IC 201P – Design Practicum

SMART CLIMATE CONTROL AGRICULTURE

Indian Institute of Technology Mandi

Navdeep (B21205)
Jiya (B21103)
Yash Rathod (B21316)
Dhruv Ranka (B21187)
Pritesh Kr. Gupta (B21211)
Saksham Bansal (B21067)

Under the supervision of
Dr. Tushar Jain

Dr. Thainswemong Choudhury

Certificate

This is to certify that the work contained in the project report entitled "**SMART CLIMATE CONTROLED AGRICULTURE**", submitted by **Group 34** to the Indian Institute of Technology Mandi, for the course **IC 201P-Design Practicum**, is a record of bona-fide research works carried out under our direct supervision and guidance.

19/05/2023

Dr. Tushar Jain

Signature and Date

Dr. Thainswemong Choudhury

Signature and Date

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ABSTRACT

Climate controlled agriculture is a concept that has been around for several decades, and its aim is to maximize crop yield under various constraints, including technical, economic, and climatic factors. The basic principle behind this philosophy is to avoid any situation that could limit the output of the crops. This involves using a range of techniques, including the use of sensors, automated systems, and data analysis, to create an ideal environment for the plants to grow in. A polyhouse is an enclosed structure used for growing plants, and it allows for the regulation of the internal environment, including temperature, humidity, and light. By using sensors, it is possible to monitor the conditions within the polyhouse and make adjustments to ensure optimal growth conditions for the plants.

The polyhouse appliance is aimed to be controlled through a web application by this project. The Temperature, humidity, and CO2 levels of the polyhouse, as well as a graphical representation of this data, will be displayed by the web application, making it easier for the environment within the polyhouse to be monitored by farmers. This data is stored in a database and can then be used to forecast the ideal growing conditions for crops at any given time, allowing for more accurate and efficient management of the polyhouse environment.

Manually controlling the polyhouse is possible, meaning that the cooling fan, cooling pad, and fogger can be switched on and off from anywhere and anytime required, providing safety to crops in case any sensor or automatic system fails.

The option to switch between automatic and manual control of the polyhouse is given. The threshold values for automatic control of actuators can be changed via the website. The live video surveillance of the polyhouse is streamed on the website for security purposes and to ensure whether the actuators are actually on and off when required or not.

Overall, the efficiency of the facility can be significantly boosted by the implementation of climate control agriculture in polyhouse farming, resulting in higher crop output and higher-quality products. The use of technology, including sensors, automated systems, and data analysis, can help farmers create an ideal environment for their crops, leading to more sustainable and profitable farming practices.

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Literature Review

The increasing world population has changed the food production scenario over the last decades. Today agriculture is changing in response to the requirements of modern society, where ensuring food supply through practices such as water conservation, reduction of agrochemicals and the required planted surface, which guarantees high quality crops are in demand. Greenhouses have proven to be a reliable solution to achieve these goals.

The health of the crops and plants is affected by many parameters in their surroundings such as temperature, humidity, water and sunlight. The distinctive feature of greenhouse cultivation, as compared to outdoor cultivation, is the presence of a barrier between the crop and the external environment. This barrier creates a distinct micro-climate within the greenhouse, protects the crop against wind, precipitation, weeds, pests, diseases and animals, and enables the grower to control the crop environment to an extent unknown in outdoor cultivation. The protection from the outside world makes it feasible to heat, to add carbon dioxide, and to effectively apply chemical and biological control for crop protection.

The presence of a cover, characteristic of greenhouses, causes, whether desired or not, a change in the climate conditions as compared with those outside: radiation and air velocity are reduced, temperature and water vapor pressure of the air increase, and fluctuations in carbon dioxide concentration are much stronger.

Originally, when control was still manual, the main issue was to avoid climatic extremes: overheating, especially due to strong radiation, and damage from low temperatures at night and during cold spells. Later, with the introduction of heating and automatic ventilation, the focus shifted towards the question of optimal setpoints for crop growth.

Climate control has evolved over the last four decades from manual to digital. Initially the incentive for automation was to save labour: the operation of ventilation windows required permanent supervision and time consuming intervention by the grower. With the advancement of control techniques, electronic devices became available that enabled more sophisticated control strategies to be developed.

When microprocessors were introduced in greenhouse climate control systems they were "simply" the digital equivalent of their analogue predecessors. The main advantages were increased flexibility through the implementation of more complex control algorithms, without changing the hardware, lower cost when controlling more than one compartment and the great benefit of registration of climate conditions.

Since the introduction of greenhouse climate computers, major advancements in hard- and software have taken place. This process in turn has been reinforced by the vastly improved price/ performance ratio of microprocessors. Control algorithms have been improved, for example, through the automatic adaptation of the control parameters to the actual situation. Moreover, an increasing variety in options required by growers with widely diverging crops, traditions and approaches has been incorporated in the systems. The development of improved user interfaces combined with an increase in the use of personal computers has facilitated the transfer and analysis of climate data in relation to other relevant nursery information.

Research on the greenhouse environment, its control and related crop response was intensified in the late seventies as a result of the energy crisis, resulting in a great deal of new insights and knowledge. Stimulated by the availability of generic crop growth models and a young generation of researchers with an open eye for the great potentials of these new techniques, these insights were integrated into physical and physiological models describing the greenhouse-crop production system. With these tools opportunities were created to predict the response of the greenhouse environment, crop growth and their interactions under varying conditions and hence to design more intelligent, more flexible, and more efficient control systems.

This project aims to control the polyhouse appliance through a web application, and the website displays a graphical representation of all the data gathered by sensors installed in the polyhouse.

To start with the project, we went to the greenhouse near the riverside and saw that it was working automatically, but there was one big disadvantage we were facing, i.e., if a sensor stops working, the automation of the green house gets disturbed, which harms the crop (because the sensor gives incorrect information to the relays, and the relays will do unconditional operations) and causes a failure.

We can estimate the temperature that is good for crops in the polyhouse in the future by recording the data in a database. The graph will display a constant line for a very long time if the sensor is destroyed, which will cause crop failure because the fan, cooling pad, and other appliances won't function. We may control the appliance from anywhere with the aid of a web application, saving the crops.

Chapter 1

1.1 Introduction

Over the past few decades, the growing global population has brought about significant changes in the realm of food production. Modern society now demands sustainable agricultural practices that conserve water, reduce the use of agrochemicals, and maximize crop yields on limited land. Greenhouses have emerged as a promising solution to meet these needs by providing a controlled environment for high-quality crop cultivation. Even while climate control has transitioned from manual to digital over the past few decades, the basic concept has remained the same. By avoiding circumstances that limit crop productivity, this concept seeks to maximize the final yield under all relevant (technical, economic, and climatic) restrictions. The goal of this project is to use a web application to control the polyhouse appliance, and the website shows a graphical representation of all the data collected by sensors placed inside the polyhouse. The information gathered by sensors is also entered into a database that will be used to estimate the best growing conditions for crops at any given time in the future. This project will help in remotely managing cooling fans and other appliances as well as figuring out whether a sensor is working thanks to the usage of graphs shown on the website. With this recommendation, the polyhouse facility would operate much more efficiently, increasing crop productivity and product quality.

1.2 Background of the problem

Several factors in the surrounding environment, such as temperature, humidity, water, and sunlight, can affect the health and growth of plants. To start working with the project, we went near the riverside where the greenhouses are installed and saw that the green house was working automatically, i.e., the actuators (cooling pad, fan, fogger, etc) weregetting on and off automatically at the set humidity and temperature values, if the sensorshowed those values. But there was one big disadvantage we were facing, i.e., if a sensorstops working, the automation of the greenhouse gets disturbed, which harms the crop (because the sensor gives incorrect information to the relays, and the relays will do unconditional operations) and causes a failure.

1.3 Scope of the problem

In the greenhouse, if a sensor stops working, the automation of the greenhouse gets disturbed as the actuators will get on and off automatically at the set humidity and temperature values, if the sensor shows those values. This will harm the crops as the crops will not get the correct optimum temperature and humidity that could not be shown due to damaged sensors. The website design shows a graphical representation of all the data collected by sensors placed inside the polyhouse. If the sensor is damaged, then the graph will show a constant line, which will result in crop failure due to the unworkability of the fan, cooling pad, and other appliances. By storing the data in a database, we can use it in the future to predict the temperature that is suitable for crops in the polyhouse. With the help of a web application, we can control the appliance from anywhere, which will save our crops.

1.4 Design philosophy used in this report

The Node MCU is connected to the Firebase cloud over the internet with the help of the "Firebase ESP8266 client" library. It is a secure, fast and reliable Firebase Realtime database library to read, store, update, delete, listen, backup, and restore data. You can also read and modify the database security rules with this library. Firebase is used for making connections between two networks, which act as a cloud between them. MongoDB is used for storing the data. It is the most popular NoSQL database, is an open-source document-oriented database. Django is used as a frontend and backend language. Nodemcu is used as a Wi-Fi module. A relay is used as a switch for controlling the appliances. The adapter is used for giving 12V DC as output, and the converter is used for converting 12V to 3.3 V for giving input to sensors and 5V for working of relay.

1.5 Problem statement

The problem statement is that a web application should show the sensor data coming from the green house with the help of graphs and control the appliances that are present in the polyhouse with the help of a web application so that we can control the appliances from anywhere with the help of a website. The website design should also show a graphical representation of all the data collected by sensors placed inside the polyhouse. If the sensor is damaged, then the graph shows a constant line. This could help in protecting the crops. By storing the data in a database, we can use it in the future to predict the temperature that is suitable for crops in the polyhouse.

1.6 Beneficiaries (Intended market)

Most websites show limited sensor data and do not provide a solution for controlling the appliances from anywhere. Existing market products are expensive. Also, websites charge for storing the data into its own database. They also require specialized installation and setup, and may not be as effective in outdoor or non-standard growing environments. Our solution allows users to remotely monitor and regulate temperature, humidity, and soil moisture in addition to turning on and off cooling fans and foggers. Additionally, it offers configurable solutions for various kinds of crops and growing settings, automated systems, cloud-based platforms, and graphical representations of sensor data for analysis. Overall, our product provides producers of all sizes with an affordable and adaptable solution that includes cutting-edge technologies that can assist optimize crop development and raise yields.

Chapter 2
MARKET RESEARCH

2.1 Introduction

This chapter discusses various existing products that enable remote control of greenhouse appliances. These products include smart greenhouse controllers, wireless sensor networks, remote-controlled irrigation systems, smart lighting systems, and remote monitoring and control systems. When comparing similar products, factors such as features, compatibility, ease of use, reliability, and pricing should be considered. Each product may have unique capabilities or integration options, so it is essential to evaluate which one aligns best with specific needs. However, there are some common issues with existing products, such as connectivity problems, limited range or coverage, compatibility issues with different greenhouse systems, complexity in setup or configuration, and potential software or hardware glitches. These challenges may vary depending on the specific product and manufacturer. Thus, different products may stand out due to their unique features, advanced technology, improved user interfaces, enhanced connectivity options, scalability, or specialized capabilities for specific greenhouse applications. It is important to carefully assess the distinguishing factors of each product to determine which one suits the requirements best. Overall, remote control of greenhouse appliances has become increasingly popular due to its convenience and efficiency. As technology continues to advance, it is likely that more innovative and sophisticated products will emerge in the market, providing even more options for greenhouse growers to optimize their operations.

2.2 Existing Products in market

There are similar products available on the market. Many companies offer solutions for remotely monitoring and controlling environmental variables in agriculture, such as greenhouses and indoor growing facilities.

Argus Controls, CropX, Tera lytic, and Grozine are some examples of companies that provide such solutions. Argus Controls offers automation systems that monitor and control variables such as temperature and humidity in indoor growing facilities. CropX provides a cloud-based platform for soil moisture monitoring that collects data from wireless sensors in the field. Teralytic offers a soil sensor system for precision agriculture that measures soil moisture, temperature, and nutrients and sends the data to a cloud-based platform for analysis. Grozine offers sensors that measure environmental variables such as temperature and humidity in indoor agriculture, which are transmitted to a cloud-based platform for analysis. The goal of these companies is to improve crop yields and efficiency by providing real-time data and control over environmental conditions.

2.3 Comparison with an existing similar product

Our product offers real-time monitoring and remote control of soil moisture, humidity, and temperature, as well as the ability to switch on and off cooling fans and foggers. It also provides graphical representations of sensor data for analysis, automation systems, cloud-based platforms, and customizable solutions for different types of crops and growing environments. Existing market products also offer similar capabilities, but may be more expensive, require specialized installation and setup, and may not be as effective in outdoor or non-standard growing environments. However, these products may be better suited for larger indoor growing facilities or growers with specific needs. Overall, our product offers an accessible and flexible solution for growers of all sizes, with advanced features that can help optimize crop growth and increase yields.

2.4 Problems associated with existing products

Here are some common problems associated with existing products in the market:

- Existing market products can be expensive, particularly for small-scale growers who may not have the budget to invest in high-end monitoring and control systems.
- Additionally, these products may require specialized installation and setup, which can be time-consuming and challenging for growers who lack technical expertise.
- Some existing products may be designed for specific types of crops or growing environments, which can limit their flexibility and usefulness for growers with different needs.
- Depending on the specific product and growing environment, existing products may not be as effective in optimizing crop growth and increasing yields as advertised.

2.5 Different from existing similar product

Our product has several key advantages that make it stand different in the market. One of the main advantages is that it provides a graphical representation of the humidity and temperature sensor data in one frame. This makes it easy for growers to compare both sets of data and gain a better understanding of how they are related. This can help growers make more informed decisions about how to improve growing conditions and maximize crop yields.

In addition to providing real-time data on temperature and humidity, This is important because soil moisture levels can have a significant impact on plant growth and crop yields. Another key advantage of our product is that it stores the sensor data in a database for further analysis. This can be extremely valuable for growers who want to track trendsover time and make data-driven decisions about how to optimize their growing conditions. Our product also allows growers to monitor and control greenhouse appliances from anywhere at any time. This is particularly valuable for growers who need to manage multiple greenhouses or who are frequently on the go. With remote monitoring and control capabilities, growers can stay connected to their operations and make adjustments as needed. The inclusion of a camera to monitor sensor activity is alsoa useful feature that can provide additional insights into the performance of the system.It can help growers quickly identify any issues with the sensors or their connectivity andtake corrective actions as needed. This can help ensure that data is accurate and reliable,which is critical for making informed decisions about growing conditions. Overall, our product offers a comprehensive solution for growers who want to optimize their growingconditions and maximize crop yields. By providing real-time data, remote monitoring and control capabilities, and advanced analytics, your product can help growers achievebetter results and improve their profitability.

Chapter 3

CONCEPTUAL DESIGN

3.1 Introduction

After different project ideas were discussed and brainstormed by the group, a list of potential projects was arrived at. To narrow down the choices, the top five ideas were initially picked from each group member. Then, these ideas were evaluated and discussed together to come up with 10 potential projects that were presented to both mentors for feedback. Valuable suggestions were provided by the mentors and the ideas were asked to be refined further.

During this process, it was mentioned by Tushar sir, one of the mentors, that a climate controlled agriculture project was under him, which was found very interesting by the group. Ideas were asked to be proposed on how to identify some of the project's shortcomings and develop ways to improve them. The group was thrilled about the opportunity to work on such an innovative project that could have a significant impact on agriculture. After research was conducted and different aspects of the project were discussed, ideas were proposed to improve the climate-controlled agriculture project.

3.2 Brainstorming and Idea generation

The polyhouse facility near the riverside was visited by us many times to understand how appliances are installed there, what their purpose is, and how they work. In addition to the observations made at the polyhouse facility, extensive research was conducted by us on climate-controlled agriculture and its various aspects. Different techniques and technologies that are being used globally to optimize crop growth and maximize yield were explored by us. The impact of different environmental factors like temperature, humidity, light, and soil nutrients on crop growth and quality was studied by us. Latest developments in automation and robotics that can help reduce labor costs and improve efficiency in agriculture were also researched by us.

Several ideas were proposed by us to improve the existing climate-controlled agriculture project based on our research and observations. One of our key suggestions was to install a special sheet or covering over the polyhouse facility that could be automatically spread during the daytime to prevent excessive heating and maintain optimal temperature levels.

This would not only reduce the need for artificial cooling systems but also help conserve energy and reduce operating costs.

Another idea that was proposed by us was to develop a small robot that could automatically detect and remove unwanted grass and weeds from the crop field. We recognized that weed control is a major challenge for most farmers, and it can significantly impact crop yield and quality. By automating this process, the need for manual labor could be reduced and overall efficiency could be improved.

Furthermore, a major drawback of the existing automated system that controls the polyhouse facility was identified by us. The system heavily relies on various sensors and data to function properly, and if any of the sensors fail, the system cannot function effectively. To address this issue, we proposed developing a robust data management and storage system that could store all the relevant data, including temperature, humidity, soil moisture, and other environmental factors. This would allow the data to be analysed by farmers, enabling them to make more informed decisions regarding crop management.

3.3 Selection of the most viable ideas proposed

We narrowed it down to three problems we can work on.

- Making a robot which can automatically identify unwanted grass and remove it from the field.
- Capturing images of growing crops and identifying whether they are growing properly or not using ML.
- Switching on and off cooling fan, fogger, irrigation system from any place at any time and Storing all the temperature, humidity, moisture data and their graphical representation for various analysis.

The team used a decision matrix to evaluate the three proposed ideas based on several criteria, such as feasibility, impact, resources required, and potential risks as shown in table 1. After evaluating the ideas using the decision matrix, the team decided to work on the third idea, which was switching on and off a cooling fan, fogger, and cooling pad from any place at any time and storing all the temperature, humidity, and moisture data along with their graphical representation for various analyses.

Ideas	**Feasibility**	**Impact**	**Resources required**	**Implementation**
A robot to automatically clean unwanted grass	Difficult	High	High	High
Prediction of crops by studying weather .	Moderate	Moderate	High	Low
Single BLDC motor Drone	Difficult	Less	High	High
Smart climate control agriculture	Difficult	High	Less	High
Automatic Drip Irrigation System.	Moderate	Moderate	Less	Low

Table 1: comparison of ideas

The team chose this idea because it offered a practical solution to the problem of climate controlled agriculture, reduced human effort, and provided more control over the polyhouse facility. The proposed solution involved using IoT devices to control the climate inside the polyhouse remotely and storing all the necessary data for further analysis. The team believed that this idea would have a significant impact on improving the efficiency of the polyhouse facility, resulting in increased crop yield and better product quality.

Chapter 4

LED DESIGN EMBODIMENT AND DETAIL

4.1 Introduction

This chapter describes the product architecture of the project. The detailed system level design with the electrical and software parts is also described. In the project, Node MCU that has an ESP8266 WIFI module is used. Node MCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espress if Systems, and hardware which was based on the ESP-12 module. The Node MCU is connected to the Firebase cloud over the internet with the help of the "Firebase ESP8266 client" library. It is a secure, fast and reliable Firebase Realtime database library to read, store, update, delete, listen, backup, and restore data. You can also read and modify the database security rules with this library. We have also used MongoDB, the most popular NoSQL database, is an open-source document-oriented database. MongoDB isn't based on the table-like relational database structure but provides an altogether different mechanism for storage and retrieval of data.

4.2 System-level design

Node MCU has an ESP8266 WIFI module, which is connected to the local Wifi of the polyhouse and gives access to the Internet. The Node MCU is connected to the Firebase cloud over the internet with the help of the "Firebase ESP8266 client" library, which helps send real-time data from the sensor to Firebase and receive commands. The firebase is connected to a website where the real-time sensor data is received, represented graphically, and then sent to the MongoDB database to be stored in order to be fetched when needed. The website also has a button to control the actuator manually. For each actuator, we have two buttons: one for selecting the operating mode (i.e., automatic or manual) and a second for switching ON/OFF if the mode is manual.

4.3 Detailed design

There are majorly two type of design, first part consists of **Electrical/Electronics** and the second part consist of **software** side which are discussed below in detail :-

4.3.1 Electrical/Electronics aspect:

The Node MCU is the main component that operates at 5 volts DC. Therefore, the first step is to obtain an adapter for converting AC to DC. The converter produces a 5-volt output that powers the Node MCU and 3.3 volts for the sensors. In the case of actuators requiring more than 5 volts, a relay is used to switch the power supply, which is controlled by the Node MCU signal. The high voltage sources supply power to the actuator through the relay. Figure 1 shows the setup of Node MCU connected to converter with the help of a breadboard and jumper wire and figure 2 shows relay setup

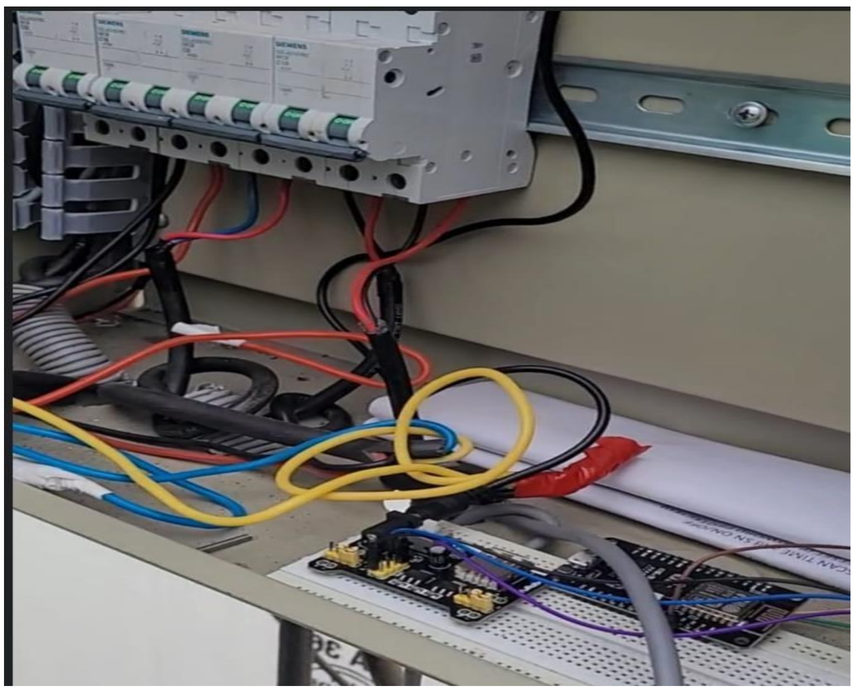


Figure1: Setup of Node MCU connected to converter

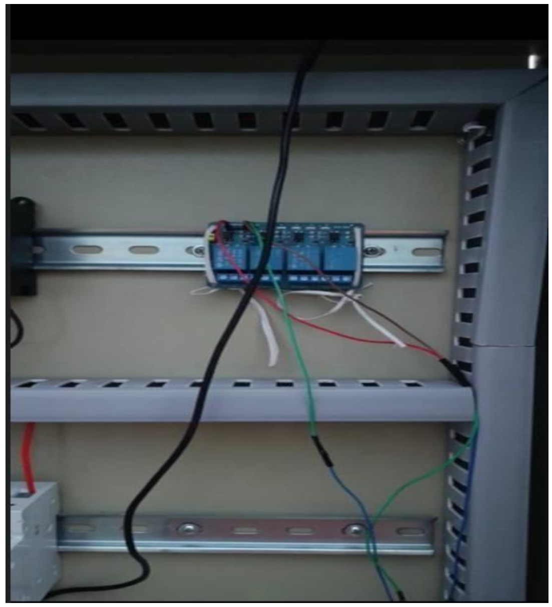


Figure 2: Four channel relay connected with jumper wire

4.3.2 Software part:

The website is developed using the Django framework. For the backend, Python is used, and for the frontend, HTML and JavaScript are used.

Arduino: Connection with Firebase is done by the “Firebase esp8266 client library." The SHT temperature and humidity sensor is connected by I2C protocol with the “DFRobot_SHT20-master” library. Example of firebase setup is shown in Figure 3

For each actuator, there are two buttons to control it manually as well as automatically.

Figure 3: Firebase interface

4.4 Results and Discussion

So, as a result achieved

- View real time data of sensors from anywhere through website
- Able to control the actuator manually when the sensor gives faulty reading.
- Able to store and retrieve the sensor data for any analysis and further uses
- Actuators threshold values can be changed via website
- Live video surveillance of polyhouse on website
- Graphical representation of sensor data on website.
- Fetching and graphical representation of past data.

4.5 Product architecture :

Different actuators and sensors are used. Node MCU is used as a microcontroller and firebase cloud is used as a link between node MCU and website.

It is further explained in figure 4.

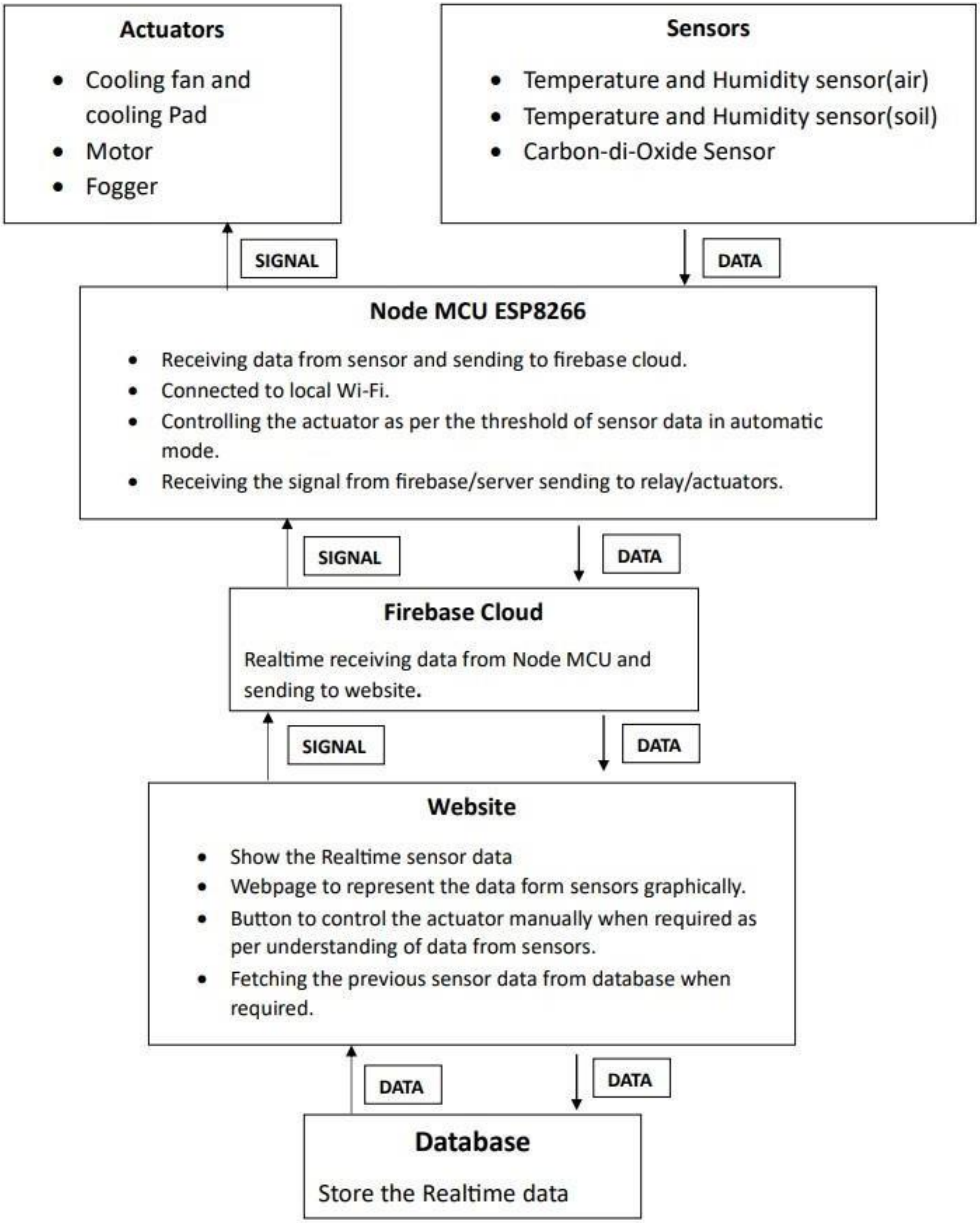


Figure 4: Block Diagram of project

Chapter 5
FABRICATION & ASSEMBLY

5.1 Introduction

This chapter comprises the list of the products and components used in the project. The bill of the materials with the quantity ordered is also mentioned. It includes the material description, dimensions and tolerances of the main electrical components used. Apart from this, the manufacturing process description, how the assembly was done, the limitations and the challenges faced, the scheduling plan and the contributions by all members of the team are contained in the chapter.

5.2 List of Component/Product

All the products/ components used in the project are listed in table 2.

Serial no.	List of Product/Component
1.	Bread Board
2.	Relay
3.	Male to Male jumper wire
4.	Male to Female jumper wire
5.	Female to Female jumper wire

6.	Converter
7.	Adapter
8	4 core shielded wire
9.	Node MCU
10.	Sun Robotics Capacitive Soil Moisture Sensor V2.0 Temperature & Humidity Sensor
11.	Raspberry Pi Camera
12.	PCB 5X3
13.	Berg Strip Male 40 Pin

Table 2: List of Product/Component

5.3 Bill of Materials

Following table represents the quantity and price of products used in project

Serial no.	**Product/Component**	**Quantity**	**Price(INR)**
1.	Bread Board	3	347
2.	Relay	2	550

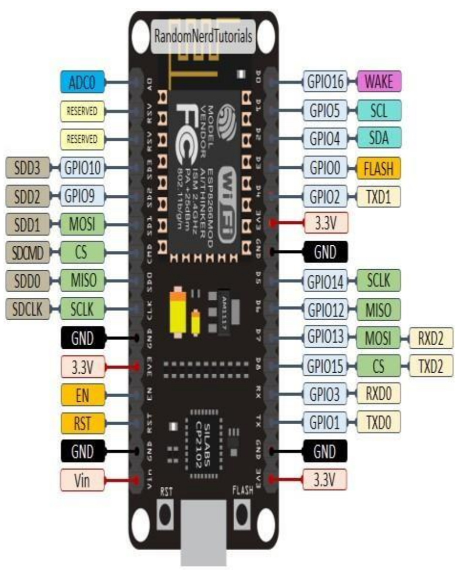
3.	Male to Male jumper wire	1 set	430
4.	Male to Female jumper wire	1 set	
5.	Female to Female jumper wire	1 set	
6.	Converter	3	540
7.	Adapter	2	500
8	4 core shielded wire	1	1795
9.	Node MCU	2	800
10.	SunRobotics Capacitive Soil Moisture Sensor V2.0 Temperature & Humidity Sensor	2	416
11.	Raspberry Pi Camera	1	405
12.	PCB 5X3	2	90
13.	Berg Strip Male 40 Pin	5	50

Table 3

5.4 Material description, dimensions, and tolerances

- **Node MCU** is a powerful and versatile microcontroller board that is widely used in electronic circuits and projects.
  Its built-in Wi-Fi connectivity and support for various programming languages make it an ideal choice for IoT applications and other projects that require connectivity and processing power. NodeMCU is used in this project to control actuators based on Wi-Fi based signal received from the website.

Node MCU



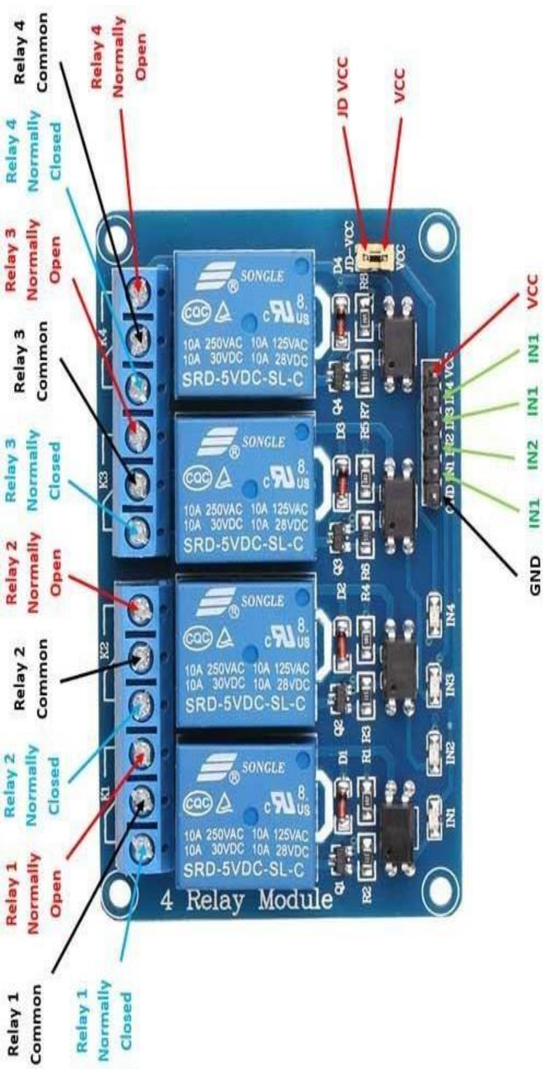
	Official NodeMCU	NodeMCU Carrier Board	LoLin NodeMCU
Microcontroller	ESP-8266 32-bit	ESP-8266 32-bit	ESP-8266 32-bit
NodeMCU Model	Amica	**Amica**	Clone LoLin
NodeMCU Size	49mm x 26mm	49mm x 26mm	58mm x 32mm
Carrier Board Size	n/a	102mm x 51mm	n/a
Pin Spacing	**0.9" (22.86mm)**	**0.9" (22.86mm)**	1.1" (27.94mm)
Clock Speed	80 MHz	80 MHz	80 MHz
USB **to Serial**	CP2102	**CP2102**	CH340G
USB Connector	Micro USB	Micro USB	Micro USB
Operating Voltage	3.3V	3.3V	3.3V
Input Voltage	4.5V-10V	4.5V-10V	4.5V-10V
Flash Memory/SRAM	4 MB / 64 KB	4 MB / 64 KB	4 MB / 64 KB
Digital I/O Pins	11	11	11
Analog In Pins	1	1	1
ADC Range	0-3.3V	0-3.3V	0-3.3V
UART/SPI/I2C	1 / 1 / 1	1 / 1 / 1	1 / 1 / 1
WiFi Built-In	802.11 b/g/n	802.11 b/g/n	802.11 b/g/n
Temperature Range	-40C - 125C	-40C - 125C	-40C - 125C

Description

Figure 5: Node MCU

- **Relay** is an electrically operated switch that is used to control the flow of current in an electric circuit. It allows a low voltage circuit to control a high voltage circuit, without the two circuits coming into direct contact with each other. In this project, relay is used to switch on and off actuators based on the command received from NodeMCU.

Relay	Description



Pin Number	Pin Name	Description
1	GND	Ground reference for the module
2	IN1	Input to activate relay 1
3	IN2	Input to activate relay 2
4	IN3	Input to activate relay 3
5	IN4	Input to activate relay 4
6	V_{CC}	Power supply for the relay module
7	V_{CC}	Power supply selection jumper
8	JD-V_{CC}	Alternate power pin for the relay module

Figure 6:Relay

- **Breadboard** is a device used in this project allows you to quickly and easily connect electronic components together by inserting their leads or wires into the holes of the breadboard.

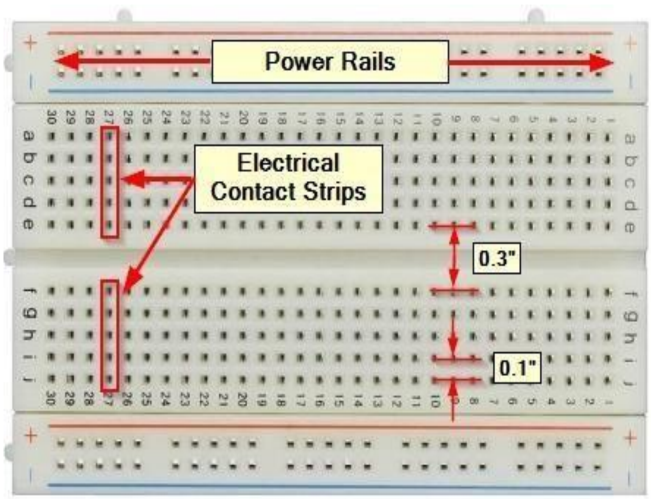
Bread Board	Description
	Dimension :- 5.5cm * 17cm A thin plastic board used to hold electronic components (transistors, resistors, chips etc) that are wired together for building circuits

Figure 7: Bread Board

- **Voltage Converters:** These are used to convert the voltage level of an electric circuit from one level to another. In this project, Voltage converter is used to convert 12V DC to 5V DC (for working of relay) and to convert 12V DC to 3.3V (for working of sensors).

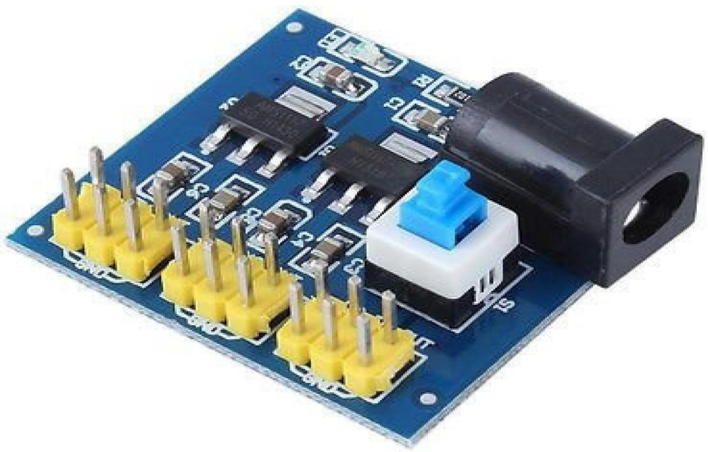
	Description
 Converter	convert DC to DC Input Pin :- 5.1mm jack Switch :- on and off Input Voltage :- 6 to 12 volts output Voltage :- 5 volts , 3.3volts , 12volts

Figure 8: Converter

- **Male and female plugs** are commonly used in electrical and electronic devices to establish a connection and allow the flow of electrical current. When a male plug is inserted into a female plug, the connection allows electrical current to flow from the power source through the male plug, into the female plug, and ultimately into the device or equipment being powered. This type of connection ensures a reliable and safe transfer of electricity between devices.

Male-Female Plug	**Description**
	Current Rating : 6 Amperes Voltage Rating : 220-240 Volts Material : Polycarbonate material Heavy Brass Parts Color : White Dimensions : 40 * 30 * 10 mm (L,W,H)

Figure 9 : Male and Female Plug

- **The Pi Camera** is a camera module that can be connected to a Raspberry Pi computer. It is primarily used for taking photos and recording videos, but it can also be used for a variety of other applications, such as computer vision, surveillance, robotics, and more.
  In this project, Pi Camera is used for security purposes and to keep watch whether actuators(Cooling fan, fogger, cooling pad) are actually on/off when required.

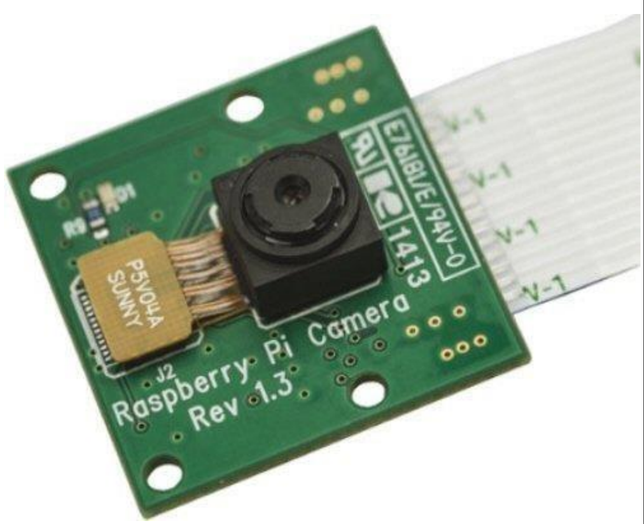
Pi Camera	Description
	**Camera Module** : 5 Megapixel Omnivision 5647 Camera Module **Photo Resolution** : 2592 x 1944 Pixels **Video** : 1080p @ 30fps, 720p @ 60fps and 640x480p 60/90 **Size**: 25mm x 23mm x 8mm **Weight** : 3 grams **Camera** :Serial Interface 15-pin MIPI (Plugs Directly into the Raspberry Pi Board) **Compatibility** : Raspberry Pi Model A, Model B and Model B + Raspberry Pi

Figure 10 : Raspberry Pi Camera

- **Adaptors** are used in electric circuits to convert one type of electrical connector or voltage level to another.
  They allow devices with different types of connectors or voltage requirements to be connected together.This project uses adaptor to convert main power supply to 12V DC.

Adapter

Model	12V2A_2MTR_DC_CP
Product Dimensions	10 x 5 x 5 cm
Item model number	12V2A_2MTR_DC_CP
Compatible Devices	Cameras
Number of items	1
Wattage	24 Watts
Power Source	Corded Electric
Material	Polyvinyl Chloride

Description

Figure 11: Adapter

- A **4-core shielded wire** is a type of cable that consists of four conductors enclosed in a shielded jacket. The four conductors are typically color-coded to make it easy to identify each conductor.
  This type of wire is commonly used in electronic circuits where noise or interference can affect the performance of the circuit.
  The shielding provides protection against electromagnetic interference (EMI) and radio frequency interference (RFI), which can be caused by other electronic devices, power sources, or even nearby radio transmitters. In this project,Shielded wire connects sensors to NodeMCU and actuators to relay.

4 core shielded wire

- Number of Cores: 4
- Conductor No/Dia (mm): 14/0.2
- Nominal Area (mm2) per core: 0.4
- Amp Rating: 2.8
- Insulation Thickness (mm): 0.3
- Sheath Thickness: 0.76
- Electrical Resistance @20°C ohm/km: 44.8
- Nominal O.D (mm): 5.4
- Sheath Colour: Grey
- Maximum working voltage 300 Volts
- Not Suitable For Connection To Mains Power GPO
- AUSTEL APPROVED A93/CA/0122
- Aluminium / Polyester Laminate Tape Screen with a 7/0.2mm Tinned Copper Drain Wire

Description

Figure 12: 4 core shielded wire

- **Jumper wires** are insulated wires that have connectors, such as pins or clips, at each end that can be inserted into the holes of a breadboard, or attached to the leads of electronic components to make electrical connection between different electrical components.Jumper wires are used in this project to make connections on the breadboard and to connect it to the relay and microcontroller.

Male to Male jumper wire

Colour	Multicolour
Number of Memory Sticks	1
Item Weight	299 g
Product Dimensions	5 x 1 x 8 cm; 299 Grams
Item model number	DPNT
Item Height	8 Centimeters
Item Width	10 Millimeters

Description

Figure 13: Male to Male jumper wire

Male to Female jumper wire

Colour	multicolor
Number of Memory Sticks	1
Item Weight	30 g
Package Dimensions	9.4 x 8 x 2.8 cm; 30 Grams

Description

Figure 14: Male to Female jumper wire

Female to Female jumper wire

Colour	Assorted color
Number of Memory Sticks	1
Item Weight	220 g
Package Dimensions	19.6 x 10.4 x 1 cm; 220 Grams

Description

Figure 15: Female to Female jumper wire Figure

- **Temperature and humidity sensor** detect the temperature and humidity inside and outside the polyhouse facility :

SunRobotics Capacitive Soil Moisture Sensor V2.0

Temperature & Humidity Sensor

Item Dimensions LxWxH	10 x 8 x 4 Centimeters
Brand	Robotbanao.com
Power Connector Type	3-Pin
Voltage	5 Volts
Wattage	2 Milliwatts
Cooling Method	Only for measuring temprature
Compatible Device	Arduino uno, Arduino nano, Arduino mega, Arduino due, Arduino nano BLE, ESP32, ESP8266
Noise Level	0.05 Sones
Material	Rubber, Sainless steel
Manufacturer	ROBOTBANAO
Country of Origin	Taiwan
Model number	ESC037
Number of Memory Sticks	1
Item Weight	200 g
Product Dimensions	10 x 8 x 4 cm; 200 Grams
Item model number	ESC037
Item Height	4 Centimeters
Item Width	8 Centimeters

Description

Figure 16 : temperature and humidity sensor

5.5 Manufacturing Process description:

- In this project we are using hardware as well as software so for the manufacturing process of hardware we need semiconductor, plastic, copper and for fabrication process we have used cutting, winding etc.

5.6 Assembly

- At first, we needed a power supply for any electrical appliance to work on, so we discussed and decided to get an adapter which converts 240v AC to 12v DC because we are working on small electrical appliances such as sensors
- Secondly, we need a very low voltage power supply to operate Node MCU, so we discussed and decided to get a voltage converter from 12v DC to 5v DC & 3.3v DC.
- Now at third we need a device which operates on Wi-Fi and can send & and receive signals, So we researched and got to know about Node MCU which does the same and it operates at a voltage of 3.3v. As for our project we need to send and receive signal through Wi-Fi.
- After this we received a signal and now fourth, we have a mechanical switch which can work on, So we discussed and researched to get to know about Relay which operates on 5 volts.
- So finally at fifth we were ready to control the sensors.
- At the end sixth we completed the circuit and started installing it with 4 core shielded wire (with this wire we can send & receive very less size of data.

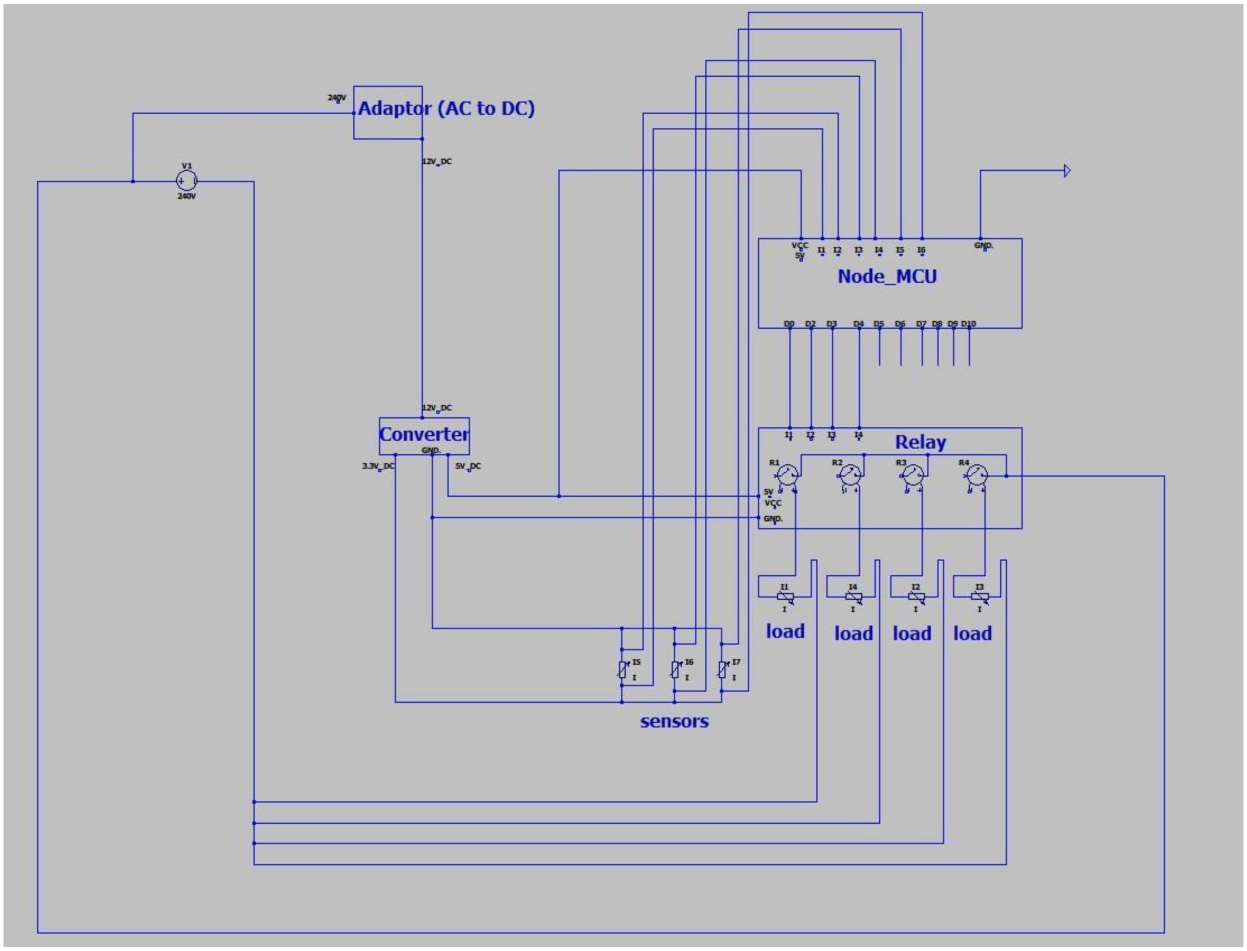


Figure 17: Circuit diagram

5.7 Limitations and Challenges:

- Understanding the project itself was challenging.
- This project was far away from the campus so for the detailed information we have to reach there physically every time.
- Every student is of a different branch so getting a common time was challenging.
- Getting all the equipment.
- check whether all the components are working or not.
- working on a high voltage power supply was risky.

- Working with low volts IC was a difficult task.
- Working inside the polyhouse at very high temperature .

5.8 Scheduling plan:

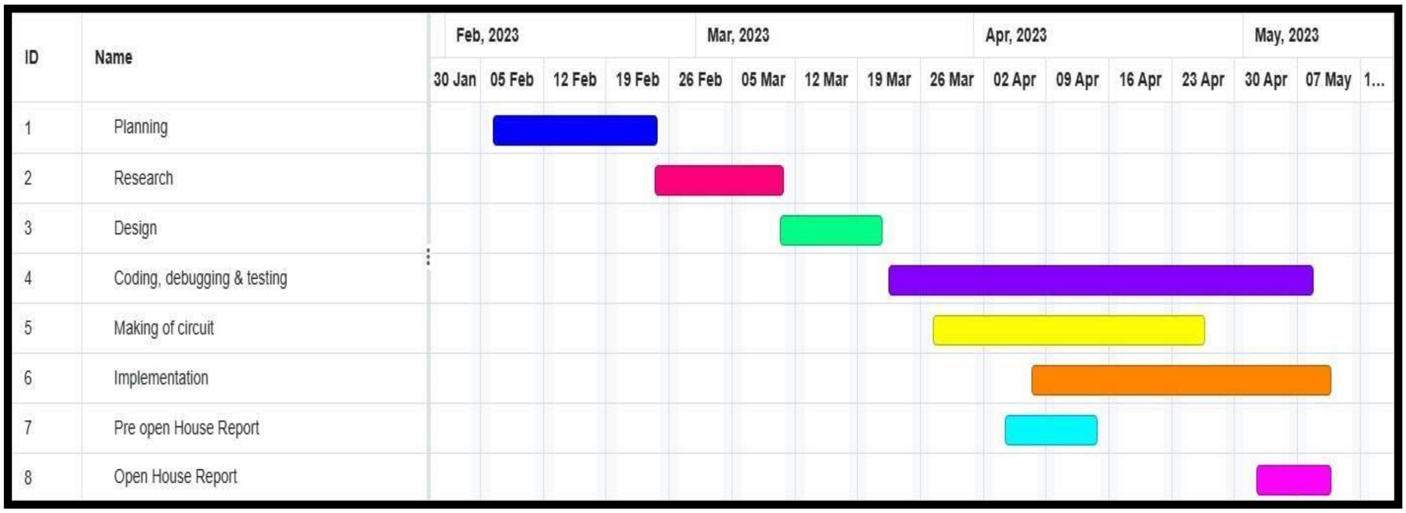


Table 4: Gantt chart

5.9 Contribution:

	Saksham Bansal (B21067)	Dhruv Ranka (B21187)	Jiya (B21103)	Navdeep (B21205)	Pritesh Kumar Gupta (B21211)	Yash Rathod (B21316)
Coding for automation and debugging of the code		✔		✔		✔
Implementing Electronic circuits	✔				✔	

Research in Electrical sensors			✔		✔	
Frontend of login page and graph page				✔	✔	
Frontend of homepage which includes graph control panel etc .		✔				
Installation of raspberry pi in polyhouse	✔		✔	✔	✔	
Arduino Coding for sensors and Relay						✔
Backend for connecting website to firebase		✔				
Installation of all sensors and electrical appliances	✔	✔	✔	✔	✔	✔
Coding of Firebase for connecting between two networks in arduino		✔				

Helped in Firebase connection and setup		✔		✔		✔
Experimented and finalized this electric circuit in the lab		✔		✔	✔	✔
Making of poster	✔		✔			
Coding of Raspberry pi for live streaming						✔
Purchasing components	✔	✔	✔	✔	✔	✔
Report making	✔	✔	✔	✔	✔	✔

Table 5: Contribution Table

5.10 Conclusion:

Initially, our team was faced with the challenge of controlling the polyhouse facility from a remote location. We realized that the existing manual operations made it difficult to monitor and adjust environmental factors like temperature, humidity, and lighting, which are crucial for optimizing crop growth and yield. Moreover, we were uncertain about the accuracy and reliability of the sensors installed in the polyhouse.

To overcome these challenges, we decided to design a website that would collect and display real-time data from the sensors installed in the polyhouse. This would enable us to monitor and analyse the environmental factors affecting crop growth, even from a remote location. We also developed a web application that would allow us to control the appliances in the polyhouse remotely, giving us greater control over the climate inside the facility.

Through this solution, we were able to address the challenges faced by farmers and polyhouse operators, allowing them to monitor and control their operations from anywhere at any time. This not only improved the efficiency of the polyhouse facility but also resulted in increased crop yield and better-quality produce.

The website we developed displays the data collected from the sensors in a graphical format, making it easy to read and analyse. This provides farmers with valuable insights into the environmental factors affecting their crops, allowing them to make data-driven decisions regarding crop management. The web application we designed enables farmers to adjust the settings of the appliances in the polyhouse remotely, ensuring that the environment remains optimal for crop growth.

Overall, our solution has made it easier for farmers and polyhouse operators to manage their operations, save time and effort, and improve the quality and quantity of their produce. Our team is proud to have contributed to the advancement of climate-controlled agriculture and hopes that our solution will continue to benefit farmers worldwide.

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Department of Biological and Agricultural Engineering, Universiti Putra Malaysia, Serdang, Selangor, Malaysia)

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EDITORS J.C. Bakker G.P.A. Bot H. Challa N.J. Van de Braak

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