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MEASURE SOIL NUTRIENT USING NPK SENSOR

Understanding its origins and impact

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PRESENTATION HIGHLIGHTS

FOCUS AREAS

- What is NPK?
- Bill of Materials
- Soil NPK Sensor
- MAX485 TTL to RS-485 Interface Module
- Interfacing NPK sensor with Arduino
- Modbus Command for NPK Sensor
- Source Code
- Monitoring Soil NPK Data on OLED
- About the Team

WHY IS NPK?

Knowing the NPK (Nitrogen, Phosphorus, and Potassium) values of soil is important because these are the three major nutrients required for healthy plant growth. Nitrogen is necessary for plant growth and is a key component of chlorophyll, which is essential for photosynthesis. Phosphorus is necessary for root growth and flowering, and Potassium helps with the overall health and resilience of the plant, including the regulation of water movement.

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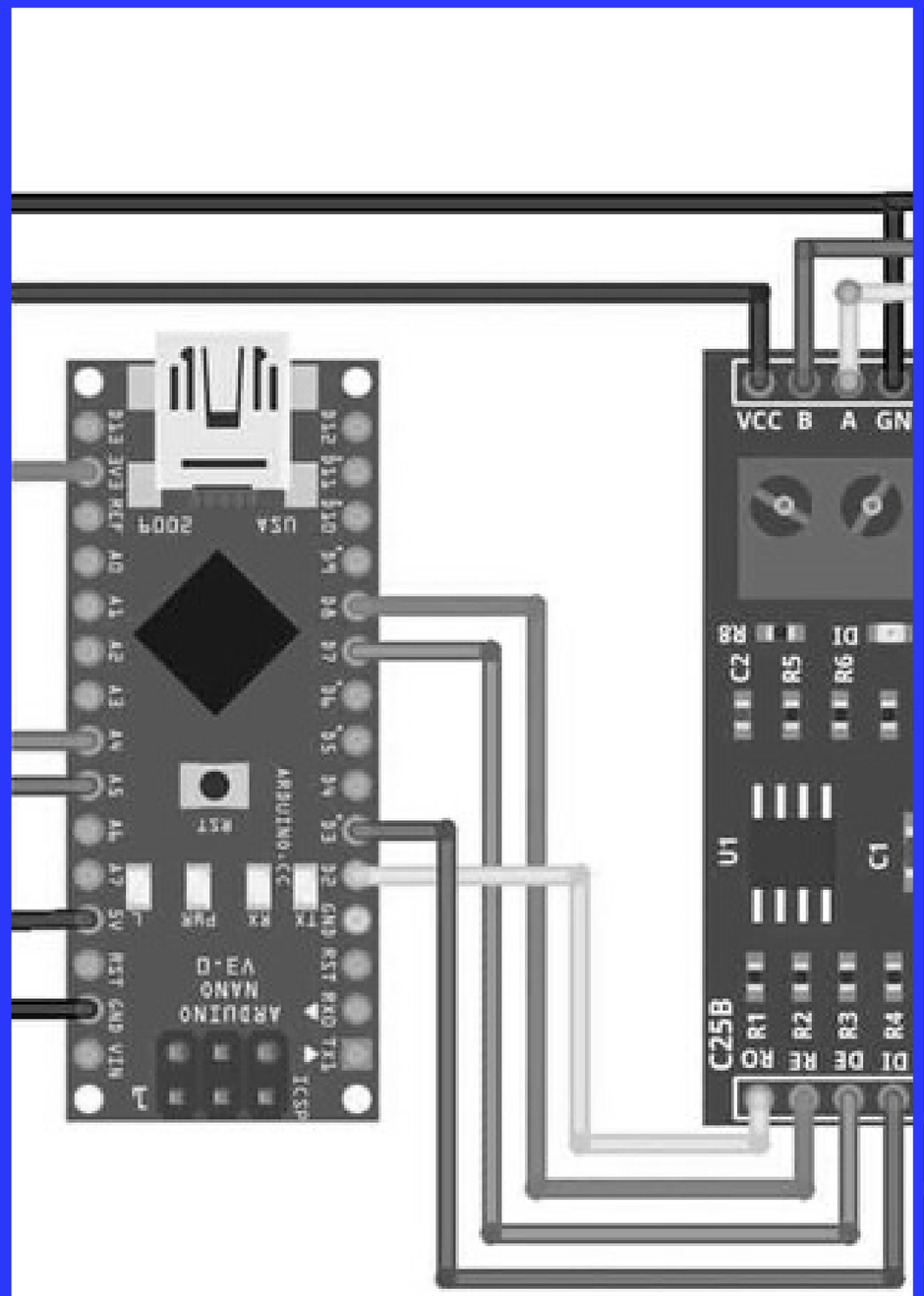

BILL OF MATERIALS

1 ARDUINO NANO BOARD:	RS. 70,22
2 NPK SENSOR 1:	RS. 1353.62
3 0.96-INCH OLED SCREEN 1:	RS.109.98
4 MAX485 MODBUS MODULE 1:	RS. 61.76
5 9-12V DC POWER SUPPLY 1:	RS. 196.28
6 CONNECTION CABLES 10:	RS. 100
7 BREADBOARD 1 :	RS. 100

Prices listed are from AliExpress

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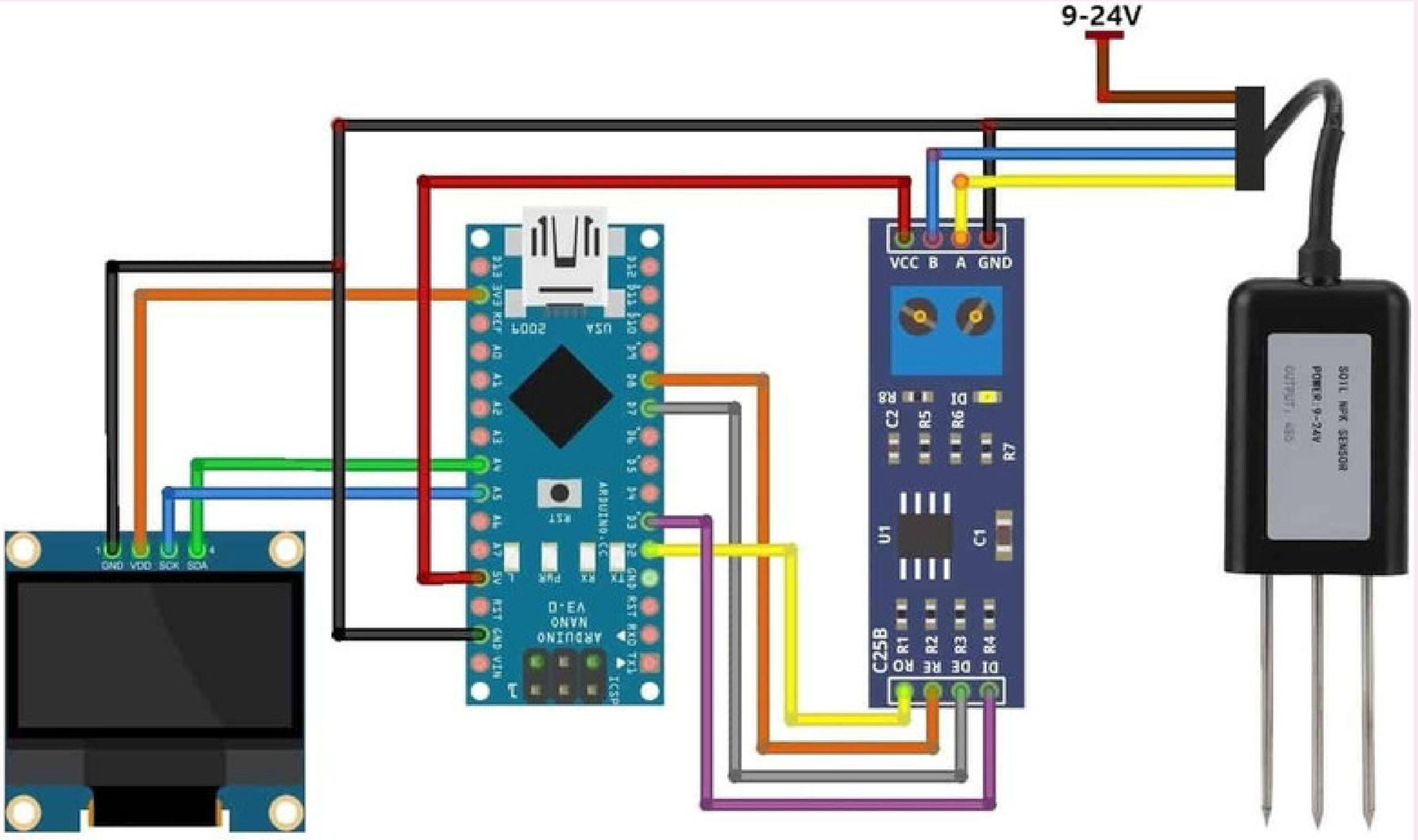
CIRCUIT DIAGRAM

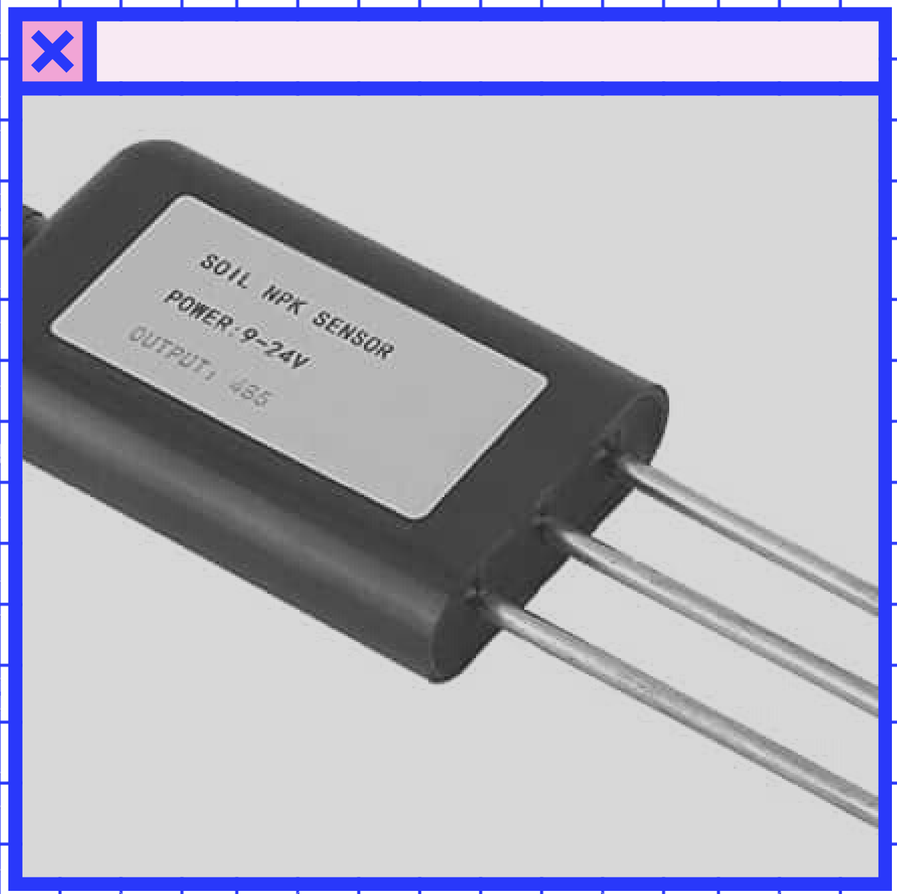


SOIL NPK SENSOR

THE SOIL NPK SENSOR IS SUITABLE FOR MEASURING SOIL CONTENT OF NITROGEN, PHOSPHORUS AND POTASSIUM. IT HELPS DETERMINE SOIL FERTILITY, WHICH FACILITATES A SYSTEMATIC ASSESSMENT OF SOIL CONDITION. THE SENSOR CAN BE BURIED IN THE GROUND FOR A LONG TIME. IT HAS HIGH-QUALITY SENSOR, RUST RESISTANCE, ELECTROLYSIS RESISTANCE, SALT AND ALKALI CORROSION RESISTANCE TO ENSURE THE LONG-TERM PERFORMANCE OF THE SENSOR PART. IT IS SUITABLE FOR ALL TYPES OF SOIL. THE SENSOR DOES NOT REQUIRE A CHEMICAL REAGENT. BECAUSE IT HAS HIGH MEASUREMENT ACCURACY, FAST RESPONSE SPEED AND GOOD INTERCHANGEABILITY. THE SENSOR CANNOT BE USED DIRECTLY WITH A MICROCONTROLLER BECAUSE IT HAS A MODBUS COMMUNICATION PORT. THEREFORE YOU NEED ANY MODBUS MODULE (EG RS485/MAX485) AND CONNECT THE SENSOR TO THE MICROCONTROLLER. TALKING ABOUT THE ACCURACY OF THE SENSOR, IT IS UP TO 2%. THE RESOLUTION OF NITROGEN, PHOSPHORUS AND POTASSIUM MEASUREMENT IS UP TO 1 MG/KG (MG/L). WITH THIS SOIL NPK SENSOR, YOU CAN BUILD YOUR OWN ARDUINO SOIL NPK METER OR ANY CLOUD-IOT-BASED SOIL NUTRIENT MONITORING SYSTEM.

Technical Specs:

1. Power: 9V-24V
2. Measuring range: 0-1999 mg/kg (mg/l)
3. Working temperature: 5-45 °C
4. Resolution: 1mg/kg
5. Accuracy: ± 2% F.S.
6. Output signal: RS485
7. Data transmission: 2400/4800/9600
8. Protection class: IP68



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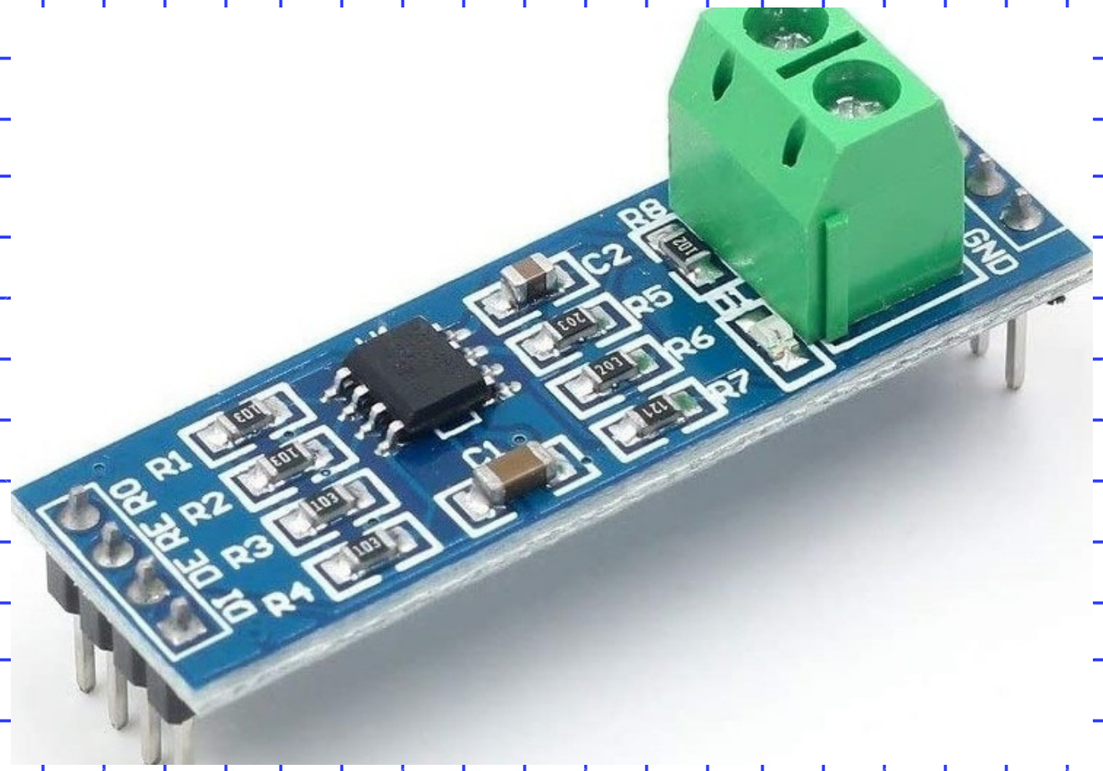
MAX485 TTL TO RS-485 INTERFACE MODULE:

THE MAX485 TTL TO RS-485 INTERFACE MODULE ENABLES THE USE OF A DIFFERENTIAL RS-485 SIGNAL FOR ROBUST LONG-DISTANCE SERIAL COMMUNICATION OVER DISTANCES OF UP TO 1200 METERS OR IN ELECTRICALLY NOISY ENVIRONMENTS, AND IS WIDELY USED IN INDUSTRIAL ENVIRONMENTS. IT SUPPORTS DATA TRANSFER RATES UP TO 2.5 MBIT/S, BUT THE MAXIMUM SUPPORTED DATA RATE DECREASES AS THE DISTANCE INCREASES. THE DATA STARTS AS A TYPICAL TTL LEVEL SEQUENCE THAT TOUCHES THE MICROCONTROLLER, WHILE THE RS-485 MODULE TAKES CARE OF CONVERTING THE ELECTRICAL SIGNALS BETWEEN TTL AND THE DIFFERENTIAL SIGNAL USED BY RS-485. A MAJOR ADVANTAGE OF RS-485 IS THAT IT SUPPORTS MULTIPLE DEVICES (UP TO 32) ON THE SAME CABLE, OFTEN REFERRED TO AS A "MULTI-DROP" CABLE.



TECHNICAL SPECS:

1. Use a MAX485 interface chip
2. Uses differential signaling for noise immunity
3. Distances up to 1200 meters
4. Speed up to 2.5 Mbit/s
5. Multi-drop supports up to 32 devices on the same bus
6. Red power indicator light
7. 5V operation

PINOUT AND MODULE CONNECTION:

THE MODULE HAS TWO 4-PIN HEADERS ON THE ASSEMBLY.

1 X 4 HEADER (DATA SIDE):

RO = Receiver Output.

RE = Receiver Enable.

DE = Driver Enable.

DI = Driver Input.

1 X 4 HEADER (OUTPUT SIDE):

VCC = 5V

B = Data 'B' Inverted Line.

A = Data 'A' Non-Inverted Line. Connects to A on far end module

1 X 2 SCREW TERMINAL BLOCK (OUTPUT SIDE):

B = Data 'B' Inverted Line.

A = Data 'A' Non-Inverted Line.

CONNECT THE SOIL NPK SENSOR TO ARDUINO:

Now we connect the Soil NPK sensor to the Arduino Nano board using the MAX485 Modbus module. Connect the Modbus R0 and DI pins D2 and D3 to the arduino using the software. Similarly, we must allow DE and RE to be high. You can do this by connecting the DE and RE pins to the D7 and D8 pins of the Arduino. The NPK sensor has 4 wires. Brown is VCC which needs a 9V-24V power supply. GND pin which is black in color. So connect it to Arduino GND. The blue wire which is the B pin is connected to the B pin of the MAX485 and the yellow wire which is the A pin is connected to the A pin of the MAX485. The 0.96-inch SSD1306 OLED display is an I2C module. Connect the VCC and GND pins of the OLED display to the 3.3V and GND pins of the Arduino. Similarly, connect its SDA and SCL pins to Arduino A4 and A5 connectors. You can follow the circuit diagram and assemble the circuit on a breadboard or make a custom printed circuit.

Modbus command for NPK sensor:

MODBUS COMMANDS CAN CONTROL A MODBUS DEVICE:

1. CHANGE THE VALUE IN ONE OF ITS REGISTERS TO BE WRITTEN TO THE COIL AND KEEP RECORDS

2. I/O PORT READ: READ INFORMATION ABOUT DISCRETE AND COIL PORTS,

3. TELLS THE DEVICE TO RETURN ONE OR MORE VALUES CONTAINED IN ITS WRAPPER AND KEEP A RECORD

SOURCE CODE

Presentations are communication tools that can be used as lectures.

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Next slide has the source code to connect the Soil NPK sensor to Arduino and get the soil nutrient value from the sensor via Modbus command. You can send a command and get the value as a HEX code. The HEX code must be converted to decimal to obtain measured soil nutrient content data. Since we are using an OLED screen to display soil nutrients (nitrogen, phosphorus and potassium) in mg/kg, you will need an OLED library. Download the following OLED library and add it to the Arduino IDE. 1. Adafruit SSD1306 Library: Download

2. Adafruit GFX Library: Download

SOURCE CODE

```
#include <SoftwareSerial.h>
#include <Wire.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128    // OLED display width, in pixels
#define SCREEN_HEIGHT 64    // OLED display height, in pixels
#define OLED_RESET -1       // Reset pin # (or -1 if sharing Arduino reset pin)
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

#define RE 8
#define DE 7

//const byte code[]= {0x01, 0x03, 0x00, 0x1e, 0x00, 0x03, 0x65, 0xCD};
const byte nitro[] = {0x01,0x03, 0x00, 0x1e, 0x00, 0x01, 0xe4, 0x0c};
const byte phos[] = {0x01,0x03, 0x00, 0x1f, 0x00, 0x01, 0xb5, 0xcc};
const byte pota[] = {0x01,0x03, 0x00, 0x20, 0x00, 0x01, 0x85, 0xc0};

byte values[11];
SoftwareSerial mod(2,3);

void setup() {
  Serial.begin(9600);
  mod.begin(9600);
  pinMode(RE, OUTPUT);
  pinMode(DE, OUTPUT);
```

SOURCE CODE

```
  display.begin(SSD1306_SWITCHCAPVCC, 0x3C); //initialize with the I2C addr 0x3C (128x64)
  delay(500);
  display.clearDisplay();
  display.setCursor(25, 15);
  display.setTextSize(1);
  display.setTextColor(WHITE);
  display.println(" NPK Sensor");
  display.setCursor(25, 35);
  display.setTextSize(1);
  display.print("Initializing");
  display.display();
  delay(3000);
}

void loop() {
  byte val1,val2,val3;
  val1 = nitrogen();
  delay(250);
  val2 = phosphorous();
  delay(250);
  val3 = potassium();
  delay(250);


  Serial.print("Nitrogen: ");
  Serial.print(val1);
  Serial.println(" mg/kg");
  Serial.print("Phosphorous: ");
  Serial.print(val2);
  Serial.println(" mg/kg");
  Serial.print("Potassium: ");
  Serial.print(val3);
  Serial.println(" mg/kg");
  delay(2000);
```

SOURCE CODE

```
  display.clearDisplay();


  display.setTextSize(2);
  display.setCursor(0, 5);
  display.print("N: ");
  display.print(val1);
  display.setTextSize(1);
  display.print(" mg/kg");

  display.setTextSize(2);
  display.setCursor(0, 25);
  display.print("P: ");
  display.print(val2);
  display.setTextSize(1);
  display.print(" mg/kg");

  display.setTextSize(2);
  display.setCursor(0, 45);
  display.print("K: ");
  display.print(val3);
  display.setTextSize(1);
  display.print(" mg/kg");

  display.display();
}

byte nitrogen(){
  digitalWrite(DE,HIGH);
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(nitro,sizeof(nitro))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
```

SOURCE CODE

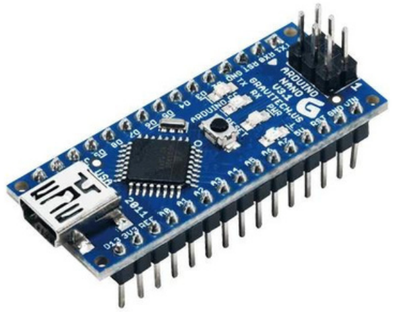
```
    for(byte i=0;i<7;i++){
      //Serial.print(mod.read(),HEX);
      values[i] = mod.read();
      Serial.print(values[i],HEX);
    }
    Serial.println();
  }
  return values[4];
}

byte phosphorous(){
  digitalWrite(DE,HIGH);
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(phos,sizeof(phos))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
      //Serial.print(mod.read(),HEX);
      values[i] = mod.read();
      Serial.print(values[i],HEX);
    }
    Serial.println();
  }
  return values[4];
}

byte potassium(){
  digitalWrite(DE,HIGH);
  digitalWrite(RE,HIGH);
  delay(10);
  if(mod.write(pota,sizeof(pota))==8){
    digitalWrite(DE,LOW);
    digitalWrite(RE,LOW);
    for(byte i=0;i<7;i++){
```

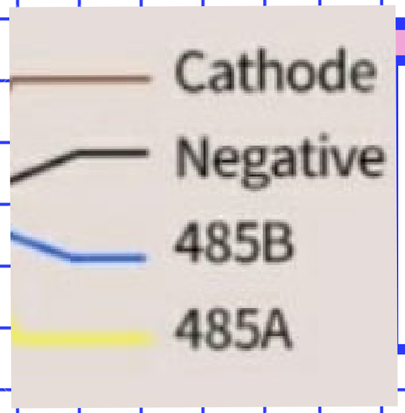
SOURCE CODE

```
    for(byte i=0;i<7;i++){
      //Serial.print(mod.read(),HEX);
      values[i] = mod.read();
      Serial.print(values[i],HEX);
    }
    Serial.println();
  }
  return values[4];
}
```



Arduino Nano

0.96" OLED Display



Terminals of NPK

Compile the code and upload it to the Arduino Nano board. Note: The code is the only one capable of measuring soil NPK values up to 255 mg/kg. This is because we are only reading an 8-bit value. According to the sensor information sheet, a value of up to 1999mg/kg can be measured. To read such a value, we need to read 16-bit data. Refer to the Soil EC sensor code to read such high values.

MONITORING SOIL NPK DATA ON AN OLED SCREEN:

After uploading the code to the Arduino nanoboard, the OLED together with the sensor will be initialized. The sensor takes some time to stabilize and the reading may be incorrect at first. Once the sensor is installed, you can sink the sensor into the soil to get an NPK reading. The amount of nitrogen, phosphorus and potassium, which is the ammonium content of the soil, is shown in mg/kg.

This is how you connect the soil nutrient sensor to the Arduino and get NPK readings. Similarly, place the sensor in different soil samples. Depending on the type of soil, you will see differences in the amount of NPK.

OLED SCREEN

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The internet is not a luxury, it is a necessity.

BARACK OBAMA, 44TH PRESIDENT OF THE UNITED STATES OF AMERICA