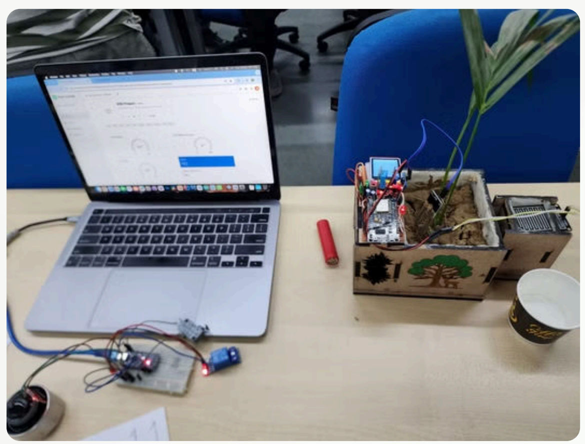
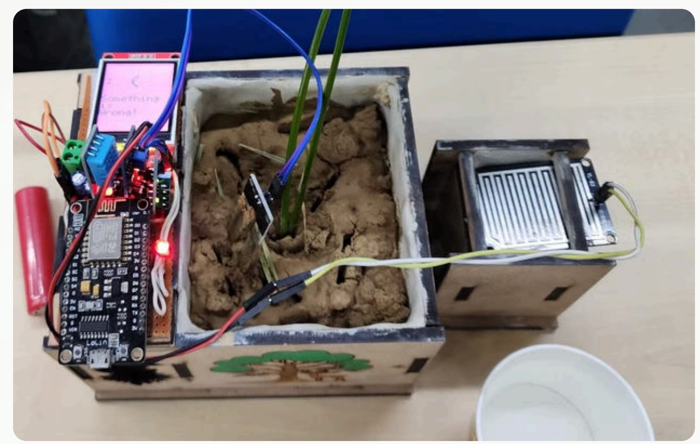
Smart IoT Botany STEM Kit





ESD (ECE211) Course Project.

Abhishek Jha (2022023)

Group11

Team Name: IronMan.

Project Overview

Project Overview:

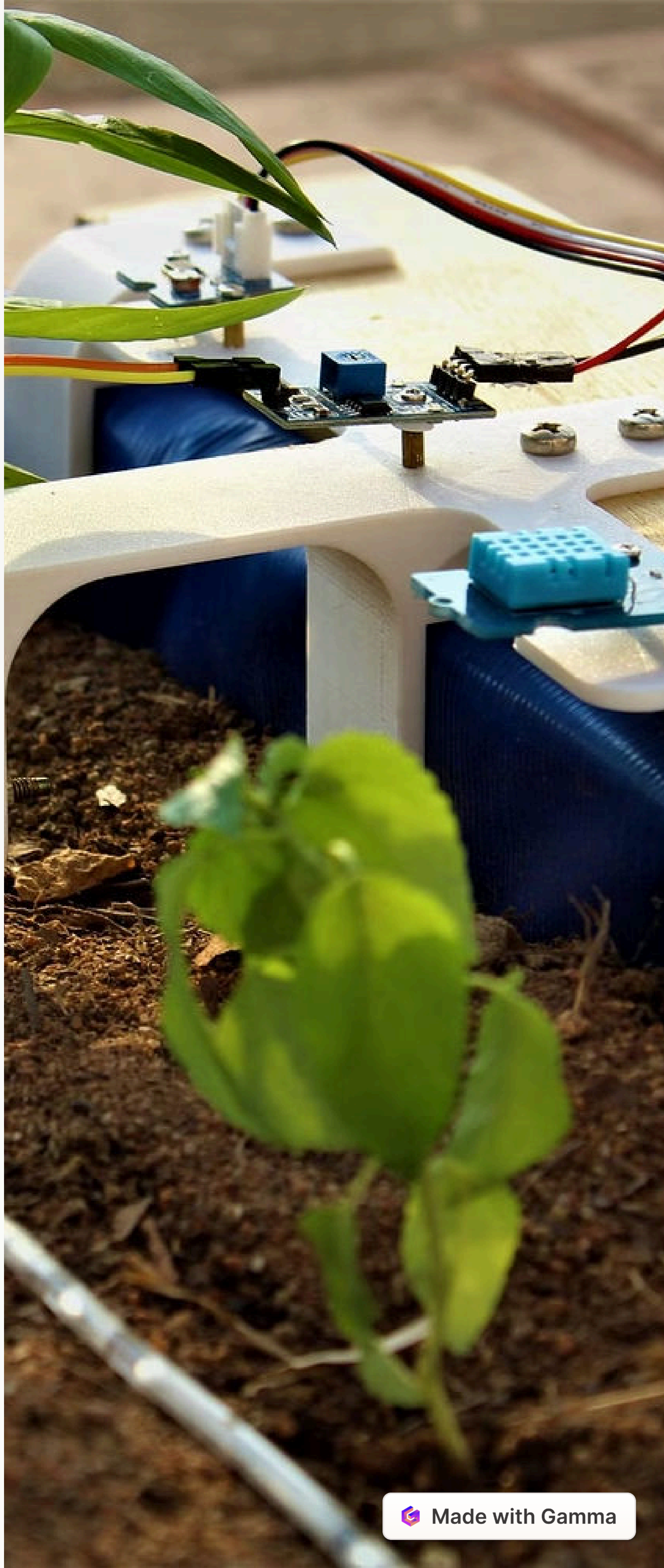
The Smart IoT Botany STEM Kit is an innovative educational tool designed to engage and inspire teenage kids aged 10-13 in the captivating world of botany and STEM (Science, Technology, Engineering, and Mathematics) learning. This comprehensive kit provides hands-on, interactive experiences that foster a passion for science and the natural environment, empowering the next generation of young botanists and scientists.

Introduction:

In today's digital age, fostering an interest in science and nature among young learners is more important than ever. The Smart IoT Botany STEM Kit represents a unique fusion of technology and botany, offering an immersive learning experience that combines hands-on exploration with cutting-edge IoT (Internet of Things) technology.

Designed with teenage kids aged 10-13 in mind, this kit introduces students to the fundamentals of plant care and horticulture while integrating real-time monitoring and control capabilities through IoT tech. By leveraging sensors, microcontrollers, and a user-friendly app interface, students can actively monitor and nurture their plants, gaining valuable insights into plant growth and environmental conditions.

Through gamification features like leaderboards and streaks, the Smart IoT Botany STEM Kit transforms plant care into an engaging and rewarding experience, encouraging students to develop critical thinking, problem-solving, and digital literacy skills. Ultimately, this innovative STEM solution empowers students to explore the fascinating world of botany while cultivating a sense of responsibility towards the environment.



Project Objectives

The primary objective of the Smart IoT Botany STEM Kit is to provide a comprehensive and engaging platform for teenage kids aged 10-13 to explore the captivating realms of botany, STEM (Science, Technology, Engineering, and Mathematics) learning, and environmental stewardship. This multifaceted project aims to achieve the following goals:

1. **Introduce Botanical Concepts:** Foster a deeper understanding and appreciation for botany and plant science among teenage learners through hands-on exploration and experimentation.
2. **Utilize IoT Technology:** Harness the power of IoT (Internet of Things) technology to enable real-time monitoring and remote control of plant growth parameters, enhancing the learning experience and promoting technological literacy.
3. **Promote Environmental Awareness:** Cultivate a sense of responsibility and environmental stewardship by emphasizing the importance of sustainable plant care practices and ecosystem conservation.
4. **Engage and Motivate Users:** Gamify the plant care experience by incorporating features such as leaderboards, streaks, and rewards, motivating users to actively participate in nurturing their plants and fostering a sense of achievement.
5. **Target Audience:** Tailor the Smart IoT Botany STEM Kit to meet the needs and interests of teenage kids aged 10-13, a demographic characterized by curiosity, eagerness to learn, and responsiveness to hands-on, interactive educational experiences.
6. **Remote Software Control through Blynk:** Enable users to remotely monitor and control their plants using the Blynk app, providing a seamless and intuitive interface for adjusting settings, receiving alerts, and accessing real-time data from anywhere.
7. **Plug and Play Functionality:** Design the Smart IoT Botany STEM Kit with plug-and-play functionality for ease of setup and operation, ensuring that users can quickly assemble the kit and start exploring without the need for extensive technical knowledge or experience.

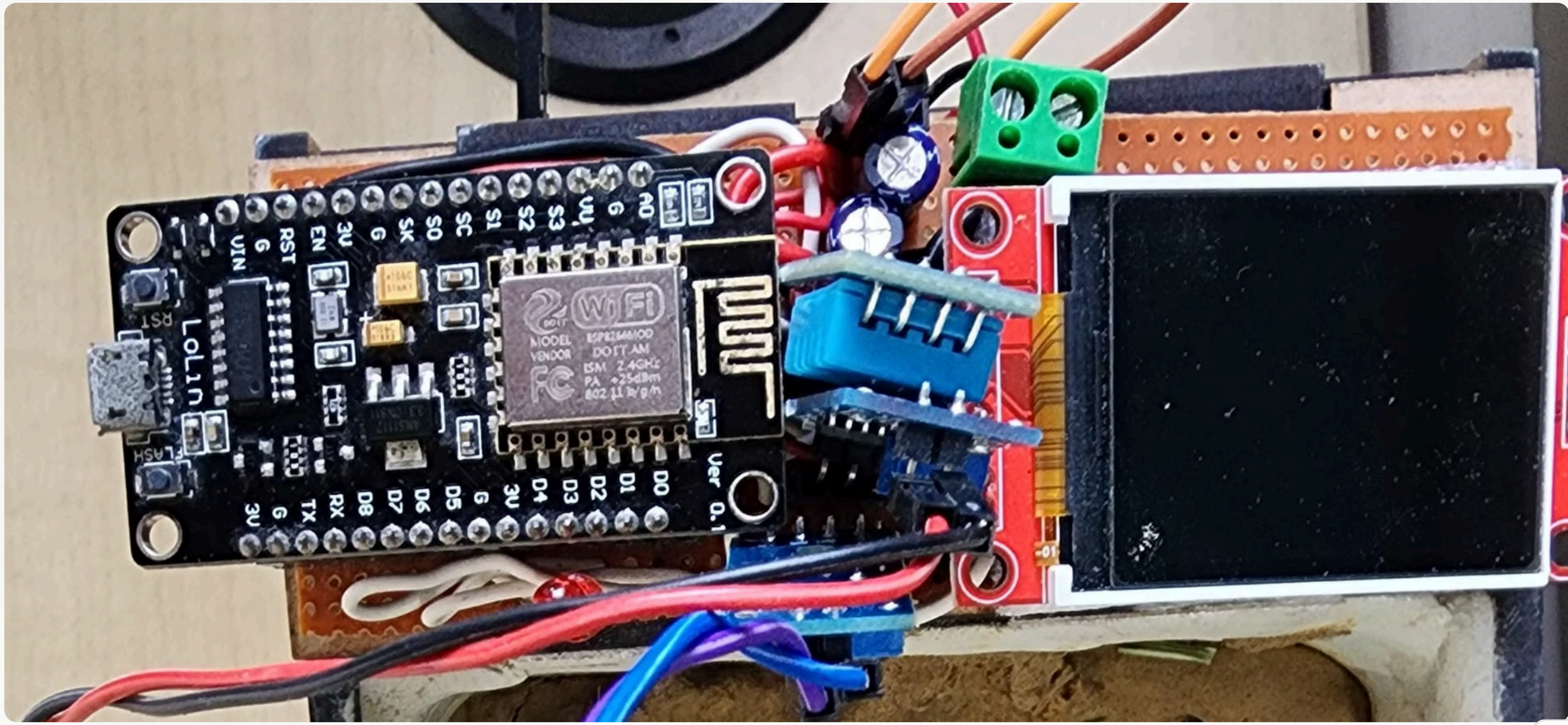
Project Components

Hardware Components	- Microcontroller Unit (e.g., Arduino or NodeMCU) - Sensors: Soil Moisture, Water Level, Temperature & Humidity - LCD Display Screen - Enclosure (MDF board, acrylic panels) - Power Supply (batteries or power adapter) - Connecting Wires and Breadboard
Software Components	- Arduino IDE for programming the microcontroller - Blynk app for remote monitoring and control - Libraries for sensor interfacing and data processing
Educational Resources	- Curriculum materials (lesson plans, worksheets) - Online resources (videos, articles) for further learning - Gamification elements (leaderboards, achievements)
Miscellaneous Components	- Waterproofing material (MSEAL clay) for electronics - Planting pot or tray for the plant - Mounting hardware (screws, nuts) for assembly
Documentation and Instructions	- Assembly instructions - User manual for setup, operation, and troubleshooting - Educational guides on botany, environmental science, STEM
Packaging and Branding	- Packaging materials (box, labels) for safe transport - Branding elements (logo, colors) for visual identity

NodeMCU Microcontroller

The NodeMCU ESP8266 is a highly capable and compact microcontroller board that boasts built-in Wi-Fi connectivity. Powered by the powerful ESP8266 chip, it offers a 32-bit processor, ample GPIO pins, and generous flash memory for running diverse IoT applications.

With support for the Arduino IDE and Lua scripting, NodeMCU makes it easy to build innovative connected solutions, from home automation to environmental monitoring systems. Its affordable price point and vibrant community support make it a popular choice for hobbyists and professionals alike.



Node MCU PinOut

NodeMCU Development Board Pinout Configuration

Pin Category	Name	Description
Power	Micro-USB, 3.3V, GND, Vin	**Micro-USB:** NodeMCU can be powered through the USB port **3.3V:** Regulated 3.3V can be supplied to this pin to power the board **GND:** Ground pins **Vin:** External Power Supply
Control Pins	**EN, RST**	The pin and the button resets the microcontroller
Analog Pin	A0	Used to measure analog voltage in the range of 0-3.3V
GPIO Pins	GPIO1 to GPIO16	NodeMCU has 16 general purpose input-output pins on its board
SPI Pins	SD1, CMD, SD0, CLK	NodeMCU has four pins available for SPI communication.
UART Pins	TXD0, RXD0, TXD2, RXD2	NodeMCU has two UART interfaces, UART0 (RXD0 & TXD0) and UART1 (RXD1 & TXD1). UART1 is used to upload the firmware/program.
I2C Pins		NodeMCU has I2C functionality support but due to the internal functionality of these pins, you have to find which pin is I2C.

Methodologies used-:

Design Thinking Process

- Empathize: Understanding the needs, motivations, and pain points of the target audience (teenage kids aged 10-13).
- Define: Defining the problem and identifying opportunities for innovation.
- Ideate: Generating creative solutions to address the defined problem statement.
- Prototype: Developing tangible prototypes to test and refine ideas.
- Test: Testing the prototypes with real users to gather feedback and iterate on the design.
- Implement: Bringing the final design to life and preparing it for production.

Laser Cutting of MDF Boards

- Utilizing laser cutting technology to precisely cut and engrave Medium-Density Fiberboard (MDF) for the prototyping base.
- Using Computer-Aided Design (CAD) software such as AutoCAD to create precise designs and layouts for the MDF enclosure.

Electronics Methods

- Selecting appropriate electronic components such as sensors, microcontrollers, and displays for the project.
- Wiring and soldering the electronic components according to circuit diagrams and schematics.
- Programming the microcontroller unit (e.g., Arduino or NodeMCU) using the Arduino IDE or other compatible software to control sensor readings, display outputs, and communication with the IoT platform.

IoT (Internet of Things)

- Integrating IoT technology into the project to enable real-time monitoring and control of plant growth parameters.
- Using IoT platforms such as Blynk to develop a smartphone app for remote monitoring and control of the Smart IoT Botany STEM Kit.
- Establishing Wi-Fi connectivity between the microcontroller unit and the IoT platform to facilitate data communication and user interaction.

By employing these methodologies and techniques, the project team was able to design, develop, and implement the Smart IoT Botany STEM Kit, providing an engaging and educational experience for teenage kids while fostering their interest in botany and STEM learning.

Software For Cloud Networking:

Blynk (Visit Website: https://blynk.io/)

- Blynk is an intuitive IoT platform designed for creating IoT projects and applications.
- Users can build custom interfaces for controlling and monitoring IoT devices using a smartphone app.
- The platform offers drag-and-drop functionality for easy interface design.
- Blynk supports a variety of hardware platforms and communication protocols.
- It caters to both beginners and experienced developers, providing accessibility and advanced features.
- With Blynk, users can quickly prototype and deploy IoT solutions with minimal time and effort.

WHY BLYNK?

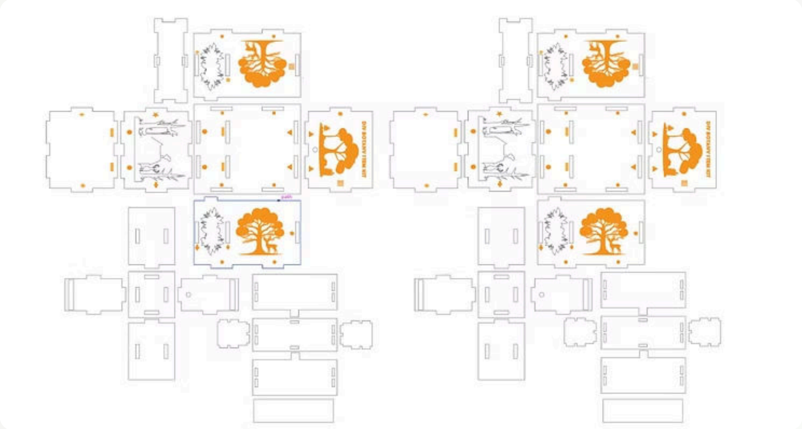
Here we are controlling LED bulb on off from remote area .

WITH BLYNK WE CAN CONTROL OUR SYSTEM FROM ANY PART OF THE WORLD
AS IT WORKS ON CLOUD NETWORKING BASIS.

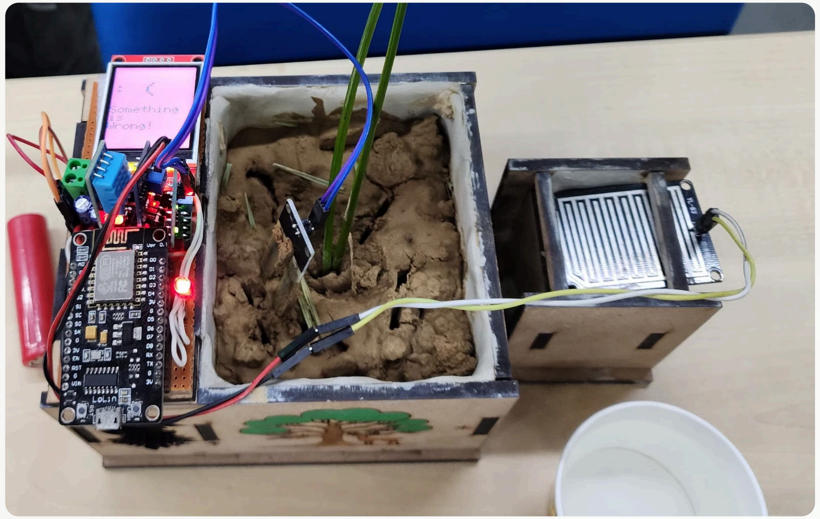
Software For Layout Of Designing Box (AutoCad)https://www.googleadservices.com/pagead/aclk?sa=L&ai=DChcSEwim7l6i_I-GAxXUWA8CHYgHAMsYABAAGgJ0Yg&ase=2&gclid=CjwKCAjwupGyBhBBEiwA0UcqaMR-5zFVebV-Cq08jqEPbdfB6EPpOPDP6IWScsvm6H29Bl7KBT5ddBoCuVoQAvD_BwE&ohost=www.google.com&cid=CAESVeD21xWc9Ldp4EcsHIRL_IF3eCp7jjqX3qdYx0JTfe2jxmTsXZqqgey4Jt0n5a18mk367josUJWSAtsxPVaQ8trXWbtyTjK9nxFDG7BdTeG4ef0KTMw&sig=AOD64_3kY4i-Z99qssdALNUSkkOLdAzXCA&q&nis=4&adurl&ved=2ahUKEwjZkomi_I-GAxV8lFYBHShjBc0Q0Qx6BAgGEAE

AutoCAD is a widely-used computer-aided design (CAD) software that allows users to create precise 2D and 3D drawings and models. It offers a comprehensive set of tools for drafting, modeling, and annotation, making it suitable for a wide range of design tasks, including designing MDF boxes.

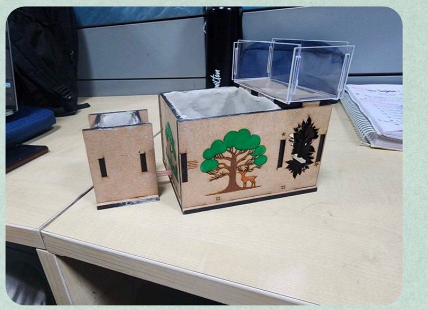
AutoCAD allows users to create detailed plans, layouts, and prototypes, and it provides features for precise measurement, scaling, and editing of designs. With its intuitive interface and powerful capabilities, AutoCAD is a popular choice among engineers, architects, designers, and hobbyists for creating accurate and professional-quality designs.

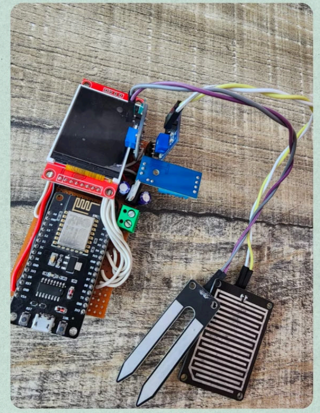


The Design of integration Box.



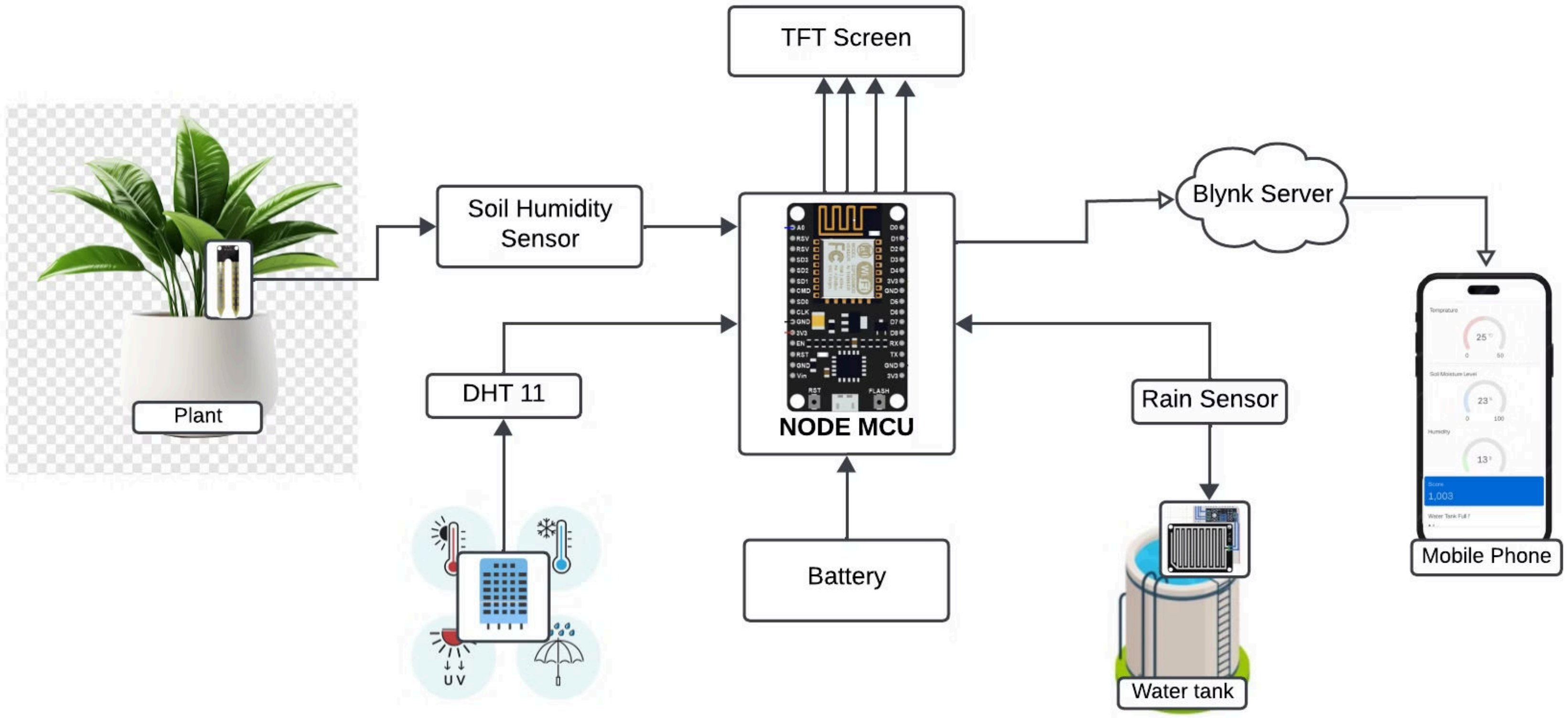
Final Box Look



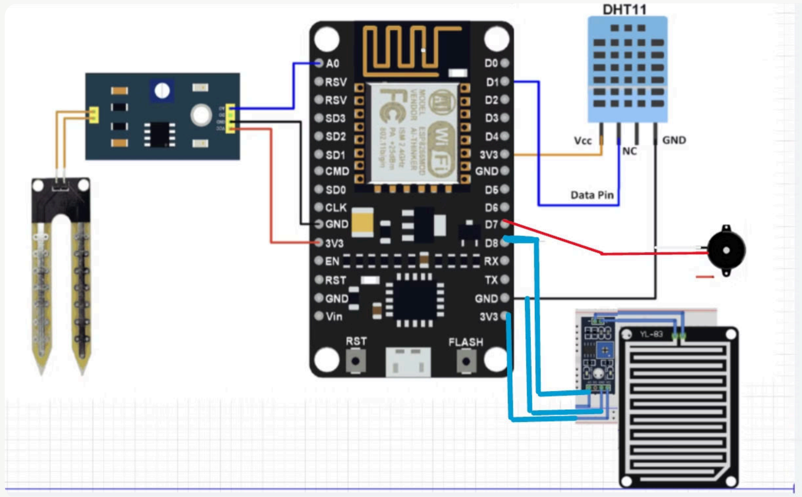


Electronics Components and Applying Clay on box for water proofing.

System Architecture

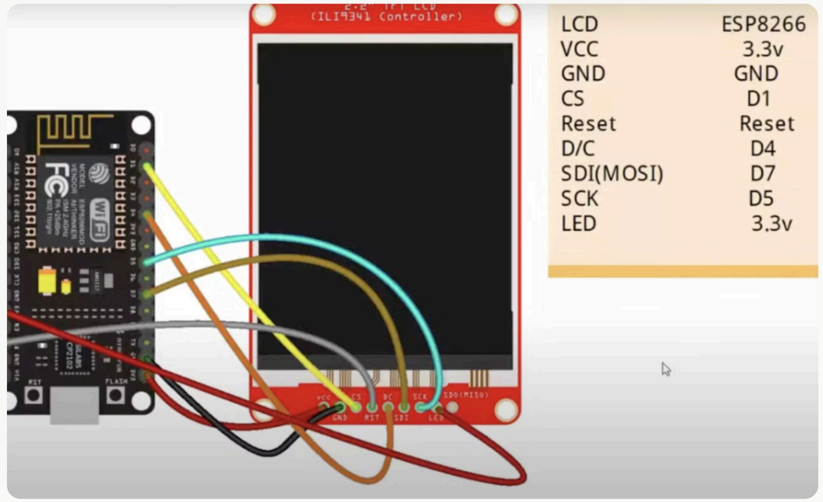


Pinouts To Make Connections



Connect DHT11, rain sensor in digital pins. Provide voltage through battery, add voltage step down bug converter wherever needed to step down the voltage according to device, mcu, supply.

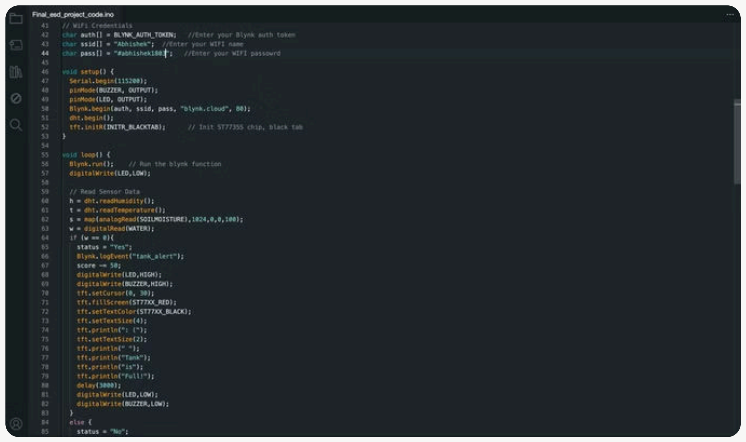
Connect Soil Humidity Sensor to analog pin of the NodeMcu.

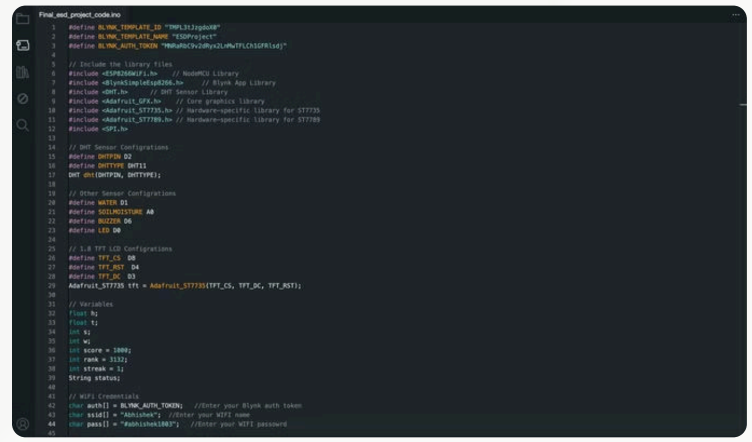


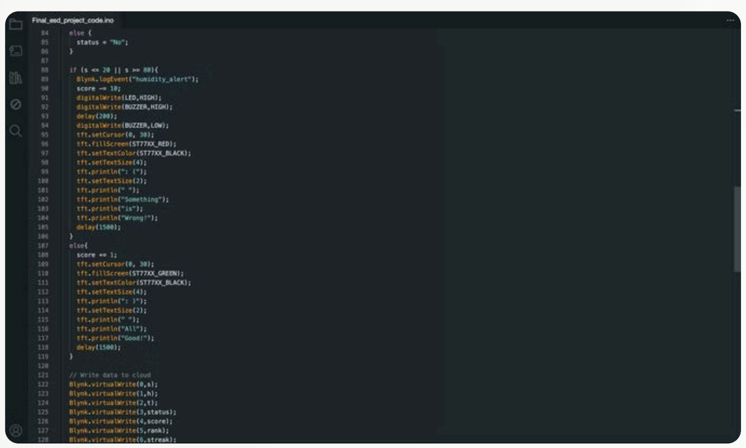
For TFT display, we are using SPI communication so we need 4 lines to connect : MISO,MOSI,SC,SCLK.

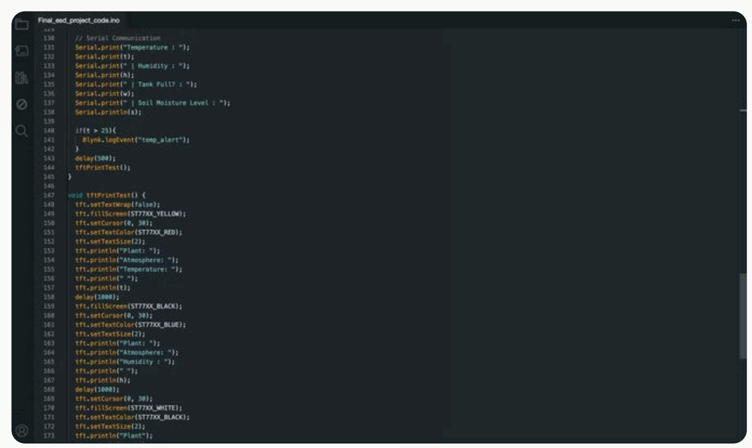
Link for reference (https://arduino.stackexchange.com/questions/63133/how-to-connect-tft-lcd-display-with-nodemcu)

Arduino IDE code:https://drive.google.com/drive/folders/1S62ak2Khb0cf2gZoCW0tRsCLQegYBpGj?usp=sharing







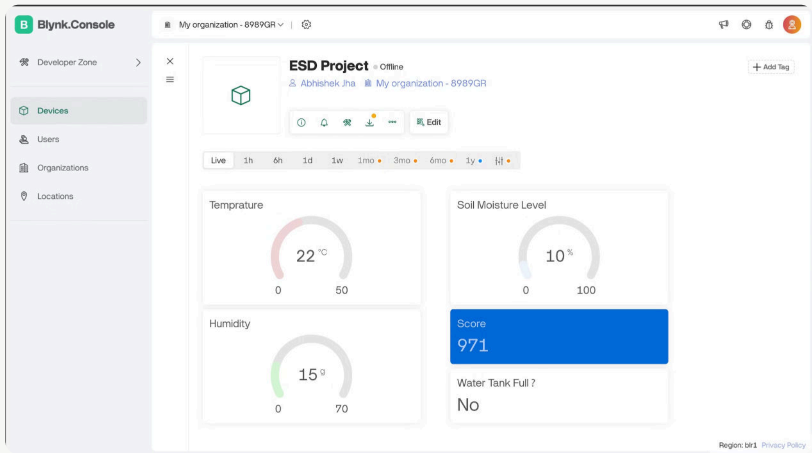


The architecture of the Smart IoT Botany STEM Kit :

1. **Hardware Components:**
    - **Microcontroller Unit (MCU):** The MCU serves as the brain of the system, responsible for gathering data from sensors, processing information, and controlling output devices.
    - **Sensors:** Soil moisture sensor, water level sensor, and temperature & humidity sensor collect data related to plant health and environmental conditions.
    - **Display Screen:** An LCD display screen provides visual feedback to users, such as current soil moisture level, temperature, and humidity readings.
    - **Enclosure:** The MDF board and acrylic panels form an enclosure to house the electronic components and protect them from external elements.
    - **Power Supply:** Batteries or a power adapter provide the necessary power to operate the system.
2. **Software Components:**
    - **Arduino IDE:** Used for programming the MCU to read sensor data, process it, and control output devices based on predefined logic.
    - **Blynk App:** An IoT platform used for remote monitoring and control of the Smart IoT Botany STEM Kit. It allows users to view real-time sensor data and adjust settings from a smartphone or tablet.
3. **Data Flow:**
    - The sensors continuously monitor plant health parameters such as soil moisture level, water level in the tank, temperature, and humidity.
    - Sensor data is collected by the MCU, which processes the information and determines if any actions need to be taken (e.g., watering the plant).
    - The MCU communicates with the Blynk app via Wi-Fi, sending sensor data and receiving commands from the user.
    - Users can view real-time sensor data and adjust settings (e.g., watering schedule) using the Blynk app.
    - Based on user input and sensor readings, the MCU controls output devices such as the display screen to provide feedback and alerts.
4. **Integration:**
    - The hardware and software components are integrated to create a cohesive system that enables users to monitor and control plant growth parameters remotely.
    - The MCU serves as the central hub, orchestrating the flow of data between sensors, the Blynk app, and output devices.
    - The enclosure provides physical protection for the electronic components while allowing for easy access and visibility of the display screen.

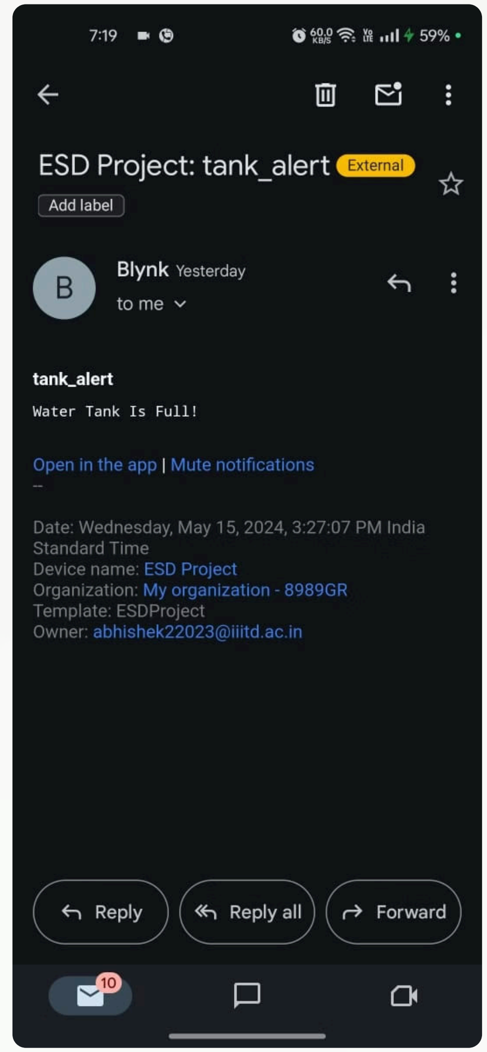
Overall, the architecture of the Smart IoT Botany STEM Kit is designed to be user-friendly, flexible, and reliable, enabling users to engage in hands-on botany and STEM learning experiences while leveraging IoT technology for plant care.

Blynk Software



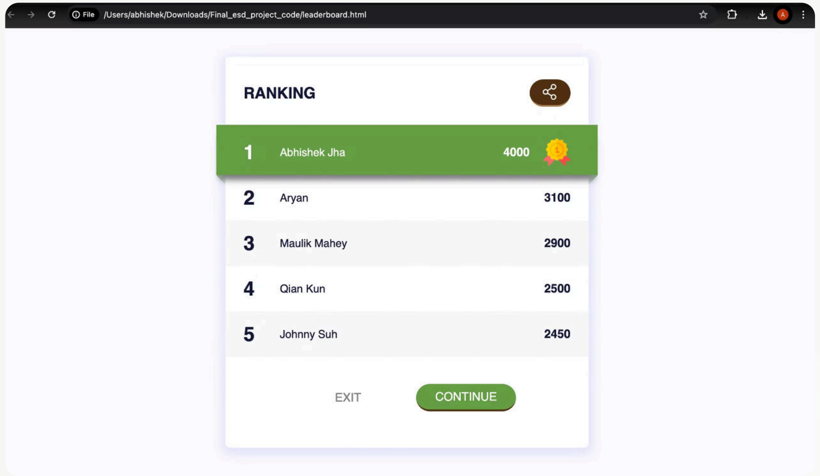
This is the real time update of data and score of the plant. Includes temperature , humidity and moisture level and Tank details.

Score is a scaled level of all 3 above.



You will get real time notifications if everything is good or not.

You can also use blynk app to get al data on your mobile.



Link to leaderboard:

Gamification

The leaderboard and streak elements of the Smart IoT Botany STEM Kit gamify the plant care experience, adding fun and motivation for users. The leaderboard lets users compete to achieve the best plant growth results, while the streak feature rewards consistent plant care routines. These elements encourage engagement, competition, and dedication to nurturing plants, making the learning experience more interactive and rewarding.

IMPLEMENTAION DETAILS:

1. **Assembly of Hardware Components:**
    - Begin by assembling the hardware components onto the MDF board. This includes mounting the microcontroller unit (MCU), sensors (soil moisture, water level, temperature & humidity), and the LCD display screen.
    - Ensure that the components are securely attached and properly connected using jumper wires or soldering, following the circuit diagrams and schematics.
2. **Waterproofing the Enclosure:**
    - Apply MSEAL clay or similar waterproofing material to the enclosure to protect the electronic components from moisture and spills. This step is crucial to ensure the longevity and reliability of the Smart IoT Botany STEM Kit.
3. **Programming the Microcontroller Unit (MCU):**
    - Use the Arduino IDE or compatible software to program the MCU. Write code to read data from the sensors, process it based on predefined thresholds, and control output devices accordingly.
    - Implement logic to monitor soil moisture levels, water levels in the tank, and environmental conditions (temperature and humidity). Trigger alerts or actions (such as watering the plant) when necessary.
4. **Configuring the Blynk App:**
    - Set up the Blynk app to communicate with the MCU via Wi-Fi. Create a user interface with widgets to display real-time sensor data and control settings.
    - Establish communication protocols and authentication mechanisms to ensure secure and reliable data exchange between the app and the MCU.
5. **Testing and Calibration:**
    - Test the Smart IoT Botany STEM Kit thoroughly to ensure that all components are functioning correctly. Verify sensor accuracy and responsiveness under different environmental conditions.
    - Calibrate sensors if necessary to ensure accurate readings and optimal performance.
6. **User Manual and Documentation:**
    - Prepare a user manual that provides detailed instructions on how to assemble, set up, and operate the Smart IoT Botany STEM Kit. Include troubleshooting tips and FAQs to assist users in resolving common issues.
    - Document the implementation process, including circuit diagrams, code snippets, and configuration settings, for future reference and troubleshooting.
7. **Packaging and Branding:**
    - Design packaging materials (box, labels, etc.) for the Smart IoT Botany STEM Kit to create a cohesive and professional presentation.
    - Incorporate branding elements (logo, colors, etc.) to establish a recognizable identity for the product and enhance its appeal to users.

User Guide of the product.

Assembly Guide for Smart IoT Botany STEM Kit

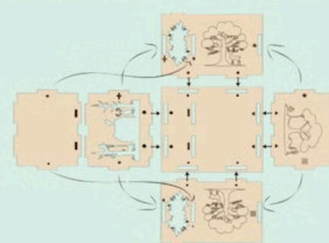
1 Unboxing

Remove all components from the packaging and ensure that you have everything needed:

- **MDF Board** (prototyping base)
- **MSEAL Clay** (waterproofing)
- **Acrylic Panels** (transparency)
- Sensors (**water level sensor, soil moisture sensor, temperature & humidity sensor**)
- Electronic components (**Arduino board, buzzer, LED indicators, LCD Screen**)
- **Water tank** (for excess water collection)

2 Joining the MDF Planks

- Make Sure to align the Shapes printed on the MDF planks with their matching shapes and join them by putting the cutouts into the slits.
- For better Demonstration, please refer to the Illustration beside.



3 Waterproofing

Apply MSEAL clay to the enclosure to waterproof the kit. Ensure that all seams and edges are properly sealed to protect the electronic components from moisture and spills. Allow the clay to dry completely before proceeding to the next step.

4 Plant Placement

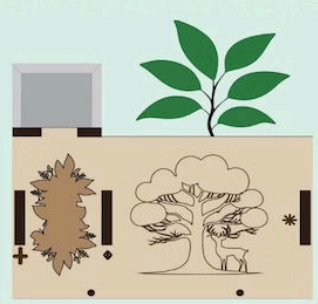
Carefully place your favorite plant into the designated planting area on the MDF board.

5 Electronic Component Setup

Carefully place the already prepared Circuit using Breadboard, Sensors and Chipsets into the Empty side compartment.

6 Final Assembly and App Setup

Secure all components in place and double-check that everything is properly aligned and connected. Download the companion app on your smartphone and follow the setup instructions to connect to the Smart IoT Botany STEM Kit via Wi-Fi. Once connected, you can access real-time sensor data and control features directly from the app.



Demonstration Video:

Google Docs

My movie 1.mp4

Testing and Evaluation:

During the development of the Smart IoT Botany STEM Kit, rigorous testing procedures were employed to ensure the reliability, functionality, and safety of the system. Various tests were conducted to evaluate the performance of hardware components, verify sensor accuracy, and validate the effectiveness of the IoT platform. Here's an overview of the testing and evaluation process:

1. **Voltage and Current Testing:**
    - Voltage and current measurements were taken at different points in the circuit to ensure that components were operating within their specified ranges and that power requirements were met.
    - Testing included verifying the voltage supplied to the microcontroller unit (MCU) and sensors, as well as measuring the current drawn by the system during different operation modes.
2. **Buck Converter Evaluation:**
    - The performance of the buck converter used to regulate voltage levels for the MCU and other components was evaluated.
    - Efficiency tests were conducted to assess the converter's ability to step down voltage while minimizing power losses.
    - Output voltage stability and ripple were measured to ensure a consistent and reliable power supply to the system.
3. **Sensor Calibration and Accuracy Testing:**
    - Soil moisture, water level, temperature, and humidity sensors were calibrated against known standards to verify their accuracy and reliability.
    - Sensor readings were compared to reference measurements to assess their precision and consistency across different environmental conditions.
    - Calibration curves were generated to translate sensor readings into meaningful data points for plant monitoring and control.
4. **IoT Platform Testing:**
    - The Blynk app interface was tested for compatibility with various smartphones and tablets, ensuring a seamless user experience across different devices.
    - Communication protocols between the MCU and the Blynk server were evaluated to verify data transmission reliability and security.
    - User interactions with the app, such as adjusting settings and viewing real-time sensor data, were tested to identify any usability issues or bugs.
5. **End-to-End System Testing:**
    - Comprehensive end-to-end testing was conducted to validate the functionality and integration of hardware and software components.
    - This included testing scenarios such as sensor data acquisition, alert triggering based on predefined thresholds, remote control via the Blynk app, and display of real-time data on the LCD screen.
    - System performance was assessed under normal operating conditions as well as stress tests to identify any potential failure points or performance bottlenecks.

By conducting thorough testing and evaluation, the Smart IoT Botany STEM Kit was able to deliver a reliable, user-friendly, and effective solution for engaging teenage kids in botany and STEM learning while leveraging IoT technology for plant care.

Future Enhancements:

1. **Integration of Telegram Bot for Enhanced User Interface:**
    - In future iterations of the Smart IoT Botany STEM Kit, we plan to integrate a Telegram bot as an alternative user interface for even greater accessibility and ease of use.
    - The Telegram bot will allow users to monitor their plants, receive notifications, and adjust settings directly from their smartphones using the Telegram messaging platform.
    - This additional interface will provide users with more flexibility and convenience in interacting with the Smart IoT Botany STEM Kit, catering to diverse preferences and technological capabilities.
2. **Automated Threshold Setting Algorithm for Optimal Plant Care:**
    - To further streamline the plant care process, we aim to develop an automated algorithm that dynamically sets the required thresholds for water level, humidity, and temperature based on specific plant requirements.
    - This algorithm will utilize machine learning techniques and plant database information to analyze historical sensor data and determine optimal environmental conditions for different types of plants.
    - By removing the need for manual input and calibration, this automated approach will simplify setup and maintenance tasks for users, ensuring that plants receive optimal care without requiring constant monitoring or intervention.
    - Additionally, the algorithm will continuously adapt and refine its recommendations over time, taking into account changing environmental factors and plant growth stages to optimize long-term plant health and productivity.

These future enhancements will further elevate the Smart IoT Botany STEM Kit, making it more user-friendly, intelligent, and effective in fostering botanical learning and environmental stewardship among teenage users.

Challenges Faced:

1. **Voltage Conversion**: Voltage compatibility between components can present challenges, particularly when different components require varying voltage levels for optimal operation. Ensuring proper voltage conversion while maintaining current requirements is crucial to prevent damage to components. In our project, the utilization of buck converters facilitated voltage regulation without affecting the current, addressing voltage conversion challenges effectively.
2. **Power Supply Design**: Designing a stable and efficient power supply system can be challenging, especially when powering multiple components with diverse voltage and current requirements. Challenges such as voltage regulation, noise suppression, and power efficiency optimization must be addressed to meet the project's power supply needs reliably.
3. **Component Soldering and Assembly**: Proper soldering and assembly practices are essential for robust connections and reliable circuit operation. Challenges may arise in ensuring high-quality solder joints, precise component placement, and mechanical stability, particularly in small-scale or densely packed circuits.
4. **Testing and Debugging**: Identifying and resolving issues in electronic circuits through testing and debugging can be time-consuming and challenging. Comprehensive testing procedures, including functional testing, signal analysis, and troubleshooting techniques, are necessary to validate circuit performance and diagnose problems effectively.
5. **Component Limitations and Trade-offs**: Working within the constraints of available resources, such as limited pins or memory, can pose challenges in component selection and circuit design. Making informed decisions and balancing trade-offs based on project requirements are essential to overcome such limitations effectively. For example, in our project, the use of a rain sensor instead of a water level sensor due to pin constraints on the NodeMCU required careful consideration of sensing capabilities and trade-offs in functionality.

Obstacles

Output pins of sensors give 5V output but nodeMCU was taking 3.3v input for safety precautions.

Bug Converer

Solutions

We used 5V→3V Volatage converters.
They work on the principle of

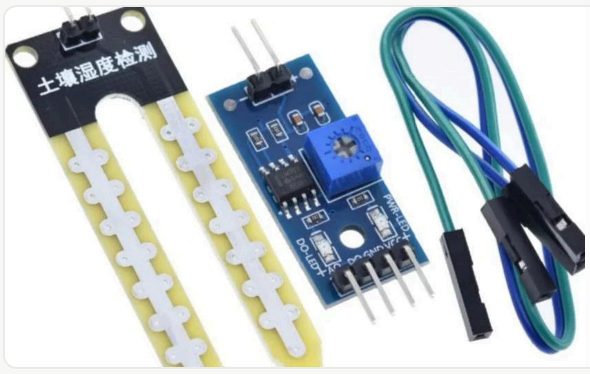
1. U1/U2=N1/N2, that is, for any two coils of the same transformer, the voltage is proportional to the number of turns.
2. P in = P out, that is, no matter how many secondary coils are working, the input power of the transformer is always equal to the sum of all output powers.

Bill Of Materials and Purchase Links:

1 Microcontroller Unit (MCU):

- NodeMCU(ESP 8266) | RS.151/-

2 Soil Moisture Sensor| RS.74/-

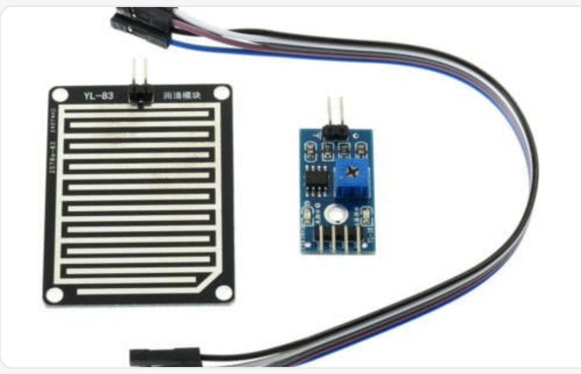


Robocraze

Soil Moisture Sensor Module

Soil Moisture Sensor Module This is Soil Moisture Sensor Module or Soil Moisture Meter, Soil Humidity Sensor, Water...

3 Rain Sensor| RS.48/-



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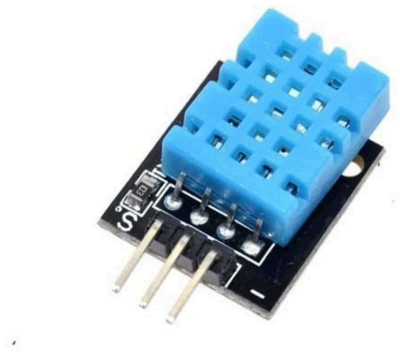

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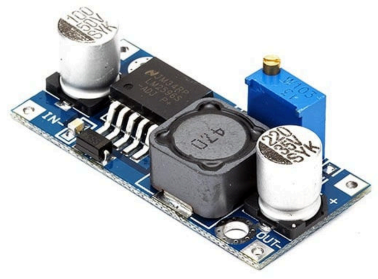

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