ECE 445: Proposal

Climate Control Grow Box

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Introduction

Problem

Many houseplants struggle to survive due to improper climate conditions, with factors like cold winter temperatures, humidity levels, lighting, and water availability all contribute to a plant's continued survival. Existing climate control solutions are designed for large areas, such as entire rooms or whole homes, forcing plant owners to share the same environmental conditions as their plants. These solutions lack the ability to create small, isolated climate zones suited for specific plants with unique needs particularly there is a lack of a targeted climate control system that allows individuals to maintain ideal conditions for a select few plants in a residential building where space is at a premium.

This system is different from similar devices on the market since it is an all in one kit, everything is in one location. The goal is for it to be designed for casual use by the general population, without many complicated features. As well as its smaller design.

Solution

Our solution is to create a climate control grow box that has the ability to control the humidity, light, and airflow. This would allow us to control these variables as necessary to create an environment suited for a house plant. We will do this using different sensor inputs and a STM32 or similar board, which will control the individual subsystems.

Visual Aids

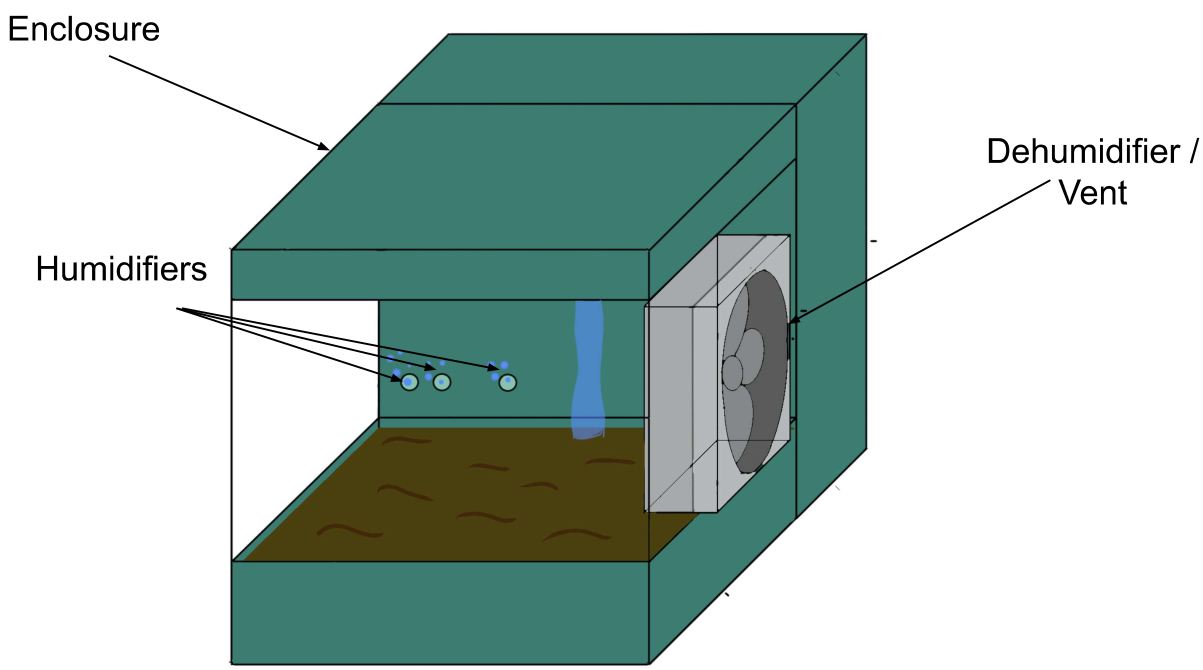


Figure 1: Visual of major components of Grow Box

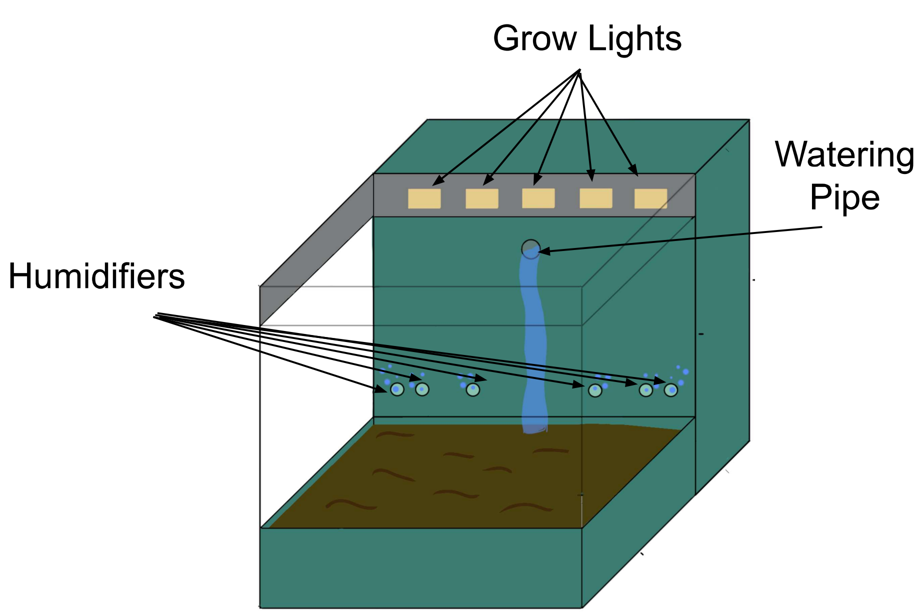


Figure 2: Visual of major components of Grow Box (Cross section)

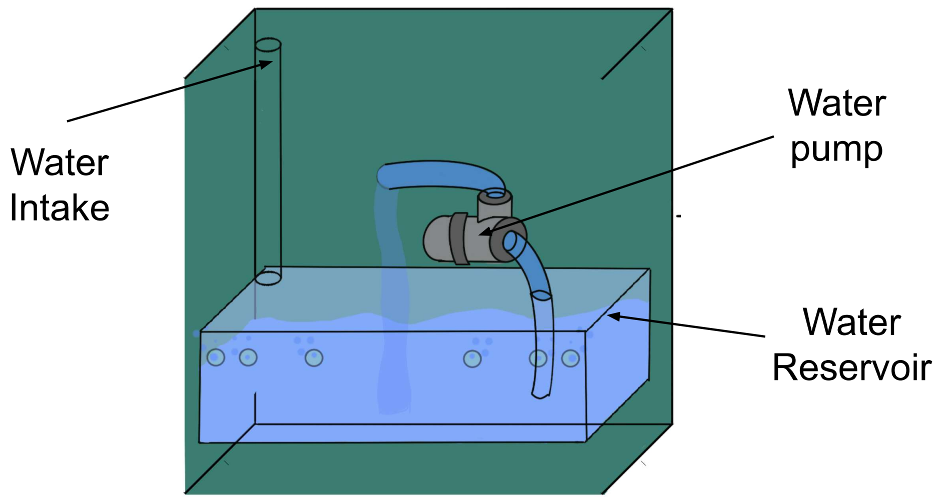


Figure 3: Visual of hidden components of Grow Box

High Level Requirements List

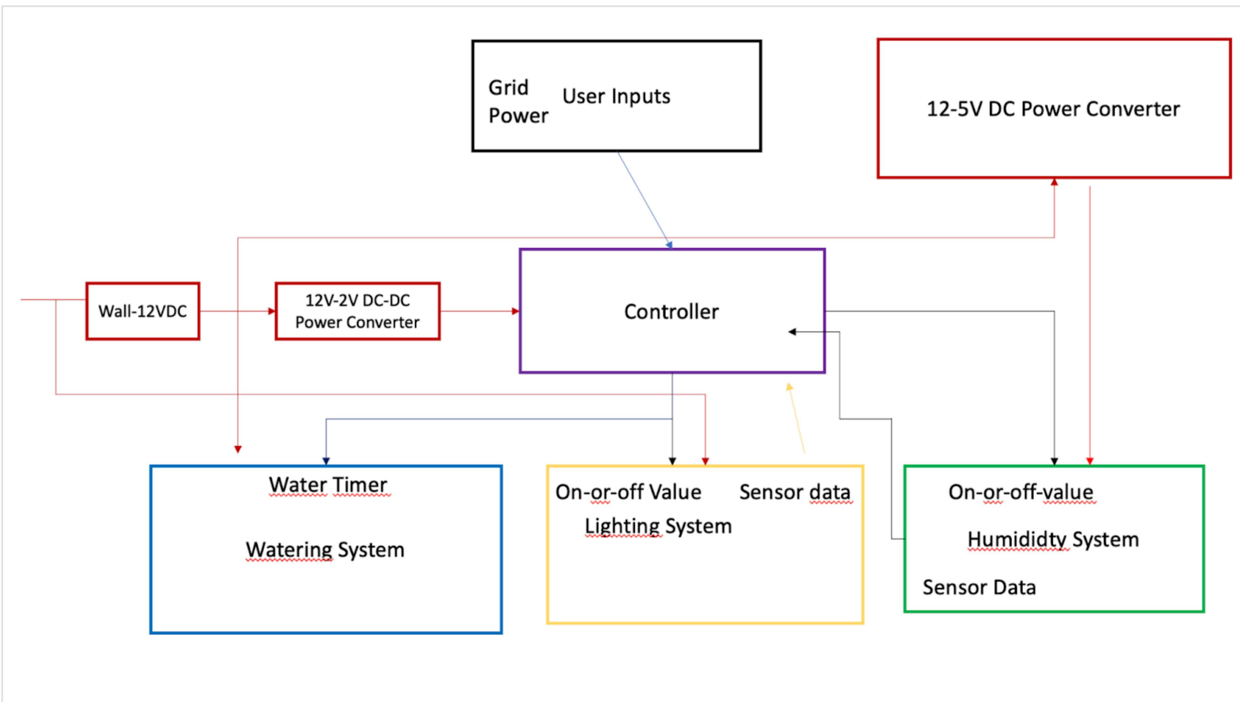
Accuracy: Our first requirement would be a high level of accuracy for our control systems. The humidity should maintain within a set tolerance of +- 2% in within the acceptable range of +-10% the exterior humidity. The water dispensed should be in increments of ¼ cups and be accurate within +-10g.

Ease of use: Our second requirement is that the product must be easily movable and thus must weight less than 15 lbs without soil or water and have a design that allows for one person to move it

Responsivity: When a new climate is chosen by the user the system should respond within less than five seconds. Additionally the sensors should detect the current environment every three minutes and begin to respond accordingly to the Changes, these responses should also respond in less than five seconds.

Design

Block Diagram



Subsystem Overview

<u>Humidity Control Subsystem</u>

The humidity control subsystem is responsible for monitoring and regulating the humidity levels within the enclosure. It reads in the current humidity from the sensor within the enclosure and the input humidity option chosen and with help of our microprocessor determines if the humidity is too low or too high or if it is within the acceptable tolerance range of the input. If it is too low or too high, this subsystem is also responsible for starting a humidifier or dehumidifier vent respectively until the current humidity is within tolerance. It is reliant on the power control subsystem to supply the needed power to its components and receives water for the humidifier from the water subsystem.

<u>Light Control Subsystem</u>

The light control subsystem is responsible for the lighting levels within the enclosure. Using light diodes of differing strength we will be able to tell if the light level in the enclosure is at or above the light level selected by the user. If the light level is below the desired level this system is responsible to detect the light level and pass the information to the microprocessor and will trigger the lights at the top of the enclosure to be lit or dimmed respectively as is needed to respond to external stimuli.

Water Subsystem

This system will be controlled to release a ¼ cup water after a certain interval of time. It will include a tank for water which is external to the rest of the system as well as a tube and pump to relocate the water. The control system will control the times in which the pump is on and pumping water.

Control Subsystem

This system will accept values given in from the user from the system's buttons/switches. These will then be converted into reference values for the rest of the system or to timing devices. This system will compare the reference values that were generated from the user inputs for both the lighting and humidity system to the sensor values to create the control signals. This system will also operate the timer control for the watering system as well as generate the q(t) control for the power systems. This system will be run through the microcontroller and require inputs from a variety of sensor systems.

Power Subsystem

The Grow box is meant to be a stand alone system that requires little maintenance. Due to this fact we will be connecting the system to the grid(or wall power) to run it. The lighting system needs to operate at 110-140V of alternating current so this system's power will be hooked directly to the grid. To power the rest of the systems we will need a 5V DC line, 3V Dc line, and a 12V DC line.

We will use a DC-DC buck converter to generate the 5V and 3 V from the 12V system. These two systems will draw from the power provided by the 12V adapter.

Subsystem Requirements

<u>Humidity Control Subsystem</u>

Requirement	Verification
If the humidity is lower than what it needs to be then a small humidifier will receive water from the water subsystem and increase the humidity	We can test to see if it works by taking the humidity at a certain time, increasing the humidity input, then checking to see if the humidity in the tent increased
If the humidity is higher than what it needs to be then a dehumidifier vent will be used to decrease the humidity	We can test to see if it works by taking the humidity at a certain time, decreasing the humidity input, then checking to see if the humidity in the tent decreased

<u>Light Control Subsystem</u>

Requirement	Verification
If the light is higher than the light level desired, the light should be decreased using by using the microprocessor to trigger the light diodes to be dimmed	We can test this by taking the light level, decreasing the light level input, and checking to see if the microprocessor received the signal and if the diodes dimmed
If the light is lower than the light level desired, the light should be increased using by using the microprocessor to trigger the light diodes to be raised	We can test this by taking the light level, increasing the light level input, and checking to see if the microprocessor received the signal and if the diodes got brighter

Watering Subsystem

Requirement	Verification
Must be able to accurately dispense water using timed dispension in ¼ cup intervals up to dispensing the entire reservoir	We can test and weight the dispensed water with varying amounts of water to be dispensed
Must be able to stop when notified that the proper amount of water has been dispensed. There should be minimal latency between the signal and the end of water being dispensed	We can create test cases when programming the microcontroller to verify that the pump stops dispensing water within 10ms delay

Control Subsystem

Requirement	Verification
Must be able to create the control variables for humidity and light	Test to see if the user inputs are being stored accurately and see if the signals are getting through to the sensors
Must be able to operate timer control for the water subsystem	Test to see if the water being dispensed is the correct amount

Power Subsystem

Requirement	Verification
12V-5V DC-DC Buck	We can test this with a voltmeter in the lab. We will know it's not working if the system fails to turn on or something starts on fire. There will also need to be testing to ensure the current does not exceed 25mA. There is a chance that we could be able to use the control chip to generate the needed power.
12V-2V DC-DC Buck	We can test this with a voltmeter in the lab. We will know it's not working if the system fails to turn on or something starts

	on fire. There will also need to be testing to ensure the current does not exceed 25mA.

Tolerance Analysis

Power system

The adapter we will be using has a 120W limit and a current rating of 10A.

The first concern arises from the current limit.

The humidity devices use around 300mA, and we will use six of them, which leads to a total of 1.2A. Both the controller and humidity device will use at most a combined 2A, and the fan will use up to 5A of current. This is below the max limit of 10A being drawn with a total draw of about 8.2A and 98.4 W. This leaves some elbow room for other components.

Humidity

We plan to have a volume of 2 cubic feet or roughly 0.0566337 cubic meters for the plant enclosure. GIven the average room temperature of 72° Fahrenheit (20° Celsius). This temperature has a saturation point of 2.34 kPa.

To calculate Relative Humidity (RH) from Absolute Humidity (AH) and temperature, use the formulas:

$$RH = (AH / \text{Saturation Vapor Pressure at given temperature}) \times 100$$

$$\text{Absolute Humidity [AH] } (g/m^3) = (\text{Mass of Water Vapor } (g) / \text{Volume of Air } (m^3))$$

where "Saturation Vapor Pressure" is the maximum amount of water vapor the air can hold at a specific temperature, and is typically found using a table or a formula based on temperature.

Our humidifiers can atomize water at a rate of 40-50 ml/h and with six of them active at once that provides approximately 240-300 g/hr of water being added to the air or 4-5 g/minute

$$40\text{-}50 \text{ ml/h} * 6 = 240\text{-}300\text{ml/hr} = 240\text{-}300 \text{ g/hr} = 4\text{-}5 \text{ g/m}$$

On the lower bound of 4g/m

$$\Delta AH = 4 \text{ (g/min)} /0.0566337 \text{ (m}^3\text{)} = 70.629 \text{ ((g/m}^3\text{)/min)}$$

We can find the change relative humidity per minute by

$$\Delta RH = (\Delta AH/\text{Saturation Vapor Pressure })*100$$

$$= (70.629/ 781.95730806)*100$$

$$= 9.032 \text{ humidity \%/m}$$

With a volume of 0.0566 cubic meters to increase the humidity level within the enclosure 10% it would take approximately 1.107 minutes.

<u>Ethics and safety</u>

- We will make sure to use a water tight container for the watering system and maintain physical distance between so as to not disrupt or harm the system.
- No one will be testing in the lab alone
- Prior to entering the lab we will remove bio materials from the grow box.
- Plants grown during testing will be legal and non-invasive species following general ethics

Refrences:

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[2] “Amazon.com: ATIMOSOS 1PC Wired DHT22/AM2302 Digital Temperature and Humidity Sensor AM2302 : Appliances,” *Amazon.com*, 2025. https://www.amazon.com/ATIMOSOS-AM2302-Digital-Temperature-Humidity/dp/B073TW7V1T?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=AXI6THZLFAC34&gQT=1 (accessed Feb. 13, 2025).

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[4]“Product documentation portal,” *Vaisala.com*, 2025. https://docs.vaisala.com/r/M211280EN-D/en-US/GUID-BF3EEF1B-ECEF-4B2C-AB1C-5F7DD642D24C (accessed Feb. 13, 2025).

[5]“Arm®Cortex®-M0+ 32-bit MCU,” *st.com*. https://www.st.com/resource/en/datasheet/dm01085881.pdf

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