

AUTOMATED AEROPONICS SYSTEM FOR INDOOR FARMING USING ARDUINO

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ABSTRACT

Vertical farming is on its way to becoming an addition to conventional agricultural practices, improving sustainable food production for the growing world population under increasing climate stress. While the early development of vertical farming systems mainly focused on technological advancement through design innovation, the automation of hydroponic cultivation, and advanced LED lighting systems, more recent studies focus on the resilience and circularity of vertical farming. These sustainability objectives are addressed by investigating water quality and microbial life in a hydroponic cultivation context. Plant growth-promoting rhizobacteria (PGPR) have been shown to improve plant performance and resilience to biotic and abiotic stresses. The application of PGPRs to plant-growing media increases microbial functional diversity, creating opportunities to improve the circularity and resilience of vertical farming systems by reducing the dependency on chemical fertilizers and crop protection products. Here, we give a brief historical overview of vertical farming, review its opportunities and challenges in an economic, environmental, social, and political context, and discuss advances in exploiting the rhizosphere microbiome in hydroponic cultivation systems.

Keywords: Aeroponics System, Arduino, Farming

1. INTRODUCTION

Weather describes the atmospheric condition at a place over a short duration of time. Weather is defining different variables, such as temperature, humidity, air pressure, and the wind. Weather or Climatic change plays an important role in human life.

Weather monitoring is important for our household, farming to the industrial environment. There has been always a huge importance of climate for human life and to develop agriculture to its observation. Nowadays, there are many automation systems and weather forecasting systems all over the world collecting the environmental parameter continuously for forecasting. Weather plays an important role in agricultural production. It has a profound influence on crop growth, development, and yields, on the incidence of pests and diseases, on water needs, and on fertilizer requirements. For more production, a farming system needs real-time monitoring and update of soil moisture, rain detection, and different data analysis For better production and harvesting rare crops and fruits, farming system needs real time weather update. This weather monitoring system can get update of temperature, humidity, soil moisture rate, and rain detection analysis. Sometime weather climates can change unfortunately or soil needs more water or remove water, so that this device can detect this problem and give update to farmer for quick solution. This proposed system has three sensors which can detect temperature, humidity, soil moisture, and rain detection measurement from analog to digital. Arduino will receive readings from various sensors and then process the data and then data will be available on pi monitoring system for viewing of user at remote location. This system also can control soil moisture and water supply system.

2. OBJECTIVE

A multilayer indoor plant production system in which all growth factors, such as light, temperature, humidity, carbon dioxide concentration ([CO₂]), water, and nutrients, are precisely controlled to produce high quantities of high-quality fresh produce year-round, completely independent of solar light and other outdoor conditions.

Vertical farms are divided according to size and purpose of use [3]:

1. Plant factory with artificial lighting (PFAL), an industrial-scale vertical farm located in a devoted building.
2. Container farm, a modular vertical farm contained in a shipping container.
3. In-store farm, a vertical farm located at the place of consumption or purchase (i.e., Retail and restaurants).
4. Appliance farm, a vertical farm appliance integrated into a home or office.

3. LITERATURE SURVEY

1. **Deepa. K. et al.**, “Optimal Energy Management of Greenhouse by using ARM LPC1768” ISSN:2278-0181, vol.5 Issue 09.

IDEA OF EXTRACTION:

- The proposed model is to control the greenhouse and reduce the energy cost while maintaining the required operational constraints such as temperature, soil moisture and PH.
- ARM controller receives data on greenhouse environment conditions from a number of sensors and transfers the data to and from a personal computer.
- Accordingly, it changes the state of greenhouse control devices namely heaters, fans, bulb, etc. According to the necessary condition of the crops.

DEMERITS:

- Memory and bandwidths are limited in ARM processors.
- The performance of the processors depends on the execution. If the programmer doesn't execute it properly then it can take a long time to work properly.

2. **DR. D. Saraswathi (1). et al.**, “AUTOMATION OF HYDROPONICS GREEN HOUSE FARMING USING IOT” 2018 International IEEE, 2018

IDEA OF EXTRACTION:

- The first one is to automate the greenhouse environment monitoring.
- The subsequent is automation of PH level and electrical conductivity maintenance.
- IOT is used to transfer the retrieved data to the internet (mass storage) and mobile app is used to communicate the current status to the user through the use of internet to their mobile phones, so that monitoring and maintenance will be easier.

DEMERITS:

- The limitation in greenhouse environment is to maintain the temperature, pressure, humidity value at a particular level.
- In addition to that, monitoring on PH value and electrical conductivity in hydroponics is another challenge.

3. **Hamza BENYEZZA et al.**, “Fuzzy Greenhouse Temperature and Humidity Control based on Arduino” Publisher IEEE-2018

IDEA OF EXTRACTION:

- The aim of this work is the implementation of an intelligent controller based on fuzzy logic to

provide an environment conducive to plant growth within the greenhouse, where the main objective is controlling the inside temperature and relative humidity.

- The fuzzy logic controller is implemented with success on Arduino microcontroller, the interaction between humidity and temperature is taken into account, so that temperature has an effect on humidity, temperature increases, the humidity decreases and vice versa.

DEMERITS:

- The controller should be developed and tested on MATLAB before implementation on Arduino until it shows effectiveness of the proposed controller.
- Fuzzy logic is not always accurate. The results are perceived as a guess, so it may not be as widely trusted.

4. Ozlam ALPAY. et al., “Climate Control of a Smart Greenhouse based on Android” publisherIEEE-2017.

IDEA OF EXTRACTION:

- In this study, the amount of energy and water consumed for controlling the climate parameters of a greenhouse has been predicted by using data from node packets placed in the greenhouse.
- Node packs are placed in star topology using wireless sensor network.
- Climate parameters are greenhouse internal temperature, relative humidity and soil moisture.
- Output data has been obtained by applying fuzzy logic method to received input data from sensors.
- The user remotely has controlled and monitored the greenhouse via the developed Android-based interface.

DEMERITS:

- Android based many applications contain virus and does not give accurate output.
- A lot of process in the background that lead to the battery quickly drains.

5. Mohamed A. Elashiri. et al., “Fuzzy Smart Greenhouses Using IoT” Publisher, IEEE — 2018.

IDEA OF EXTRACTION:

- This paper proposes a fuzzy logic for one of the applications of internet of things (IoT) in agriculture i.e, fuzzy smart greenhouses using IoT for crop tracking system.
- The hardware part contains some of the sensors, actuator and microcontrollers, the functions of these sensors are perpetually recording the natural measures such as temperature, ground wet and humidity.

DEMERITS:

- Need high maintenance and complicated operation and easily influenced by external interference

4. PROPOSED SYSTEM

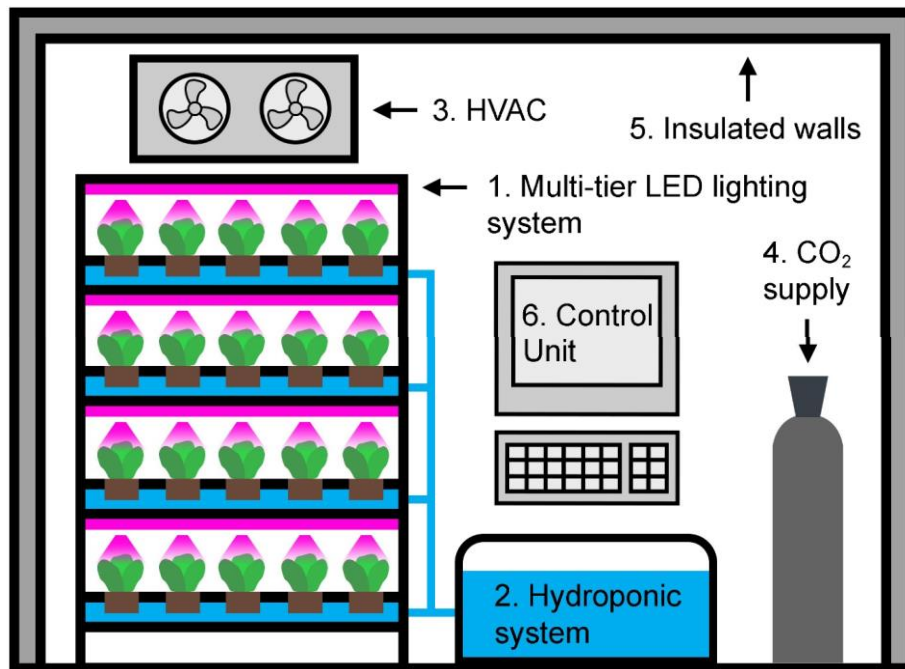


Fig: 1 Proposed Vertical farming System:

Block Diagram

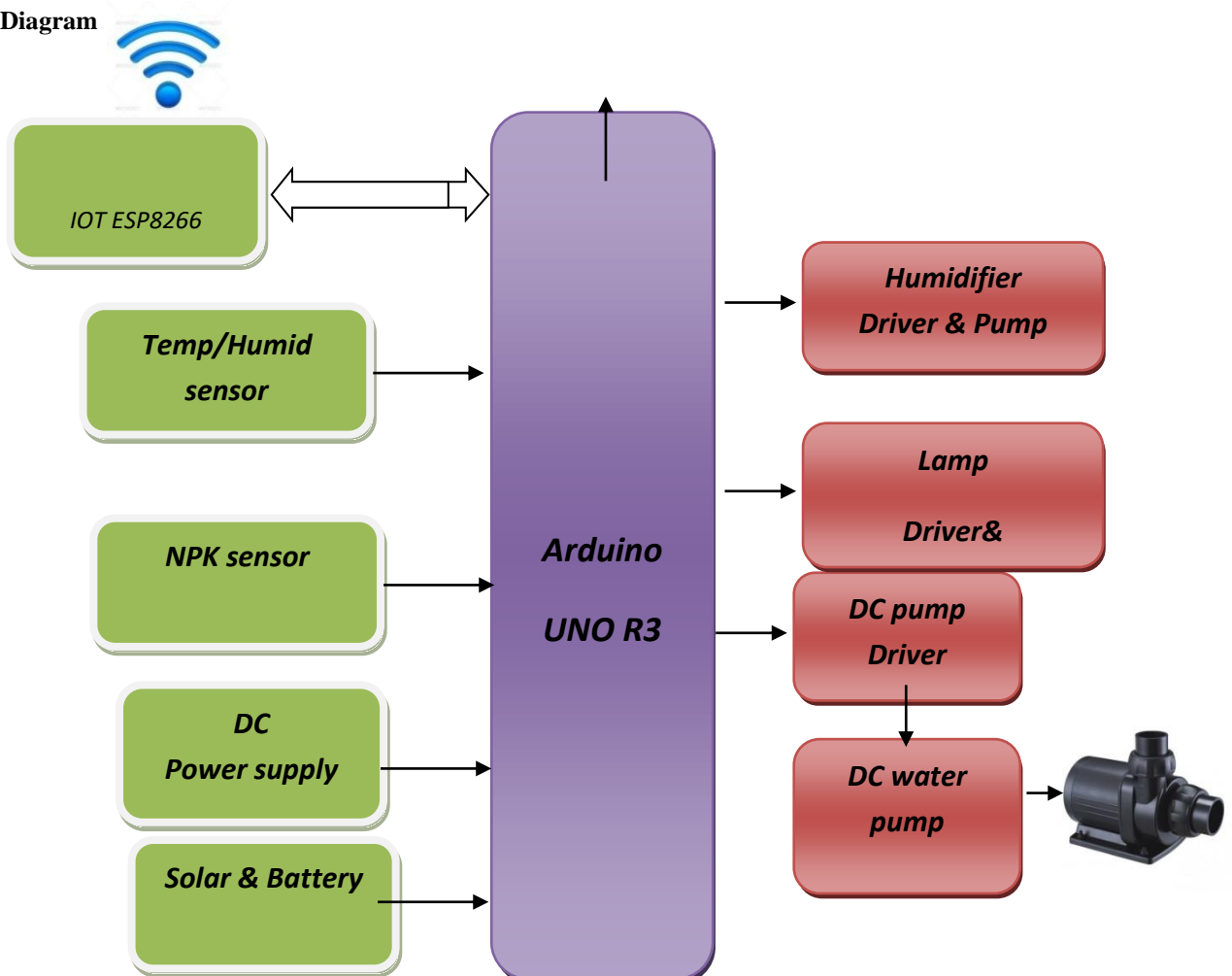


Fig: 2 Block Diagram:

5. METHODOLOGY

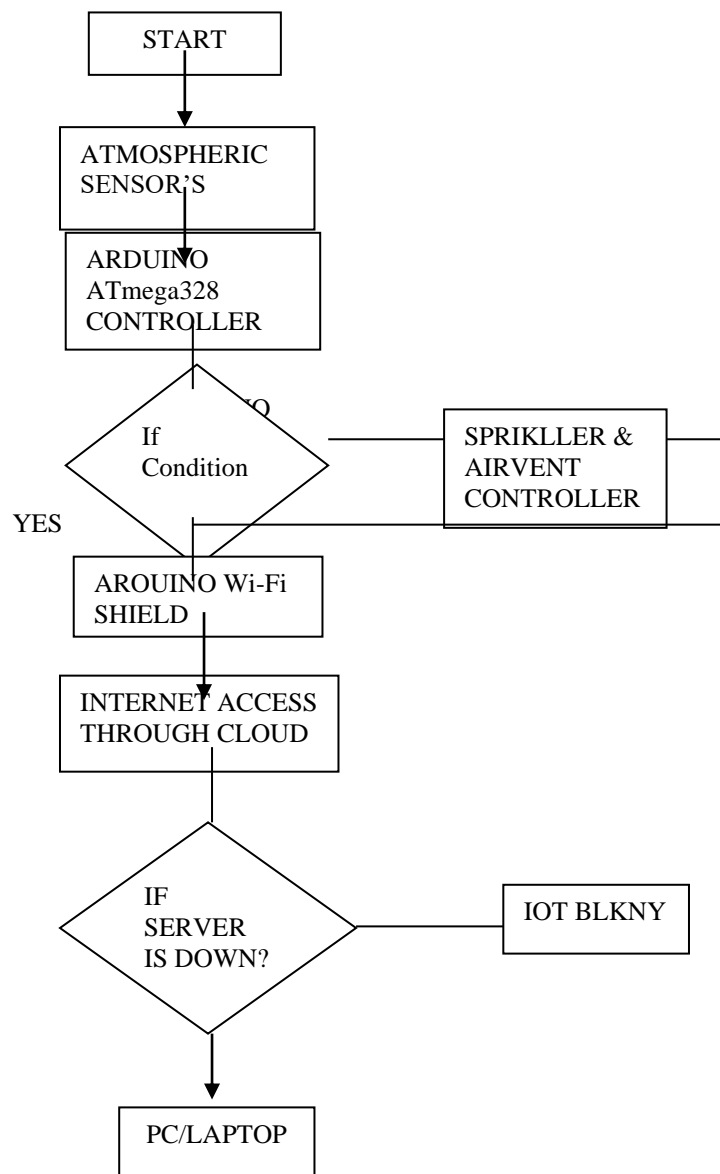


Fig: 2

6. HARDWARE REQUIRMENTS

Arduino UNO

Overview

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Revision 3 of the board has the following new features:

□ 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to the RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with the Arduino Due that operate with 3.3V. The second one is a not connected pin, that is reserved for future purposes.

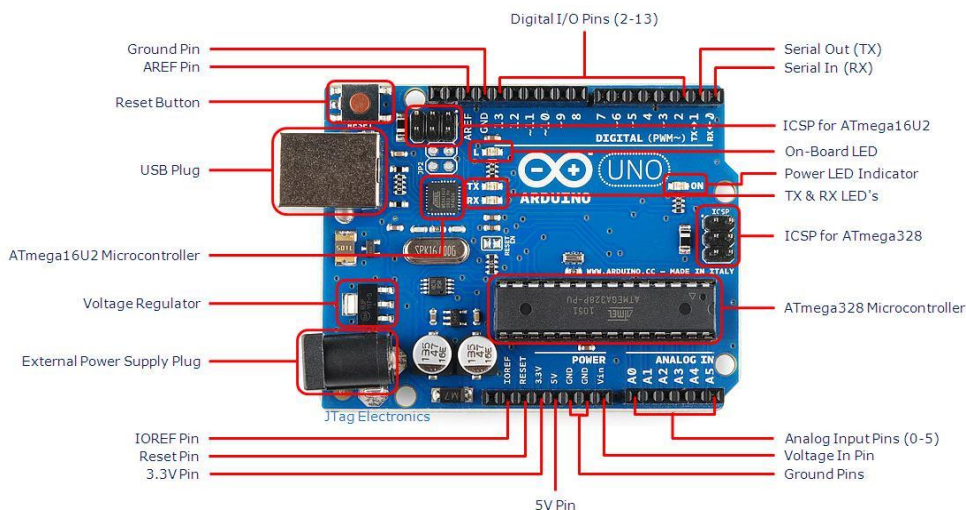


Fig: 3 Arduino UNO:



Fig: 4 NPK Sensor

The **soil nutrient** content can be easily measured using NPK Soil Sensor & Arduino. Measurement of soil content **N (nitrogen)**, **P (phosphorus)**, and **K (potassium)** is necessary to determine how much additional nutrient content is to be added to soil to increase crop fertility.

The **soil fertility** is detected using NPK sensors. A major component of **soil fertilizer** is nitrogen, phosphorus, and potassium. The knowledge of the soil nutrient concentration can help us to learn about **nutritional deficiency** or abundance in soils used to endorse plant production.

There are multiple methods of measuring the soil nutrient content like using some **optical sensors** or using the **spectrometer**. But the **spectral analysis method** is not convenient and the drawback is the data are only **60-70%** correct. While comparing the spectral analysis method with traditional wet chemistry methods, the accuracy of the products is yet to be fully resolved, given the paucity of data in that regard.

So, here we will use a **JXCT Soil NPK Sensor** to detect the soil nitrogen, phosphorous & Potassium in a soil. The JXCT Soil NPK sensor is a **low cost, quick responsive, high precision & portable** Sensor that works

with **Modbus RS485**. The advantage of this sensor over a traditional detection method is that it gives very **fast measurement** & data are **highly accurate**.

DHT11 Temperature and Humidity Sensor

DHT11 is a part of DHTXX series of Humidity sensors. The other sensor in this series is DHT22. Both these sensors are Relative Humidity (RH) Sensor. As a result, they will measure both the humidity and temperature. Although DHT11 Humidity Sensors are cheap and slow, they are very popular among hobbyists and beginners.

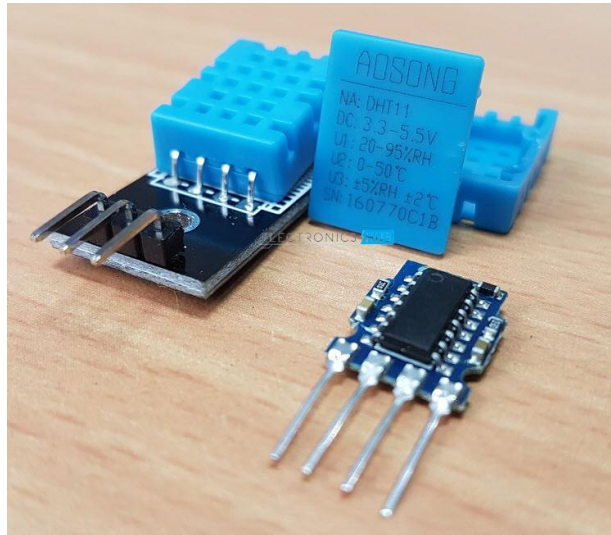


Fig: 5 DHT11 Temperature and Humidity Sensor

The DHT11 Humidity and Temperature Sensor consists of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by any microcontroller or microprocessor for further analysis.

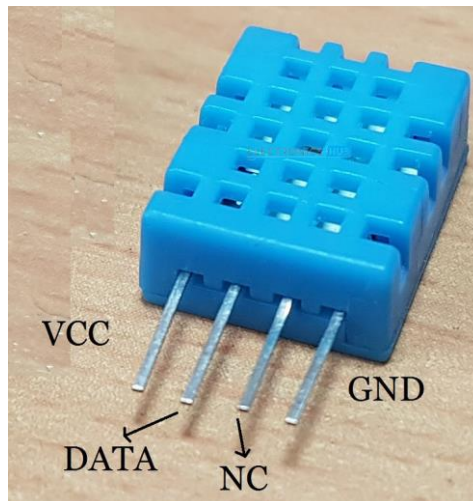


Fig: 6 Output pins

DHT11 Humidity Sensor consists of 4 pins: VCC, Data Out, Not Connected (NC) and GND. The range of voltage for VCC pin is 3.5V to 5.5V. A 5V supply would do fine. The data from the Data Out pin is a serial digital data.

The following image shows a typical application circuit for DHT11 Humidity and Temperature Sensor. DHT11 Sensor can measure a humidity value in the range of 20 – 90% of Relative Humidity (RH) and a temperature in the range of 0 – 50°C. The sampling period of the sensor is 1 second i.e

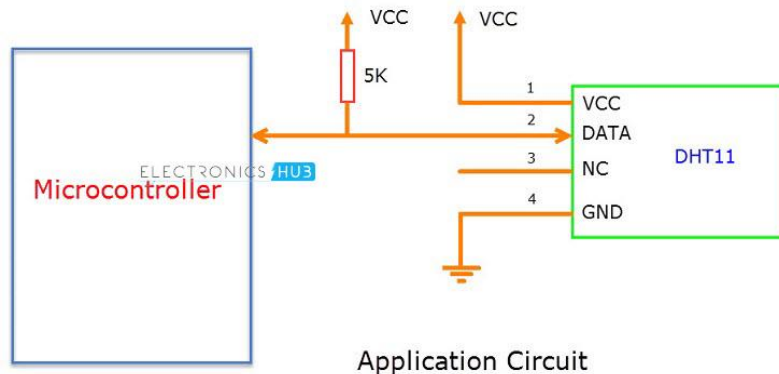


Fig: 7 DHT11 Circuit

All the DHT11 Sensors are accurately calibrated in the laboratory and the results are stored in the memory. A single wire communication can be established between any microcontroller like Arduino and the DHT11 Sensor.

Also, the length of the cable can be as long as 20 meters. The data from the sensor consists of integral and decimal parts for both Relative Humidity (RH) and temperature.

LDR light control:

Light Dependent Resistor:



Fig: 7 Light Dependent Resistor

Light dependent Resistor or “LDR” is a variable resistor sensitive to light intensity in according to the photoelectric effect. The effect frees electrons proportional to the flux of light shines. The unit observed in the microcontroller is the electric pressure. In the project LDR is used to adjust the light intensity outdoors.

Table:1 Illumination different from sources

Light source	Illumination (Lux)
Moon Light	0.1
60W bulb at 1m	50
Light source	Illumination (Lux)
Fluorescent Lighting	500
Bright sunlight	3000

Working Principle of LDR

A light dependent resistor works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity is increased when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy strikes on the device, more and more electrons are excited to the conduction band which results in large number of [charge carriers](#). The result of this process is more and more [current](#) starts flowing through the device when the circuit is closed and hence it is said that the [resistance](#) of the device has been decreased.

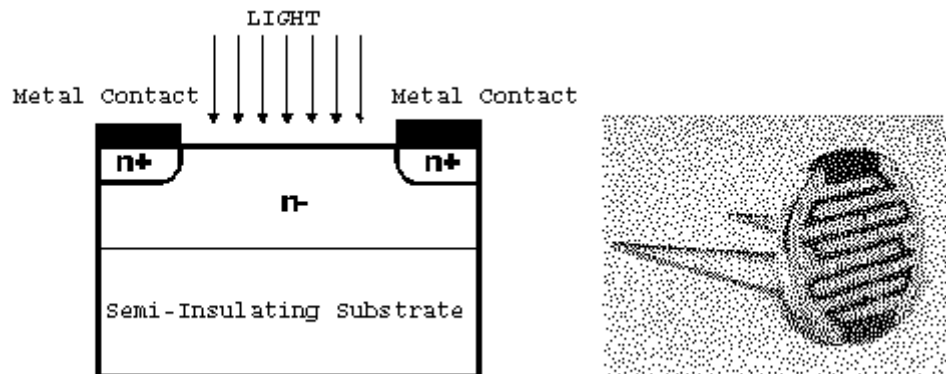


Fig: 8 LDR working

A Brief Note on Water Flow Sensor

Water Flow Sensor, as the name suggests, is a device to measure the flow of water. The Water Flow Sensor used in this project is shown in the image below.



Fig: 9 Water Flow Sensor

It has a plastic valve body with a rotor and a hall sensor circuit. It has three wires namely +5V (Red), GND (Black) and Output (Yellow). Since it works on +5V, it can be interfaced with any microcontroller like Arduino, for example.

If you notice the water level sensor, there is some information on the top and bottom of the sensor. On top, there is a label with vital information about the sensor.

The information on the label is as follows:

- Model: YF-S201

- Working Range: 1 – 30 L/min
- Water Pressure: ≤ 1.75 MPa

Wi-Fi ESP8266:

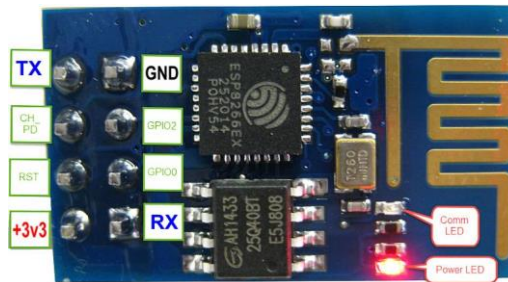


Fig: 9 Wi-Fi ESP8266

ESP8266 offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

When ESP8266 hosts the application, and when it is the only application processor in the device, it is able to boot up directly from an external flash. It has integrated cache to improve the performance of the system in such applications, and to minimize the memory requirements.

Alternately, serving as a Wi-Fi adapter, wireless internet access can be added to any microcontroller-based design with simple connectivity through UART interface or the CPU AHB bridge interface.

Software Requirement:

Arduino:

Arduino is a type of computer software and hardware company that offers open-source environment for user project and user community that intends and fabricates microcontroller based inventions for construction digital devices and interactive objects that can sense and manage the physical world. For programming the microcontrollers, the Arduino proposal provides an software application or IDE based on the Processing project, which includes C, C++ and Java programming software. It also support for embedded C, C++ and Java programming software.



Fig: 9 Arduino

Blynk:



Fig: 9 Wi-Fi ESP8266

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

There are three major components in the platform:

Blynk App - allows to you create amazing interfaces for your projects using various widgets we provide.

Blynk Server - responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynk server locally. It's open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.

Blynk Libraries - for all the popular hardware platforms - enable communication with the server and process all the incoming and outgoing commands.

Now imagine: every time you press a Button in the Blynk app, the message travels to space the Blynk Cloud, where it magically finds its way to your hardware. It works the same in the opposite direction and everything happens in a blink of an eye.

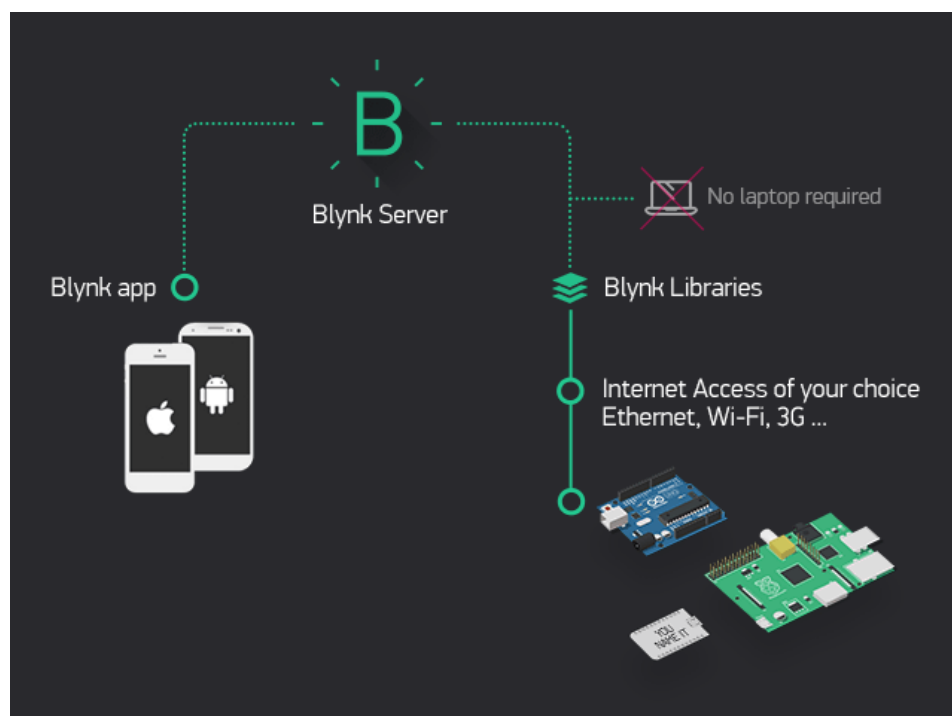


Fig: 10 Blynk Working

7. IMPLEMENTATION

1. Hardware.

An Arduino, Raspberry Pi, or a similar development kit.

Blynk works over the Internet. This means that the hardware you choose should be able to connect to the internet. Some of the boards, like Arduino Uno will need an Ethernet or Wi-Fi Shield to communicate, others are already Internet-enabled: like the ESP8266, Raspberri Pi with WiFi dongle, Particle Photon or SparkFun Blynk Board. But even if you don't have a shield, you can connect it over USB to your laptop or desktop (it's a bit more complicated for newbies, but we got you covered). What's cool, is that the list of hardware that works with Blynk is huge and will keep on growing.

2. A Smartphone:

Enter the Blynk App

The Blynk app is available for free on Android and iOS. It's the starting point for your projects, featuring a simple to use drag and drop system for building custom controls for your IoT setup. The workflow is fast: when starting a new project you're prompted to choose your development board from an extensive list, and also your method of connection. The app then sends an authorization token via email for connecting to your device over the Blynk server.

Control elements are called Widgets: various types of input methods and output displays including buttons, sliders, a joystick, graphs and text feedback. There are also component specific widgets, with stylized controls for LEDs, LCD displays, and even live streamed video. Also notable are widgets that add features, like automatic posting to Twitter, and custom notifications.

While the app is free, it limits how many widgets you can use at once by giving them all an "Energy" cost. The app gives a balance of 2,000 to play with, with the option to buy more if needed.

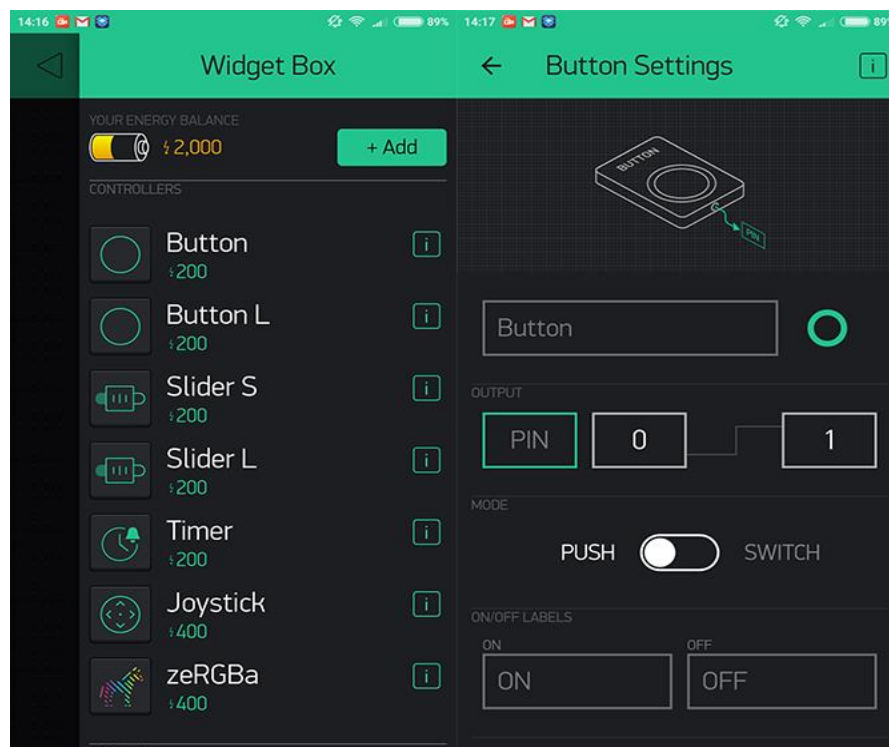


Fig: 11 9 Blynk UI

Each widget has an editing menu allowing you to change the name and color. You then choose which pin to affect (whether it be a pin on your board or one of Blynk's virtual pins) along with the range of values to send. For output displays such as graphs and text boxes, you can also choose how often you wish it to be updated, potentially saving precious bandwidth.

Blynk also features the ability to assign instructions to "virtual" pins, which are user configured connections between the app and the hardware. A single button in the app can therefore be used to trigger many different events on the device. We'll cover how to use these later in the article. The app gives the option of sharing the project with others. A QR code is generated which can be sent via email or scanned directly, and used by anyone who also has the Blynk app.

ADVANTAGES OF THE PROPOSED SYSTEM:

The proposed system is going to play an important role in future of agriculture system and hopefully it would going to help in boosting the efficiency of growth and production of agriculture industry. Apart from that some of the important advantages of the proposed system are listed below.

1. Easy to use
2. Easy to implement
3. More accurate results
4. Increase Fertility
5. Better Productivity
6. Focus is on important parameters

APPLICATIONS

The project has a great application in agriculture sector and can be used in greenhouses, botanical gardens and agriculture farms. Temperature monitoring and controlling action can be used in home or various halls like conference room, seminar hall to control the temperature of room. With little modification, this project can be used in Mechanical companies to measure various parameters of operating machines like temperature and light.

8. CONCLUSION

The different parameters which are present in the proposed greenhouse environment for example, temperature, dampness, light power, CO₂ focus, fog, moisture content in soil and any humidity are measured by the temperature sensor, LDR sensor. Light sensor, soil sensor and humidity sensor respectively. When the temperature and humidity is high, cooler will be on and control the temperature and humidity in the greenhouse by using ventilation opening and closing technique. When artificial lighting system in greenhouse light intensity is low, bulb will be on. When concentration of CO₂ in greenhouse is low, CO₂ or fog generator will be on. These parameters are monitored and controlled by the Arduino UNO automatically.

The results will be displayed in the screen of the computer. This greenhouse is giving low cost production, high product quality, save water and energy, more than one crop per year, and less man power. This greenhouse is providing an excellent controlled environment for plants production.

9. FUTURESCOPE

The system can also be enhanced by installing roof top solar panel for electricity generation that will help to meet electricity requirements as well as if the generation is more than the requirement for greenhouse and can supply the same to grid. Internet of Things can also be connected to greenhouse. Then from any places in the world, the greenhouse can be monitored and controlled easily without others help or man power. These constitute to the future scope of this proposed system.

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