Automated Botanical System "Autobott"

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***Abstract* — The Autobott is an indoor smart garden sustained within an aesthetically pleasing wood cabinet. The Autobott is scalable and can grow a number of produce, flowers, or herbs based on the user's needs. This system will be automated from top to bottom and controllable from a web and mobile application, so it gives the user freedom from anywhere in the world to manipulate the conditions of their environment. This product has improved existing designs by increasing the size of the enclosure and allowing for scalability within the environment, while still maintaining the efficiency of hydroponics as the feeding method for the plants.**

***Index Terms* — Automatic control, control design, wireless sensor network, computer application, database, Pumps**

I. Introduction

The project was created with the mindset of scaling down an outdoor garden and fitting it inside a house. The Autobott resembles what looks like a wooden cabinet with two doors that open together on the top and a small drawer on the bottom to pull out. The cabinet is powered by a typical 120 volt outlet that is the standard in most if not all homes. The circuitry portion of our project will convert the AC power into directed current utilizing the full amount of power from the outlet. Furthermore, the cabinet is made up of two sections: the enclosed environment (held within the top part of the cabinet), in which, the air and surroundings are controlled; and the hydroponics or water quality system (held in the drawer section of the cabinet) that will feed the plants the nutrients and water they need to grow efficiently. Within the environment, sensors are used to detect the humidity and temperature at all times to keep the growing conditions at optimal levels. Once a parameter is out of boundaries, then the system will correct itself by dehumidifying the environment or cooling the air inside the enclosure by circulating air through with an HVAC system. Likewise, the hydroponics system will contain sensors and meters that measure the water quality. In this form, the water will be treated if necessary after every full cycle of feeding the plants. Measurements such as, pH levels and electrical conductivity (EC) of the water, along with the environment parameters will be held in a database and relate to specific plants. This will give the user the capability to set the desired environment and water nutrient levels for the specific plant they are growing, enabling the plant to grow at its optimal conditions. The user will be able to access, add, and update this database to their likings through a web and mobile application. The web and mobile application will be intuitive and functional, giving a novice gardener the resources they need to learn about growing plants efficiently, as well as targeting the more experienced gardeners by providing them with every piece of data they need to grow an outstanding garden.

II. Goals and Objectives

The main two goals this projects focus is towards are portability and scalability. Our group sees more use and convenience in a garden that is portable, allowing the user to easily move it throughout an area of space in their home and allowing the user to bring it with them where ever they move. We can make this objective available to a user by using only the 120V AC outlet in a common household. Also, this project will concentrate on creating an environment that is scalable, given the limitations of the infrastructure. We will do this by creating multiple types of trays that hold anywhere from two plants up to ten plants, depending on the size of the matured size of the plant. This gives the user freedom to grow different types of plants and customize their indoor garden entirely. By tailoring our objectives to efficient space utilization, we are uniquely following the trend of the general market in a sense that we are creating a high tech product that is able to conveniently take up small space and use the limited amount of space the product offers to its full potential.

We believe our goals and objectives for this product will generate quality prospective ideas in the smart garden industry and create a new market for high tech gardeners. This product brings the new and improved smart garden technology to a new level in the current market. The design of this product has many benefits that target a residential market, such as, portability, scalability, low power, an intuitive user interface that can be controlled over the web and on mobile devices, and full control over the automation features. Giving users the ability to control such high tech devices and conditions at the touch of their fingertips not only gives them high self-esteem with newer technology but it also helps a skeptical clientele buy into the direction this product wants to go in the smart garden industry.

III. Hardware Design

The project requirements and specifications are used to define the high level purpose of the subsystems, items, and all the way down to the wiring design of the PCB board. Each component in the Autobott is unique to a specific purpose and must meet certain requirements for the full system to operate at perfect conditions. For example, the water pump must have enough power to pump water vertically upward through a PVC pipe up to three feet and also pump the water into the plant trays at a certain rate. This is the extent to what the water pump will serve in our project; however, this is a very simple item in the full design and has a significant requirement to meet. Below are the rest of the components that are given a certain requirement and specification to meet so that the Autobott is able to operate flawlessly.

A. Physical Enclosure

The physical enclosure must first of all have ample grow space for the plants. We also want the enclosure to include a non-invasive opening that can be used to check on the plants and perform any needed plant maintenance. The physical enclosure should be made out of durable materials, with compartments on the bottom for the water reservoir and pump, on the side for electronics and water pipes, and room on the top for the lights, fan, and HVAC system. Preferably, the walls of our enclosure will be insulated to keep the temperature within our system close to our optimum temperature for the plants. The inner walls will also need to be covered with a reflective surface, most likely Mylar, to help all of the excess light bounce around until it becomes fully absorbed by the plants.

We anticipate building the enclosure, show in figure 1, to be a total of 6 feet tall, 3.5 feet wide, and 2.5 feet deep. It will be divided into three compartments. We will create one on the very bottom that will run the entire width of the cabinet, and be about 1.5 feet tall. Here is where we will put most of the machinery for our hydroponic system. This bottom cavity will hold our water pump, nutrient pumps, water reservoir, air stone, nutrient and pH reservoirs, and leave some room for the necessary piping. A few of our sensors will be present to accompany their corresponding parts, such as the EC Sensor, water level sensor, and pH sensor.

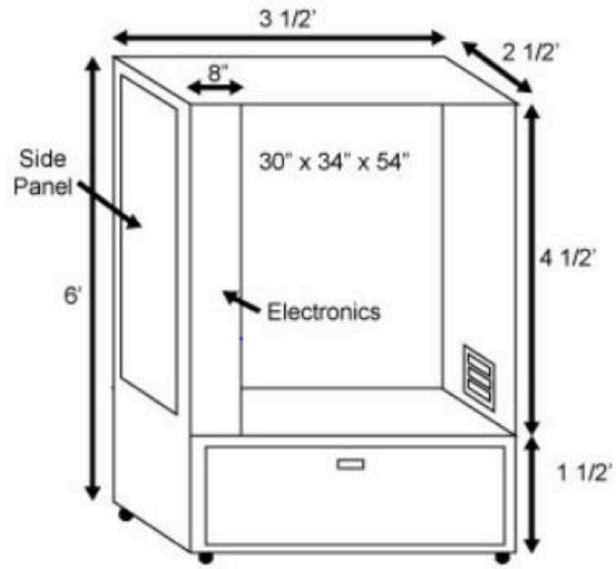

Fig. 1. Physical enclosure, which will house all components

Our plants will need a place to be housed while they grow over their lifespans. We will be using basic trays that should be deep enough to hold water with enough room for the plant's roots, and shallow enough where the roots can reach the running water. There will be openings on the top surface of the trays where some small cups can be placed to hold our growing medium where the plants will live and grow. These plant trays need to be food-grade trays that won't dissolve or leave any trace chemicals in the water that is running through it. This is important because any foreign chemicals or pathogens that may run off of the trays can severely harm whatever plants are present in our cabinet.

B. Hydroponic System

For the water in our system to reach the plants, there needs to be a channel for them to travel through. The type of piping or hosing that we use to push the water up is important because our pump will be utilizing this. The first requirement for the hoses is that it must fit the dimensions of our pump. It must create a tight, waterproof seal around the lip of the pump, and be secure enough as to not be disturbed whenever the cabinet is moved. The 'upward-bound' pipe only needs to be between 2 and 3 feet to carry the water up to the plant trays.

In order to deliver the nutrients, and pH adjusting chemicals into the water reservoir, we will be using small peristaltic pumps. The pumps have a tiny tube already built into them, to which we will be attaching another longer extension tube to assist in delivering the chemicals. We need these small hoses to be flexible, and attach to the peristaltic pump securely and snugly so as to prevent leakages that can lead to a lot of waste. These tiny pipes will also be very inexpensive, making it extremely easy to replace in event of a ruptured hose.

The drainage pipes coming from the grow channels will travel down out of the primary plant enclosure, and into the bottom compartment that contains our reservoir, nutrients, and pH up/down solutions. Along the way back to the water reservoir, these drainage pipes will pass by the nutrient reservoirs. At this point, we will have small tubes running from the nutrient solutions, being injected into the stream of draining water. In doing so, we have an extremely simple and viable way of fully mixing the minerals and pH-altering solutions into our huge water reservoir. According to our design, this will help us avoid having a poorly-mixed nutrient supply for the plants.

C. Water Quality – pH

After the nutrients are all mixed into our water reservoir, we will take readings of the pH in the reservoir to see if it needs adjustment to get back to the optimum level. The design of our hydroponic system requires the pump to be running constantly, which means that our nutrient/water mix will be running over the plant roots all day and all night. Since the plants are receiving so much of the mix, it is crucial for our system to be able to precisely balance the pH in our water, or otherwise risk adverse effects on the growth of the specimens. The ideal pH range for most hydroponic plants is between 5.5 and 6.5. The pH sensors must be able to monitor the pH levels in the water so that it can communicate to the system to add a small amount of acid or alkali in order to restore the proper pH level. If we use pH Up and pH Down to help adjust the pH, our system should only need 1ml-2ml of pH Up/Down per gallon of water. After adjusting by small increments at a time, the system will wait 15-30 minutes to check again before making additional adjustments. [2]

The pH sensor interacts with the Hydroponic subsystem. It measures the pH, or level of acidity, of the water in the reservoir used for the plants. Measuring the pH level at consistent intervals allows for any corrections to be made if it falls out of the acceptable range of values. The pH sensor will be connected to an I/O pin of the microcontroller. The microcontroller's I/O pin will be programmed to recognize the pH meter and receive a voltage that signifies the water's pH level. This value will be compared to the program's range of accepted values, and if the found value falls out of range, the program will notify that the pH is either too low or high and action will be taken to correct it.

The Analog pH Meter Kit measures pH between the temperatures of 32 and 140 degrees Fahrenheit, which is within the temperature ranges of the grow environment. The module is low power at 5 Volts, and provides accurate readings of the pH level. It also has a relatively fast response time of less than a minute.

D. Water Quality – Electric Conductivity

The electrical conductivity (EC) sensor, like the pH sensor, is inside a probe, which is inserted into the water reservoir for the plants. It measures the total dissolved nutrients in the water, which includes ions from dissolved salts, acids, and bases. The unit of measure for conductivity is Siemens per meter (S/m). The reading from by the sensor is first measured as a current, and then the total dissolved measurement will be interpreted from the conductivity value based on knowledge of the nutrients being supplied.

The electrical conductivity sensor will be connected to the analog I/O pins on the microcontroller and interact with the program written for the microprocessor. It will measure the conductivity of dissolved nutrients in the water and compare it to the accepted range of values of nutrients for those plants. If the conductivity is outside of the accepted range, the program will notify that the conductivity is either too low or too high and action will be taken to correct it.

Like the pH probe, the EC probe must be able to accurately measure the electrical conductivity of the water after being submerged for extended periods of time. It also must be able to operate under varying temperatures. For accurate measurements, the probe must first be inserted into a test solution. Then, the probe should be used to stir the solution, letting the conductive portion of the electrode have full contact with it. When the temperature and conductivity are both stable, then a value can be measured.

While the Atlas Scientific Conductivity K 1.0 Kit is more accurate and operates at a wider range of temperatures, it is also very costly. Compared to the DFRobot Analog Electrical Conductivity Meter ($69.90), the Atlas Scientific kit sells for $206.99. For the scope of the project, it is not required for readings to be that accurate. The expected temperatures of the grow environment will also not exceed the ranges of the DFRobot sensor. Therefore, we have opted to use the DFRobot EC meter.

E. Water Quality – Liquid level

The unit must be able to send notification for the user to refill the water when water reservoir is low. The system should also be able to tell when the water level is rising too high, so that it will not overflow as it corrects itself for off-balance nutrient levels. Our unit should also be designed to have the proper amount of water pressure to ensure that the pump can provide every plant with the enriched water that it needs.

The water level sensor measures the amount of water in the reservoir beneath the plants. If it runs too low, more water will have to be added to so that the plants can absorb the correct amount of nutrients. Water level sensors usually either float on top of the water or are partially submerged and provide alarms for when the water level drops below a certain threshold. The sensor must be small enough to fit in the reservoir without disrupting any of the other sensor's activities, but large enough to accurately measure the water level. The sensor must also be able to accurately operate at various temperatures. Table 5.11 shows the specifications for a liquid level sensor that we have chosen.

The eTape sensor has an active length of 12.4 inches, which allow the full length to be submerged vertically in the reservoir with some extra space left. It will sense the hydrostatic pressure applied by the water to the portion of the sensor that is submerged. The sensor operates at a very wide range of temperatures, which will be helpful in dealing with a wide variety of plants. It can be mounted to the side of the reservoir so that is does not interfere with the EC and pH sensors. Figure 2 below shows the top of the eTape sensor, and where adhesive can be applied to it to mount it. When mounting, the pins need to be completely insulated because very humid environments may damage the crimp-flex pins.

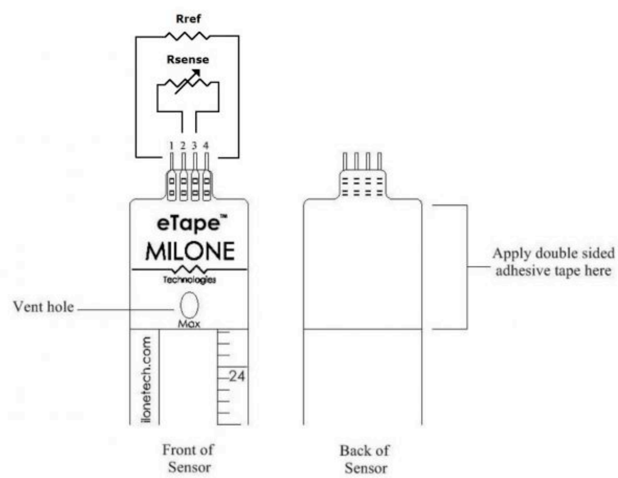

Fig. 2. eTape liquid level sensor (front and back)

F. Air Quality – Temperature and Humidity

Most plants prefer to grow in temperatures of 65-85 degrees Fahrenheit, and depending on the plants stage these number can vary. Temperature of the air inside the cabinet will be kept under control by switching on the exhaust fan to expel the warm air inside. The temperature sensor is the first step for the fan to be triggered if necessary. A thermistor inside the sensor measures the air inside the cabinet. Thermistors are resistors made from semiconductor materials that change value based on a change in temperature, as temperature increases the resistance decreases. Resistivity of the thermistors around the Autobott's target temperature is sensitive enough to provide accurate readings, which provides more consistent temperature values. This resistance is always constant for a constant temperature, if we know the resistance we then in turn know the temperature. These sensors are very low cost because of the semiconductor materials used to create them and are made for various temperature-reading scales. The sensor will be place below the light and around the plant canopy; this is around the center of the interior chamber. Placing the sensor here will allow the sensor to take temperature readings of what the plant is experiencing, including heat from the light and air that is drawn from the intake.

Humidity inside the cabinet is measured using the same sensor that measures the inside temperature. Humidity control is important in all stages of the plant cycle, starting from seed until harvest. Starting from seed a plant needs as much water and light as possible to survive. This water mainly comes from the relative humidity around the plant because the root structure has not yet developed enough to supply enough water. Lack of humidity in this stage will slow growth almost to a stop. In the vegetative stage most plants prefer higher humidity as well, since this allows for quicker growth. As plants mature, fruit or flower, depending on the type the humidity can range from low(30%) to very high (up to 100%). As the plant takes in water from the roots, it takes whatever nutrients and water it need and perpetrates the rest, which raises humidity. For the Autobott humidity will tend to be a bit higher so cucumbers, tomatoes and peppers will be perfect options when humidity becomes difficult to control. Humidity is also affected by temperature, as temperature increases so does the amount of moisture that the air can contain, so controlling the air temperature will assist in controlling humidity. This will help reduce chances of mold and mildew as well since the moisture wont be still for extended periods. Most humidity sensors are capacitive and as the voltage across the plates change due to moisture collecting then the signal sent to the microprocessor changes.

The function of the temperature and humidity sensor is to allow the hydroponic system to have knowledge about how hot or cold it is, as well as how much water is in the air. These pieces of information are vital to a plant's growth. As previously mentioned, the sensor is very small and will be placed below the light and around the plant canopy to ensure that the readings are accurate for the immediate surrounding area. The chosen sensor is the DHT11 Temperature and Humidity Sensor, which feature a calibrated digital signal output.

G. HVAC System

To cool the Autobott a strong exhaust fan will be used to expel the warm air inside and bring in cooler air from the room it is in. The air will be brought in through the lower portion of the grow chamber through a backdraft damper. Hot air that builds up inside the cabinet will tend to rise towards the top, this is also where the light, the main source of heat is located. The exhaust fan will be placed towards the top of the enclosure expelling the heat up and out. This fan must also generate enough pressure to open the backdraft dampers to pull the air in.

Movement of air is measured in cubic feet per minute, or CFM. Most fans are also rated with a CFM allowing the user to determine if the fan is strong enough for their needs. in our case and from research from other grow rooms, we decided that the cabinet should circulate the air inside three times every minute. To calculate we determined the volume of our grow chamber, rounded up to be 32 cubic feet, then multiply by 3 since we want to move 32 cubic feet 3 times, resulting in 96. Now we want to move 96 cubic feet of air every minute so a fan rated at 96 CFM will be needed. However, this number does not take into account air resistance encountered from the backdraft dampers or obstacles such as the plant growing inside or any air filters in the intake and exhaust. Considering these variables, a 50% increase to 140 CFM was decided.

Axial, squirrel cage, and inline are the three types of exhaust fans available for our cabinet. Axial fans are traditional fan blades that spin on an axel. They are small and very quiet however most that fit our design size are too weak, ranging from the low 60CFM up to 110 CFM. To achieve a higher cfm, several axial fans must be stacked in series with each other to increase CFM, or increase the total size of the fan, which is not an option for our cabinet size. Squirrel cage fans, or centrifugal fans, are shaped like a squirrel tail with an intake and exhaust. These fans pull in air through the circular intake, which is then pushed and expelled by multiple blades along the wheel. Squirrel cage fans range from small CPU fans up to 800+ CFM for grow rooms. These fans while very efficient tend to be very loud for their size and CFM rating.

Inline fans are the fans of choice for many grow rooms and cabinets. Their circular tunnel design allows air to enter through one end and exit the other with very low noise during operation. These fans can also be connected in series with ducting to guide airflow in the desired direction as well as air filters to filter out unwanted particles. For our calculated rating of 140 CFM, a 4 inch flange inline fan is the perfect choice. This also gives us extra power if we decide to include the filter in our final design. Figure 3 shows an inline fan, rated at 120-150CFM, which the Autobott will utilize, and it will be located towards the top, to expel warm air and keep the growing chamber cool.

Fig. 3. Inline fan rated at 150 CFM. This is the fan installed in the Autobott

H. Lights

The device that consumes the most power in the Autobott is the light, which is why the most energy efficient light must be selected. Indoor gardens today use fluorescent, High intensity discharge (HID), High pressure sodium (HPS) or LED lights to grow their plants. Depending on the system, budget, environment and also which part of the plant cycle the plant is in different lights can be used. Efficiency is measure in lumens per watt and foot print of the light is measured in lumens per square feet. We will be aiming for about 4000-5000 lumens per square feet, which will provide optimal coverage to the plant

With the Autobott's dimensions, T5 grow lights would seem to be the fluorescent light of choice. According to BHG, they are also the most efficient and effective Fluorescent grow light on the market right now, measuring at a tube diameter of 5/8 of an inch. [1] These tubes are placed inside a reflective casing where they are lined up and mounted inside. These casings come in a variety of sizes to accommodate different grow room configurations. Since the bulbs are all lined in parallel, if one were to fail, the entire fixture will continue to function. They give off very little heat, operating at around 95 degrees Fahrenheit when on, and are long lasting, up to 20,000 hours of light. Cooling the lights requires circulating fans blowing away the hot air from the lamps. T5 fixtures do not come enclosed so the heat released it expelled into the grow environment, the aluminum metal fixture also helps dissipate the heat.

They also simulate the spectrum of natural sunlight, with 6500 K T5 lamps simulating white light and 3000 K T5 lamps simulating warmer orange light. During the plant vegetative stage the cooler 6500 K lamps will be used and in the mature plant phase or flowering phase the warm 3000 K lamps will be used. Grow rooms often use T5 lamps to supplement other sources, for example a greenhouse would supplement light using the T5 bulbs if it were a cloudy day. Most T5 fluorescent lights available today have an efficiency of 100 lumens per watt. Since the Autobott has a 3 feet by 2 feet growing area, if we wanted about 5000 lumens per square feet(30,000 total) we would need to use 300 Watts worth of T5 lighting.

Metal halide (MH) high intensity discharge lamps produce light by passing current through a glass tube filled with gas to emit an intense light up to 125 lumens per watt. This light is a bright white color, due to the mixture of gas inside the tube, and is on the blue end of the light spectrum, around 450nanometers – 460nanometers, which triggers the plant to produce more compact leafy growth and would be the light of choice when the plant is in it vegetative stage. Better Homes and Gardens provides a formula to determine how much wattage is needed to cover a certain square footage. Using a 1000-Watt bulb as an example, they recommend 20-40 watts per square foot, and concluded that this 1000-Watt bulb can illuminate 25-50 square feet of floor space. For more sensitive plants we may decide to use the lower end of 20 watts per square foot, to assure the plant is not stressed by the intensity or heat from the light, which metal halide bulbs can emit up to 600 degrees Fahrenheit. Recommended distance from plants is between 6 inches to 10 inches. With a lifespan of around 10,000 hours, and leaving the light on for 12 hours a day, metal halide bulbs will last 2.5 years or more.

High Pressure Sodium (HPS) lamps produce light exactly the same as metal halides but using a mixture of different gasses, and are slightly more efficient at 140 lumens per watt. High pressure sodium lamps fall into the high intensity discharge category and are used for street lights, outdoor lighting, and indoor grow light. The bulb emits a reddish orange light, 630 nanometers to 650 nanometers, which is ideal for the fruiting and flowering phase of plants. These bulbs also reach temperatures of around 500 degrees Fahrenheit and can be kept closer to the plants canopy with a recommended distance of 4 inches to 6 inches. With a lifespan of around 20,000 hours, and leaving the light on for 12 hours a day, high pressure sodium bulbs will last 4.5 years or more.

When a high intensity discharge bulb is turned on, current passes through the gasses inside the tube emitting light and the bulb can take several minutes to warm up and reach maximum power. In order to initially turn on, a very high voltage spike is needed to spark the contents in the glass tubes, and once on the current and voltage must be maintained and regulated. HID electrical Ballasts are AC-DC converters that increase voltage during the lights ignition phase, and also regulates the voltage and current to provide consistent output power. Initial spark voltages depend on if the light is being activated when it is cool or warm. Lights will be on 12 hours at a time in an indoor garden; by the time the light turns on again it is cool, requiring 3000 Volts to 5000 Volts depending on the type of HID bulb. Warm-up times can be as long as 6 minutes and once running the ballast will keep all values consistent for the bulb.

Low power, very little heat, and effective spectrums, LED lights are the newest and potentially best option for grow lights. Small LED diodes, typically 3 Watts each, cover board and are angled downward to provide the plants with high intensity light. The LED diodes range from blue to red to ultraviolet light to provide a broad spectrum the plant needs. The lens angle also determines the footprint of the light, with lower angles like 30 degrees focusing the light straight down, and wider angles up to 90 degrees to spread out the light. A typical LED grow light spectrum focuses mainly on blues; which promote vegetative growth, and reds; which promote flowing or fruiting.

The light of choice for the Autobott is the 300Watt (180 actual watt) LED grow panel light from mars hydro. This is a full spectrum grow light and will be used from start to finish. It consists of 100, 3 watt led diodes ranging in full spectrum. This light covers a footprint of 7.5 square feet, which is perfect coverage for our growing chamber. The LED lenses are angled at 90 degrees, which helps in the distribution of light for the footprint. Built in PC fans help keep the already low temperature grow light cool. operating with minimum noise. it is recommended to test the light for 24 hours to ensure proper function and that each LED diode is illuminated. Figure 4 shows the MarsHydro 300 watt LED grow panel light.

Fig. 4. Mars Hydro 300 Watt LED grow light (90 degree lens angle)

I. Microcontroller

The microcontroller is the central processing hub for the entire cabinet. Because the cabinet uses many sensors, many different aspects must be considered. The power consumption, clock rate, memory, pin count, and analog to digital pin count are heavily considered in deciding which microcontroller to use.

The ATMega328 is made by Atmel and is an 8-bit RISC based microcontroller. The ATMega328 microprocessor is used in the Arduino Uno development board, which includes sensor testing. This microprocessor contains 32KB of flash memory, operates at 20MHz, has 2KB of RAM and contains a maximum of 23 I/O pins. The operating voltage is slightly higher than the MSP430 boards, ranging from 1.8V to 5V DC. The main communication interfaces used by the ATMega328 are Asynchronous Serial Receiver and Transmitter (USART), Two-wire Serial Interface (TWI), and the SPI.

The ATMega2560 is another development board created by Atmel and is similar to the ATMega328. Even though the ATMega2560 is a more powerful microprocessor than the ATMega328, it operates at a lower frequency of 16MHz compared to the other's 20MHz. Despite this, the rest of the specifications are rated higher on the 2560. This microprocessor has 256KB of flash memory. This is eight times larger than the 328's flash memory size. This is the microcontroller we chose to use in out system.

J. Power

The Autobott will be connected to a home outlet at all times, which will power the lights, fans, pumps, sensors and MCU. The LED light, HVAC fan and water/air pumps will be powered directly from the outlet, being triggered on or off through relays controlled by the MCU, while the AC voltage from the outlet will need to be transformed to DC and regulated to lower voltages for the printed circuit board. The last socket is "Always on" and will be the one we use to power the PCB. Once regulated, other integrated circuits within the PCB use this voltage to regulate the voltage for other components.

The 12V from the power supply will be used as a main power supply and branch out to other regulated voltages. We will use this 12V rail but also need 3.3V power supply for the microcontroller and electric conductivity circuit, and 5V power supplies for the temperature sensor and pH circuit and wifi module. From the same 12V rail, we designed a regulator circuit to output 5 Volts to power the temperature sensor, pH circuit and drive the relays.

K. Wifi Module.

We have chosen the HLK-RM04 module. This module has many uses and is capable of many WiFi options. We are simply using it as a serial to WiFi client. We can do this by connecting it to a WiFi access point, with our given credentials (SSID and password for that specific network) and simply importing HTML tags into the code and use a HTTP 1.1 protocol to transmit to local machine. This module is also relatively low cost, at only $10 minus shipping and handling.

IV. Software Design

Of the two microprocessor coding environments, Code Composer Studio and Arduino IDE, Arduino IDE was chosen for this project. TI boards do not support Wi-Fi modules as easily as Arduino based PCBs. The Arduino IDE contains more features as well as an infinite coding space compared to the free version of CCS, and is also open source which means there are extensive amounts of libraries that are relevant to the use of the Autobott. Another advantage of Arduino IDE over CCS is that it is object-oriented, basing its code from C++. CCS uses either C or Assembly language, which limits functionality and is harder to code for.

The system starts when the Autobott is powered on. Once on, the initial start up processes begin. Power is sent to all active components such as the water pump, nutrients and pH pumps, and any LEDs to show the initial status of the system. The next step of this phase includes checking the EC levels of the water before nutrients are added. This will ensure for more accurate readings once different EC readings need to be obtained once the plants are added. Finally, all the Wi-Fi settings are configured so that it may automatically connect to a network on start up. Settings include the SSID, passphrase, and connection type (WEP, WPA, WPA-2).

After the setup state, the system will attempt to ping the server to verify its connection. If the server responds that the ping is successful, the hardcoded values stored in system memory are loaded. If not, the power LED for the Wi-Fi module is turned off to show that the connection was unsuccessful. The hardcoded values include threshold values for all sensor readings. They are stored as variables and can be edited through input via the website. If the user chooses a specific plant, they will already have pre-loaded values for all the sensor readings. If the user does not input any values, the loaded ones are transmitted to the system for use in the sensor checks.

Once the system is turned on and the setup is complete, it goes into an idle state. From the idle state a request can be given from the server or the system can begin sensor testing. Requests from the web server include creating new test values for the sensors and changing which plant is being grown. After the sensor testing is finished, the data is sent back to the system, which then continues to remain idle until another test begins or another request from the server is made.

The web server chosen for the project was Apache HTTP server. It was chosen because of the initial design decision to use an SQL database and having prior experience with PHP. Even though there was mild familiarity with a MEAN stack, group members did not feel comfortable enough with the technologies to complete the project using one. The use of these technologies ensures that the webpages are relatively static, with only the sensor values and plant types changing.

To ensure that the user knows whether the cabinet is functioning properly or not, the user may be notified of a potential problem with the system through connection loss. When the server is idle, it doesn't receive any signals. When it is idle for forty-five minutes without receiving a request, the server notifies the user that the cabinet may have lost connection or another problem has occurred.

V. Conclusion

The Autobott is a wonderful product to own if say the geographic living conditions are not suitable for an outside garden. This product will allow the user to grow almost anything inside the enclosure and give positive results. The Autobott can be used for produce, flowers, or any assortments that are desirable. The physical enclosure design targets what looks like a piece of furniture to suit even the residential households. With the growth and future of this product, more designs are sure to come with a more modern look, pertaining to many different stereotypes. All in all, the system does the same thing just looks different. The fully automated indoor hydroponics smart garden is the future with resources being more limited and water scarce. In conclusion, the full design of this product is one of high tech and the future of gardening.

The Engineers

David Rooney is a Computer Engineer Major out of the University of Central Florida. David has experience in software and programming languages, where he codes small scripts for personal use and enjoys programming innovative applications. Through David's college education, he landed a co-op with IBM as a Hardware/Software Engineer and later signed a full-time employment contract with IBM as a Software Engineer, graduation pending.

Eric Velazquez is an Eletrical Engineer Major graduating from University of Central Florida. He is Currently employed with Apple and has experience in power systems, control systems, and PCB design. Eric plans to continue his career in engineering with Apple.

Steven Lo is a graduating Computer Engineering student from Merritt Island, Florida. He hopes to get a full time position as a Software Engineer after graduation. Other plans include co-hosting national video game events and traveling the world to meet extended family.

Antonio Orosa is a Florida native, born and raised in Palm Beach. He is graduating from university of Central Florida with a B.S. in Electrical Engineering and a minor in Business Administration. He is interested in many fields including clean power generation and wireless networks, and aims to land a full time position after graduation.

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References

[1] Better Homes and Gardens, Ellen Zachos. Choosing Plant GrowLights. http://www.bhg.com/gardening/houseplants/care/choosing-plant-grow-lights/

[2] Chris Woodford. pH Meters. 6 Aug. 2014 http://www.explainthatstuff.com/how-ph-meters-work.html