IoT based Smart Greenhouse Framework and Control Strategies for Sustainable Agriculture

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Abstract— The greenhouse industry is the fastest growing sector worldwide. The greenhouse separates crop from the environment, thus providing same way of shelter from the direct influence of the external weather condition. Here the greenhouse parameters are send through the internet to the open source cloud server. By using a low cost more efficient programmable module to detect the climatic behavior inside the greenhouse and controlling the parameters according to their crop production need, through various techniques with the use of board ESP8266 Node MCU module. The parameters that need optimization are the water content of the soil, the light intensity coming from the natural or artificial sources, the temperature and humidity of the field area. The design proposes monitoring by soil moisture sensor, LDR sensor, and DHT11(temperature and humidity) sensor; all these sensors collected the data and given to the Node MCU module, and then after processing the data all the parameters are controlled via Motor fan, exhaust system, and light system as per the data calculations. The collected environmental parameters data sent to smartphones via online mode to the farmers to make the proper overlook on their fields, no matter how far they are just by using the IoT platform. In the field of agriculture and food production, the technology has paced up very quickly and is still furnishing its way, to optimize and achieve maximum plant growth in the field of agriculture.

Keywords—Internet of Things; Arduino UNO Board; DHT11 Sensor; Soil Moisture sensor; Humidity; LDR Light Sensor; Relay; LED; WIFI Module; LCD Display.

I. INTRODUCTION

The demand for greater efficiency in resource management is rapidly increasing. This is true in many domains, including industrial, household, and transportation, where public opinion, sensitized by environmental issues, encourages scientific, technological, and legislative communities to make more efforts to conserve the planet while still preserving the lifestyle attained in this era. Agriculture, which had been neglected in the past, is becoming increasingly important within these sectors. In reality, the decline in cultivable land owing to soil occupation combined with human activity suggested building a new type of agriculture that optimizes the use of soil and water These efforts are a prelude to the colonization of space, where resources will undoubtedly be scarce and of poor quality. As a result, the development of efficient techniques and a linked control system may be critical for the development of long-term space programmers. Soilless cultivations are becoming increasingly important among these techniques and appear to be the most promising for space applications. In actuality, the option of not carrying soil, is winning during a space voyage for the reduction of weight and the volume occupied on the vessel, but also for the novel geometries in the positioning of the plants, undoubtedly more imaginative than a traditional crop, that allow to further manage the space on board.

A greenhouse is a building where plants that require controlled climate conditions are grown. Its walls and roof are mostly made of transparent materials, like glass. A covered structure that shields plants from severe external weather conditions and diseases, fosters an ideal microenvironment for growth, and provides a flexible answer for efficient and sustainable year-round cultivation is a covered structure, according to a more scientific definition. Considering that a modern greenhouse functions as a system, it is also known as a controlled environment plant production system or controlled environment agriculture. High-tech production.

Facilities for vegetables or flowers can be found in many commercial glass greenhouses or hothouses. The glass greenhouses are equipped with heating, cooling, lighting, and other systems that can be managed by a computer to create the ideal environment for plant growth. Then, in order to lower production risk before the cultivation of a particular crop, various techniques are used to evaluate the optimality-degrees and comfort ratio of the greenhouse micro-climate (i.e., air temperature, relative humidity, and vapor pressure deficit). A greenhouse is feasible for almost any property, ranging from large freestanding structures to small window-mounted structures.

II. LITERATURE SURVEY

The research is grounded in academic standards and advances the researcher's ideas, and this section highlights the related works that were used in this project. There are many studies that bring technology to assist in agriculture and show the results in comfort and productivity.

. The Internet of Things, or IOT, is currently used widely in agriculture. Through an Android smart phone, the Grow-Pro hydroponic system is automatically controlled. Operating four different sensors for growing plants works well.

Incorporating IOT and sensors, the Titan Smartphones system controlled parameters through a web interface, and the results showed that the plants grown in the control system grew better than the outside system . The nutritional water flow system was implemented using an Arduino Uno Microcontroller, and the results indicated that the sensor can accurately detect and manage the water level in hydroponic tubes . A Hydroponics Control System, according to Mark Griffiths , manages and monitors the essential nutrient requirements using an Arduino 2560 board, and the system performs well in all other areas, including pH, EC, air and water levels. The smart phone with an Android operating system is made to collect data from sensor nodes and send it to centralized computing that is synchronized with the WSN. IOT for Agricultural Environment Monitoring, the prototype collected the field environment information to investigate and real-time collect information to monitor the field, can also effectively improve supply chain conditions by integrating RFID and network database technology. With the help of inexpensive, simple-to-install sensors and the wealth of insightful data they provide, the opportunity to improve agricultural products has thus been greatly expanded by the Internet of Things.

III. EXISTING SYSTEM

Numerous studies on greenhouse automation are currently being conducted. These studies vary according to the parts that fall under the categories of communication and control infrastructure, embedded systems used in greenhouses, sensors, and converters developing system and user-interface skills. Several communication protocols, depending on system installation cost, distance, and data transmission rate, have been used for infrastructure, including wired data communication-based RS485, Bluetooth, CAN (Controller Area Network), GPRS (General Packet Radio System), GSM (Global System for Mobile Communications), and Internet. The user interface is complex and data updating will be extremely slow because it uses SMS functionality to communicate with the client.

Drawbacks of existing system:

- *Manual setup:* This set-up involves visual inspection of the plant growth, manual irrigation of plants, turning ON and OFF the temperature controllers, manual spraying of the fertilizers and pesticides. It is time consuming, vulnerable to human error and hence less accurate and unreliable.
- *Partially automated setup:* This set-up is a combination of manual supervision and partial automation and is similar to manual set-up in most respects but it reduces the labor involved in terms of irrigating the set-up.

IV. PROPOSED SYSTEM

For optimum plant growth, increased crop yields, and effective use of water and other resources, the environment must be suitable. Information can be gathered using this system with less labor by automating the data acquisition process for the soil characteristics and various climatic parameters that influence plant growth. This IOT greenhouse monitoring system uses phone- or PC-based systems to continuously update the owner on the state of the greenhouse.

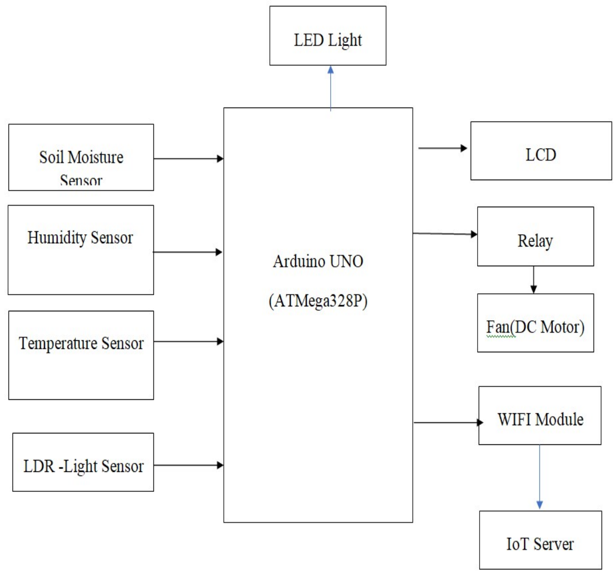


Fig:4.1 Block Diagram of Proposed System

Arduino UNO(ATMega328P):

Arduino is a single-board microcontroller that makes it easier for people to use electronics in cross-disciplinary projects. An open-source hardware board built around an 8-bit AtmelAVR or 32-bit Atmel ARM microcontroller serves as the hardware. A boot loader and a compiler for a common programming language make up the software that runs on the microcontroller.

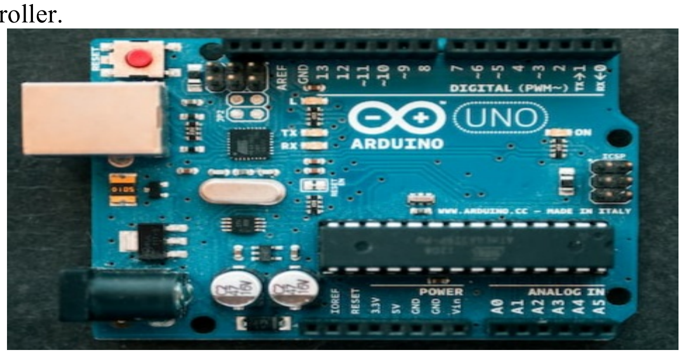
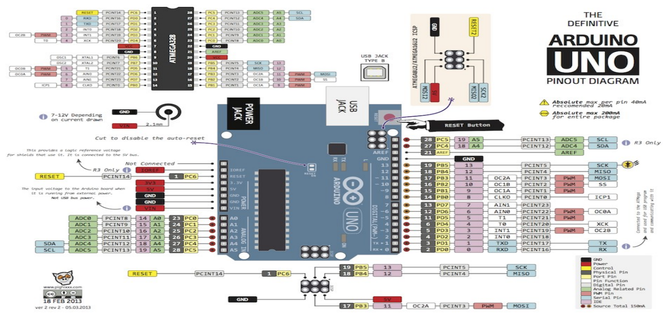


Fig:4.2 Arduino UNO Board

The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms.



MEMORY: The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM

INPUT AND OUTPUT PINS: Each of the 14 digital pins on the Uno can be used as an input or output, using pin Mode(), digital Write(), and digital Read() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor (disconnected by default) of 20-50 ohms. In addition, some pins have specialized functions:

• ***Serial:*** *0 (RX) and 1 (TX).* Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
• ***External Interrupts:*** 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. See the attach Interrupt() function for details
• ***.PWM: 3, 5, 6, 9, 10, and 1:***. Provide 8-bit PWM output with the analog Write() function.
• ***SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK)*** **;**These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
• ***SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK)*** **;**These pins support SPI communication, which, although provided by the underlying hardware, is not currently included in the Arduino language.
• ***LED: 13:*** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.

The Uno has 6 analog inputs, labeled A0 through A5, each of which provide 10 bits of resolution (i.e. 1024 different values). By default they measure from ground to 5 volts, though is it possible to change the upper end of their range using the AREF pin and the analog Reference () function. Additionally, some pins have specialized functionality:

- ***TWI*****:** A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- ***AREF***. Reference voltage for the analog inputs. Used with analog Reference.
- ***Reset.:*** Bring this line LOW to reset the microcontroller. Typically used to add a reset button to shields which block the one on the board.

COMMUNICATION**:** The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .in file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB to serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1).

A Software Serial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus; For SPI communication, use the SPI library.

PROGRAMMING: The Arduino Uno can be programmed with the Arduino

Select "Arduino Uno from the Tools > Board menu (according to the microcontroller on your board). For details, see the reference and tutorials.
The ATmega328 on the Arduino Uno comes returned with a boot loader that allows you to upload new code to it without the use of an external hardware programmer. It communicates using the original STK500 protocol You can also bypass the boot loader and program the microcontroller through the ICSP (In -Circuit Serial Programming) header;
The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available . The ATmega16U2 /8U2 is loaded with a DFU boot loader, which Can be activated by:

- On Rev1 boards: connecting the solder jumper on the back of the board and then resetting the 8U2.

- On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode.

DHT11 Sensor:

DHT11 is one of the basic affordable digital sensors which can measure temperature and humidity. It has an operating voltage of 3 to 5 volts & max-current of 2.5mA..The temperature range lies between 0°C to 50°C, while the humidity percentage ranges between 20% to 80%. It consists of a thermistor which employs Negative Temperature Coefficient (NTC) and a humidity sensing component to detect the moisture in the air.

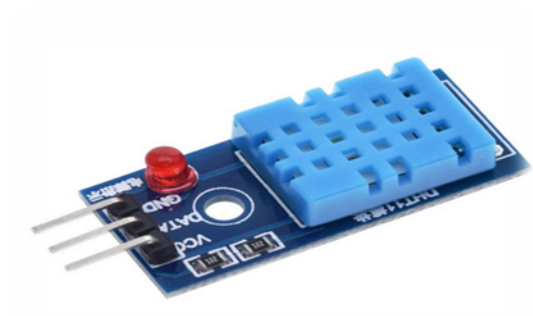


Fig:4.5 DHT11 Humidity & Temperature Sensor

Measuring Humidity Using Sensor (DHT11) Humidity is the measurement of the amount of water in the atmosphere. Vapour refers to the gaseous state of water. More water vapour can be produced as the air temperature rises. Due to the potential impact on both employee health and safety and business costs associated with the product, humidity measurement in industries is crucial. Therefore, a humidity sensor is crucial, especially in the systems that regulate industrial processes like paper and textile manufacturing food pr ocessing, film desiccation, dryers, ovens, and chemical gas purification. The measurement of humidity in agriculture is crucial for soil moisture monitoring, plant protection (green houses), and other purposes. To estimate the amount of moisture in the air, the majority of humidity sensors use capacitive measurement. This kind of measurement depends on two electrical conductors with a non-conductive polymer film positioned between them to establish an electrical field. When moisture from the air accumulates on the film, the voltage levels between the two plates change. After accounting for the air temperature, this change is then transformed into a digital measurement of the relative humidity of the air.

The electrical resistance between two electrodes is measured by the DHT11 in order to determine relative humidity.A moisture-holding substrate with electrodes attached to the surface serves as the DHT11's humidity sensing component. Ions are released by the substrate as a result of the absorption of water vapour, which raises the conductivity between the electrodes. The relative humidity has a direct relationship with the change in resistance between the two electrodes. Greater relative humidity causes the resistance between the electrodes to decrease, whereas lower relative humidity causes the resistance to increase.

A. Soil Moisture Sensor:

The amount of water in the soil is measured by soil moisture sensors. Multiple soil moisture sensors make up a soil moisture probe. A capacitance sensor, which operates in the frequency domain, is one popular type of soil moisture sensor used in industry. The neutron moisture gauge is a different sensor that makes use of the neutron moderator qualities of water. Two electrodes are used in less expensive sensors, which are frequently used in homes, to measure the resistance of the soil. There are probes with wires embedded in gypsum, but sometimes these are just two bare wires. Since water has a high dielectric constant and a higher water concentration results in a higher average dielectric constant for the soil, time domain transmission (TDT) and time domain reflect meter (TDR) are other methods used to measure moisture content. When measuring the speed of propagation along a transmission line that is buried, the average dielectric constant can be determined.

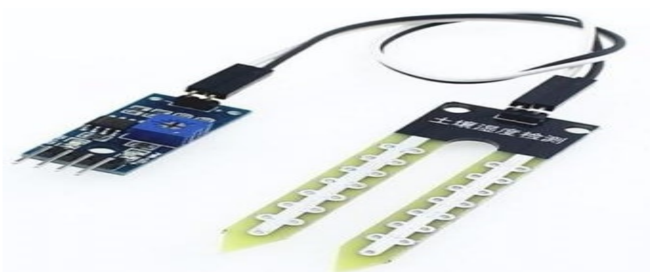


Fig:4.6 Soil Moisture Sensor

Measuring soil moisture is important in agriculture to help farmers manage their irrigation systems more efficiently. Not only are farmers able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages.

Besides agriculture, there are many other disciplines using soil moisture sensors. Golf courses are now using sensors to increase the efficiencies of their irrigation systems to prevent over watering and leaching of fertilizers and other chemicals offsite.

B. LDR-Light Sensor:

A device whose resistivity depends on the electromagnetic radiation that strikes it is known as a light dependent resistor (LDR) or a photo resistor. As a result, they are light-sensitive technology. They may also go by the names photo conductors, photo conductive cells, or just photocells. High resistance semiconductor materials are used in their construction. One of the most widely used symbols for aLDR is depicted in the figure below. The arrow points to where light is falling on it.

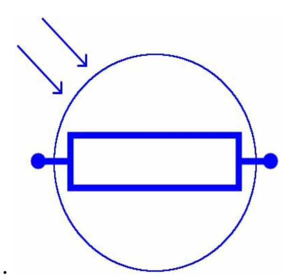


Fig: 4.7 LDR Symbol

The concept of photo conductivity underlies the operation of a light-dependent resistor. Photo conductivity is an optical phenomenon whereby light absorption causes a material's conductivity (and thus resistivity) to decrease. The electrons in the semiconductor material's valence band are excited to the conduction band when light strikes the object, or when photons strike it. To cause the electrons to move from the valence band to the conduction band, these photons in the incident light must have energy greater than the semiconductor material's band gap. Therefore, when light with sufficient energy is incident on the device, more and more electrons are excited to the conduction band, producing a large number of charge carriers. As a result of this process, the device's resistance is said to have decreased as more and more current starts to flow. This is how LDR typically operates.

C. Relay:

Relays are switches that electrically or electromechanically open and close circuits. By opening and closing contacts in another circuit, relays can regulate one electrical circuit. Relay diagrams demonstrate that when a relay contact is marked as normally open (NO), there is an open contact even when the relay is not powered on. When a relay contact is normally closed (NC), the contact is closed even when the relay is not powered on. The contacts' state will be altered in either scenario by electrical current.

Fig:4.8 Channel Relay

Protective relays can stop equipment damage by spotting electrical anomalies like reverse, under, over, and overcurrent currents. Furthermore, relays are frequently used to switch heating elements, pilot lights, starting coils, and alarms that can be heard.
In this project we have used two channel relay. One relay is connected to fan, for cooling purpose. Another one relay is conneted to LED, for heating purpose.

D. WIFI Module:

Node MCU is an open-source LUA based firmware developed for operating in ESP8266 WIFI chip. To explore the functionality of the ESP8266 chip, Node MCU firmware comes with the ESP8266 Development board which is also called Node MCU Development board. Since Node MCU is an open-source platform, its design of hardware is open for user to edit, to modify and to build its functions. Node MCU Dev board has an ESP8266 WIFI enabled chip. The **ESP8266** is a Wi-Fi chip developed by Express if Systems with TCP/IP protocol.

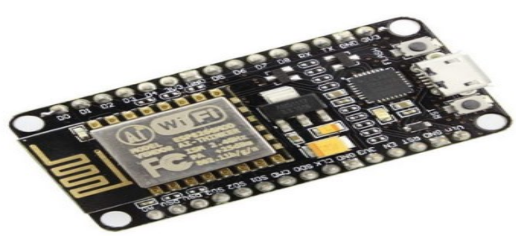


Fig: 4.9 WIFI Module

Node MCU Dev Kit has Analog (i.e. A0) and Digital (D0-D8) pins in the board. It serial communication protocols i.e. UART, SPI, I2C, etc. are supported. With such serial protocols one can connect it with serial devices like I2C enabled LCD display, MPU-6050 Gyro meter, Accelerometer, RTC Module, GPS modules, touch screen displays, SD cards, etc.

E. LED LIGHT:

Light intensity is an important factor for the plant growth. If the light intensity is low then it affects the growth of the plants. To resolve the problem of low light, artificial lights are used.

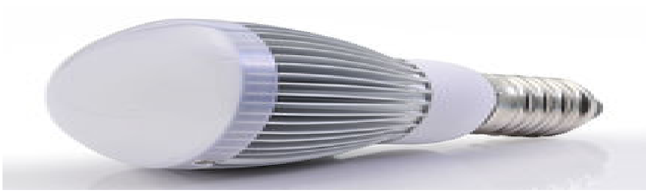


Fig:4.10 LED Light

Here in this project LED Light is used for demonstration. When light intensity is lower than a defined level, the artificial lights turns on, and when the light intensity comes in normal range artificial lights automatically turns off and a notification message is also sent to the owner.

F. LCD Display:

LCD stands for liquid crystal; this is a output device with a limited viewing angle. The choice of LCD as an output device was Because of its cost of use and is better with alphabets when compared with a 7-segment LED display. We have so many kinds of LCD today and our application requires a LCD with 2 lines and 16 characters per line, this gets data from the microcontroller and displays the same. It has 8 data lines, 3 control line, a supply voltage Vcc (+5v and a GND. This makes the whole device user friendly by showing the balance left in the card. This also shoes the card that is currently being used. In recent years the LCD is finding widespread use replacing LED's. This is due to the following reasons:

Fig 4.11 16x2 LCD Screen

Pin Description:

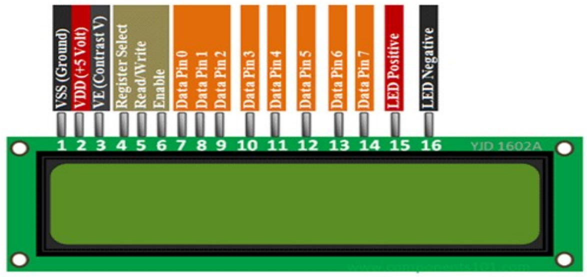


Fig 4.12 LCD Pin Description

- **VCC, VSS and VEE:** While VCC and VSS provide +5v and ground respectively, VEE is used for controlling LCD contrast.

- **RS, Register Select:** There are two very important registers inside the LCD. The RS pin used for their selection as follows. If RS=0, the instruction command code register is selected, allowing the user to send a command such as clear display, cursor at home ,etc .IF RS=1 the data register is selected, allowing the user to sent data to be displayed on the LCD.

- **R/W Read/Write:** R/W input allows the user to write information to the LCD or read information from it R/W=1 when reading; R/W=0 when writing.

- **E, ENABLE:** The enable pin is used by the LCD to latch information present to its data pins. When data is supplied to data pins, a high to low pulse must be applied to this pin in order for the LCD to latch in the data present at the data pins. This pulse must be a minimum of 450ns wide.

- **D0-D7:** The 8-bit data pins, D0-D7, are used to sent information to LCD or read the contents of the LCD's internal registers. The LCD commands codes are as shown in table.4. To display letters and numbers, we send ASCII codes for the letters A-Z, a-z, and numbers 0-9 to these pins while making RS=1.

V. RESULT AND DISCUSSION

A. Visualization of Results

Blink is an IOT Platform with ions' and Android apps to control Arduino, Raspberry Pi and the likes over the Internet. It is like a digital dashboard where one can build a graphic interface for the project by simply dragging and dropping widgets. Blink is not tied to some specific board or shield. Instead, it's supporting hardware of your choice. Whether your Arduino or Raspberry Pi is linked to the Internet over Wi-Fi, Ethernet or this new ESP8266 chip, Blink will get you online and ready for the **Internet Of Your Things**.

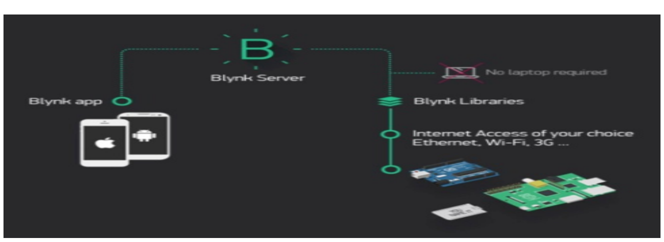


Fig:5.1 IOT Platform in Bilk App

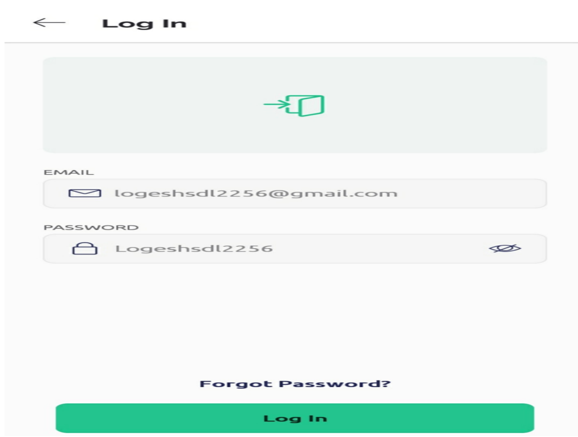


Fig:5.2 Blink App Login Page

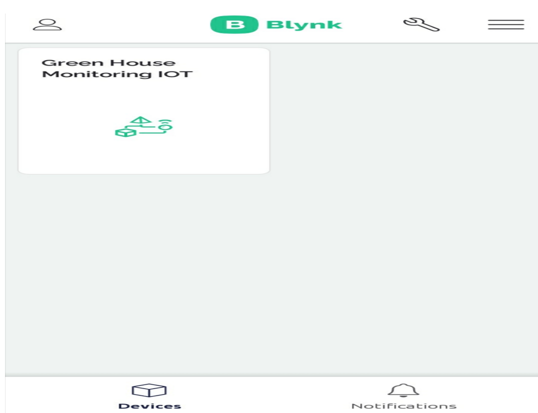


Fig: 5.3 Dashboard

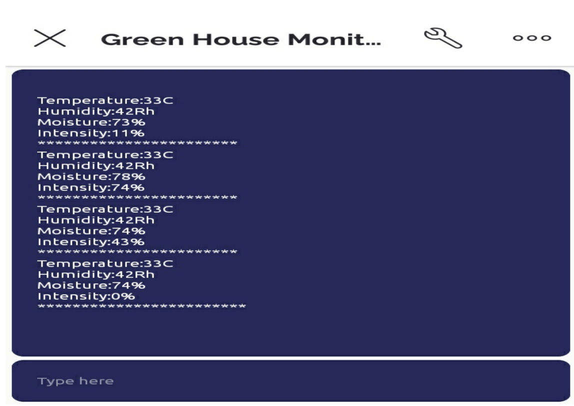


Fig5.4 Updated information to farmers via Mobile Application

B. Hardware Setup:

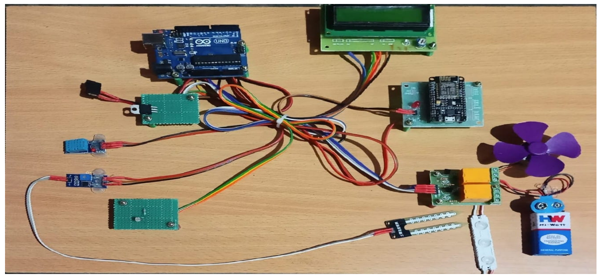


Fig:5.5 Project Module Kit

Fig: 5.6 Project Execution

Fig: 5.7 Execution Output

VI. CONCLUSION AND FUTURE SCOPE

The advantage of Smart Greenhouse over conventional farming is that we are able to produce insecticide and pesticide
Free crops and create a climate for the proper growth of plants. Moreover this system can be installed by any individual in his
House (Rooftop greenhouse), who do not have knowledge about farming. Since one can maintain any climatic condition in this type of Greenhouse, it is possible to cultivate any type of crop.

The smart greenhouse can be further upgraded in many ways and can be used in wide agricultural applications. It can be placed and operated in any of the environmental conditions to grow any kind of vegetation. Non-conventional energy sources such as solar panels, wind mills are used to supply power to the automatic greenhouse equipment and Pettier effect for cooling .
Soil-less farming can be performed to further improve the nutritional value. Integration of farming with IoT can make it much more efficient and profitable activity. Smart Greenhouse has a bright scope of future in agriculture field and it will create a revolution in the way the agriculture is carried out in India

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