RCC Institute of Information Technology
Department of ECE
Report on mini lab project

Paper code: EC 692 **Academic session: 2024-2025**

Title: Low-cost wireless soil moisture monitoring system using NRF24L01 and Arduino Nano microcontrollers.

Group No: 5				
	Group member 1	**Group member 2**	**Group member 3**	**Group member 4**
Name	**NAZEYA NEHAL**	**SOHINI KUNDU**	**GRACY GHOSH**	**NISHA VIDYARTHI**
Email ID	**ece2022076@rcciit.org.in**	**ece2022078@rcciit.org.in**	**ece2022072@rcciit.org.in**	**ece2022069@rcciit.org.in**

ABSTRACT:

This project presents a **low-cost wireless soil moisture monitoring system designed to enhance irrigation efficiency in agriculture**. The system employs **Arduino Nano microcontrollers and NRF24L01 wireless transceivers** to collect and transmit real-time soil moisture data from multiple points in a field to a central monitoring unit. Each sensor node is equipped with a soil moisture sensor that measures the water content in the soil and sends the data wirelessly to a base station. This enables farmers to make informed irrigation decisions, leading to better water management, higher crop yields, and reduced labor costs. The system is cost-effective, scalable, and energy-efficient, making it suitable for use in both small-scale and large-scale agricultural environments. By integrating embedded systems and wireless sensor networks, this project contributes to the advancement of smart agriculture and supports sustainable farming practices.

NOVELTY OF THIS WORK:

The novelty of this project lies in its combination of affordability, simplicity, and scalability using widely available and low-power hardware components. Key novel aspects include:

1. Use of NRF24L01 for Multi-Node Communication: Unlike many existing systems that rely on expensive Wi-Fi or GSM modules, this project uses NRF24L01, a low-cost, low-power 2.4GHz transceivers.The system supports multi-point to single-point communication, enabling the deployment of several sensor nodes across a large field.

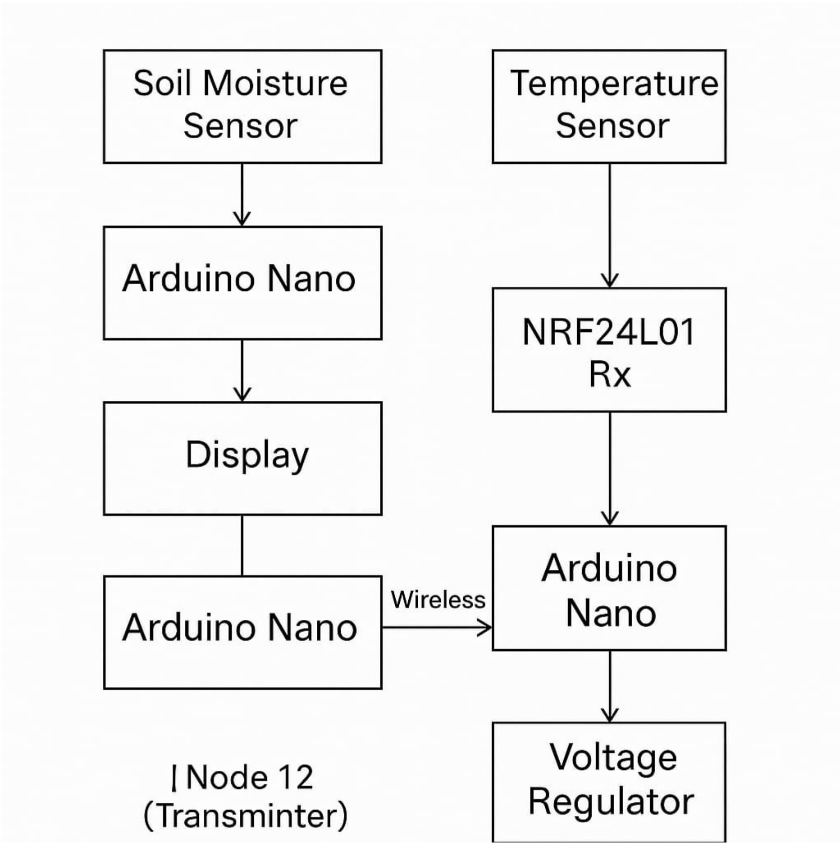
2. Cost-Effective Design: All components used (Arduino Nano, analog soil sensor, NRF24L01) are inexpensive and easy to source, making the system affordable for small-scale farmers.

3. Modular and Scalable Architecture: The system supports modular expansion, meaning new sensor nodes can be easily added without changing the core system.This scalability makes it adaptable to different field sizes and crop types.

4. Real-Time Monitoring with Low Power Consumption : The NRF24L01 operates with ultra-low power, making the nodes ideal for battery or solar-powered operation, which is critical for remote or off-grid agricultural areas.

5. Practical Application of Wireless Sensor Networks (WSN) in Agriculture : While WSNs are a theoretical concept in computer networks, this project presents a real-world implementation specifically optimized for agricultural applications.

FUNCTIONAL BLOCK DIAGRAM:



WORKING METHODOLOGY:

The project works by continuously sensing soil moisture and temperature in the field, then wirelessly transmitting this data to a central base station for monitoring and possible decision-making. The system is structured as a Wireless Sensor Network (WSN)**.**

System Components:

1. Arduino Nano : Acts as the main controller at both sensor nodes and the receiver station.Reads analog data from the soil sensor and controls the NRF24L01.Compact, low-cost, and easy to program using Arduino IDE.

2. Soil Moisture Sensor: Analog sensor that measures the water content in the soil.Outputs a voltage signal proportional to soil moisture.Types: Capacitive (preferred for durability) or resistive.

3. NRF24L01 Transceiver Modules : 2.4 GHz wireless transceiver module for data communication.Enables low-power, short-range wireless communication (up to 100 meters with antenna).Communicates between sensor nodes and the central base station.

4. Power Supply: Each node is powered using Rechargeable battery pack (Li-ion, LiPo)Or solar panel for sustainable outdoor operation Voltage regulators may be used for 3.3V supply to NRF24L01.

5. 16x2 LCD Display: Displays real-time moisture readings locally.Useful for visual inspection without a PC or serial monitor.

6. Base Station Hardware: Arduino Nano + NRF24L01 at receiver side

7. Miscellaneous Components: Breadboards , Jumper wires and headers, Resistors.

8. Temparature Sensor: Adding a temperature sensor enhances the system's capability by providing critical environmental data that improves precision agriculture and crop health management.

Tools Used:

- Arduino IDE (for coding and uploading programs)
- Serial Monitor (for data debugging)
- Soldering tools (for permanent connections)

➢ **Workflow Steps:**

1. Data Sensing at Node (Transmitter Unit): The soil moisture sensor reads the water content of the soil.The temperature sensor reads the ambient temperature.Both sensors are connected to an Arduino Nano, which reads the data through its analog and digital pins respectively.

2. Data Processing The Arduino Nano:Converts analog moisture data into percentage values.Reads and formats temperature data in °C. Combines both readings into a single data packet.

3. Wireless Data TransmissionThe NRF24L01 transceiver module is used to send the sensor data wirelessly from the transmitter node.It operates on 2.4 GHz frequency, with low power usage and support for multiple nodes.Each node has a unique address allowing communication with a single base station.

4. Data Reception at Base Station :Another Arduino Nano, connected to an NRF24L01 module, acts as the receiver.It receives data packets from all active sensor nodes.

5. Display & Monitoring: The received soil moisture and temperature data is displayed via:16x2 LCD screen

6. Manual or Automatic Decision Making: Farmers can make manual irrigation decisions by observing sensor readings.

7. Repeat Cycle: The system continues in a loop:Sense → Process → Transmit → Receive → Display → Act. This ensures real-time monitoring of soil conditions.

APPLICATIONS:

- Smart irrigation systems

- Greenhouse monitoring
- Precision agriculture
- Academic and research projects in IoT and environmental monitoring

Advantages:

- Low cost and easy to implement
- Wireless data transmission with good range
- Real-time monitoring with local and remote display
- Energy-efficient operation

CODE:

Node 1:

```
#include <SPI.h>

#include <nRF24L01.h>

#include <RF24.h>

RF24 radio(9, 10); // CE, CSN

const byte address[6] = "00001";

const int soilPin = A0;

void setup() {

  Serial.begin(9600);

  radio.begin();

  radio.openWritingPipe(address);

  radio.setPALevel(RF24_PA_LOW);

  radio.stopListening();

}

void loop() {

  int soilValue = analogRead(soilPin);

  Serial.print("Soil Moisture: ");

  Serial.println(soilValue);
```

```
  radio.write(&soilValue, sizeof(soilValue));
  delay(2000);
}
```

Node 2:

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>
#include <Adafruit_GFX.h>
#include <Adafruit_SSD1306.h>

#define SCREEN_WIDTH 128
#define SCREEN_HEIGHT 64
#define OLED_RESET -1
Adafruit_SSD1306 display(SCREEN_WIDTH, SCREEN_HEIGHT, &Wire, OLED_RESET);

RF24 radio(9, 10); // CE, CSN
const byte address[6] = "00001";
int soilValue = 0;
void setup() {
Serial.begin(9600);

 // OLED setup
if (!display.begin(SSD1306_SWITCHCAPVCC, 0x3C)) {
Serial.println(F("SSD1306 allocation failed"));
 for (;;);
}
 display.clearDisplay();
display.setTextColor(SSD1306_WHITE);
```

```
display.setTextSize(1);
display.setCursor(0, 0);
 display.println("Waiting for data...");
 display.display();


 // NRF24 setup
radio.begin();
radio.openReadingPipe(1, address);
 radio.setPALevel(RF24_PA_LOW);
radio.startListening();
}

void loop() {
 if (radio.available()) {
radio.read(&soilValue, sizeof(soilValue));
Serial.print("Received Soil Moisture: ");
Serial.println(soilValue);



display.clearDisplay();
display.setCursor(0, 0);
display.setTextSize(1);
display.println("Soil Moisture");
display.setTextSize(2);
 display.setCursor(0, 20);
display.print(soilValue);
```

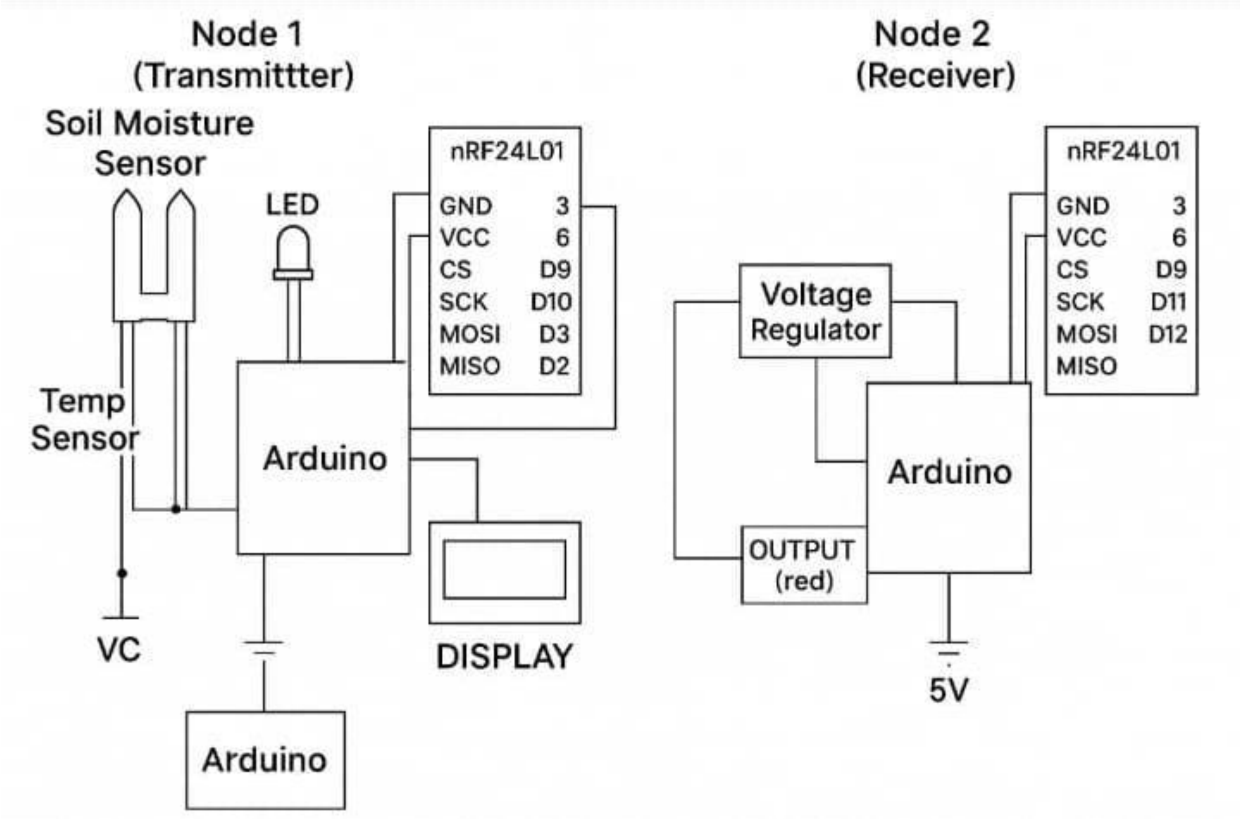
```
display.display();

}

delay(1000);

}
```

CIRCUIT DIAGRAM:



RESULT: Moisture Monitoring System using NRF24L01 and Arduino Nano" was successfully implemented and tested under field-like conditions. The system performed as expected and delivered reliable wireless monitoring of soil conditions.

Observed Outcomes:

1. **Real-Time Soil Moisture Readings:**The system accurately read soil moisture levels using a capacitive/resistive sensor.Moisture data was clearly displayed on the local LCD screen at Node 1.

2. Temperature Monitoring: Ambient temperature was accurately measured using a DHT11/DHT22 sensor.Temperature readings were transmitted along with moisture data.

3. Wireless Communication: NRF24L01 modules successfully transmitted sensor data over a range of 50–100 meters without significant packet loss.Multiple sensor nodes were able to communicate with a single base station when configured.

4. Stable Data Reception at Base Station: Data received by the receiver Arduino Nano was accurately displayed on monitor.

5. Low Power Consumption: The system worked efficiently with a small battery, and showed potential for solar-powered operation in rural or remote farms.

OBSERVATION: The observation is presented in the following table

Observation Aspect	**Description**
Soil Moisture	Moisture values decrease as soil dries.
Temparature Sensor	Varies with room/outdoor conditions.
LCD Display	Clear output for both values and proper display of real time sensor values.
Power Consumption	Operates on battery or solar, suitable for field deployment.
Data transmission Accuracy	Sensor used for this is NRF24L01 and Arduino Nano. Minimal packet loss in open space and it has good reliability.
Code Simplicity	C Programs readability made the system easy to develop, debug, and extend.

CONCLUSION: This project successfully demonstrates a cost-effective, reliable, and scalable solution for real-time monitoring of soil moisture and temperature using wireless sensor networks. By integrating the NRF24L01 radio transceivers, soil moisture sensors, and Arduino Nano microcontrollers, the system is able to collect and transmit environmental data over a considerable distance with low power consumption.

The inclusion of a temperature sensor (DHT11/DHT22) enhances the data's accuracy and usefulness, allowing for smarter irrigation decisions based on both soil moisture and ambient conditions.

The system provides the following key advantages:

- Continuous real-time monitoring
- Remote wireless data transmission
- Low-cost hardware and ease of installation
- Potential for automation (e.g., irrigation control)
- Applicability in agriculture, greenhouses, and research

Overall, the system proves to be a practical and sustainable tool for precision agriculture, especially in rural or resource-constrained environments. It lays a strong foundation for further development, such as cloud-based analytics, mobile notifications, or solar-powered operation.

REFERENCES: The engineering projects https://justdoelectronics.com/soil-moisture-sensor-arduino-tutorial/.