Design and Implementation of Low-Cost Plants Growth Chamber with IoT Monitoring

B.Sc. ELECTRICAL ENGINEERING

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Session: 2020 – 2024

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DECLARATION

This statement report is an arrangement of our creative study task. Moreover, additions of other peoples are elaborate, every determination is made to empower this clearly, with due reference to the literature, and acknowledgment of combined research and discussions. We also assure you that this work is the output of our research, except was identified by references and free from plagiarism of the work of other people.

Signature:

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Date: …………

RESEARCH COMPLETION CERTIFICATE

It is certified that the research work contained in this dissertation titled **"Design and Implementation of Low-Cost Plants Growth Chamber with IoT Monitoring"** has been investigated and carried out by Muneeb Ahmad, Nasir Mehmood, Akif Saleem for the degree of Bachelor of Science in Electrical Engineering.

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ACKNOWLEDGEMENTS

In the name of God, who is most beneficial and most merciful.

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Thank you,

Muneeb Ahmad

Nasir Mehmood

Akif Saleem

DEDICATION

We dedicate this work to our last prophet Holy Prophet Muhammad (Peace Be Upon Him), my great hero and messenger of Allah Almighty. One of the most influential person, that humanity has ever witnessed.

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LIST OF ACRONYMS

CAD: Computer Aided Design

CO_2: Carbon dioxide

IoT: Internet of Things

LCD: Crystal Display

NH3: Ammonia

PAR: Photosynthetically Active Radiation

PWM: Pulse Width Modulation

RFID: Radio Frequency Identification

UV: Ultra Violet

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ABSTRACT

The thesis presents a plant growth chamber designed to regulate environmental factors vital for optimal plant growth using advanced technology. This chamber, serving as a controlled environment, ensures plants receive specific conditions necessary for consistent and superior cultivation outcomes.

Its significance spans agricultural research, biotechnology. By providing a controlled environment, researchers can study plant responses under diverse conditions, experiment with new crop varieties, and address global challenges such as food security and sustainability.

The incorporation of Internet of Things (IoT) technology is central to the chamber's design. It integrates advanced sensors like the DHT22 for temperature and humidity monitoring, resistive soil moisture sensors, and the MQ-135 for carbon dioxide levels. These sensors enable real-time data acquisition and feedback for precise control over crucial environmental parameters.

To regulate temperature, a Peltier module and heating bulb simulate and control variations, facilitated by an IoT-based system for remote monitoring and control. A microcontroller interprets sensor data, facilitating communication and adjustments through a user-friendly interface. This closed-loop control system ensures real-time adaptation to plant needs.

This methodology maintains a balance between precision and adaptability, advancing precision agriculture and offering new possibilities for data-driven insights and remote management. The chamber's applications range from agricultural research to biotechnology, promising precise plant cultivation and laying the groundwork for a more connected and efficient approach to cultivation.

CHAPTER 1

1.1 Introduction:

Plant growth chambers, often referred to as environmental or climatic chambers, play a pivotal role in scientific research, education, and commercial applications [1]. These specialized devices provide a controlled environment to study the effects of specific conditions on various subjects, ranging from microelectronics and industrial products to biological samples [2]. The conventional use of environmental chambers has primarily centered around reliability testing, exposing materials to amplified and accelerated damaging processes, such as erosion, pressure extremes, humidity variations, thermal shocks, vibrations, corrosive agents, and UV light [3]. Moreover, these chambers have found applications in atmospheric chemistry studies and simulations of extraterrestrial environments, showcasing their versatility.

While environmental chambers have proven instrumental in diverse fields, the focus shifts to a specific subset known as plant growth chambers in this project. This subcategory, often referred to as environmental chambers or Fitotrons, is tailored for experimental plant biology research and horticultural endeavors [4]. However, the inherent limitations of conventional Fitotrons, characterized by their large size and high cost, have hindered their accessibility. This challenge has prompted the emergence of a project aimed at designing an innovative plant growth chamber, addressing the gap in affordable and accessible solutions for plant enthusiasts and semi-professionals [5].

The primary purpose of this proposed device is to democratize access to advanced plant growth environments, breaking down barriers for individuals lacking the technical expertise to design and construct specialized setups [6]. Rooted in practical horticultural experiences, the project strives to inspire and popularize scientific and nature interests, particularly among the youth. Beyond individual enrichment, the broader vision encompasses contributing to nature preservation and conservation efforts, emphasizing the pivotal role of ex situ cultivation in safeguarding vulnerable plant species.

The introduction of a low-cost plant growth chamber aligns seamlessly with the overarching mission of fostering nature preservation and conservation projects. By making these plant growth chambers accessible and affordable, the project envisions contributing to the preservation of fragile and precious plant species while engaging a broader audience in scientific and nature-related pursuits [7]. This inclusive approach seeks to bridge the gap between professional and non-professional plant enthusiasts, opening up possibilities for wider participation in plant research and conservation initiatives [8].

As the paper unfolds, it will delve into the intricacies of designing and constructing the proposed plant growth chamber. This journey involves addressing challenges, outlining innovative solutions, and contributing to the evolution of controlled environment agriculture. The narrative will explore both the technical aspects of chamber construction and the broader implications of democratizing access to advanced plant growth environments [9]. The subsequent sections will illuminate the integration of Internet of Things (IoT) technology, hardware updates, and the extensive testing protocols employed to ensure the efficacy of the designed system [10].

One crucial aspect of this project involves not only providing affordable plant growth chambers but also making them technologically advanced. The integration of IoT technology represents a significant leap forward, allowing remote monitoring and control of the growth environment. This shift toward smart plant growth chambers introduces a layer of innovation that aligns with contemporary technological trends [11]. The narrative will unravel the strategic decisions behind hardware updates, the selection of appropriate sensors, and the careful testing protocols implemented to ensure the seamless functioning of the IoT-enabled system [12].

The journey of democratizing plant growth chambers encompasses addressing market challenges and exploring the potential impact on both individual users and broader conservation initiatives. The paper aims to provide a comprehensive understanding of the project's goals, methodologies, and outcomes. By sharing insights into the design and implementation process, the narrative seeks to inspire future endeavors in the realm of controlled environment agriculture and foster a community-driven approach to plant research and conservation [13]. In essence, this project represents a significant step toward making advanced plant growth environments accessible to all, contributing to a more inclusive and sustainable future in plant science and horticulture.

1.2 Problem Statement:

Problem: Commercial plant growth chambers are expensive and difficult to operate, which makes them out of reach for many consumers, researchers, and plant enthusiasts. Additionally, many commercial growth chambers are not designed to be easily modified or customized, limiting their flexibility and usefulness for specific applications.

Solution: Develop a new type of plant growth chamber that is more affordable, accessible, and customizable than commercial growth chambers. This new growth chamber should be able to meet the needs of a wide range of users, including, but not limited to, researchers, hobbyists, and commercial growers.

1.3 Project Goal/Objectives:

The goal of this project is to design and build a smart plant growth chamber. A smart plant growth chamber is a controlled environment chamber that uses sensors and actuators to monitor and control the environmental conditions inside the chamber. This allows for the creation of an optimal environment for plant growth and development, regardless of the climate outside. The main goals of this project are to:

- Design and build a smart plant growth chamber that is affordable, easy to use, and effective.

- Develop a control system for the smart plant growth chamber that can maintain the desired environmental conditions inside the chamber.

- Demonstrate the effectiveness of the smart plant growth chamber by growing a variety of plants under different environmental conditions.

CHAPTER 2

2.1 Literature Review:

Smart plant growth chambers use sensors and actuators to monitor and control the environmental conditions inside the chamber automatically [1]. Plant growth chambers are enclosed chambers that provide a controlled environment for the growth of plants. They are typically used in research, education, and commercial settings. Plant growth chambers allow researchers to study the effects of different environmental factors on plant growth and development, educators to teach students about plant physiology and ecology, and commercial growers to produce high quality plants year-round [2]. Traditional plant growth chambers are typically controlled manually. This can be time-consuming and labor-intensive, and it can be difficult to maintain consistent environmental conditions This allows for the creation of an optimal environment for plant growth and development, regardless of the climate outside. Smart plant growth chambers are still a relatively new technology, but they have the potential to revolutionize the way that plants are grown and produced [3]. Here is a brief overview of some of the latest research on smart plant growth chambers: A recent study by Singh showed that a smart plant growth chamber could be used to produce high-quality lettuce plants using 95% less water than traditional farming methods [4]. A third study by Patel showed that a smart plant growth chamber could be made using off the shelf components [5]. Another study by Miller showed that a smart plant growth chamber could be used to produce tomatoes with 20% higher yields and 30% less pesticide use than traditional farming methods [6]. These studies demonstrate the potential of smart plant growth chambers to improve the efficiency and sustainability of plant production. Smart plant growth chambers can also be used to produce high-quality plants in areas with limited arable land or unfavorable climates. In addition to the research cited above, there are a number of companies that are developing and commercializing smart plant growth chambers.

These companies are offering smart plant growth chambers for a variety of applications, including research, education, and commercial plant production. The development of smart plant growth chambers is a significant step forward in the field of controlled environment agriculture. Smart plant growth chambers have the potential to revolutionize the way that plants are grown and produced, making it possible to produce high-quality plants more efficiently and sustainably.

2.1.1 Internet of Things (IoT):

The idea of smart farming is getting popular, mainly because IOT sensors can give a lot of info about fields and respond to what users want. In this paper, we're focusing on making a system that keeps an eye on parameters like temperature, water levels, moisture, and any movements in the field that could harm crops. We're using sensors connected to an Arduino UNO board to make this happen.

The main thing in this study is bringing together new technologies, especially IOT and smart farming through automation. The project aims to keep up with the changes in tech and the needs of farming. So, we're planning to update both the hardware and software as things evolve.

When it comes to hardware, the paper talks about making regular updates, and these updates are like creating a new version of the software. It's not just about keeping up with new technology; it is about being ready for what farming needs. But with every update, there is a crucial step which is testing. Testing is very important to check if the new hardware works smoothly with the existing software. This careful testing makes sure that the changes in the new version do what they're supposed to do without causing problems or bugs in other parts of the software.

This careful approach is essential because any changes in one part of the hardware can affect the whole system. So, testing everything thoroughly is like a safety check, making sure the updated system works well in the complex world of smart farming technologies.

We are using Blynk application for the remote monitoring of parameters like temperature, humidity, soil moisture and carbon-dioxide levels.

2.1.2 Plants Growth Chamber:

Plant growth chamber are very important for studying plants, helping make sure observations are consistent. [3] They control things like temperature, humidity, and light cycles really precisely. But, they're expensive, and that can make it tough to decide how big and doable your experiments can be. [13] So, to tackle this money problem, we made a low-cost plant growth room.

We also got a portable air conditioner for good cooling and a water mister to crank up the humidity. Inside the room [14], we kept a close eye on temperature, humidity, and light cycle using a z-wave home automation system. This system let us control things from afar and tweak settings online. [15]

In our tests, we optimized the temperature control and kept humidity levels just right. Additionaly, the results from our chamber were as good as what you'd get from a expensive commercial one. So, our budget-friendly plant growth room could open up a lot more chances for research in plant biology. It's like a way for folks to get into the game without breaking the bank, making plant research more accessible and exciting for everyone.

2.2 Research Gap:

Through the review of research papers, we are providing a low cost but effective plants growth chamber which will meet the markets need. As it has the same attributes like the previous chambers have but it is also cost effective. The main prospect of this chamber is that it has IoT in its features through which we can check the environment of the plant on internet at any place and at any time.

In the world of farming, there's a thing called plant growth chambers. These are like special chambers where scientists can control parameters like temperature, humidity, and light to make plants grow in different ways. It's super helpful for studying how plants behave and respond to their surroundings. Conventional growth chambers usually don't use the latest technology like the Internet of Things (IoT), which is all about smart and connected devices.

We are starting to use IoT in these plant rooms to make them even more reliable. With IoT, you can keep an eye on the plants in real-time and control things from far away. Not many people have looked into making these high-technology plant chambers affordable for everyone, especially when you want to connect lots of them together.

If we take a look at what others have written about this, we see there is not much out there about making these plant rooms cheap and smart with IoT. That is where our project comes in. We want to dive into making plant growth chamber that don't cost a ton but still have IoT features.

This could change how we do farming, making it more efficient and helping us grow food smarter. With our project, we're trying to make these smart plant chamber something that anyone – even people with fewer resources – can use. Imagine farmers or researchers being able to check on and control their plants from anywhere, making farming better for everyone.

So, in simple terms, our project is all about making plant growth chamber that are both cost effective and effecient due to IoT. We are doing it to make a real difference in how we grow our food and take care of our plants.

Now we are using MQ 135 gas sensor in the chamber because it has wide detecting scope, fast response and high sensitivity, stable and long life, simple drive circuit. This sensor is used in air quality control equipment for buildings and offices etc. and is suitable for detecting NH_3,NO_x, alcohol, Benzene, smoke,CO_2 ,etc.

Detecting concentration scope： 10ppm-300ppm NH_3 10ppm-1000ppm Benzene 10ppm-300ppm Alcohol

We are using DHT22 sensor for temperature and humidity sensing. Each DHT22 element is strictly calibrated in the laboratory that is extremely helpful in measuring humidity and temperature. The measurement range of this sensor is 0-50C .It’s power supply ranges from 3.5-5V.

CHAPTER 3

3.1 Project Methodology:

Following is a proposed methodology for building a smart plant growth chamber:

3.1.1 Design the chamber:

The first step is to design the physical chamber. The chamber should be made of a material that is durable, insulated, and easy to clean. The chamber should also be equipped with a door or opening to allow for access to the plants. We will use Acrylic sheet box as a chamber.

3.1.2 Sensors:

The next step is to select the sensors that will be used to monitor the environmental conditions inside the chamber. The most common sensors used in smart plant growth chambers are temperature sensors, humidity sensors, light sensors, and CO_2 sensors

3.1.3. Actuators:

The next step is to select the actuators that will be used to control the environmental conditions inside the chamber. The most common actuators used in smart plant growth chambers are heaters, coolers, humidifiers, and fans.

3.1.4. Design the control system:

The next step is to design the control system for the smart plant growth chamber. The control system will be responsible for monitoring the sensor data and controlling the actuators to maintain the desired environmental conditions inside the chamber. Arduino will be the microcontroller used in the chamber for the setup and controlling desired environment.

3.1.5 Assemble the chamber:

Once all of the components have been selected, the next step is to assemble the chamber. The chamber should be assembled according to the manufacturer's instructions.

3.1.6 Calibrate the sensors:

Once the chamber is assembled, the sensors should be calibrated to ensure that they are providing accurate reading.

3.1.6 Program the control system:

The next step is to program the control system. The control system should be programmed to maintain the desired environmental conditions inside the chamber.

3.1.7 Test the chamber:

Once the chamber is assembled and programmed, it should be tested to ensure that it is working properly. The chamber should be tested with a variety of plants under different environmental conditions

3.1.8 Schematic Diagram:

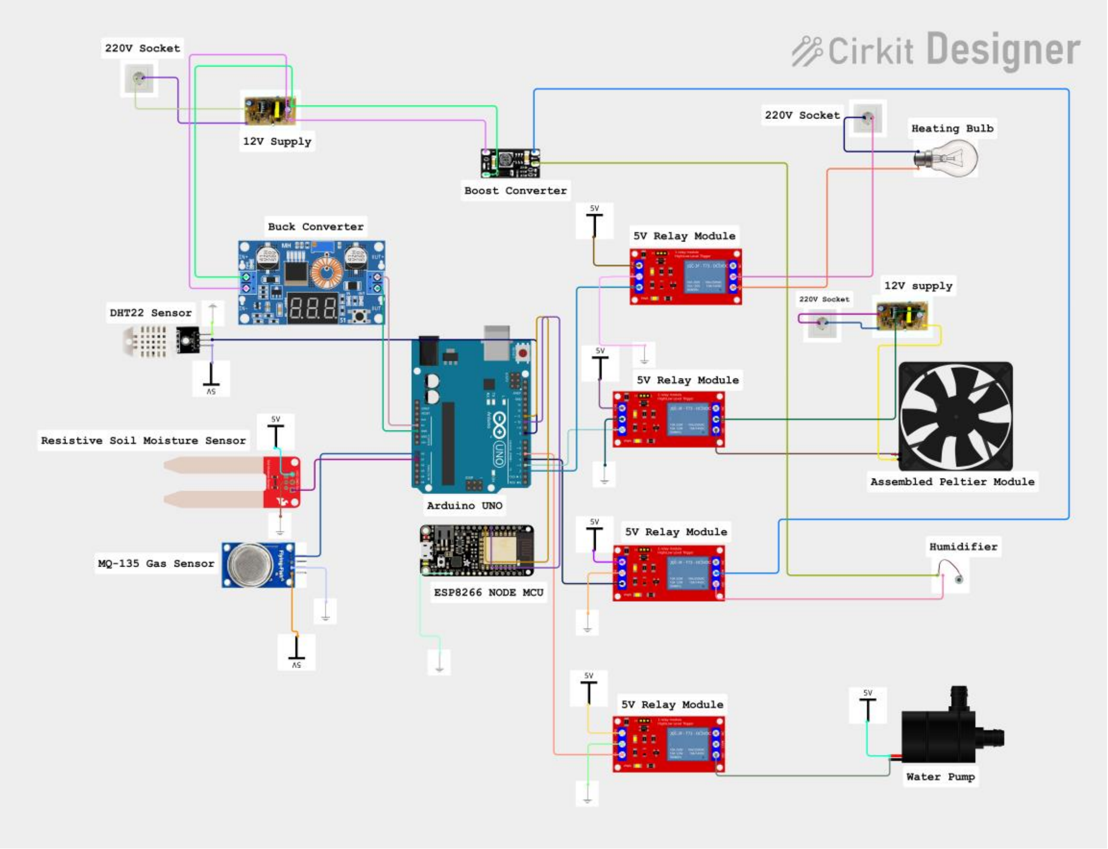

Figure 1 Schematic Diagram

3.2 Simulation:

3.2.1 Components:

1. LCD 16x2
2. MQ-135 Sensor
3. DHT 11 Sensor
4. Resistive Soil Moisture Sensor

5. Arduino Mega

Explanation:

We are using LCD 16x2, MQ-135 gas sensor, DHT 11 sensor, Resistive soil moisture sensor and Arduino Mega in simulation. The results of the parameters that are temperature, humidity, soil moisture and carbon-dioxide gas levels on the LCD. The sensors are connected with Arduino Mega. As it is just a simulation set-up, therefore it will just give random values of parameters as an output on LCD. The simulation is done with the help of Proteus software which is very useful for making electrical and electronic circuits. The simulation set-up is shown in Figure 3.

3.2.2 Flow chart of working of chamber:

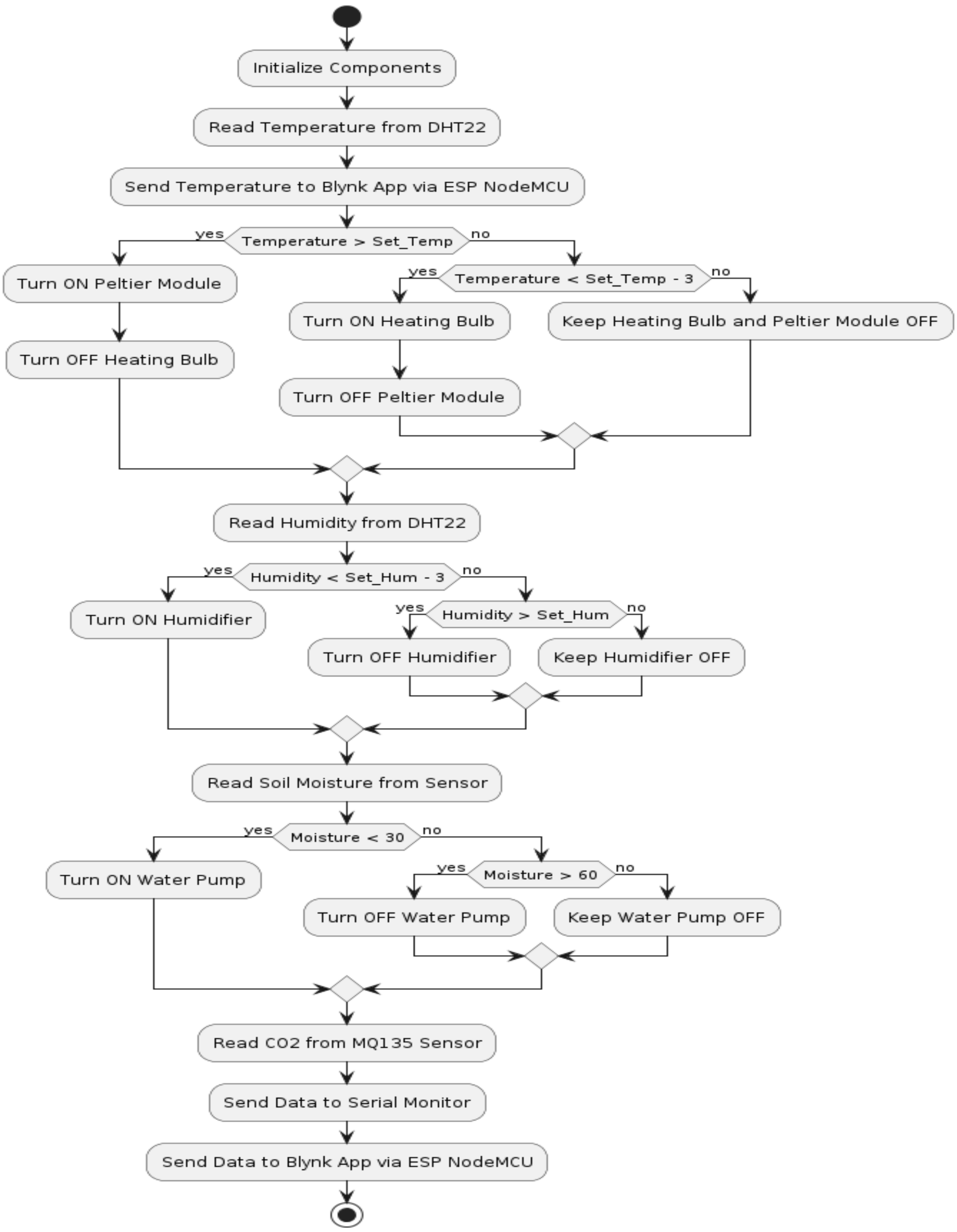

Figure 2 Project Flowchart

3.2.3 Proteus Simulation:

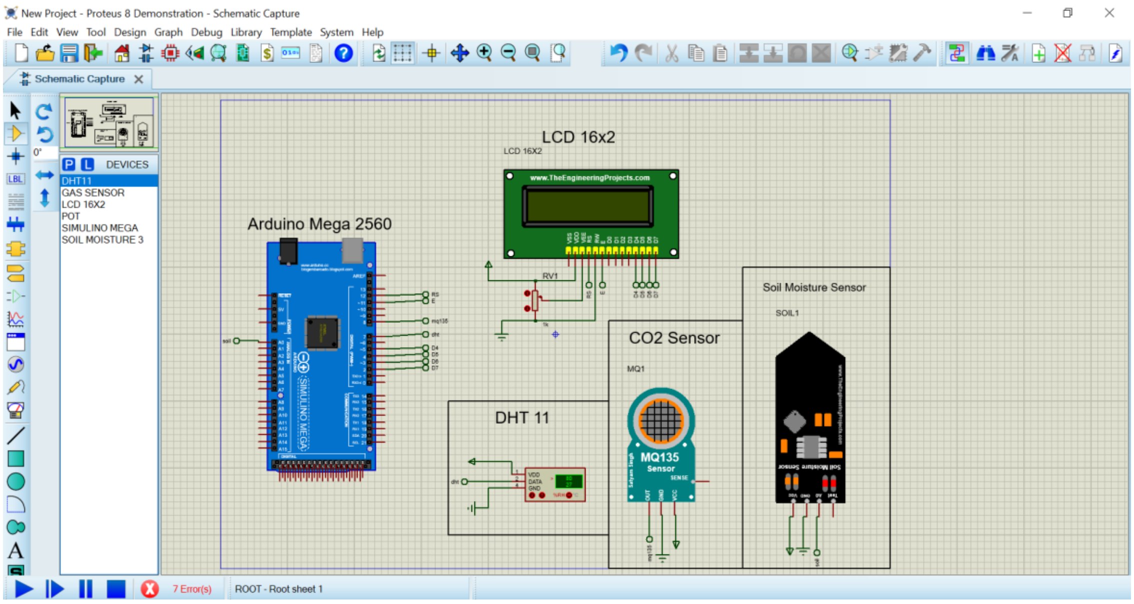

Figure 3: Proteus Simulation

The simulation figure illustrates the integration of sensors, including the DHT11, capacitive soil moisture sensor, and MQ-135 gas sensor, with an Arduino Mega 2560 microcontroller. Each sensor is connected to the Arduino board via appropriate interfaces for data acquisition. The Arduino board processes the sensor data and generates real-time feedback, which is displayed on a 16x2 LCD screen. The figure demonstrates the interconnectedness of the sensors and the Arduino board, highlighting the seamless integration that enables continuous monitoring of temperature, humidity, soil moisture, and carbon dioxide levels within the plant growth chamber. This simulation serves as a visual representation of the system's functionality, showcasing its potential for enhancing agricultural research and precision plant cultivation practices

CHAPTER 4

HARDWARE/RESULTS

4.1 Arduino UNO

The Arduino UNO R3 is a popular microcontroller board that is widely used for electronics and coding projects. Here are some key details about it:

- **Microcontroller:** The UNO R3 is based on ATmega328P microcontroller, which is a versatile and widely used chip in the Arduino family.
- **Digital I/O Pins:** It has 14 digital input/output pins, of which 6 can be used as PWM outputs (for controlling things like servos or LEDs).
- **Analog Inputs:** There are 6 analog inputs, allowing you to read analog signals from sensors or other devices.
- **Clock Speed:** The Uno R3 operates at a 16 MHz clock speed using a ceramic resonator.
- **Connectivity:** It features a USB connection for programming and communication with a computer. Additionally, there's a power jack for external power supply and an ICSP header for in-circuit programming.
- **Reset Button:** The board includes a reset button for restarting your code or resetting the microcontroller.
- **EEPROM:** The ATmega328P also has 1 KB of EEPROM, which retains data even when powered off.
- **Replaceable Chip:** The ATmega328P is not soldered to the board, so it can be easily replaced if needed.
- **Battery Connector:** The Uno R3 has a barrel plug connector that works well with a standard 9V battery

Figure 4 Arduino UNO

4.2 ESP8266 NODE MCU

The ESP8266 NodeMCU is a popular development board based on the ESP8266 Wi-Fi module, widely used for Internet of Things (IoT) projects. Here are some key details about it:

- **Microcontroller:** The NodeMCU is based on the ESP8266 microcontroller, which includes a Tensilica L106 32-bit RISC processor running at 80MHz (or overclocked to 160MHz).
- **Wi-Fi Connectivity:** It features built-in Wi-Fi capabilities (IEEE 802.11 b/g/n) for connecting to wireless networks, making it ideal for IoT applications.
- **Digital I/O Pins:** The board has 11 digital input/output pins, which can be used for interfacing with various sensors, actuators, and other devices.
- **Analog Input:** It includes a single analog input pin (A0) that supports input voltages between 0V and 1V, allowing for the reading of analog sensors.
- **Flash Memory:** The NodeMCU comes with 4MB of flash memory for storing programs and data, providing ample space for complex applications.
- **Programming:** The board can be programmed using the Arduino IDE, Lua scripting language, or MicroPython, offering flexibility for developers with different preferences.
- **Power Supply:** It operates at 3.3V and can be powered via the micro-USB port or through the VIN pin with an external 5V power supply.
- **USB Interface:** The NodeMCU includes a micro-USB port for programming and serial communication, along with a built-in USB-to-serial converter (CH340 or CP2102).
- **Reset and Flash Buttons:** The board includes dedicated reset and flash buttons for easy reprogramming and troubleshooting.
- **GPIO Functionality:** The GPIO pins support various functions, including PWM, I2C, SPI, and UART, enabling versatile interfacing with other components and devices.
- **Compact Design:** The NodeMCU is compact and integrates the ESP8266 module with necessary support components, making it convenient for prototyping and small-scale projects.
- **Applications:** It is widely used in IoT projects, home automation, remote monitoring systems, wireless sensor networks, and smart devices.

Figure 5 ESP8266 NODE MCU

4.3 Peltier Module

A Peltier module, also known as a thermoelectric cooler (TEC), is a solid-state device used for cooling or heating by exploiting the Peltier effect. Here are some key details about it:

- **Working Principle:** The Peltier module operates based on the Peltier effect, where an electric current passing through two different conductors creates a temperature difference, causing one side to cool down and the other to heat up.
- **Operating Voltage:** It typically operates at a voltage range of 12V to 15V, with common modules running at 12V.
- **Temperature Range:** Peltier modules can achieve temperature differences of up to 70°C between the hot and cold sides, depending on the specific model and operating conditions.
- **Cooling Capacity:** The cooling capacity of a Peltier module is usually measured in watts, with common models providing between 40W to 200W of cooling power.
- **Response Time:** Peltier modules have a rapid response time, providing almost immediate cooling or heating upon the application of current.
- **Compact Design:** These modules are compact and lightweight, making them easy to integrate into a variety of applications, including portable cooling devices.
- **Efficiency:** While Peltier modules are effective for small-scale cooling, they are generally less efficient compared to traditional refrigeration systems, as they generate heat on the hot side that needs to be managed.
- **Polarity Reversal:** By reversing the polarity of the applied voltage, a Peltier module can switch from cooling to heating mode, offering versatile thermal management options.
- **Mounting:** They are typically mounted using a thermal interface material (TIM) to ensure efficient heat transfer between the module and the heat sink or the cooled object.
- **Applications:** Peltier modules are used in a variety of applications, including electronic device cooling, small refrigeration units, temperature control in scientific instruments, and thermoelectric generators.
- **Maintenance:** Peltier modules require minimal maintenance, but it’s important to manage the heat generated on the hot side to ensure long-term reliability and efficiency.

Figure 6 Assembled Peltier Module

4.4 Ceramic heating bulb

A 200W ceramic heating bulb is a durable and efficient heating element often used in reptile habitats, terrariums, and various industrial applications. Here are some key details about it:

- **Heating Element:** The bulb uses a ceramic heating element that emits infrared heat without emitting light, providing a consistent and gentle heat source.
- **Power Rating:** It operates at 200 watts, offering substantial heat output suitable for various applications requiring reliable and consistent heat.
- **Operating Voltage:** The bulb typically operates at a standard household voltage of 110V to 120V AC or 220V to 240V AC, depending on the model.
- **Temperature Range:** It can reach surface temperatures of up to 250°C (482°F), providing sufficient heat for many heating needs.
- **Infrared Heat:** The ceramic heating bulb emits infrared radiation, which penetrates deep into the objects and living beings, offering effective and efficient heating.
- **Lifespan:** These bulbs are designed for long-term use, often providing up to 10,000 hours of operation, making them a cost-effective heating solution.
- **No Light Emission:** Unlike traditional incandescent bulbs, ceramic heating bulbs do not emit light, making them ideal for environments where constant darkness is required, such as reptile habitats.
- **Heat Distribution:** The bulb provides a broad and even distribution of heat, ensuring consistent temperatures within the heated area.
- **Compatibility:** It fits standard E26/E27 screw sockets, making it easy to install in existing fixtures.

- **Applications:** The 200W ceramic heating bulb is widely used in reptile and amphibian enclosures, brooders for poultry, pet habitats, plant germination, and various industrial processes that require controlled heat.
- **Safety:** When using ceramic heating bulbs, it's essential to have appropriate fixtures that can handle the high temperatures and to use protective guards to prevent burns from direct contact.

Figure 7 Ceramic Heating Bulb

4.5 24V Ultrasonic Humidifier

A 24V ultrasonic humidifier is a device that uses ultrasonic vibrations to create fine mist for increasing humidity in the air. Here are some key details about it:

- **Working Principle:** The humidifier uses ultrasonic vibrations to break water into tiny droplets, creating a fine mist that is dispersed into the air to increase humidity levels.
- **Operating Voltage:** It operates at 24V DC, making it energy-efficient and suitable for various applications, including home use, greenhouses, and industrial settings.
- **Humidity Output:** The device can produce a high output of mist, often in the range of 300ml to 500ml per hour, depending on the model, effectively humidifying large areas.
- **Water Tank Capacity:** Ultrasonic humidifiers typically come with a water tank capacity ranging from 1 liter to several liters, providing extended operation without frequent refills.
- **Noise Level:** These humidifiers operate quietly, usually producing less than 35 dB of noise, making them ideal for use in bedrooms, offices, and other noise-sensitive environments.
- **Adjustable Output:** Many models feature adjustable mist output settings, allowing users to control the level of humidity according to their needs.

- **Automatic Shut-off:** Most ultrasonic humidifiers include an automatic shut-off feature that turns the device off when the water level is low, preventing damage and ensuring safety.
- **Compact Design:** The 24V ultrasonic humidifier is typically compact and portable, making it easy to move and place in different locations as needed.
- **Applications:** These humidifiers are used in homes, offices, greenhouses, plant nurseries, laboratories, and industrial environments to maintain optimal humidity levels.
- **Maintenance:** Regular cleaning is required to prevent the buildup of mineral deposits and ensure consistent performance. Some models include a water filter to reduce maintenance needs.
- **Safety:** Ultrasonic humidifiers are safe to use, with no risk of burns from hot water or steam, making them suitable for environments with children, pets and plants.

Figure 8 24V Ultrasonic Humidifier

4.6 MQ-135 Sensor:

The MQ-135 gas sensor is a popular and versatile sensor used for air quality monitoring and detecting gases like ammonia, sulfide, benzene vapor, smoke, and other harmful gases. Here are some key details about it:

- **Sensing Element:** The MQ-135 uses a tin dioxide (SnO_2) semiconductor sensing element that has a lower conductivity in clean air. When target gases are present, the sensor's conductivity increases. • Detection Range: It can detect gases in the range of 10 ppm to 1000 ppm, making it suitable for various air quality monitoring applications.
- **Analog Output:** The sensor provides an analog output signal proportional to the concentration of the detected gases, which can be read using an analog input pin on a microcontroller.
- **Operating Voltage:** The MQ-135 operates at a voltage range of 5V, making it compatible with most microcontrollers, including Arduino.
- **Preheat Time:** The sensor requires a preheat time of 24 to 48 hours to achieve optimal stability and accuracy.

- **Response Time:** It has a quick response time, typically less than 10 seconds for stable readings, which is ideal for real-time monitoring.
- **Temperature and Humidity:** The sensor operates effectively within a temperature range of -20°C to 50°C and a humidity range of 20% to 90% RH.
- **Heater Consumption:** It has a heater consumption of less than 800 mW, which is necessary for its operation.
- **Compact Design:** The MQ-135 is compact, making it easy to integrate into various electronic projects and systems.
- **Applications:** It is widely used in air quality monitors, gas leakage detection systems, industrial applications, and safety equipment.

Figure 9 MQ-135 Sensor

4.7 DHT22 Sensor:

The DHT22 sensor is a popular and accurate sensor used for measuring temperature and humidity in various applications. Here are some key details about it:

- **Sensing Elements:** The DHT22 uses a capacitive humidity sensor and a thermistor to measure the surrounding air and provides a digital output signal.
- **Temperature Range:** It can measure temperatures in the range of -40°C to 80°C with an accuracy of ±0.5°C, making it suitable for a wide variety of environments.
- **Humidity Range:** The sensor can measure humidity levels from 0% to 100% RH with an accuracy of ±2% RH, which is useful for both indoor and outdoor applications.
- **Digital Output:** The DHT22 provides a digital output signal, which is easy to read using a microcontroller without the need for an analog-to-digital converter (ADC).
- **Operating Voltage:** The sensor operates at a voltage range of 3.3V to 6V, making it compatible with most microcontrollers, including Arduino.
- **Communication:** It uses a single-wire protocol for communication, requiring only one digital input pin for data transmission.
- **Response Time:** The sensor has a response time of 2 seconds, providing updated readings every 2 seconds, which is sufficient for most applications.
- **Long-term Stability:** The DHT22 is known for its excellent long-term stability and reliability in various environmental conditions.

- **Power Consumption:** It has a low power consumption of about 1.5mA during data acquisition and 40-50µA during idle mode, making it energy-efficient for battery-powered projects.
- **Compact Design:** The DHT22 is compact and easy to integrate into various electronic projects and systems.
- **Applications:** It is widely used in weather stations, environmental monitoring systems, HVAC systems, and other temperature and humidity monitoring applications.

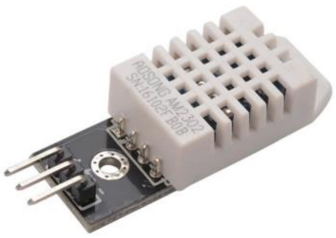

Figure 10 DHT22 Sensor

4.8 Resistive Soil Moisture sensor:

The resistive soil moisture sensor is a simple and effective sensor used to measure the moisture content in soil for various gardening and agricultural applications. Here are some key details about it:

- **Sensing Element:** The sensor uses two probes to measure the electrical resistance of the soil, which changes with moisture content; lower resistance indicates higher moisture levels.
- **Analog Output:** It provides an analog output signal that is proportional to the moisture content in the soil, which can be read using an analog input pin on a microcontroller.
- **Operating Voltage:** The sensor typically operates at a voltage range of 3.3V to 5V, making it compatible with most microcontrollers, including Arduino.
- **Easy Interface:** It has a simple interface that requires minimal additional components, making it easy to integrate into various projects.
- **Response Time:** The sensor has a quick response time, providing near real-time feedback on soil moisture levels, which is useful for automated watering systems.
- **Probe Material:** The probes are usually made of a corrosion-resistant material to ensure durability and longevity, although they can still corrode over time if used extensively in very wet conditions.
- **Low Power Consumption:** The sensor consumes very little power, making it suitable for battery-powered applications and long-term monitoring systems.
- **Compact Design:** The resistive soil moisture sensor is compact and easy to insert into the soil, fitting well into small spaces in gardening or agricultural setups.

- **Applications:** It is widely used in automated watering systems, soil moisture monitoring for gardening, greenhouse management, and agricultural projects to ensure optimal soil conditions for plant growth.
- **Maintenance:** Regular calibration and cleaning are recommended to maintain accuracy and extend the lifespan of the sensor, especially in harsh soil conditions.

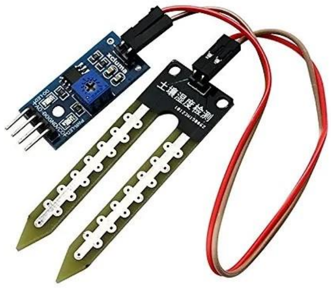

Figure 11 Resistive Soil Moisture Sensor

4.9 5v Pump

A 5V air pump is a compact and efficient device used for various applications, such as inflating small objects, providing aeration, or creating airflow in small systems. Here are some key details about it:

- **Operating Voltage:** The air pump operates at 5V DC, making it compatible with USB power sources, microcontroller projects, and battery-operated systems.
- **Power Consumption:** It typically consumes low power, usually in the range of a few hundred milliamps, making it energy-efficient for continuous operation.
- **Airflow Rate:** The pump can provide an airflow rate of around 1-2 liters per minute (L/min), suitable for small-scale applications such as aeration in aquariums or small inflatable objects.
- **Pressure:** The pump can generate a pressure of around 10-15 kPa, allowing it to inflate or aerate efficiently within its capacity range.
- **Noise Level:** 5V air pumps are designed to operate quietly, producing minimal noise, which is ideal for applications in quiet environments such as bedrooms or offices.
- **Compact Design:** These pumps are compact and lightweight, making them easy to integrate into various projects and systems without taking up much space.

- **Durability:** The pumps are built with durable materials to withstand continuous operation and ensure long-term reliability.
- **Applications:** 5V air pumps are used in a variety of applications, including aquarium aeration, small-scale inflatables, air circulation in electronic enclosures, wearable devices, and portable air purification systems.
- **Control:** They can be easily controlled using microcontrollers like Arduino or Raspberry Pi, allowing for automated or remote operation in smart projects.
- **Connectivity:** The pumps typically come with standard tubing connectors, making it easy to attach air hoses or other fittings as needed.
- **Maintenance:** These pumps require minimal maintenance, though regular cleaning of the air intake and tubing is recommended to ensure optimal performance.
- **Safety:** The low operating voltage of 5V makes these air pumps safe to use, with minimal risk of electrical hazards, making them suitable for a wide range of DIY and educational projects.

Figure 12 Water Pump

4.10 5v Relay Module:

A 5V relay module is a versatile and essential component for controlling high-power devices with low-power signals in various electronic projects. Here are some key details about it:

- **Operating Voltage:** The relay module operates at 5V DC, making it compatible with most microcontrollers, including Arduino and Raspberry Pi.
- **Control Signal:** It accepts a low-power control signal (typically 3.3V to 5V) from a microcontroller to switch the relay on or off.
- **Relay Channels:** Relay modules are available in different configurations, commonly featuring 1, 2, 4, or 8 channels, allowing control of multiple devices with a single module.
- **Load Capacity:** Each relay on the module can typically handle up to 10A at 250V AC or 10A at 30V DC, suitable for controlling lights, fans, motors, and other high-power devices.
- **Isolation:** The module provides electrical isolation between the low-power control circuit and the high-power load circuit, ensuring safety and protecting the microcontroller.

- **Indicator LEDs:** The module usually includes indicator LEDs that show the status of each relay (on/off), providing visual feedback for debugging and monitoring.
- **Compact Design:** These modules are compact and can be easily integrated into various projects, with mounting holes for secure installation.
- **Trigger Type:** Relay modules can be designed to trigger on either high-level or low-level signals, offering flexibility depending on the specific application and microcontroller logic levels.
- **Safety Features:** The module often includes features such as flyback diodes to protect against voltage spikes generated by the relay coil, enhancing the longevity and reliability of the module.
- **Applications:** 5V relay modules are widely used in home automation, IoT projects, robotics, industrial control systems, and any application that requires switching high-power devices with a low-power control signal.
- **Ease of Use:** The modules typically come with screw terminals or pin headers for easy connection to the control circuit and the high-power load, simplifying the wiring process.
- **Compatibility:** They are compatible with various development platforms and can be programmed using popular IDEs, making them accessible for beginners and advanced users alike.

Figure 13 5V Relay Module

4.11 Buck Converter XL4015:

The XL4015 buck converter is a versatile DC-DC step-down converter module used for efficiently reducing voltage. Here are some key details about it:

- **Operating Voltage:** The input voltage range for the XL4015 is 4V to 38V DC, and it steps down this voltage to a lower output voltage, adjustable from 1.25V to 36V DC.
- **Output Current:** The converter can deliver a continuous output current of up to 5A, making it suitable for powering various high-current devices.
- **Conversion Efficiency:** The XL4015 offers high conversion efficiency, typically around 90% or higher, which reduces heat generation and power loss.

- **Adjustable Output:** It features a potentiometer for adjusting the output voltage, allowing for precise control according to the needs of your project.
- **Integrated Protection:** The module includes built-in over-temperature, over-current, and short-circuit protection, ensuring safe operation under various conditions.
- **Switching Frequency:** The XL4015 operates at a high switching frequency of 180 kHz, enabling the use of smaller inductors and capacitors, resulting in a more compact design.
- **Heat Dissipation:** The module is equipped with a heat sink to help dissipate heat during operation, ensuring stable performance under high loads.
- **Compact Design:** The XL4015 module is compact, typically measuring around 43mm x 21mm x 14mm, making it easy to integrate into various electronic projects.
- **Applications:** It is widely used in battery charging circuits, power supplies for LED strips, embedded systems, and other applications requiring a stable and adjustable output voltage.
- **Installation:** The module comes with mounting holes for easy installation and secure attachment to your project enclosure or circuit board.
- **Input and Output Connections:** The module typically features screw terminals or solder pads for easy and reliable connections to input and output wires.
- **Voltage Ripple:** The XL4015 provides low output voltage ripple, ensuring a stable and clean power supply for sensitive electronics.

Figure 14 Buck Converter XL4015

4.12 Boost Converter XL6009:

The XL6009 boost converter is a versatile DC-DC step-up converter module used for efficiently increasing voltage. Here are some key details about it:

- **Operating Voltage:** The input voltage range for the XL6009 is 3V to 32V DC, and it steps up this voltage to a higher output voltage, adjustable from 5V to 35V DC.
- **Output Current:** The converter can deliver an output current of up to 4A, making it suitable for powering various devices that require higher voltage.

- **Conversion Efficiency:** The XL6009 offers high conversion efficiency, typically around 94% or higher, which reduces heat generation and power loss.
- **Adjustable Output:** It features a potentiometer for adjusting the output voltage, allowing for precise control according to the needs of your project.
- **Integrated Protection:** The module includes built-in over-temperature and short-circuit protection, ensuring safe operation under various conditions.
- **Switching Frequency:** The XL6009 operates at a high switching frequency of 400 kHz, enabling the use of smaller inductors and capacitors, resulting in a more compact design.
- **Compact Design:** The XL6009 module is compact, typically measuring around 45mm x 20mm x 14mm, making it easy to integrate into various electronic projects.
- **Heat Dissipation:** The module is designed to efficiently dissipate heat, ensuring stable performance under high loads.
- **Applications:** It is widely used in battery-powered devices, power supplies for LED strips, embedded systems, and other applications requiring a stable and adjustable output voltage.
- **Installation:** The module comes with mounting holes for easy installation and secure attachment to your project enclosure or circuit board.
- **Input and Output Connections:** The module typically features screw terminals or solder pads for easy and reliable connections to input and output wires.
- **Voltage Ripple:** The XL6009 provides low output voltage ripple, ensuring a stable and clean power supply for sensitive electronics.

Figure 15 Boost Converter XL6009

4.13 Results:

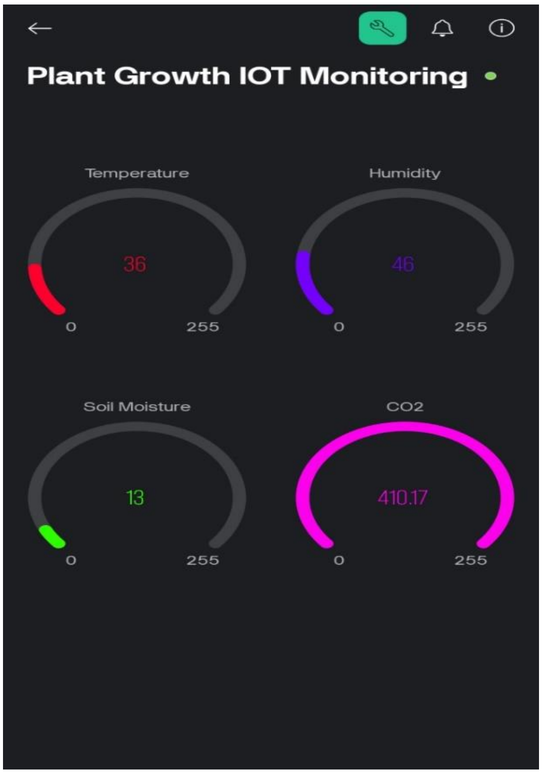

Figure 16 Parameters Output on Blynk Application via ESP8266

CHAPTER 5

CONCLUSION

5.1 Conclusion:

This final year project, titled "Design and Implementation of Low-cost Plants Growth Chamber with IoT Monitoring," successfully demonstrates the integration of various sensors and actuators to create a controlled environment for optimal plant growth. The system utilizes a DHT22 sensor to monitor temperature and humidity, an MQ-135 sensor to measure carbon-dioxide levels, and a resistive soil moisture sensor to assess soil moisture content. The data from these sensors are crucial for maintaining the necessary environmental conditions for plant growth.

The system's actuators include a Peltier module for cooling, a ceramic heating bulb for heating, a 24V humidifier for humidity control, and a 5V air pump for irrigation circulation. These actuators are effectively managed through an Arduino UNO and ESP8266 microcontroller, which ensures that the environmental parameters remain within the desired range.

The use of the Blynk application for real-time monitoring and control of the growth chamber adds a significant layer of convenience and functionality. The integration with the ESP8266 allows for remote access to the system, enabling users to monitor and adjust conditions from anywhere, ensuring that plants receive optimal care at all times.

Throughout the development of this project, several technical challenges were addressed, including sensor calibration, actuator control, and data communication between the sensors, actuators, and the Blynk app. The successful resolution of these challenges has resulted in a robust and reliable system.

The project outcomes demonstrate the feasibility and effectiveness of using IoT technology in agricultural applications, specifically in controlled environment agriculture. The system provides precise control over environmental parameters, which is critical for research and commercial applications in plant cultivation.

Future work could explore the addition of more sensors and actuators to expand the range of environmental factors monitored and controlled. Additionally, implementing machine learning algorithms could further enhance the system's ability to predict and respond to the plants' needs, optimizing growth conditions dynamically.

CHAPTER 6

BUSINESS PLAN

6.1 Executive summary:

The plants growth chamber addresses the growth of plant in required environment by controlling vital parameters for a plant like temperature, humidity, and soil moisture of a plant.

6.1.1 Core Features:

Control of temperature, humidity, soil moisture of plant. It will enhance the growth of plant by providing specific environment to plant.

6.2 Company overview:

- **Company Name:** Agrivation
- **Mission Statement:** To enhance the growth of a specific plant by giving required parameters for the growth of plant.
- **Vision Statement:** To expand the products in different cities for farmers and productions on bigger levels.

6.3 Product Description:

The project integrates the following features:

6.3.1 Temperature Control:

- Temperature control with the help of Peltier Module
- Temperature control with the help of ceramic heating bulb

6.3.2 Humidity Control:

- Humidity control with the help of an ultrasonic humidifier

6.3.3 Soil Moisture Control:

- Soil moisture control with the help of a 5V DC pump.

6.3.4 Remote Monitoring:

- This project provides the remote monitoring of parameters required for the growth a plant.

6.4 Market Analysis:

6.4.1 Target Market:

- Farmers

- Researchers
- Students
- Hobbyist

6.4.2 Market Need:

- Convenient for the people who want to grow a non-seasonal plants
- Provides sustainable and efficient usage
- Research and development in plant sciences

6.4.3 Competitive Analysis:

- Existing plants growth chambers are very expensive
- This project provides IoT in chamber which provides remote monitoring
- Easy to handle for a domestic level

6.5 Marketing Strategy:

6.5.1 Product Positioning:

This project will be positioned as a premium plants growth chamber with unparalleled integration and effectiveness.

6.5.2 Pricing Strategy:

Competitive pricing to attract early adopters while maintaining a margin for sustainability.

6.5.3 Promotion Strategy:

- Digital marketing campaigns (social media, search engines).
- Collaborations with agricultural companies, manufacturers and fleet operators.
- Public relations campaigns highlighting successful case studies and testimonials

6.6 Operational Plan:

6.6.1 Development:

- Research and development of hardware and software components.
- Testing and refinement based on user feedback.

6.6.2 Manufaturing:

- In-house manufacturing to reduce cost and maintain high standards.
- Quality control measures to ensure product reliability and safety.

6.6.3 Logistics:

- Inventory management systems to track production and sales.

- Reliable shipping partners for domestic and international distribution.

6.7 Financial Plan:

6.7.1 Revenue Stream:

- Direct sales to consumers.
- Bulk sales to agricultural companies.
- Licensing agreements with plants growth chambers manufacturers.

6.7.2 Cost Structure:

Table 6.1 Cost Structure

Sr.	Description	Amount(PKR)
1	Research and development	50,000/-
2	Manufacturing	30,000/- per unit
3	Marketing and promotion	50,000/-
4	Distribution and logistics	75,000/-
	Total	2,25,000/-

6.7.3 Pricing:

Table 6.2 Pricing

Sr.	Description	Amount(PKR)
1	Retail price per chamber	50,000/-
2	Bulk pricing(10+ units)	40,000/-

6.7.4 Projected Sales:

Table 6.3Projected Sales

Sr.	Description	Units
1	Year 1	50
2	Year 2	100
3	Year 3	150

6.8 Risk Analysis:

6.8.1 Market Risks:

- Adoption rate of new technology.
- Competition from established safety system manufacturers.

6.8.2 Operational Risks:

- Supply chain disruptions.
- Quality control issues.

6.8.3 Mitigation Strategies:

- Continuous market research and user feedback integration.
- Strong partnerships with reliable suppliers and manufacturers.
- Rigorous quality assurance processes.

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APPENDIX:

Arduino UNO code:

```
#include <MQUnifiedsensor.h>        //  Sensor             Arduino
#include "DHT.h"                    // DHT-22                8
#include <SoftwareSerial.h>         // MQ-135                A0
SoftwareSerial esp8266(10,11);      // Soil Moisture         A1
#define DHTPIN 8                    // Heater relay          2
#define DHTTYPE DHT22               // Peltier relay         3
DHT dht(DHTPIN, DHTTYPE);           // Humidifier relay      4
                                    // Water Pump            5
int Heater_rly = 2;
int Peltier_rly = 3;
int Humidifier_rly = 4;
int Water_pump = 5;
const int M_S = A1; // Moisture Sensor
int Set_Temp = 35; // Change Temperature Value
int Set_Hum = 60; // Change Humidity Value
int moisture;
int timer;
#define placa "Arduino UNO"
#define Voltage_Resolution 5
#define pin A0
#define type "MQ-135" //MQ135
#define ADC_Bit_Resolution 10
#define RatioMQ135CleanAir 3.6//RS / R0 = 3.6 ppm
MQUnifiedsensor MQ135(placa, Voltage_Resolution, ADC_Bit_Resolution,
pin, type);
void setup()
{
 Serial.begin(9600);
 esp8266.begin(9600);
 pinMode(M_S, INPUT);
 pinMode(Heater_rly, OUTPUT);
 pinMode(Peltier_rly, OUTPUT);
 pinMode(Humidifier_rly, OUTPUT);
```

```
 pinMode(Water_pump, OUTPUT);
 digitalWrite(Heater_rly, HIGH);
 digitalWrite(Peltier_rly, HIGH);
 digitalWrite(Humidifier_rly, HIGH);
 digitalWrite(Water_pump, HIGH);
 MQ135.setRegressionMethod(1); //_PPM =  a*ratio^b
 MQ135.setA(110.47); MQ135.setB(-2.862); // Configure the equation to
to calculate CO2 concentration
 dht.begin();
 MQ135.init();
 Serial.print("Calibrating please wait.");
 float calcR0 = 0;
 for(int i = 1; i<=10; i ++)
 {
   MQ135.update(); // Update data, the arduino will read the voltage
from the analog pin
   calcR0 += MQ135.calibrate(RatioMQ135CleanAir);
   Serial.print(".");
  }
  MQ135.setR0(calcR0/10);
  Serial.println("  done!.");
  if(isinf(calcR0)) {Serial.println("Warning: Conection issue, R0 is
infinite (Open circuit detected) please check your wiring and
supply"); while(1);}
  if(calcR0 == 0){Serial.println("Warning: Conection issue found, R0
is zero (Analog pin shorts to ground) please check your wiring and
supply"); while(1);}
  /****************************** MQ CAlibration
********************************************/
  MQ135.serialDebug(true);
  Serial.println("Welcome");
  }
void loop()
{
 int t = dht.readTemperature();
 int h = dht.readHumidity();
```

```
 moisture = analogRead(M_S);
 moisture = 100 - moisture /10.24;
 MQ135.update();
 MQ135.setA(110.47); MQ135.setB(-2.862); // Configure the equation to
calculate CO2 concentration value
 float CO2 = MQ135.readSensor(); // Sensor will read PPM concentration
using the model, a and b values set previously or from the setup
 Serial.print("Temperature= ");
 Serial.print(t);
 Serial.println("'C ");
 Serial.print("Humidity= ");
 Serial.print(h);
 Serial.println("%  ");
 Serial.print("Moisture= ");
 Serial.print(moisture);
 Serial.println("%  ");
 Serial.print("CO2= ");
 Serial.print(CO2+400);
 Serial.println("ppm ");
/////////////////////////////////////////////  Temperature
 if(t>Set_Temp)
 {
  digitalWrite(Heater_rly, HIGH); // Off
  digitalWrite(Peltier_rly, LOW); // On
 }
 if(t<Set_Temp-3)
 {
  digitalWrite(Heater_rly, LOW); // On
  digitalWrite(Peltier_rly, HIGH); // Off
 }
///////////////////////////////////////////// Humidity
 if(h<Set_Hum-3)
 {
  digitalWrite(Humidifier_rly, LOW); // On
 }
 if(h>Set_Hum)
```

```
 {
  digitalWrite(Humidifier_rly, HIGH); // Off
  }
///////////////////////////////////////////// Moiture
 if(moisture<30)
 {
  digitalWrite(Water_pump, LOW); // On
 }
 if(moisture>60)
 {
  digitalWrite(Water_pump, HIGH); // Off
 }
}
```

ESP8266 NODE MCU code:

```
// Plant Growth IOT Monitoring Blynk

#define BLYNK_TEMPLATE_ID "TMPL61JQOx3ln"

#define BLYNK_TEMPLATE_NAME "Plant Growth IOT Monitoring"

#define BLYNK_AUTH_TOKEN "9hCtS0bFCUfa9t5YfbgCLDuLMQ1krZRw"

#define BLYNK_PRINT Serial

#include <ESP8266WiFi.h>

#include <BlynkSimpleEsp8266.h>

#include <SoftwareSerial.h>

SoftwareSerial mySerial(D2,D3); // RX,TX

#define LED D7

#define wifiLed D4

char ssid[] = "ESP8266WIFI";    // Your WiFi credentials.

char pass[] = "1234567890";  // Set password to "" for open
networks.

// SimpleTimer timer;

BlynkTimer timer;

int flag=0;
```

```
String txtMsg = "";
unsigned char msg1size=0,msg2size=0,msg3size=0,msg4size=0;
char msg1[15];
char msg2[15];
char msg3[15];
char msg4[15];
uint8_t x =0;
void myTimerEvent()
{
 // Blynk.virtualWrite(V0, random(100));
 // Blynk.virtualWrite(V1, random(50));
 // Blynk.virtualWrite(V2, random(30));
 // Blynk.virtualWrite(V3, random(5));
  Blynk.virtualWrite(V0, msg1);
  Blynk.virtualWrite(V1, msg2);
  Blynk.virtualWrite(V2, msg3);
  Blynk.virtualWrite(V3, msg4);
}
void setup() {
   Serial.begin(9600);// Debug console
   mySerial.begin(9600);
   pinMode(LED,OUTPUT);
   pinMode(wifiLed, OUTPUT);
   digitalWrite(LED, LOW);
   digitalWrite(wifiLed, HIGH);
   Blynk.begin(BLYNK_AUTH_TOKEN, ssid, pass);
   digitalWrite(wifiLed, LOW);
   timer.setInterval(1000L, myTimerEvent);
```

```
    Serial.println("Ready");
}
void loop() {
 serialEvent();
 Blynk.run();
 timer.run();
 delay(1000);
}
 void serialEvent() {
 uint8_t x;
 while (mySerial.available()) {
 char inChar = (char)mySerial.read();
 txtMsg += inChar;
 if (inChar == '\n' or inChar == '\r') {
 /****************SETTING FOR MESSAGE
1*******************************/
     if(txtMsg.charAt(0) == 'A' and txtMsg.charAt(1) ==
'V'){masg1();}
  /*************************SETTING FOR MESSAGE 2
*******************************/
else if(txtMsg.charAt(0) == 'B' and txtMsg.charAt(1) ==
'V'){masg2();}
  /*************************SETTING FOR MESSAGE 3
*******************************/
else if(txtMsg.charAt(0) == 'C' and txtMsg.charAt(1) ==
'V'){masg3();}
  /*************************SETTING FOR MESSAGE 4
*******************************/
else if(txtMsg.charAt(0) == 'D' and txtMsg.charAt(1) ==
'V'){masg4();}
        //////////////EMPTYIING THE
BUFFER////////////////////////
```

```
        txtMsg = "";
        mySerial.flush();
        }
    }
}
void masg1(){
msg1size = txtMsg.length()-2;
for(x =0;x<msg1size;x++){
msg1[x]= txtMsg.charAt(x+3);
}
Serial.print("message 1 =");Serial.println(msg1);
}
void masg2(){
msg2size = txtMsg.length()-2;
for(x =0;x<msg2size;x++){
msg2[x]= txtMsg.charAt(x+3);
}
Serial.print("message 2 ="); Serial.println(msg2);
}
void masg3(){
msg3size = txtMsg.length()-2;
for(x =0;x<msg3size;x++){
msg3[x]= txtMsg.charAt(x+3);
}
Serial.print("message 3 =");Serial.println(msg3);
}
void masg4(){
msg4size = txtMsg.length()-2;
```

```
for(x =0;x<msg4size;x++){

msg4[x]= txtMsg.charAt(x+3);

}

Serial.print("message 4 ="); Serial.println(msg4);

}
```