in the hydroponics system. There is the dosage, air and main water pumps.

The dosage pumps are what's attached to the ph and nutrient containers that flow into our system. They work by pushing liquid through a tube in doses with a rotor. They are perfect for administering these liquids as they have a flow rate of 100ml/min. Which we use to give small amounts at a time to safely update our hydroponics system.

The air pump is responsible for oxygenating the water reservoir for the plants to absorb. Our air pump has a max flow rate of 15L/min, which is plenty for our system. It’s possible for plants to not receive proper oxygen due to not having an air pump, even with the Nutrient Film Technique design. Air pumps are also great at improving yields and prevent rotting of the roots.

The larger water pump is one of the core pieces in the hydroponic system, especially in Nutrient Film Technique, as it moves the water throughout the system in an “S” shape fashion. The water pump we have installed has a max flow rate of 150ml/min. The max flow rate is more than enough, but needed to make sure that water can flow upwards a few feet and provide an adequate amount of water through the PVC piping. With factors like water volume, PVC height and PVC angle, a strong pump is called for.

F. Local Interface

The enclosure of the Automated Home Hydroponics System features an LCD screen that can feed real time information to the user in case they do not currently have access to the Android Application or would just like to view the status of the system at a glance.

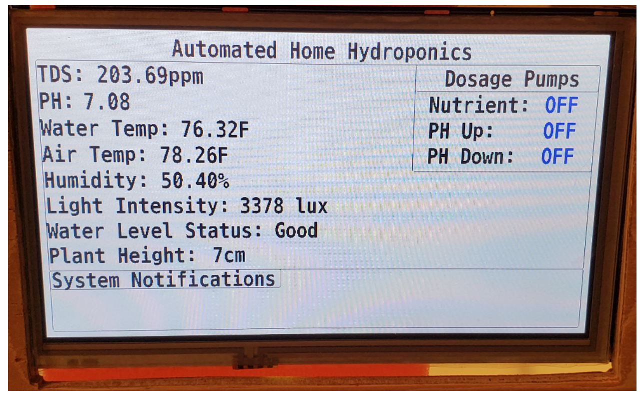

Fig. 4. The LCD screen is able to display a variety of info on the plants environmental conditions and display notifications to the user.

Feedback from all the sensors mentioned earlier are displayed in a simple to read format to the user. Underneath, any urgent messages to the user can be displayed, such as detected errors or if anything in the Automated Home Hydroponics System needs to be changed. The top right of the display shows the current status of each of the dosage pumps, indicating if they are currently running or idle.

The LCD connects to a PCB Shield board which then interfaces with a ELEGOO Mega 2560 board which is the brains. The LCD board communicates with the main PCB using serial in order to retrieve sensor data. The code for the LCD was written in C using the Arduino IDE. The graphics themselves were made using a library provided by the LCDs manufacturer, BuyDisplay.

G. Lighting

The lighting we chose for our project is the AGLEX K Series LED. This grow light is equipped with 160 LEDs with full spectrum lighting. The full spectrum lighting includes full 3500K 6500K whites and 660nm reds, which is ideal for plant growth. AGLEX is also IP65 Waterproof, which is great when dealing with hydroponics as water can damage electronics during operation. The light is also fanless, which we think consumers would appreciate in their home. There is also a dimmable knob on the side to adjust light intensity for different plants and changing plant heights. This light also only consumes 90 Watts to provide the most light intensity without greatly increasing our power consumption.

IV. Microcontroller Software Design

The AtMega2650 is the brain of our hydroponics system. It is responsible for handling the main systems logic along with reading all sensor data. The main functionality of the AtMega2560 microcontroller is broken into 3 main aspects. That of reading and handling all sensor data, sending and receiving data between the LCD and app, and finally the automation of the dosage system involving the nutrient solution and PH solutions.

The sensor functionality is one of the more key and important aspects of this project as the sensor forms the core of all the information that the user will be using in order to make key decisions about their system. There are a total of 10 sensors. Across this we are able to measure TDS, PH, water temperature, air temperature, humidity, light intensity, plant height, systems water level, and the last three sensors handle the dosage solutions in which they keep track if the chemicals and/or nutrients need refill or not. The code for this involves the reading of both analog and digital sensors and interpreting the data accordingly in order to be stored and later sent to other parts of the system.

The communication aspect of this microcontroller is also key as it needs to keep a subsystems communicating and in line with one another. One the sensors have provided new data that is stored a message is created to be sent to both the LCD and the android app. This message is generated and sent in a defined format across all systems in order to ebay avoid data corruption over transmission. Messages are often sent out about every minute or so as its important to give the sensors and subsystem time to operate in between. The MCU also checks for any incoming messages from the app at the start of every loop as far as changes in plant parameters/settings or if the user decided to disable one of the power outlets such as the lighting or main water pump. If there is an update in settings this will also be sent to the LCD such that notifications and the dosage pump status can be handled accordingly.

The last key subsystem is that of the automation of nutrient and PH dosage into the water system. The code has a series of checks that work to find if the TDS or PH are out of line in which 1-3 of the dosage pumps will dose solution in order to balance out the system parameters accordingly. Automating this process and removing the users need to add chemicals/nutrients to the water.

V. Android Application Software Design

Our android application was developed in Android Studio IDE with Java as the programming language. The purpose of this app is to allow full user customization and monitoring of their hydroponic system. Our app is able to show current system data to the user anywhere in their home while providing an easy to use interface. It also has capabilities to set monitoring ranges that are specialized for each plant a user wants to grow. That said, there are 5 main panels that the app is composed of for navigation, each with its own feature at the user's exposal. More can be seen in Fig.5

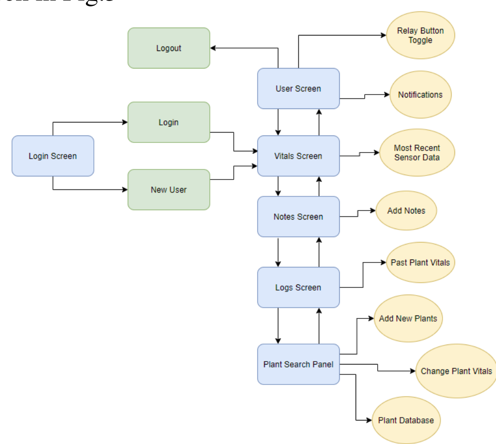

Fig. 5. An overview of the navigation controls, panels and features are laid out.

A. User Profile

In this panel we are going to have buttons available to the user that allows them to toggle power to the lighting, the water pump and the air pump. This is also where the user is able to view notifications on containers like the water reservoir, ph solution bottles and nutrient bottles. This way the user can refill any empty containers upon receiving the notification.

B. Plant Vitals

The plant vitals panel is the first page the user sees after login and is where the current plant data is displayed. The data on this panel gets updated regularly and displays the information automatically.

C. Plant Search

The plant search panel is where the user is able to set system parameters to their hydroponic system. There are a few plants already present in the database that the user can choose from. There is an option to add a new plant with custom parameters that the user can add to the database to create any environment.

D. Notes

The notes panel is a standard notes feature that allows the user to make lists and reminders relating to their hydroponics system. There is a search function that looks for titles to match the list for ease of use.

E. Logs

The logs panel is a scrollable view that shows the past plant vitals in the form of cards. The cards will be ordered based on time. This allows the user to see trends in the plant vitals over time. This panel also directly reflects what's in our database so that we can ensure only official data is being displayed.

VI. Database

We decided to use mondoDB Realm for our project as we had prior experience with it before. This database stores objects in the form of JSON. We use this database to store the recent plant vitals and keep data up to date. The app is able to make requests and receive responses from the database in order to populate recycler views that are used to power our panels.

There are 4 components to our database that our app uses to function. There is the list of users for login authentication at the beginning of our app. There is a list of notes to keep the users note data. There is a list of logs that will be used to refresh the logs panel to track the plants vitals progress. Finally, there is the plants list which will contain the present plant parameters that is available to the user to start growing.

VII. Physical Design

The structural design of the Automated Home Hydroponics System will be compact compared to many hydroponics systems but large enough to allow for a lot of plants to grow. The size specification of the Automated Home Hydroponics System is about 4’ x 29.5” x.oo 6.5’(L x W x H). The size was chosen carefully to fit inside most small homes/apartments. The structure will consist of 2 major areas. First is the wooden cabinet. This will house the 10-gallon water reservoir, water fill and drain system, nutrient control system, PVC system, PCB and other electronic components. An electrical component box will be used for the PCB and other electronic components to help protect from any water leak situation. The PVC construction is capable of holding 54 plants and split across six rows in an S formation. This allows for a large amount of plant production and variety. There are inlets and outlets for both refilling and empty the water on the top and sides respectively.

Fig. 6. The essential PVC construction atop the cabinet of the Automated Home Hydroponics System that houses the plants and provides a path for water to flow to them.

The second second major area is the canopy above the wooden cabinet. The canopy will contain the LED grow light and the distance sensor for measuring plant height.. The LED grow light consists of full spectrum lighting used in all portions of the growth cycle of the plants.

To build this structure, the main material that was used was 7 layer plywood. This was necessary in order to maintain structural integrity. The quality of wood ensures that the structure will be able to maintain its own weight and be easily maneuvered without falling apart. The only downside to using wood is that it is heavy and a solution had to be developed for easy transport. This was accomplished by adding caster wheels to the bottom of the structure.

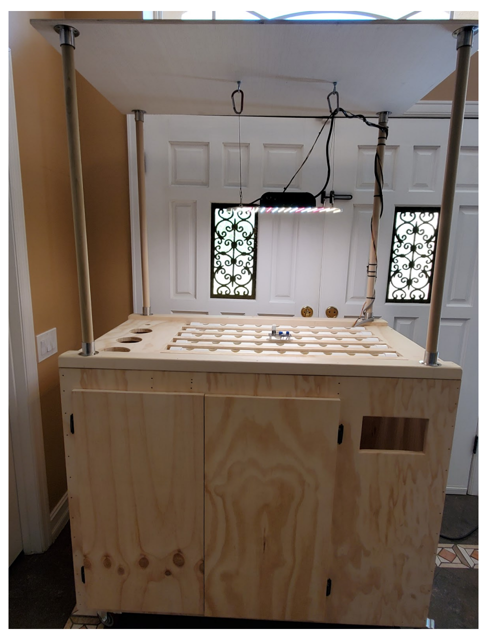

Fig. 7. The overall build of the Automated Home Hydroponics System provides a solid addition to any indoor space. Structure Dimensions: 4’ X 29.5” X 6.5’ (L x W x H)

The LCD screen that displays the status of the system is located to the right of the cabinet doors located in front of the enclosure. This will display all the necessary information about the system such as sensor readings and will also provide the user with alerts in case some action needs to be taken.

VIII. Final Design Overview

This Automated Home Hydroponic System will allow users to grow a large variety of plants and a large amount with space for up to 54 plants. Users will be able to monitor system vitals including TDS,pH, and Temperature through both the android app and the LCD. The user will be notified if system parameters fall out of line and certain parameters like TDS and PH will be automatically handled by our dosage system which will add nutrients and adjust pH levels. This is done through nutrient and pH up and down solutions which will be easily assembled at the top of the cabinet. Along with monitoring system vitals and being notified of system parameters falling out of line the user will be able to turn on and off the lighting, main water pump, and air pump through the android application in case of needed maintenance. There is an opening next to the dosage solution which allows for simpler filling of the reservoir such that the user isn't required to go inside the cabinet for topping off the water when there is evaporation. The user will be able to drain the reservoir as well by changing the direction of the flow using a 3 way split inside the cabinet that will drain the water out the side of the cabinet. This system provides a user with the ability to grow lots of different types of plants using hydroponics while being able to monitor plant vitals to track plant health and have some of the maintenance automated and streamlined in order to minimize constant involvement.

IX. Conclusion

As the two semesters of the senior design comes to a close, it has been a great experience for the group. Senior design has provided the groups with hands-on experience that has been invaluable knowledge into the computer and electrical engineering field. The entire process from the first week of senior design 1 has been fun and challenging. Throughout the research and design, to the actual prototyping of the system, challenges and problems were encountered. Throughout this course, members have learned vital teamwork, planning, and engineering principles, which will help them in future endeavors.

X. Acknowledgement

The group would like to thank the senior design professor Dr. Richie for guiding us with the project and answering any of our questions/concerns we had throughout the entire process.

XI. References

[1] Team, The Arduino. "Arduino as ISP and Arduino Bootloaders." *Arduino*, www.arduino.cc/en/Tutorial/BuiltInExamples/ArduinoISP.

XII. Group Member Biographies

Luiz Alves is a senior graduating with a degree in Computer Engineering with experience with firmware engineering. In the Spring of 2021 he looks forward to employment in the field of embedded systems.

Hardik Patel is an Electrical Engineering major from UCF. Through personal projects and two internships, he has acquired a good amount of experience in the field. He plans to get a full-time job as an Electrical Engineer after graduation.

Jarrod Pearman is graduating with a Bachelor's degree in Computer Engineering. He has gained experience through school and personnel projects primarily involving software engineering and embedded systems. In 2021 he is excited to continue his education in the pursuit of a Masters degree here at UCF.

Christopher Lopez is an Electrical Engineering senior with former experience at Lockheed Martin and the Boeing Company. He is looking forward to becoming a full-time Electrical Engineer after graduation.