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IOT BASED SMART SOIL HEALTH MANAGEMENT SYSTEM WITH REMOTE MONITORING AND CONTROL SYSTEM

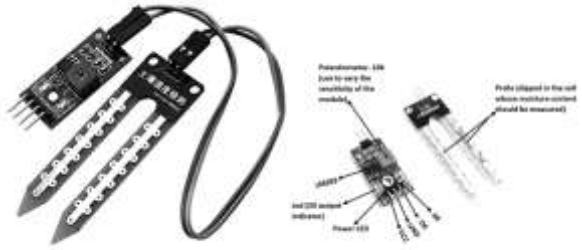
Abstract **- Soil situation monitoring sensors enable farmers to accumulate statistics about rainfall, temperature, and other metrics over time to tune tendencies and predict irrigation needs. Farmers will keep time that's normally spend manually checking crop water ranges due to the fact sensors can supply them real-time facts right away on nearly any on-line device. Sensors enable for higher water conservation whilst making sure there isn't over or under watering of vegetation. Smart soil moisture, humidity, temperature and PH monitoring and analysis. Auto-pump on-off device in fields, with excessive fast SDST Relay with low water stage cut-off machine for long-life of the water pumps. This whole project is done in very low cost keeping in mind the current financial condition of farmers of INDIA.**

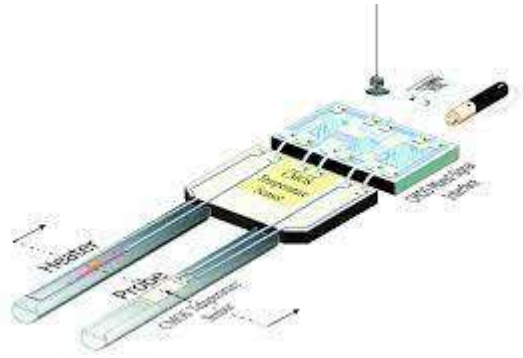
Keywords/Index Terms**–Internet Of Things (IOT), sensors, Smart Irrigation, PH monitoring, Auto-pump on-off device, Soil Hygrometer, ADC values, Blynk app, Networking, Programming, Statistics and mathematics, Embedded systems, Bridge Widget, Data analysis, Artificial Intelligence (AI), Prediction and probability, System Arcitechture, Soil health detection and monitoring.**

I. INTRODUCTION-

Details about soil sensor used in this project –
This is Soil Moisture Meter, Soil Humidity Sensor, Water Sensor, Soil Hygrometer for Ardunio. With this module, you may inform whilst your plants need watering with the aid of how moist the soil is for your pot, lawn, or backyard. the two probes at the sensor act as variable resistors. Use it in a domestic computerized watering system, hook it as much as IoT, or just use it to discover when the plants or crops need some care or not. Putting in this sensor and its PCB will have you ever in your manner to growing a green thumb.
The soil moisture sensor includes two probes which are used to degree the volumetric content material of water. the two probes allow the modern-day to bypass thru the soil and then it gets the resistance cost to degree the moisture value. when there is more water, the soil will behavior greater power because of this that there may be much less resistance. consequently, the moisture degree can be higher. Dry soil conducts energy poorly, so whilst there will be less water, then the soil will behavior much less energy because of this that there can be extra resistance. therefore, the moisture level will be lower.

Measuring soil moisture in terms of percentage –
Right here, the analog output of the soil moisture sensor is processed the use of ADC. The moisture content material in phrases of percentage is displayed at the serial monitor. The output of the soil moisture sensor modifications within the range of ADC values from 0 to 1023. this could be represented as moisture value in terms of percentage using the formulation given underneath.
Analog Output = ADC value / 1023
Moisture in percent = 100 – (Analog output * 100)
For 0 moisture, we get the most value of 10-bit ADC, i.e. 1023. This in turn gives ~0% moisture.





In exceptionally streamlined terms, dry soil is made up of strong fabric and discuss pockets, called pore spaces. A normal volumetric proportion would be 55% strong fabric and 45% pore space. As water is included to the soil, the pore spaces start to fill with water. Soil that appears soggy to the touch might presently have 55% minerals, 35% pore

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space and 10% water. This would be an illustration of 10% volumetric water substance. The most extreme water substance in this situation is 45% since at that esteem, all the accessible pore space has been filled with water. This soil is alluded to as being immersed, since at 45% volumetric water substance, the soil can hold no more water.

Setting up the minimum threshold for watering the soil –

Once the sensor has been buried and the Soil management System controller has been associated to the water system framework, the sensor must be calibrated and/or the soil water substance edge ought to be selected. Based on the sandy soils in much of Florida, the taking after steps ought to be taken after to calibrate or select a edge for the soil dampness sensor controller:

1. Apply water to the zone where the sensor is buried. Either set the water system zone to apply at slightest 1 inch of water or utilize a 5-gallon bucket to apply straight forwardly over the buried sensor.

2. Take off the range alone for 24 hours, and don't apply more water. On the off chance that it downpours amid the 24 hours, the method ought to be begun over.

3. The water substance after 24 hours is presently the sensor limit utilized to permit or bypass planned water system occasions. This threshold may be diminished somewhat (~20%) to permit more capacity for precipitation; in any case, the scene will still got to be carefully checked to guarantee that satisfactory water system is achieved.

All these steps are performed in order to set the correct minimum threshold value for that particular type of soil which is being used. This is an important process as this step will determine that for how much time the water pump will remain on/off.

Setting up the Irrigation timer with Arduino –

Soil dampness control gadgets can diminish water utilize on the grass by bypassing planned water system occasions, but it is imperative to create beyond any doubt the water system plan is modified into the water system clock accurately. Programming the water system clock accurately for the zone to be inundated can make the utilize of water system water more productive. Some time recently setting the water system plan it is critical to decide when the water will be connected and how much to apply with each water system occasion. In many regions of INDIA the days per week in which water system is permitted is as of now restricted by water limitations. Water system run time is the sum of time an water system zone has got to be turned on to apply the specified sum of water. It is influenced by the water application rate of the water system sprinklers and the time of the year.

Working Principal of the project -

Arduino Nano Details -

Arduino Nano is a microcontroller board designed by Arduino.cc. The microcontroller utilized within the Arduino Nano is Atmega328, the same one as utilized in Arduino UNO. It encompasses a wide extend of applications and could be a major microcontroller board since of its little measure and adaptability.

Features and its uses in this project -

- It has 22 input/output pins in total.
- 14 of these pins are advanced pins.
- Arduino Nano has 8 simple pins.
- It has 6 PWM pins among the advanced pins.
- It includes a precious stone oscillator of 16MHz.
- It's working voltage changes from 5V to 12V.
- It moreover underpins diverse ways of communication, which are -

1. Serial Protocol.
2. I2C Protocol.
3. SPI Protocol.

- It too encompasses a scaled down USB Stick which is utilized to transfer code.
- It moreover encompasses a Reset button on it.

Memory space available in Arduino nano -

The Atmega 328p has a specific memory location for flashing and storing programme data permanently even after it has been disconnected from the computer.

- Flash memory is 32kb.
- It has preinstalled bootloader on it, which takes a flash memory of 2kb.
- SRAM (Static RAM) memory of this board is 8kb.
- EEPROM memory size is of 1kb

The microcontroller on the Arduino and Genuino AVR based board has EEPROM: memory whose values are kept when the board is turned off (like a little difficult drive). This library empowers you to examined and compose those bytes.

The backed micro-controllers on the different Arduino and Genuino sheets have distinctive sums of EEPROM: 1024 bytes on the ATmega328P, 512 bytes on the ATmega168 and ATmega8, 4 KB (4096 bytes) on the ATmega1280 and ATmega2560. The Arduino and Genuino 101 sheets have an imitated EEPROM space of 1024 bytes.

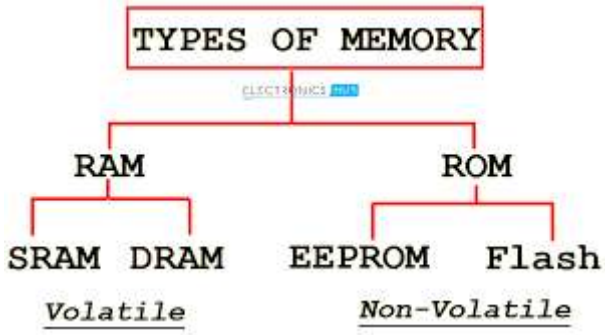
```
#include <EEPROM.h>
if(digitalRead(switch_pin) == HIGH){
count_copy = count;
EEPROM.update(memory_location, count_copy);
break;
}
```

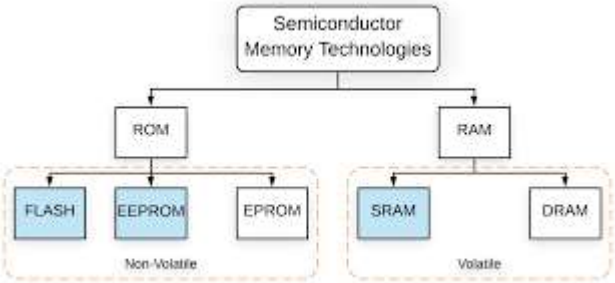
In these following lines of programming code the minimum threshold value is stored in a particular memory location of

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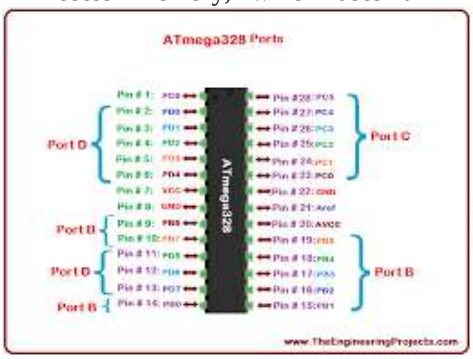
DRAM (Dynamic Ram). This helps to store the value permanently even after the arduinio/ processor resets or reboots the next time, it saves time and makes the work automatic, so that next time the system turns on, we don't need to set the value manually and it gets automatically set to the last known memory value stored.

value At Address =
EEPROM. read (Stored_memory_location);
In this above lines we are re-calling the stored memory location of the stored value and we can use it in the programme after a reboot/reset.

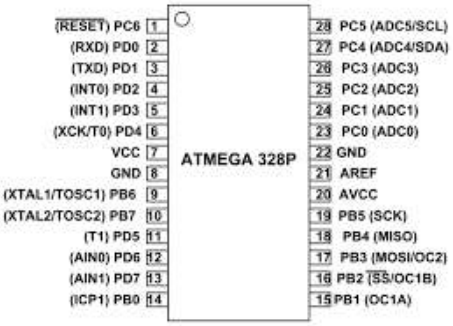




The RAM in Arduino is called SRAM or Static Random Access Memory, a type of RAM which uses a flip-flop to store 1-bit of data. The other type of RAM is called DRAM or Dynamic Random Access Memory, which uses a capacitor to store the data. The data stored in DRAM stays until the same memory location is flashed with some other values or data.



Atmega 328p Microcontroller -



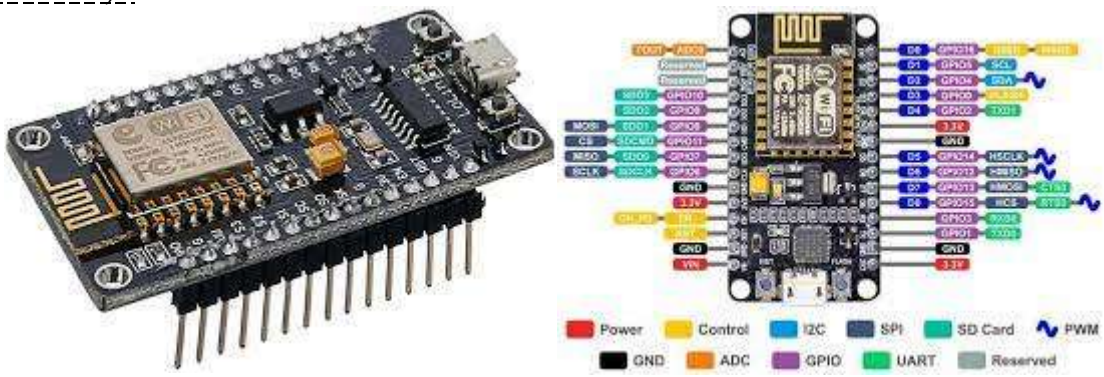
ATmega328P is a high performance and low power consumption 8-bit AVR microcontroller that is able to achieve the most single clock cycle execution of 131 powerful instructions because of its advanced RISC architecture.
The fast PWM mode that offers a excessive-frequency PWM waveform that lets in for it to be suited for strength regulation, rectification, and DAC applications. The ATmega328P is upheld with a full set-up of program and framework advancement instruments which incorporates: C compilers, large scale constructing agents, program debugger/test systems, in-circuit emulators, and assessment units.

Some of the special features of this microcontroller is –

- Processors are less complex to use, with the use of 8bit and 16bit rather than 32/64bit which are more complicated.
- Promptly usable without extra figuring parts with 32k bytes of locally available self-programmable blaze program memory as well as 23 programmable I/O lines.
- Code Efficient, every one of the 31 registers are straightforwardly associated with the math rationale unit (ALU), making it multiple times quicker than regular CISC microcontrollers.
- Streamlined for AVR and improved RISC guidance set.

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Node MCU (ESP 8266) –



NodeMCU is an IoT Module in view of the ESP8266 wifi chip Module. NodeMCU utilizes the Lua Scripting language and is an open-source Internet asset (IoT) stage. This module has CH340g USB to TTL Converter IC ready.
The ESP8266 NodeMCU CP2102 board has ESP8266 which is a profoundly incorporated chip intended for the necessities of the new IoT-associated world. Gives a total arrangement and contains a Wi-Fi organization, permitting it to have an application or download all Wi-Fi correspondence exercises from another application processor.
The ESP8266 can process and store abilities permitting it to be incorporated with sensors and other gadget explicit gadgets through its GPIOs with a couple of prior upgrades and less stacking during activity. Its elevated degree of chip incorporation takes into account insignificant outside revolution, and the whole arrangement, including the front module, is intended to oblige a little PCB region.

ESP8266 NodeMCU advancement board–
A genuine fitting and-play answer for more affordable tasks utilizing WiFi. The module comes up first with the NodeMCU firmware so they are all set - simply introduce your USB driver.
The ESP-12 LuaNodemcu WIFI Development Board Internet Of Things board contains a total ESP8266 WiFi module with all wrecked GPIO, a total USB-sequential connection point, and power in a solitary parcel of the breadboard.
The board is pre-stacked with NodeMCU - Lua-based firmware for ESP8266 that permits simple control with unadulterated prearranging language - Lua - so you're all set in only a couple of moments.
ESP-12 LuaNodeMCU WIFI Dev Board Internet Of Things with ESP8266 is an exceptionally simple to-utilize Wi-fi microcontroller + in one stage to fabricate projects with WiFi and IoT-Internet of Things.
The board depends on the ESP8266 WiFi Module chip with the ESP-12 SMD impression. The WiFi redesign board has previously introduced on its board all the ESP8266 (ESP-12E) code for getting sorted out and transferring the code.
The Microprocessor is particularly helpful for IoT applications, because of its little impression and implicit WiFi support. ESP8266 Integrates 802.11b/g/n HT40 Wi-Fi handset, so it can associate with a WiFi organization and collaborate with the Internet. It can likewise set up its own organization, permitting different gadgets to associate straightforwardly to it.

Details and features about the ESP8266 MCU -
The ESP6266 Nodemcu board accompanies 17 GPIO, these anchors allot a wide range of primary capacities like-

- 10 digit ADC channel.
- PWM yield.
- UART show.
- SPI, I2C, I2S show: to interface a wide range of sensors and gadgets.
- I2S: sound establishment for your undertaking.
- Because of the pin multiplexing element of ESP8266 (different boundaries increased by one GPIO pin). and that implies that one GPIO pin can function as a PWM/UART/SPI.

Esp8266 is a computer chip in a QFN bundle with both TCP/IP suite abilities and a microcontroller. Esp8266 brings an exceptionally incorporated WiFi arrangement that addresses the Internet business' issues for things like minimal expense, proficient power utilization, solid execution, and coordinated design. Fabricated by Espressif Systems in Shanghai, China.
The full force of the WiFi organization can act as a captive to the microcontroller administrator or as an independent application. Whenever we say a host microcontroller have it implies it very well may be utilized as a WiFi connector on any microcontroller utilizing SPI or UART interface. While utilized as an independent gadget it can empower microcontroller and WiFi organizing.

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Programming the Node MCU -

#include <ESP8266WiFi.h>

This following command is written at first in Arduino IDE to import the ESP8266 library.

WiFiServerespServer(80);

This command is written to define the Instance of WiFiServer with port number "80". 80 is the Port Number for HTTP Web Server.

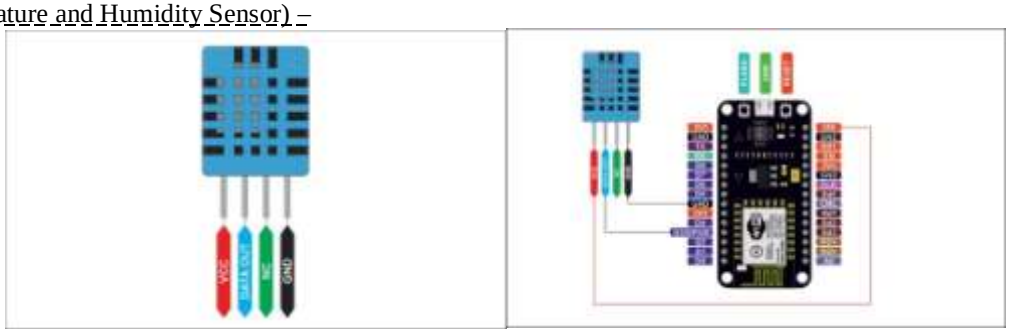
```
WiFi.mode(WIFI_STA);
WiFi.begin(ssid, password);
 while(WiFi.status() != WL_CONNECTED)
 {
   //Serial.print("*");
   delay(500);
 }
```

These above code is executed to Configure ESP8266 in STA Mode, and to ensure that wifi has been successfully connected, we are checking this connection via a pre-defined function of the ESP8266 module. The authentication credentials are passed as variables to the MCU – ssid of the WIFI and the password. Without proper authentication the wifi will not get connected and the wifi LED will not blink, indicating that the wifi is not connected yet.

WiFiClient client = espServer.available();

The above code will check weather any device/client has been connected to the remote web server of the Node MCU or not. If any device or host is not connected to the web server of Node MCU the device will go into deep sleep mode, thus saving a lot of current and making the system highly efficient.

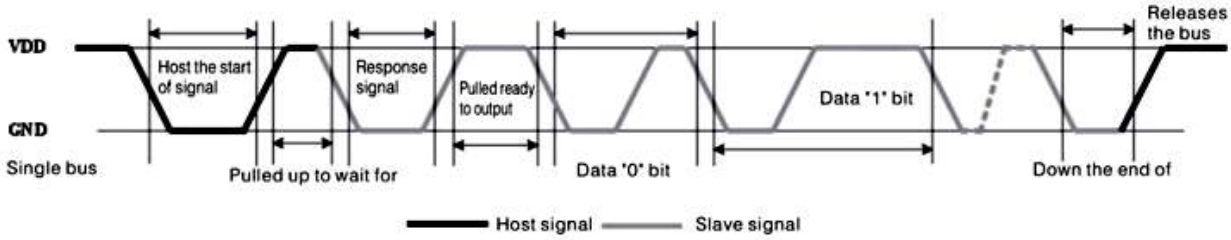
DHT 11 (Temperature and Humidity Sensor) –



The DHT11 is a regularly utilized Temperature and moistness sensor. The sensor accompanies a devoted NTC to gauge temperature and a 8-digit microcontroller to yield the upsides of temperature and mugginess as sequential information. The sensor is likewise manufacturing plant adjusted and subsequently simple to connect with other microcontrollers.

The sensor can gauge temperature from 0°C to 50°C and moistness from 20% to 90% with an exactness of ±1°C and ±1%.

The result given out by the information pin will be in the request for 8bit moistness number information + 8bit the Humidity decimal information +8 bit temperature number information + 8bit fragmentary temperature information +8 bit equality bit. To demand the DHT11 module to send these information the I/O pin must be immediately made low and afterward held high as displayed in the timing graph beneath –



Configuring Node MCU with DHT 11 –

The sketch begins by including ESP8266WiFi.h library. This library gives ESP8266 NodeMCU explicit WiFi strategies we are calling to associate with network. Following that we likewise incorporate the ESP8266WebServer.h library, which has a few techniques accessible that will help us setting up a server and handle approaching HTTP demands without expecting to stress over low level execution subtleties. At long last we incorporate DHT. hlibrary.

#include <ESP8266WiFi.h>

#include <ESP8266WebServer.h>

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#include "DHT.h"

Then, we pronounce an object of ESP8266WebServer library, so we can get to its capacities. The constructor of this article takes port (where the server will pay attention to) as a boundary. Since 80 is the default port for HTTP, we will utilize this worth. Presently you can get to the server without expecting to indicate the port in the URL.

```
// Declare the web server route for the operation to perform through the MCU
ESP8266WebServer server(80);
```

Then, we really want to characterize the ESP8266 NodeMCU's pin number to which our sensor's Data pin is associated and make a DHT object. Along these lines, that we can get to extraordinary capacities connected with the DHT library.

Inside Setup() Function we arrange our HTTP server before really running it. We, most importantly, open a sequential association for investigating reason and set GPIO ports to INPUT. We additionally need to instate the DHT object utilizing start() work.

In request to deal with approaching HTTP demands, we really want to indicate which code to execute when a URL is hit. To do as such, we use on strategy. This strategy takes two boundaries. Initial one is a URL way and second one is the name of capacity which we need to execute when that URL is hit.

The code underneath shows that when a server gets a HTTP demand on the root (/) way, it will set off the handle_OnConnect work.

```
server.on("/", handle_OnConnect);
```

Blynk app details for IOT –

Blynk is a Platform with IOS and Android applications to control Arduino, Raspberry Pi and the preferences over the Internet. It's an advanced dashboard where you can fabricate a realistic point of interaction for your undertaking by just moving gadgets.

There are three significant parts in the stage:

•Blynk App - permits to you make astonishing points of interaction for your activities utilizing different gadgets we give.

•Blynk Server - answerable for every one of the interchanges between the cell phone and equipment. You can utilize our Blynk Cloud or run your confidential Blynk server locally. It's open-source, could undoubtedly deal with large number of gadgets and might be sent off on a Raspberry Pi.

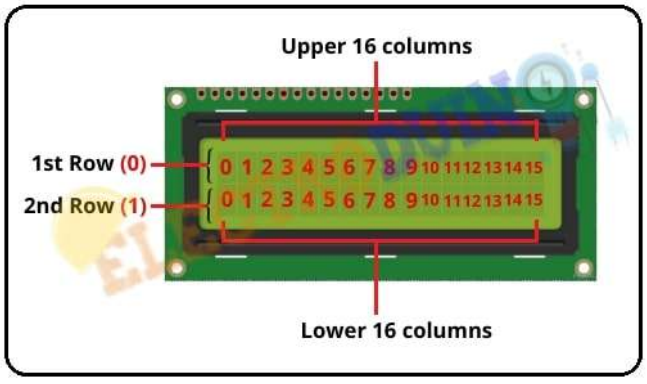
•Blynk Libraries - for all the well known equipment stages - empower correspondence with the server and interaction all the approaching and out coming orders.

LCD Display and connections -

16×2 LCD is one sort of electronic gadget used to show the message and information. The term LCD full structure is Liquid Crystal Display. The showcase is named 16×2 LCD since it has 16 Columns and 2 Rows. it very well may be shown (16×2=32) 32 characters altogether and each character will be made of 5×8 Pixel Dots. These presentations are essentially founded on multi-portion light-emanating diodes.

There are a ton of mixes of show accessible in the market like 8×1, 8×2, 10×2, 16×1, and so forth yet the 16×2 LCD is generally utilized. These LCD modules are minimal expense, and developer well disposed, thusly, is utilized in different DIY circuits, gadgets, and installed projects.





These 16 x 2 LCD show modules are steady of 16 Columns and 2 Rows. The first line of this module has an aggregate of 16 sections 0 to 15 and the place of the primary column is 0. Likewise, the second line has a sum of 16 segments 0 to 15 and the place of the subsequent column is position is 1. So the complete quantities of the segment are 16 x 2 = 32.

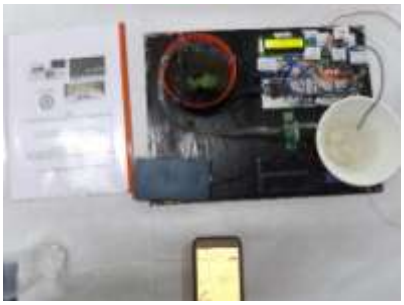
Its means 16 x 2 LCD module can show 32 characters simultaneously.

Every section will be made of 5×8 Pixel Dots. So every BOX will be made of 5×8 = 40 Pixel Dots. It implies absolute presentation has (32×40) 1280 Pixels.

It will be an exceptionally confounded assignment to deal with everything with the assistance of a microcontroller. So

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an Interface IC like HD44780 is utilized, which is mounted on the posterior of the LCD Module. The capacity of this IC is to get the Commands and Data from the microcontroller and process them to show significant data onto the LCD Screen.



This is the final setup and working of the whole project. As the complete circuit can be seen in this project, the water moisture sensor and along with DHT11 sensor, it is taking the reading of the soil moisture percentage, humidity and temperature of the soil. According to the set moisture threshold the pump will get turned on/off through the relay module. All the data which we get from the sensors are then transferred to Node MCU through I2C communication channel and that data is sent to the BLYNK app, where we can see all the data of the soil health condition. In the BLYNK app it also has a pump on/off Switch through which the pump can be controlled remotely. Also we can see all the graphical representation of the soil parameters in the app. This graphical data is stored in BLYNK cloud for 1 year and from this data we can analyze that which seed will be best suitable for the soil.

Soil gives supplements that increment the development of a yield. A few substance and actual properties of soil, like its dampness, temperature, soil nitrogen, phosphorous and potassium content vigorously influence the yield of a harvest.

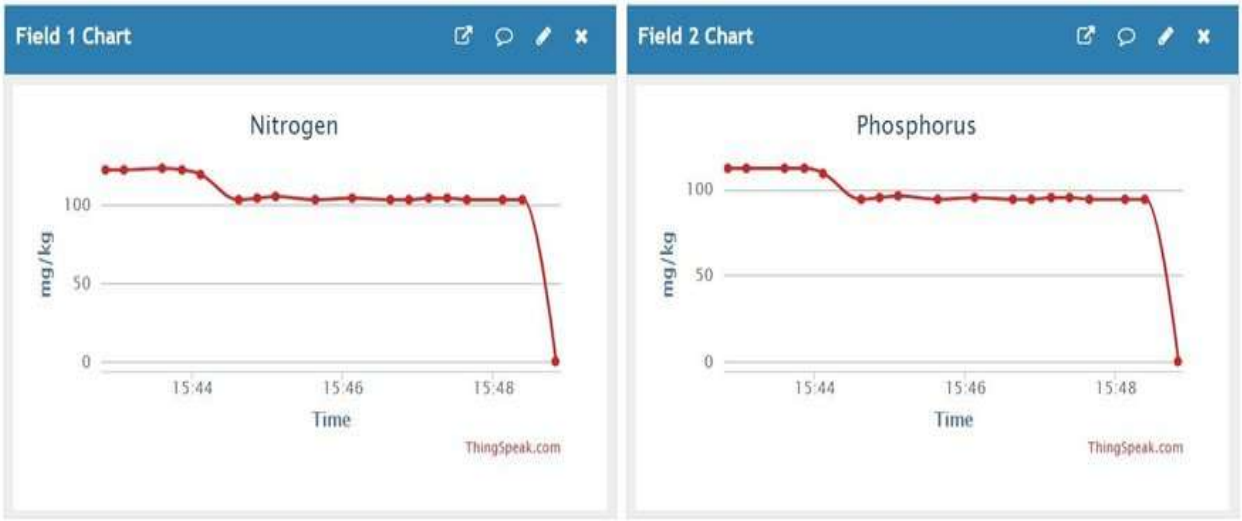
Soil Nutrient and PH – Sensor with Arduino and Node MCU -

The sensor requires no compound reagent. The sensor has high estimation precision, quick reaction speed, and great compatibility and can be utilized with any microcontroller. To peruse the NPK Data you really want any Modbus Module like RS485/MAX485. The Modbus module is associated with Microcontroller and to Sensor.

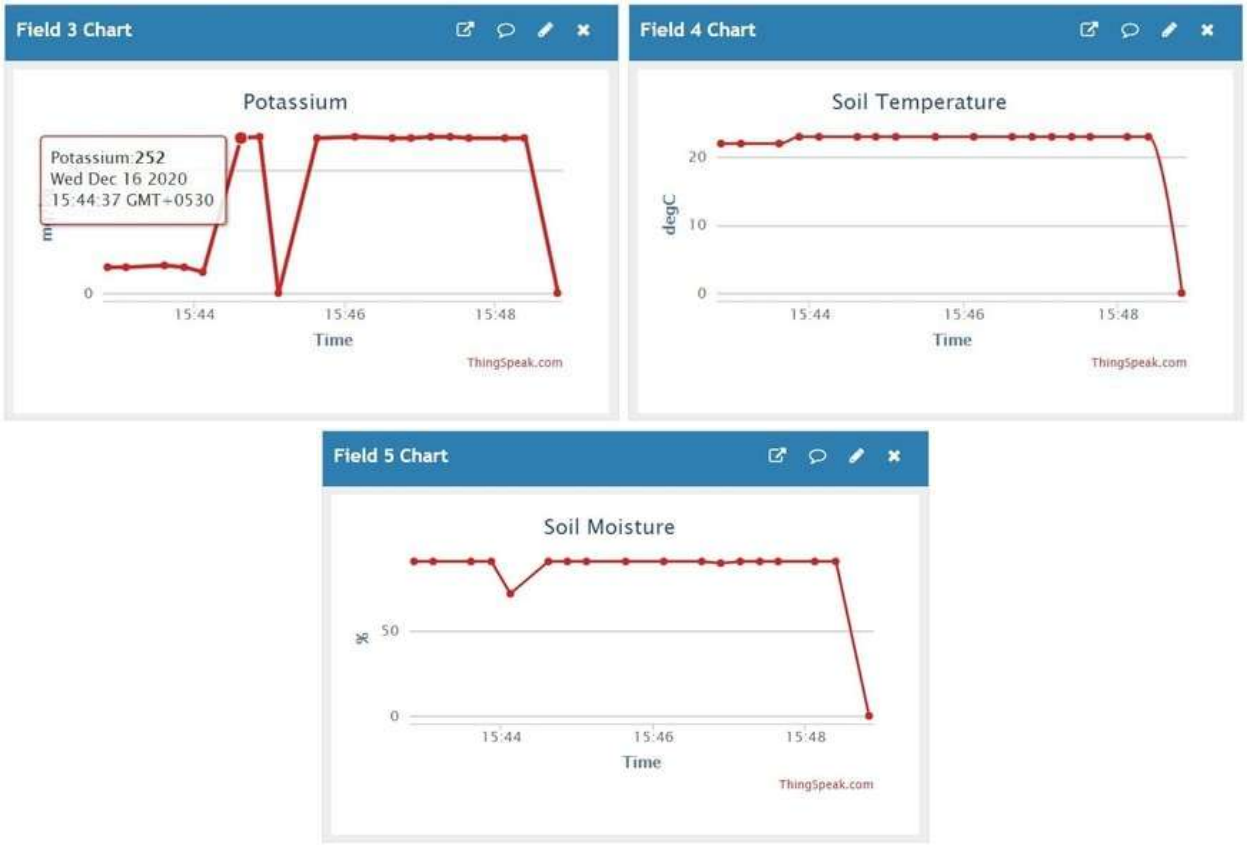
The sensor works on 9-24V. The exactness of the sensor ultimately depends on inside 2%. The nitrogen, phosphorous and potassium estimating goal really depends on 1mg/kg (mg/l).

For the entryway part, we utilized ESP32 WiFi Module alongside the NRF24L01 Transceiver Module. The Sensor Node Sends the information to the Gateway and the Gateway transfers the information to the Thingspeak Server. The information is sent remotely to the beneficiary/entryway segment. The passage gathers the information and transfers it to the Thingspeak Server.

Graphical data of each parameters which we got from the sensors –



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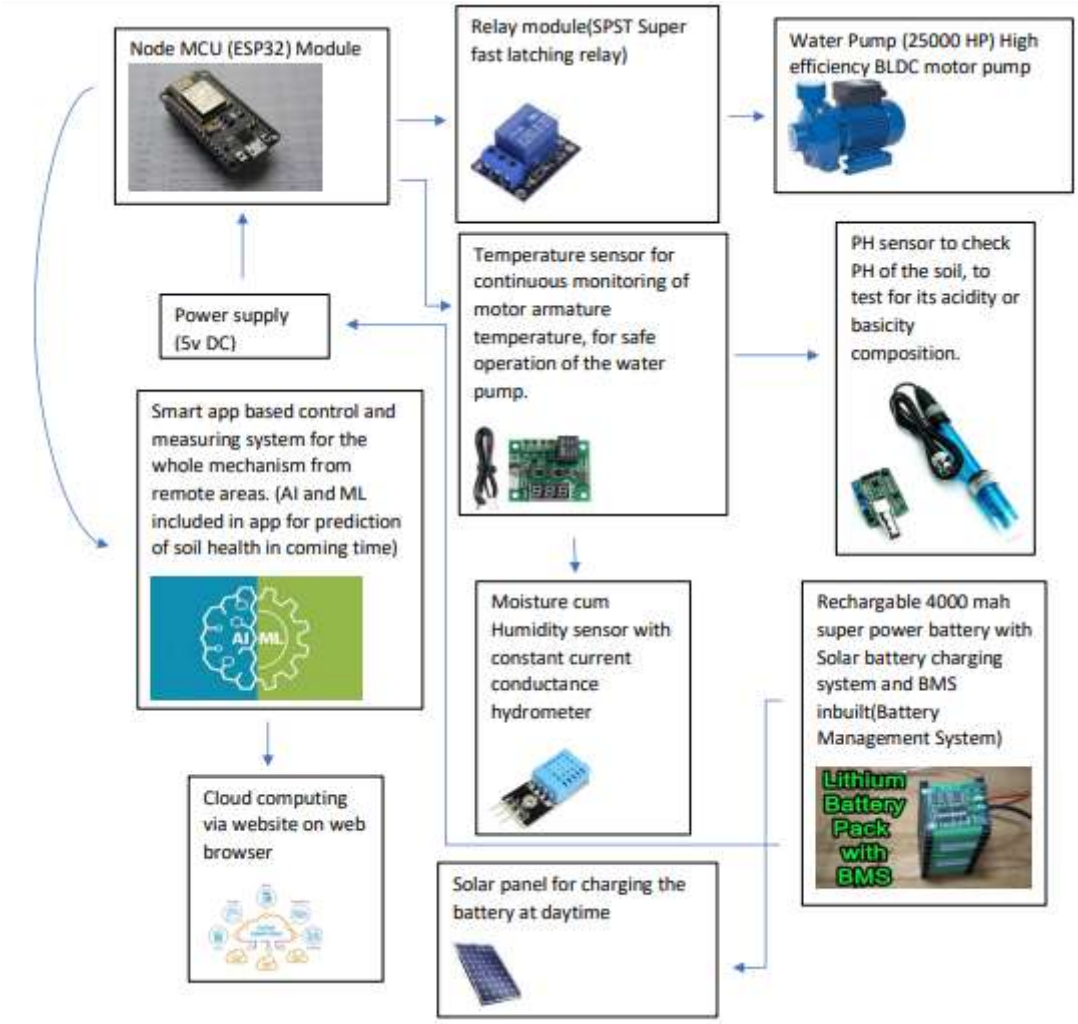
The Serial Monitor on the sensor hub shows the information read from the sensor like the worth of soil dampness in rate, the temperature in degree Celcius, the NPK Content in mg/Kg.

```
if (request.indexOf("/GPIO4ON") != -1)
  {
    //Serial.println("GPIO4 LED is ON");
digitalWrite(gpio4LEDPin, LOW);
    gpio4Value = LOW;
  }
```

The above code shows the actual working principal and syntax of the node MCU and the command that it will perform after successful connection to an internet and send data to BLYNK server through wifi.

Working principal of the system and main theme of Controlling via IOT

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II. RESULTS AND DISCUSSIONS (CONCLUSION)-

Finally we have come to the end of our project research. In the end we get the data of different parameters of the soil. From those parameters we can predict which particular seed to harvest so that it gives the best yield for the farmer. The main problem with the farmers is, they cannot get to know the exact condition/health of the soil to bow a particular type of seed, through this project they can determine which type of seed will be best suited for the soil. Farmers will save time that is generally spend physically checking crop water levels since sensors can give them continuous data right away on practically any web-based gadget. IOT-empowered sensors set aside some margin to set up and there is a long battery duration, which prompts less support costs. The smart AI System of the cloud computer can process the given data very fast and provide us with the reliable output as we want. The soil data is kept in the cloud server for minimum 1 year of time period and after that the memory gets cleared and its automatically ready to get the next set of data for the upcoming years. This is an extremely reliable and cost-efficient project , in which poor farmers can get a good output for their crops in very low maintenance and fitting cost of this product, it is a onetime investment for the farmer. As yield per acere of the land will the high profit will be high and in turn the net GDP of the country will increase and it will lead to a huge economic development.

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soal may rest in peace and I am very happy than I could fulfill his incomplete work towards the advancement in the field of agriculture. At last, my parents are always there in the backbone for supporting me in every aspect of my life.

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