A project report on

AUTOMATED MULTI CROP IRRIGATION USING IOT

Submitted in partial fulfillment for the award of the degree of

Bachelor of Technology

in

Electronics and Communication Engineering

by

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SCHOOL OF ELECTRONICS ENGINEERING

May, 2023

DECLARATION

I hereby declare that the thesis entitled "AUTOMATED MULTI CROP IRRIGATION USING IOT " submitted by me, for the award of the degree of Bachelor of Technology, is a record of bonafide work carried out by me under the supervision of Dr.Yamarthi Narasimha Rao.

I further declare that the work reported in this thesis has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Place: Amaravati A.Dhanya sree

Date: 26-05-202 **Signature of the Candidate**

CERTIFICATE

This is to certify that the Senior Design Project titled "**AUTOMATED MULTI CROP IRRIGATION USING IOT**" that is being submitted by **ADDAGALLA DHANYA SREE (19BEC7100)** is in partial fulfillment of the requirements for the award of Bachelor of Technology, is a record of bonafide work done under my guidance. The contents of this Project work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma and the same is certified.

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ABSTRACT

Multi-crop irrigation is an essential aspect of modern agriculture that helps increase crop yield and conserve water resources. The use of Internet of Things (IoT) technology in agriculture has revolutionized traditional irrigation methods. In this project, we propose a multi-crop irrigation system that utilizes soil moisture sensors, humidity sensors, temperature sensors, and an Arduino microcontroller to automate the irrigation process.

The system collects data from the sensors and processes it using the Arduino microcontroller. The data is analyzed to determine the moisture level, humidity, and temperature of the soil. Based on this data, the irrigation system is controlled to deliver the optimal amount of water to the crops. The system is connected to an IoT platform via wifi module which allows farmers to monitor and control the irrigation system remotely.

The proposed system is expected to increase crop yield by providing optimal water levels and reducing water wastage. The use of IoT technology makes the system cost-effective, efficient, and environmentally friendly. The results of this project have the potential to significantly impact modern agriculture by improving crop yields, reducing water usage, and promoting sustainable farming practices.

Also, we will see what and which type of sensors can be used in real time if we use this approach.Comparison of sensors,voltage consumption and their efficiency are also described.

ACKNOWLEDGEMENT

It is my pleasure to express with deep sense of gratitude to Dr.Yamarthi Narasimha Rao,professor, School of Computer and Engineering, VIT-AP, for his constant guidance, continual encouragement, understanding; more than all, he taught me patience in my endeavor. My association with him is not confined to academics only, but it is a great opportunity on my part to work with an intellectual and expert in the field of IoT.

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In jubilant mood I express ingeniously my whole-hearted thanks to Dr.Jayendra Kumar, Professor, all teaching staff and members working as limbs of our university for their not-self-centered enthusiasm coupled with timely encouragement showered on me with zeal, which prompted the acquirement of the requisite knowledge to finalize my course study successfully. I would like to thank my parents for their support.

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Place: Amaravati ADDAGALLA DHANYA SREE

Date: 26-05-2023 **Name of the student**

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VWC	Volumetric Water Content
ADC	Analog to Digital Converter

Chapter 1

Introduction

1.1 INTRODUCTION

Agriculture is done on a large scale in many of the countries. Population is growing every day, thus farming is necessary to generate more food. Farming includes sowing, manuring, irrigation, weeding and harvesting out of which irrigation and manuring are the most important ones which need a lot of attention. We need to decrease the amount of labor that farmers must do and boost the crop's efficiency through the use of current technologies, such as automation. We are fusing modern technologies, such as automating processes, with agriculture. So, to reduce the time spent on irrigation and to yield good crops by not overly irrigating, we are using Soil moisture sensors. Also factors like temperature and humidity affect the growth of crops. High temperature causes shoot and root growth inhibitions and high humidity causes reduced CO_2 intake and reduced transpiration. In order to avoid these problems, we need to continuously monitor them so that farmers can take necessary actions. So, here we are also using temperature and humidity sensors. We are diverting the water to the crop according to the moisture values recorded. The status of the pump and values of humidity and temperature sensors can be monitored by farmers on a web page.

1.1.1 ADVANTAGES OF SMART MULTI CROP IRRIGATION

Water conservation,improved crop yield,cost savings,time efficiency,environmental sustainability,data-driven decision making,scalability and flexibility,disease and pest management and remote monitoring and control can be achieved by following smart multi-crop irrigation.

- With smart irrigation systems, farmers can remotely monitor and control irrigation operations using mobile devices or computers. This feature allows them to respond quickly to changing conditions, make adjustments as needed, and address any issues without physically being present on the field.
- Smart multi-crop irrigation systems can be easily scaled and adapted to different field sizes and crop types. They offer flexibility in terms of irrigation methods, enabling farmers to choose the most suitable technique for their specific needs, such as drip irrigation, sprinklers, or precision sprinklers.
- Automated features and remote monitoring capabilities allow farmers to manage irrigation systems more effectively. They can remotely control and monitor irrigation activities, enabling them to allocate their time and resources more efficiently.

1.2 MOTIVATION

Globally agricultural land area is approximately five billion hectares, or 38 percent of the global land surface. This sums to the large amount of water usage in irrigating crops. Security and privacy issues, factors concerning climate conditions and real-time soil and air features that affect irrigation control make the development of such a system challenging. Irrigation is a critical component of modern agriculture, playing a vital role in ensuring optimal plant growth and maximizing crop yields. However, conventional irrigation methods often suffer from inefficiencies, leading to water wastage, increased costs, and environmental concerns. To address these challenges, the integration of Internet of Things (IoT) technology with multi-crop irrigation systems offers a compelling solution.By undertaking a project on smart multi-crop irrigation using IoT, we aim to address critical challenges in agriculture, such as water scarcity, resource conservation, and sustainable food production. Through the integration of IoT technology, data analytics, and precision irrigation, we can create a transformative solution that optimizes crop yield, promotes sustainable farming practices, and ensures a more secure future for our agricultural systems.

1.3 OVERVIEW OF SMART MULTI CROP IRRIGATION

The Arduino serves as the main controller, receiving data from the soil moisture sensors and DHT11 sensor to monitor the moisture levels and environmental conditions in real-time. Based on the collected data, the Arduino triggers the relay to control the DC motor pump, delivering water to the crops as needed.NodeMCU, acting as the IoT gateway, enables wireless communication between the irrigation system and a central monitoring station or mobile application. This allows remote monitoring and control of the irrigation system, providing convenience and flexibility to the farmers.The soil moisture sensors accurately measure the moisture content in the soil, ensuring precise irrigation scheduling. The DHT11 sensor monitors temperature and humidity, providing additional environmental data to optimize irrigation decisions.The DC motor pump, controlled by the Arduino through the relay, supplies water to the crops with adjustable flow rates and durations. This ensures that each crop receives the appropriate amount of water for optimal growth and yield.The system's IoT capabilities enable data collection, analysis, and visualization, empowering farmers to make data-driven decisions. The collected data can be utilized for predictive analytics, enabling proactive irrigation adjustments based on weather forecasts and crop water requirements.Overall, the Smart Multi-Crop Irrigation using IoT project integrates various components and technologies to create an efficient, automated, and remotely accessible irrigation system. By leveraging IoT, this project aims to conserve water, reduce costs, improve crop productivity, and promote sustainable agricultural practices.

1.4 OBJECTIVES

- In this automated irrigation system, the pumping motor turns ON and OFF based upon the moisture content of the soil. The soil moisture sensor is a sensor that detects the exact amount of moisture in the soil. Now here comes the role of IOT to give the information to the farmers about the status of the water moisture. Farmers can see the status of moisture content in a web page using a modem or in a mobile application. They can check whether the water sprinklers are turned ON or not at any time.
- Also with readings of DHT11, farmers can regulate the irrigation of crops.
- List possible soil moisture sensors which can be used in real time and compare their performance.

Chapter 2

BACKGROUND

2.1 LITERATURE SURVEY

Several studies have investigated the use of IoT technology in irrigation systems. In a study by Yan et al., a wireless sensor network-based irrigation system was developed to optimize water usage in maize cultivation. The system utilized moisture sensors, temperature sensors, and a decision-making algorithm to determine the optimal irrigation timing and amount. In another study by Wang et al., an IoT-based smart irrigation system was developed to monitor and control the water flow in greenhouses. The system utilized a combination of moisture sensors, temperature sensors, and actuators to maintain optimal growing conditions for various crops.

•Agriculture falls under the primary sector category which indicates that the majority of the country's economy is dependent on that. China is the top in the list of agricultural countries and India is recorded as the second top agricultural country in the world. The yield of a crop depends upon several factors like water, external temperature, the fertility of the soil etc. Among these, irrigation is one of such factors where human attention has to be provided more. Traditional plant watering methods has two important things to consider, that is when to water the plants and how much water will be sufficient for the plant. Not all types of crops require the same amount of water. Crops like rice need more water than other weed plants. This paper proposes an idea of a smart irrigation system based on IoT applications to increase the crop yield. If the available land is less then multi-crop is one of the good ideas to improve the profits or the crop yield in less time. This paper proposes an idea of a smart irrigation system with smart control of decision in which decision is made by taking the real-time data from the land. In this automated irrigation system, the pumping motor turns ON and OFF based upon the moisture content of the soil.

•Joaquin Gutierrez, Juan Francisco Villa-Medina, and Alejandra Nieto-Garibay, Miguel Angel Porta-Gandara

•In Automated Irrigation System Using a Wireless Sensor Network and GPRS Module mentioned about using automatic irrigation system in which irrigation will take place by wireless sensor units (WSUs) and a wireless information unit (WIU), linked by radio transceivers that allowed the transfer of soil moisture and temperature data, implementing a WSN that uses ZigBee technology. It takes a measure of temperature and moisture using a sensor and is controlled by a microcontroller. The WIU has also a GPRS module to transmit the data to a web server via the public mobile network. The information can be remotely monitored online through a graphical application through Internet access devices. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability and it is a feasible system. But due to the Zigbee protocol this system becomes more costly.

•In Wireless Sensor Network based Remote Irrigation Control System and Automation using DTMF code mentioned about using automated irrigation system for proper yield and handled remotely for farmer safety. Wireless sensor network and Embedded based technique of DTMF (Dual Tone Multiple Frequency) signaling to control water flow for sectored, sprinkler or drip section irrigation. Circuit switching instead of packet switching used by SMS controlled devices available currently in the market. The farmer can use his cell phone or landline phone for the purpose of starting and controlling the irrigation and the pesticide spraying, just by dialing and sending the DTMF commands over the GSM network. This system will be very economical in terms of the hardware cost, power consumption and call charges. Farmers have to control (on/off) the valves from time to time (even at night) which increases the running cost because every time we have to make a call to on or off the valves and it is also very inconvenient. Farmers are unable to know the status of power supply at the field.

2.2 PROBLEM SURVEY

Many smart irrigation systems are proposed in different ways, but none talk about Irrigating multiple crops simultaneously. The proposed system will divert the water to the other crop so it is suitable for irrigating the multiple crops based on crop requirements. The existing systems do not give priority to the crops; they follow the soil moisture sensor values and irrigate the crop. The existing systems will cover one crop at a time but the proposed system covers multiple crops at a time so it saves them time and grows multiple crops simultaneously.Also, the sensors used in prototype cannot be used in real time.The proposed system will contain all the sensors which can be used in real time theoretically along with the prototype sensors.

Chapter 3

METHODOLOGY

3.1 COMPONENTS

Arduino uno

The Uno with Cable is a microcontroller board based on the ATmega328. 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 an AC-to-DC adapter or battery to get started.Arduino Uno is a popular microcontroller board based on the ATmega328P chip.It features digital input/output pins, analog inputs, PWM outputs, and a USB interface for programming and communication.

With 14 digital I/O pins, it provides flexibility for connecting sensors, actuators, and other electronic components.The board runs on 5V power supply and has a clock speed of 16 MHz.It can be programmed using the Arduino IDE, which offers a user-friendly platform for coding and uploading sketches.Arduino Uno is widely used for various projects, including robotics, automation, IoT, and prototyping.It supports a wide range of sensors and modules, making it versatile for different applications.The board has built-in voltage regulators, making it compatible with a variety of power sources.

Arduino Uno is beginner-friendly, making it an ideal choice for those new to electronics and programming.It has a large and supportive community, providing extensive documentation, tutorials, and project examples.

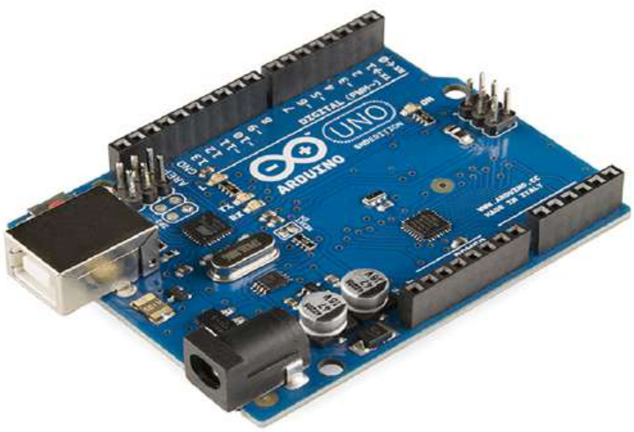

Fig 1: Arduino UNO

Arduino IDE

Arduino IDE (Integrated Development Environment) is a software platform designed for programming and uploading code to Arduino boards.It provides a user-friendly interface that simplifies the process of writing and uploading sketches to Arduino microcontrollers.

The IDE supports the C and C++ programming languages and includes a range of libraries and functions specific to Arduino boards.It features a code editor with syntax highlighting, auto-completion, and error checking, aiding developers in writing clean and error-free code.The built-in Serial Monitor allows real-time communication between the Arduino board and the computer, enabling debugging and data exchange.

Arduino IDE supports a wide range of Arduino boards, including popular models like Arduino Uno, Nano, Mega, and more.It offers a straightforward process for compiling and uploading code to the Arduino board with just a few clicks.The IDE provides a library manager, allowing easy installation and management of third-party libraries for extended functionality.

Arduino IDE is cross-platform and compatible with Windows, macOS, and Linux operating systems, ensuring accessibility for users on different platforms.It has a vast and active community that contributes to the development of libraries, tutorials, and examples, making it easier for beginners to learn and explore Arduino programming.

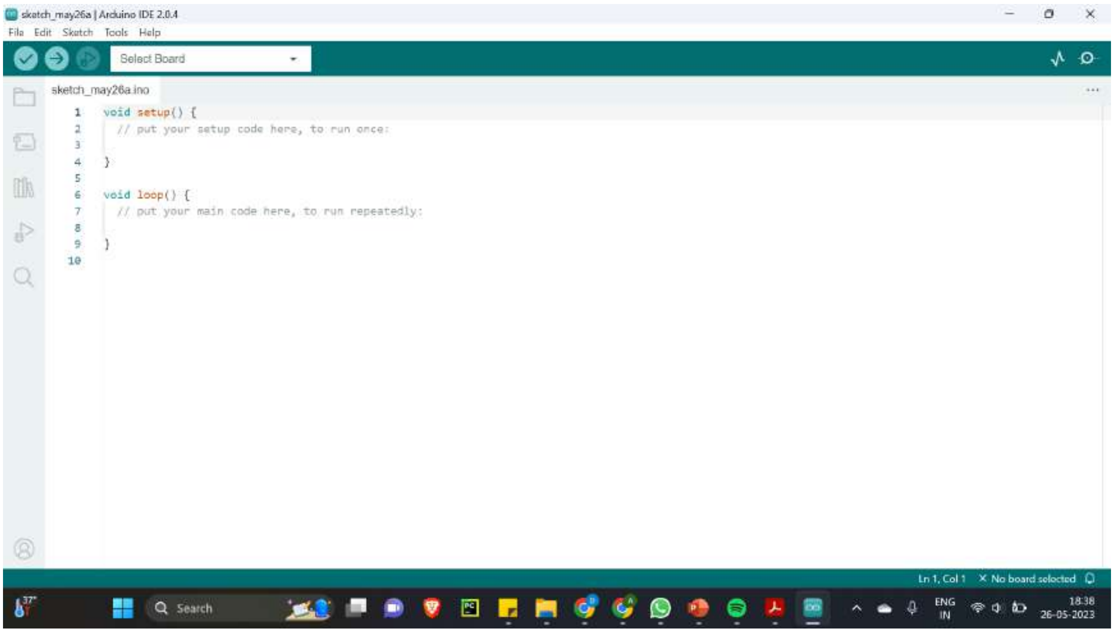

Fig 2: Arduino IDE

The IDE supports a variety of hardware shields, modules, and sensors, enabling seamless integration with Arduino projects.It provides a standardized framework for developing Arduino-based projects, ensuring compatibility and ease of collaboration among developers.Arduino IDE offers a streamlined process for configuring and selecting Arduino board settings, simplifying the setup and initialization of projects.
It includes a serial plotter, allowing developers to visualize data from sensors and other sources in real-time graph plots.

The IDE supports version control systems like Git, enabling developers to manage and track changes in their Arduino projects.It provides extensive documentation, tutorials, and examples on the official Arduino website, helping users learn and troubleshoot effectively.The IDE allows users to create and manage multiple projects simultaneously, providing organization and flexibility in development.Arduino IDE supports over-the-air (OTA) updates, allowing wireless programming of Arduino boards without the need for physical connections.It offers a vibrant and supportive online community where users can seek assistance, share their projects, and collaborate with others.Arduino IDE continues to evolve and improve with regular updates and bug fixes, ensuring a reliable and user-friendly development environment.

The IDE supports the C and C++ programming languages and includes a range of libraries and functions specific to Arduino boards.It features a code editor with syntax highlighting, auto-completion, and error checking, aiding developers in writing clean and error-free code.The built-in Serial Monitor allows real-time communication between the Arduino board and the computer, enabling debugging and data exchange.

Soil moisture sensor

Resistive soil moisture sensors are commonly used sensors in agriculture to measure the moisture content of the soil.These sensors work based on the principle of electrical conductivity in the soil.

They consist of two electrodes that are inserted into the soil, and the resistance between these electrodes changes with the moisture level.As the soil moisture increases, the conductivity of the soil increases, resulting in a decrease in the sensor's resistance.The resistance values are then correlated with moisture levels using calibration curves or equations.

Resistive soil moisture sensors are cost-effective and relatively simple to use and install.They are compatible with various microcontrollers and Arduino boards for data acquisition and analysis.These sensors are versatile and can be used for a wide range of soil types and crops.They provide real-time measurements, enabling farmers to monitor soil moisture levels and make informed irrigation decisions.

However, resistive soil moisture sensors are influenced by factors like soil type, temperature, and salinity, requiring proper calibration and adjustment.They may also require periodic maintenance and cleaning to ensure accurate and reliable measurements.Resistive soil moisture sensors are durable and can withstand harsh environmental conditions.They are suitable for both small-scale and large-scale farming applications.These sensors play a crucial role in optimizing irrigation practices, conserving water, and improving crop yields.They can be integrated with IoT systems to enable remote monitoring and control of irrigation processes.
Resistive soil moisture sensors are widely available in the market and are a popular choice among farmers and researchers for soil moisture monitoring.

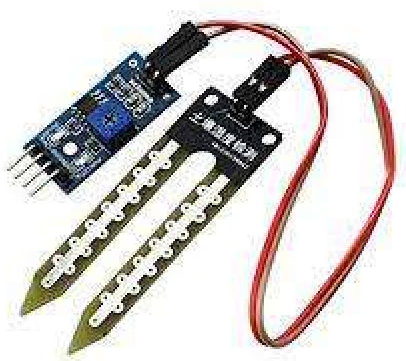

Fig 3: Resistive Soil moisture sensor

DHT11

DHT11 is a popular and affordable digital temperature and humidity sensor module. It is capable of measuring temperature ranging from 0 to 50 degrees Celsius with an accuracy of ±2 degrees Celsius.The humidity measurement range of DHT11 is 20% to 90% with an accuracy of ±5%.

The sensor module uses a single-wire digital communication protocol, making it easy to interface with microcontrollers like Arduino.DHT11 operates on 3.3V to 5V power supply and consumes very low power.It provides digital output for temperature and humidity readings, making it convenient for data acquisition.

The sensor module has a compact design and is suitable for various applications, including environmental monitoring and home automation.DHT11 requires a pull-up resistor and a stable power supply for reliable performance.It offers a basic level of accuracy and functionality, making it suitable for simple temperature and humidity monitoring projects.DHT11 libraries and code examples are widely available, making it easy to integrate with microcontroller projects.

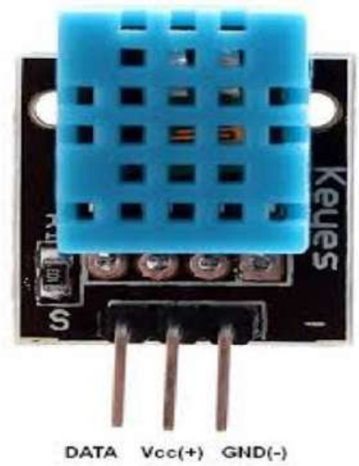

Fig 4: DHT11

NodeMCU

NodeMCU ESP8266 is a widely used development board based on the ESP8266 Wi-Fi module.It combines the power of a microcontroller and Wi-Fi connectivity, making it ideal for IoT projects.The board is compatible with the Arduino IDE and can be programmed using the Lua scripting language or Arduino programming language.

NodeMCU ESP8266 features a built-in USB-to-serial converter, eliminating the need for additional hardware for programming.It offers GPIO pins for connecting sensors, actuators, and other peripheral devices.The board supports Wi-Fi connectivity, enabling seamless communication with other devices and cloud platforms.NodeMCU ESP8266 operates on 3.3V power supply and has an onboard regulator for stable voltage regulation.

It provides a convenient and cost-effective solution for prototyping and developing IoT applications.NodeMCU ESP8266 has a large and active community, offering extensive documentation, tutorials, and support.The board's compact size, ease of use, and affordability make it a popular choice for IoT enthusiasts and developers.

Fig 5: NodeMCU ESP8266

DC WATER PUMP

A High Performance non submersible dc water pump is a device which has a hermetically sealed motor close-coupled to the pump body. Some part of the assembly is submerged in the fluid to be pumped. The main advantage of this type of pump is that it prevents pump cavitations, a problem associated with a high elevation difference between pump and the fluid surface.

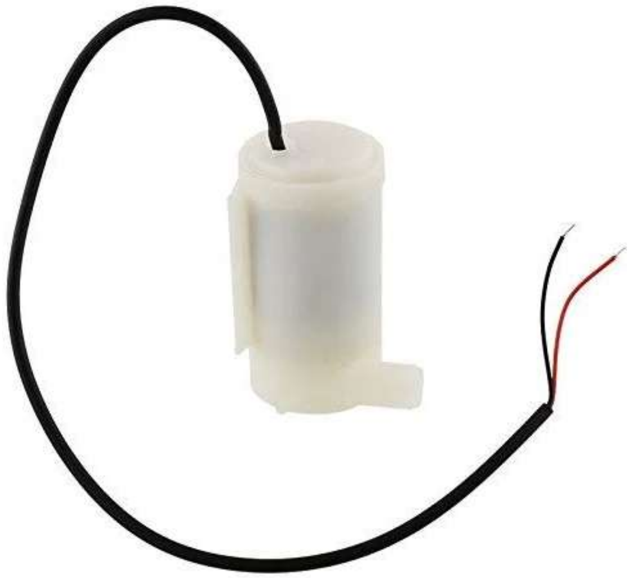

Fig 6: DC water pump

5V DC Water Pump for Arduino is a low cost, small size Submersible Water Pump which can be operated from a 2.5 ~ 6V power supply. It can take up to 120 liters per hour with a very low current consumption of 220mA. The main advantages of this water pump is their operating current.

RELAY

A relay board, also known as a relay module or relay shield, is an electronic module designed to simplify the control of multiple relays in Arduino projects. It provides an interface between the Arduino board and the relays, allowing for easy integration and control of high-power devices or circuits.

Functionality: A relay board typically consists of multiple relays, commonly ranging from 2 to 8 or more, mounted on a single PCB (Printed Circuit Board). Each relay on the board can be individually controlled to switch high voltage or current loads using a low-voltage signal from the Arduino.

Connection: Relay boards are designed to connect to an Arduino board using jumper wires or by directly plugging onto the Arduino headers. The control signals from the Arduino are connected to the input pins on the relay board, while the output contacts of the relays are connected to the load circuits.

Power Considerations: Relay boards often have separate power inputs to provide power to the relay coils and the connected loads. These power inputs are typically connected to an external power supply or a separate power source capable of providing the required voltage and current for the loads.

Optocouplers and Isolation: Some relay boards incorporate optocouplers or other isolation components to provide electrical isolation between the Arduino and the high-power circuits. This isolation helps protect the Arduino from voltage spikes, electrical noise, and potential damage.

Compatibility: Relay boards are designed to be compatible with Arduino boards, ensuring that the control signals and power requirements are suitable for use with the Arduino's I/O pins. They are often designed to work with the Arduino Uno, Arduino Mega, or other Arduino models.

Programming: To control a relay board in Arduino, the Arduino code needs to be written to set the appropriate control signals on the specified pins. This involves using digital output functions to send the logic high or low signals to the relay board's input pins, activating or deactivating the relays accordingly.

Applications: Relay boards are widely used in Arduino projects for various applications, including home automation, industrial automation, robotics, smart agriculture, security systems, and more. They can control devices such as lights, motors, solenoids, valves, heaters, fans, and other high-power loads.

Expandability: Relay boards can be cascaded or combined with other modules to control a larger number of relays or to add additional functionalities. This allows for scalability and flexibility in projects requiring control of multiple devices or circuits.

Relay boards provide a convenient and efficient way to interface and control relays in Arduino projects. They simplify the wiring and offer additional features like isolation and compatibility with Arduino boards, making them a popular choice for controlling high-power loads in various applications.

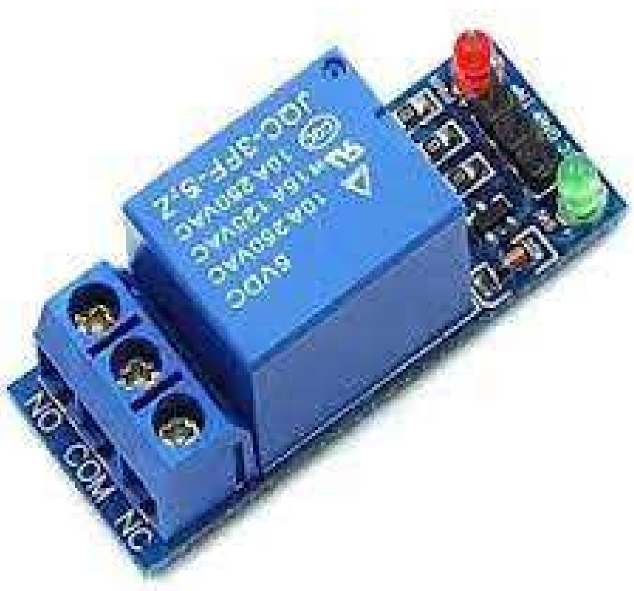

Fig 7: Relay

3.2 WORKING

The multicrop irrigation system developed in this study consists of moisture sensors, humidity and temperature sensors, DC pumps, Arduino and NodeMCU boards, and 3 relays. The moisture sensors are used to measure the soil moisture content, while the humidity and temperature sensors are used to monitor the growing conditions.

The DC pumps are used to water the crops, while the Arduino and NodeMCU boards are used to control the system's operation. The relays are used to switch the DC pumps on and off.The system operates as follows: The moisture sensors continuously monitor the soil moisture content. If the moisture content falls below a certain threshold, the Arduino board sends a signal to the NodeMCU board to activate the DC pumps. The pumps then water the crops until the moisture content reaches the optimal level. The humidity and temperature sensors monitor the growing conditions and adjust the irrigation schedule accordingly. The entire system can be monitored.

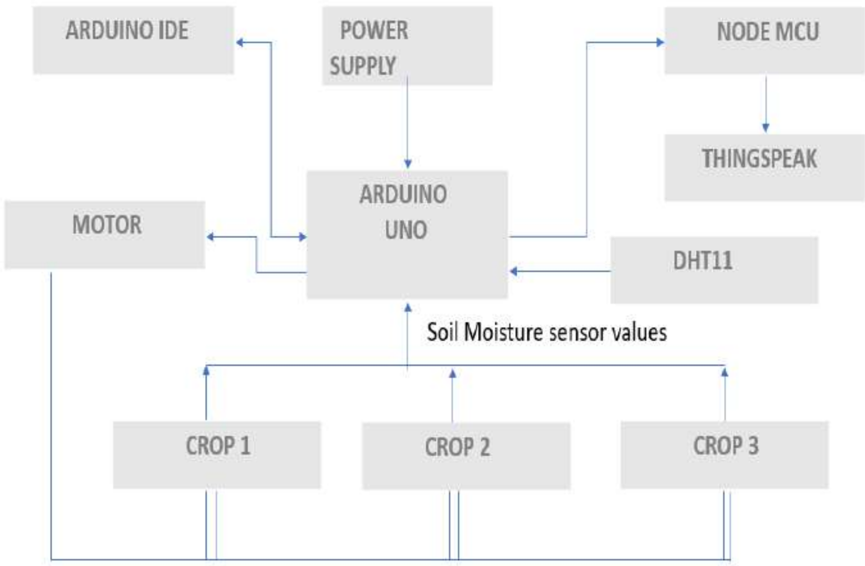

Fig 8: Block diagram of smart multi-crop irrigation system

Fig 9: Multi crop

Soil moisture sensors are placed in each crop of a multi crop field. Here we are taking 3 crops in a field,so three soil moisture sensors are used.These sensors which are connected to Arduino continuously monitor the readings and turn the water pump on and off accordingly and divert the water to the field. When the moisture level of a certain specific crop is below its threshold value then water is pumped to that crop and when it reaches its threshold then the pump is stopped.

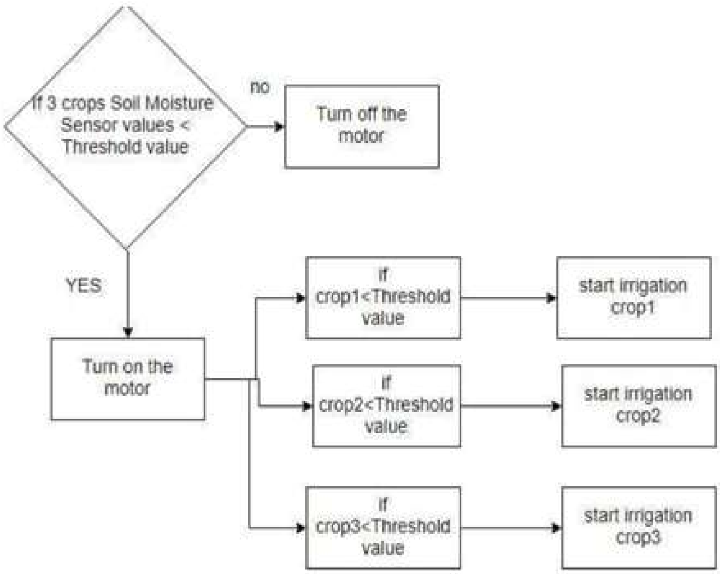

Fig 10: ON & OFF MOTOR PUMP

3.2.1 TEMPERATURE AND HUMIDITY

Temperature and humidity significantly influence the irrigation requirements of crops. So, we will also be using a DHT11 sensor which can record both temperature and humidity readings.

Temperature: Higher temperatures lead to increased evaporation rates, causing faster water loss from the soil and plants. Consequently, crops may experience water stress more quickly, necessitating more frequent irrigation to maintain adequate moisture levels.

Crop water demand: Higher temperatures often result in increased crop water demand due to enhanced evapotranspiration rates. Evapotranspiration refers to the combined loss of water through plant transpiration and soil evaporation. As temperature rises, plants require more water for growth and cooling, which requires sufficient irrigation to meet their needs.

Water uptake and nutrient absorption: Elevated temperatures affect root activity and water uptake efficiency. In warmer conditions, crops may have reduced access to water in the soil, leading to decreased nutrient absorption. Adequate irrigation is crucial to ensure plants can access water and nutrients for healthy growth.

Water loss through leaf transpiration: High temperatures can promote rapid transpiration from crop leaves, resulting in greater water loss. If irrigation is insufficient, crops may experience wilting and reduced productivity. Maintaining proper soil moisture through irrigation helps mitigate excessive water loss through transpiration.

Humidity: Humidity levels influence the rate of evaporation and transpiration from plants. Higher humidity reduces the evaporative demand, resulting in slower water loss from the soil and reduced crop water requirements. In humid conditions, irrigation may need to be adjusted accordingly to avoid overwatering and potential water logging issues.

Microclimates: Temperature and humidity can vary within microclimates in agricultural areas. Factors such as shade, wind exposure, or elevation can create localized variations in temperature and humidity. Understanding these microclimates is important for accurate irrigation management to ensure adequate water supply for crops in different areas.

Irrigation scheduling: Monitoring temperature and humidity helps determine appropriate irrigation scheduling. Using weather data, such as temperature forecasts and relative humidity, farmers can adjust their irrigation practices accordingly. They can fine-tune irrigation frequency, duration, and timing to align with the crop's water requirements based on prevailing temperature and humidity conditions.

In summary, temperature and humidity influence crop water demand, evaporation rates, transpiration rates, and nutrient absorption. By considering these factors, farmers can optimize irrigation practices to ensure sufficient water supply and promote healthy crop growth in different environmental conditions.

3.2.2 VOLUMETRIC WATER CONTENT

The volumetric water content is the proportion of water volume to soil volume. Assuming a unit surface area, volumetric water content can be stated as a ratio, percentage, or depth of water per depth of soil, such as inches of water per foot of soil.

Generally, resistive soil moisture sensors are designed to measure moisture levels in a small area of soil around the sensor. For example, a typical resistive soil moisture sensor may have a sensing length of 5 cm or less, which means it can measure the moisture content of soil within a 5 cm radius of the sensor.

$$\text{AnalogOutput} = (\text{ADCValue})/1023$$

$$\text{Moisture in percentage} = 100 - (\text{Analog output} * 100)$$

For zero moisture, we get a maximum value of 10-bit ADC, i.e. 1023. This, in turn, gives 0% moisture.

Chapter 4

CODE

4.1 ARDUINO UNO CODE

```
#include <LiquidCrystal.h>
#include <DFRobot_DHT11.h>
#define DHT11_PIN 11

DFRobot_DHT11 DHT;
LiquidCrystal lcd(5, 6, 7, 8, 9, 10);
#define rly1 2
#define rly2 3
#define rly3 4

#define sensor1 A0
#define sensor2 A1
#define sensor3 A2

int pump1, pump2, pump3;
int val1, val2, val3;

void setup() {
  Serial.begin(9600);
  lcd.begin(16, 2);
  pinMode(rly1, OUTPUT);
  pinMode(rly2, OUTPUT);
  pinMode(rly3, OUTPUT);
  digitalWrite(rly1, HIGH);
  digitalWrite(rly2, HIGH);
  digitalWrite(rly3, HIGH);

  pinMode(sensor1, INPUT);
  pinMode(sensor2, INPUT);
  pinMode(sensor3, INPUT);
}

void loop() {
  val1 = analogRead(sensor1);
  val1 = map(val1, 0, 1023, 1023, 0);  //map function is used to reduce the data size
  val2 = analogRead(sensor2);
  val2 = map(val2, 0, 1023, 1023, 0);
  val3 = analogRead(sensor3);
  val3 = map(val3, 0, 1023, 1023, 0);

  lcd.clear();
  lcd.print("Multicrop");
  lcd.setCursor(0, 1);
```

```
lcd.print("Irrigation");
delay(2000);
lcd.clear();
lcd.print("Using IOT");
delay(2000);


DHT.read(DHT11_PIN);
lcd.clear();
lcd.print("temp: ");
lcd.print(DHT.temperature);
lcd.print(" C");
lcd.setCursor(0, 1);
lcd.print("humi: ");
lcd.println(DHT.humidity);
lcd.print(" %");
delay(2000);


lcd.clear();
lcd.print("Sensor-1");
lcd.setCursor(0, 1);
lcd.print(val1);
delay(2000);

if (val1 < 350) {
  digitalWrite(rly1, LOW);
  lcd.clear();
  lcd.print("pump-1 ON");
  pump1 = 1;
  delay(2000);
} else {
  digitalWrite(rly1, HIGH);
  pump1 = 0;
}

lcd.clear();
lcd.print("Sensor-2");
lcd.setCursor(0, 1);
lcd.print(val2);
delay(2000);

if (val2 < 450) {
  digitalWrite(rly2, LOW);
  lcd.clear();
  lcd.print("pump-2 ON");
  pump2 = 1;
  delay(2000);
} else {
  digitalWrite(rly2, HIGH);
```

```
    pump2 = 0;
  }

  lcd.clear();
  lcd.print("Sensor-3");
  lcd.setCursor(0, 1);
  lcd.print(val3);
  delay(2000);

  if (val3 < 600) {
    digitalWrite(rly3, LOW);
    lcd.clear();
    lcd.print("pump-3 ON");
    pump3 = 1;
    delay(2000);
  } else {
    digitalWrite(rly3, HIGH);
    pump3 = 0;
  }

   String str = "a" + String(val1) + "b" + String(val2) + "c" + String(val3) + "d" +
String(DHT.temperature) + "e" + String(DHT.humidity) + "f" + String(pump1) + "g"
+ String(pump2) + "h" + String(pump3) + "i";
   Serial.println(str);
  delay(2000);
}
```

4.2 NODEMCU ESP8266 CODE

```
#include <ESP8266WiFi.h>
#include "secrets.h"
#include "ThingSpeak.h"
#include <SoftwareSerial.h>
String data;
String val1, val2, val3;
int a, b, c;

char ssid[] = SECRET_SSID;
char pass[] = SECRET_PASS;
int keyIndex = 0;
WiFiClient client;

unsigned long myChannelNumber = SECRET_CH_ID;
const char* myWriteAPIKey = SECRET_WRITE_APIKEY;
String myStatus = "";

void setup() {
  Serial.begin(9600);     while (!Serial) {
    ;
  }

  WiFi.mode(WIFI_STA);
  ThingSpeak.begin(client);
  if (WiFi.status() != WL_CONNECTED) {
    Serial.print("Attempting to connect to SSID: ");
    Serial.println(SECRET_SSID);
    while (WiFi.status() != WL_CONNECTED) {
      WiFi.begin(ssid, pass);
      Serial.print(".");
      delay(5000);
    }
    Serial.println("\nConnected.");
  }
}

void loop() {


  while (Serial.available() > 0) {
    data = Serial.readString();
    Serial.println(data);
    a = data.indexOf("a");
    b = data.indexOf("b");
    a = a + 1;
    val1 = data.substring(a, b);
    Serial.println(val1);
    ThingSpeak.setField(1, val1);
```

```
delay(1000);

b = data.indexOf("b");
c = data.indexOf("c");
b = b + 1;
val2 = data.substring(b, c);
Serial.println(val2);
ThingSpeak.setField(2, val2);
delay(1000);

c = data.indexOf("c");
a = data.indexOf("d");
c = c + 1;
val3 = data.substring(c, a);
Serial.println(val3);
ThingSpeak.setField(3, val3);
delay(1000);

b = data.indexOf("d");
c = data.indexOf("e");
b = b + 1;
val1 = data.substring(b, c);
Serial.println(val1);
ThingSpeak.setField(4, val1);
delay(1000);

c = data.indexOf("e");
a = data.indexOf("f");
c = c + 1;
val2 = data.substring(c, a);
Serial.println(val3);
ThingSpeak.setField(5, val2);
delay(1000);

a = data.indexOf("f");
b = data.indexOf("g");
a = a + 1;
val3 = data.substring(a, b);
Serial.println(val3);
ThingSpeak.setField(6, val3);
delay(1000);

b = data.indexOf("g");
c = data.indexOf("h");
b = b + 1;
val2 = data.substring(b, c);
Serial.println(val2);
ThingSpeak.setField(7, val2);
delay(1000);
```

```
    c = data.indexOf("h");
    a = data.indexOf("i");
    c = c + 1;
    val3 = data.substring(c, a);
    Serial.println(val3);
    ThingSpeak.setField(8, val3);
    delay(1000);
  }

   ThingSpeak.setStatus(myStatus);

  int x = ThingSpeak.writeFields(myChannelNumber, myWriteAPIKey);
  if (x == 200) {
    Serial.println("Channel update successful.");
  } else {
    Serial.println("Problem updating channel. HTTP error code " + String(x));
  }
  delay(20000);  // Wait 20 seconds to update the channel again
}
```

Chapter 5

RESULT

5.1 PROTOTYPE RESULT

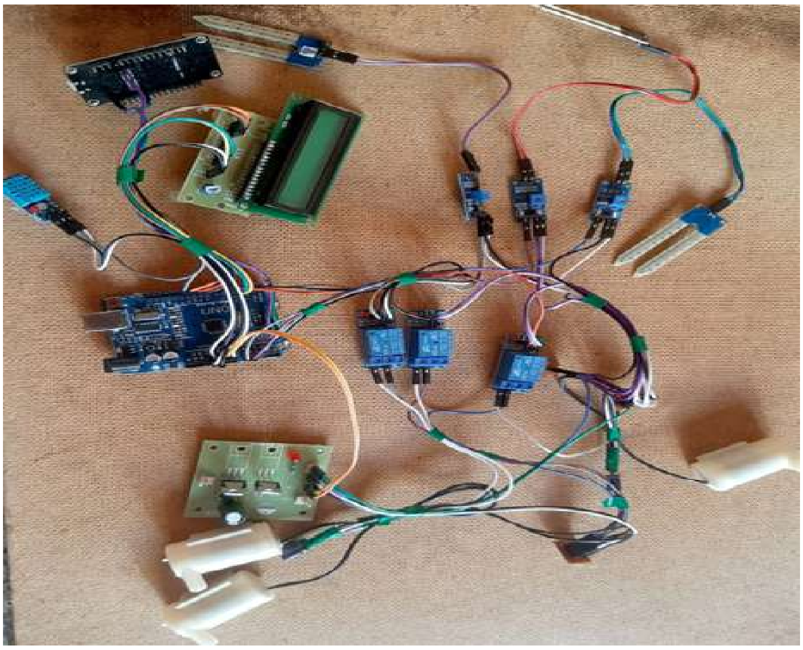

Fig 11: Prototype

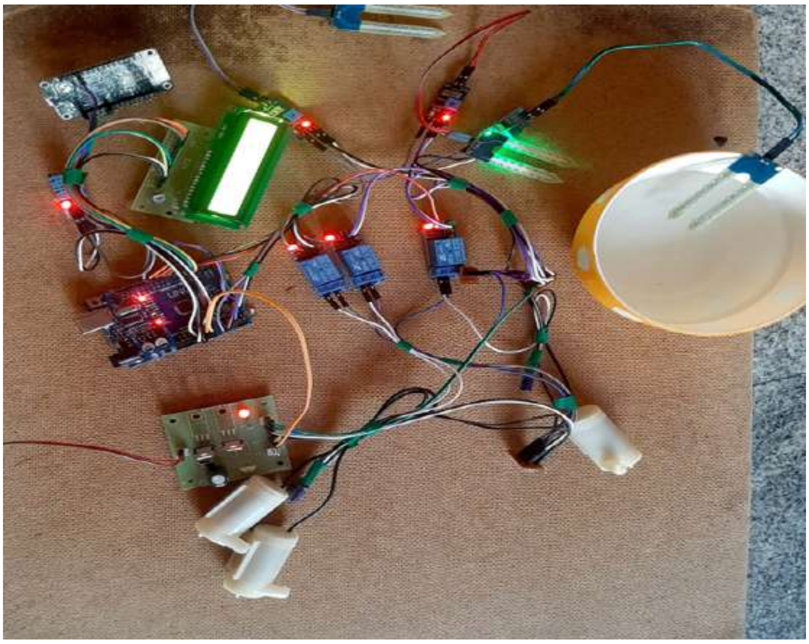

Fig 12: Working of prototype

5.2 THINGSPEAK

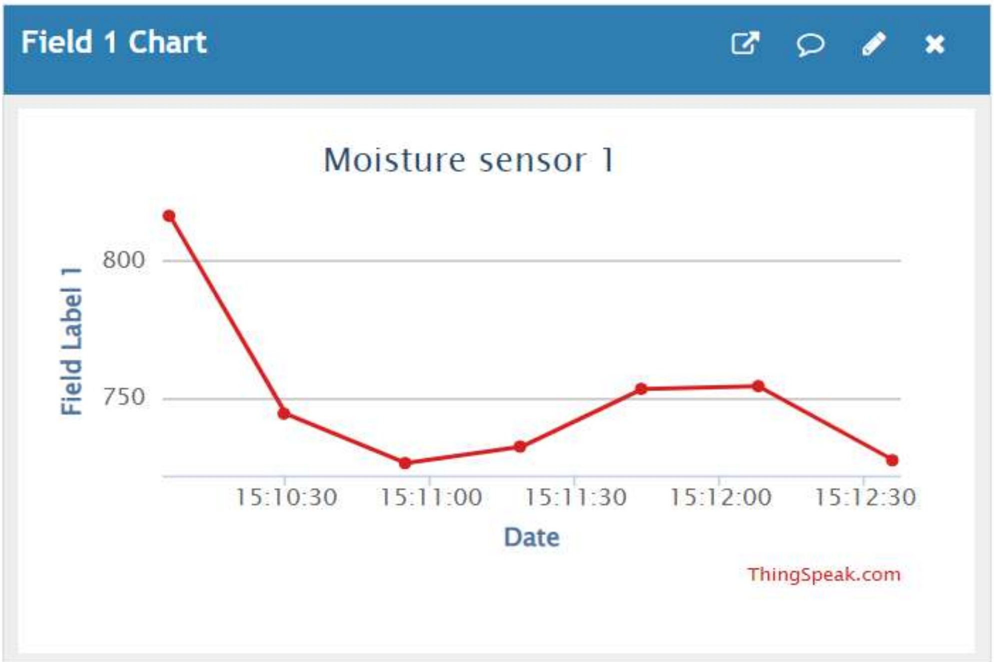

Fig 13: Sensor 1 Moisture content

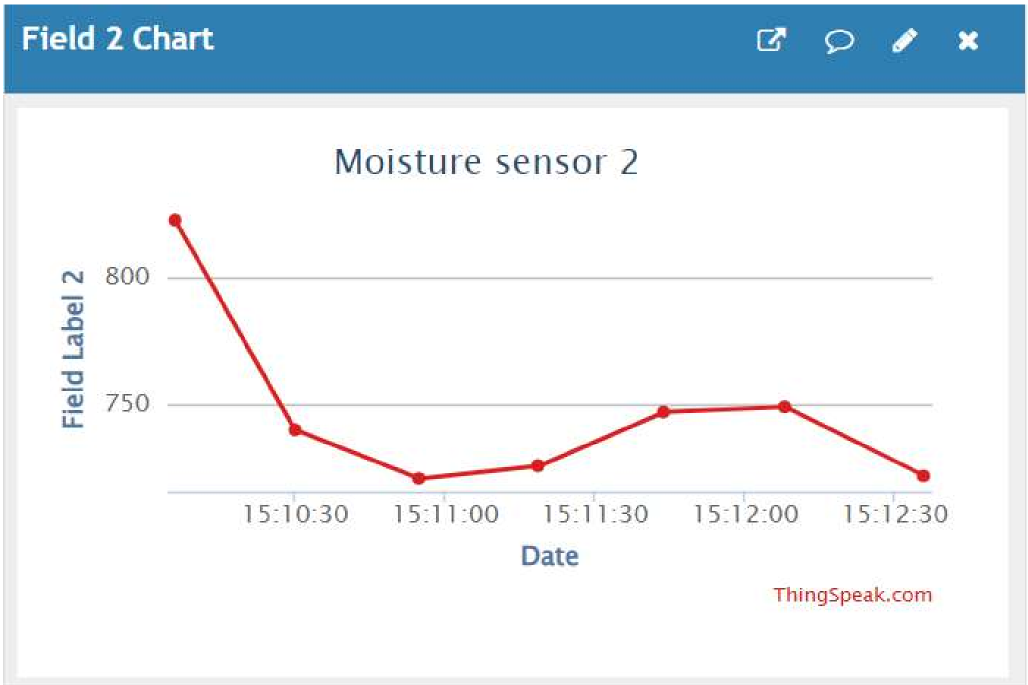

Fig 14: Sensor 2 Moisture content

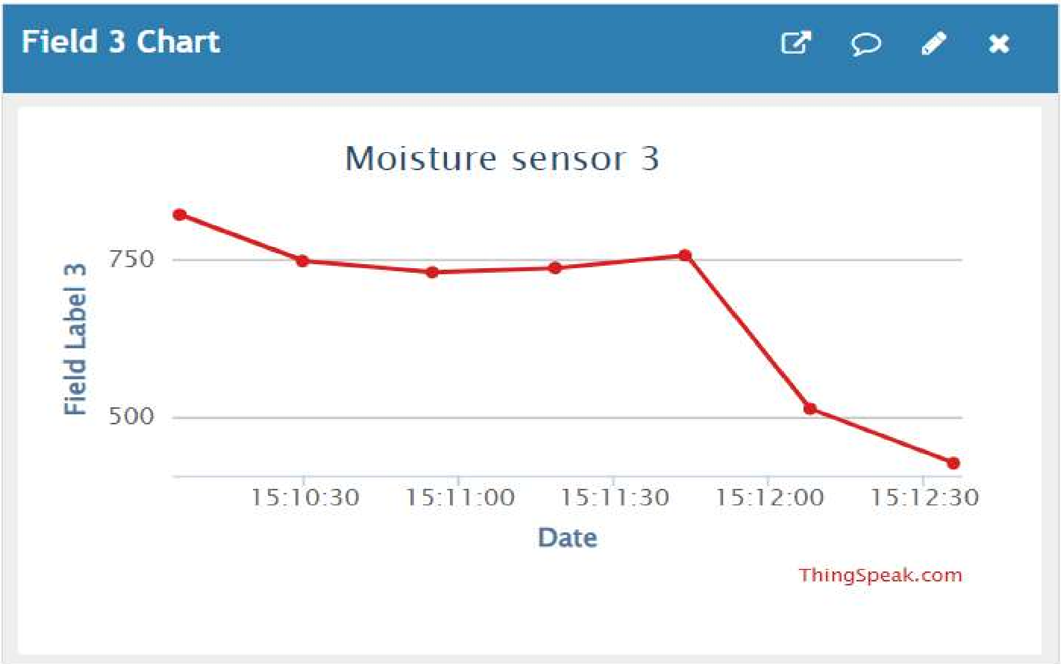

Fig 15: Sensor 3 moisture content

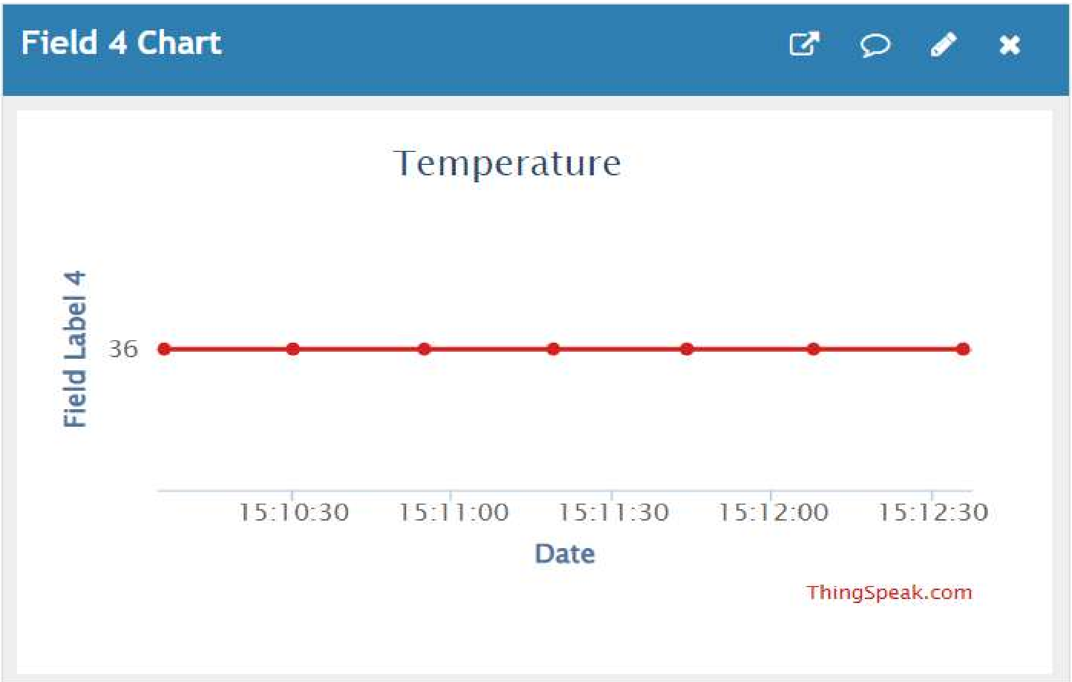

Fig 16: Temperature Readings

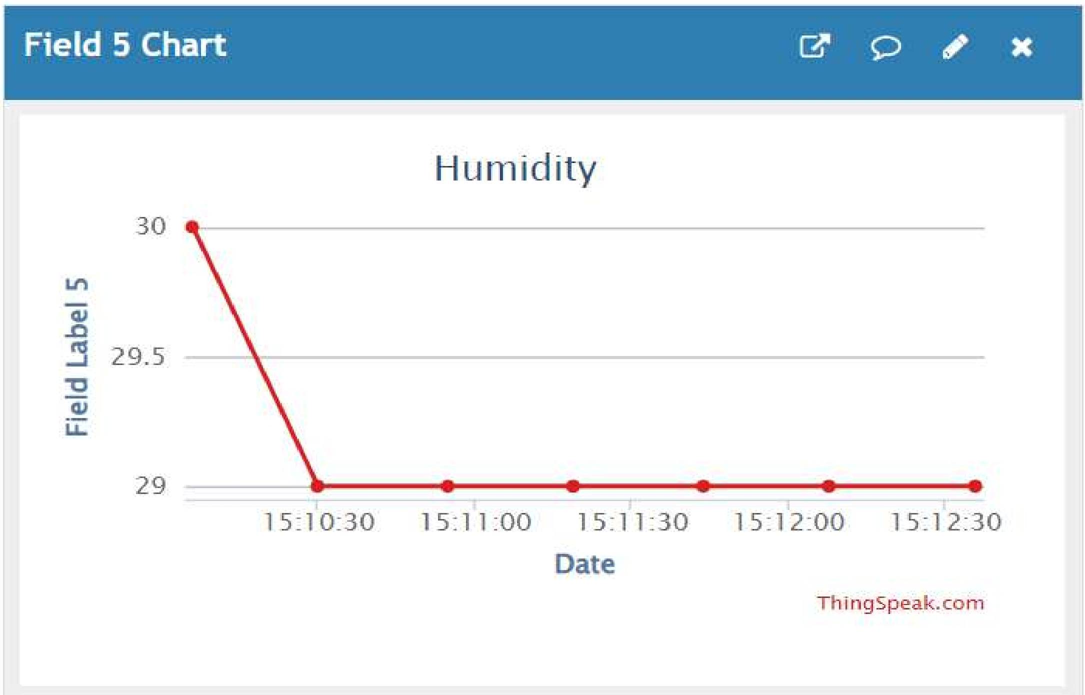

Fig 17: Humidity Readings

Chapter 6

REAL TIME USAGE

6.1 SENSORS USED IN REAL TIME

In practice, resistive moisture sensors can not be used because of its less coverage area.

Sensors like TDR(A), FDR(B), gypsum blocks(C), neutron probes(D), amplitude domain reflectometry(E) etc. are used because of the length of its probes, and can cover wide range

According to agricultural scientists an amount of 20 TDR sensors are required in an acre land[For a flat land] and varies for hard land.

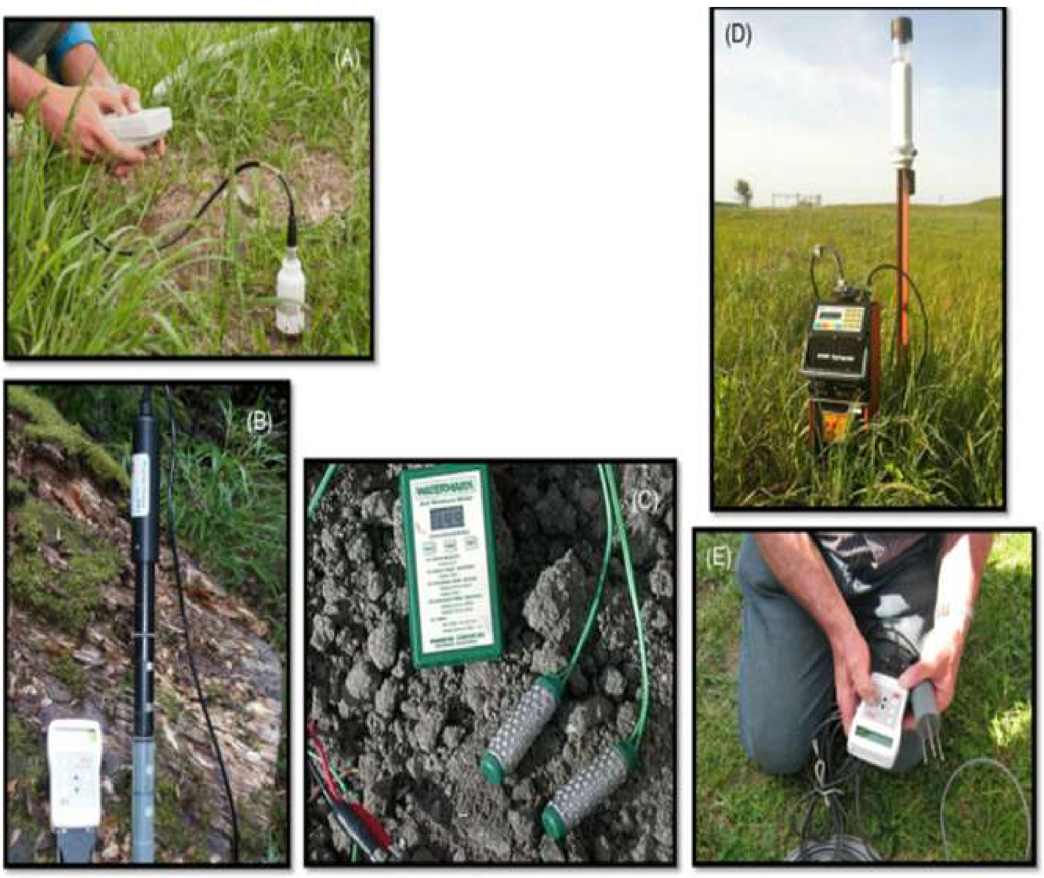

Fig 18: Sensors used in real time

TIME DOMAIN REFLECTOMETRY(TDR)

TDR (Time Domain Reflectometry) sensors are widely used for analyzing moisture content in the soil. TDR sensors employ the principle of electromagnetic waves to measure moisture levels in the soil.They work by sending short electrical pulses into the soil and measuring the time it takes for the waves to reflect back.The reflected waves provide information about the soil's dielectric permittivity, which is directly related to its moisture content.TDR sensors offer a non-destructive and accurate method for assessing soil moisture, making them valuable in agricultural and environmental applications.

Farmers and researchers use TDR sensors to optimize irrigation practices and enhance crop yield by ensuring proper soil moisture levels.TDR technology enables real-time monitoring of moisture gradients and helps prevent overwatering or underwatering.These sensors are also useful in soil science and geotechnical engineering to assess soil compaction and determine drainage characteristics.TDR systems can be deployed in various soil types, including sandy, loamy, and clay soils, making them versatile and adaptable.

They are often integrated into automated irrigation systems and weather stations to provide accurate data for informed decision-making.
Overall, TDR sensors play a crucial role in optimizing water usage, promoting sustainable agriculture, and understanding soil behavior in different applications.

Fig 19: TDR SENSOR

FREQUENCY DOMAIN REFLECTOMETRY(FDR)

Frequency Domain Reflectometry (FDR) sensors are extensively used for analyzing moisture content in the soil. FDR sensors utilize the frequency domain to measure soil moisture levels accurately and non-destructively.These sensors work by transmitting high-frequency electromagnetic signals into the soil and analyzing the reflected signals.By examining the changes in the frequency response of the reflected signals, FDR sensors can determine the soil's moisture content.FDR technology offers precise and continuous measurements, making it valuable for soil moisture monitoring in agriculture and research.

Farmers utilize FDR sensors to optimize irrigation strategies, prevent water wastage, and improve crop productivity by maintaining optimal moisture levels.FDR sensors are suitable for a wide range of soil types, including sandy, loamy, and clay soils, ensuring their versatility in different applications.These sensors find applications in environmental studies, hydrology, and land management to assess soil moisture dynamics and water availability.

FDR systems can be integrated into automated irrigation systems, weather stations, or soil moisture networks to provide real-time data for decision-making.The high accuracy and reliability of FDR sensors contribute to water conservation efforts and sustainable land management practices. Overall, FDR sensors play a vital role in understanding soil moisture dynamics, optimizing irrigation practices, and promoting efficient water resource management in various domains.

Fig 20: FDR SENSOR

GYPSUM BLOCKS

Gypsum blocks sensors are commonly used for analyzing moisture content in the soil. Gypsum blocks sensors are moisture probes that consist of a porous gypsum block and electrodes.These sensors work on the principle of electrical resistance measurement, where moisture affects the conductivity of the gypsum block.Gypsum blocks sensors are buried in the soil, and as the soil moisture changes, it alters the resistance between the electrodes.

By measuring the electrical resistance, Gypsum blocks sensors provide an indirect measure of soil moisture content.These sensors are cost-effective, durable, and suitable for long-term soil moisture monitoring applications.Gypsum blocks sensors are commonly used in agriculture, horticulture, and environmental research to optimize irrigation and water management practices.
They are particularly useful in measuring soil moisture in semi-arid and arid regions where water availability is critical.

Gypsum blocks sensors are often integrated into automated irrigation systems to ensure efficient water usage and prevent water stress in plants.They are compatible with different soil types and can be used in various depths to capture moisture variations across the soil profile.Overall, Gypsum blocks sensors offer a practical and reliable solution for assessing soil moisture content, aiding in water conservation, and promoting sustainable agriculture practices.

Fig 21: GYPSUM BLOCKS

NEUTRON PROBES

Neutron probe sensors are commonly used for analyzing moisture content in the soil.Neutron probe sensors work on the principle of measuring the amount of hydrogen, which is directly related to soil moisture content.These sensors emit fast or slow neutrons into the soil and measure the rate of neutron moderation or scattering.Neutron moderation is influenced by the presence of hydrogen, primarily in the form of soil moisture.By analyzing the rate of neutron moderation, neutron probe sensors provide accurate and direct measurements of soil moisture content.

These sensors are particularly useful for deep soil moisture profiling and can measure moisture content at various depths.Neutron probe sensors find applications in agriculture, hydrology, and research to optimize irrigation scheduling and water management practices.They are valuable tools for assessing soil water availability, estimating crop water requirements, and preventing water stress.

Neutron probe sensors can be installed permanently in the soil or used as portable devices for on-the-spot measurements.They are reliable and widely accepted in the scientific community, providing quantitative data on soil moisture dynamics.Overall, neutron probe sensors play a crucial role in understanding soil moisture distribution, optimizing irrigation practices, and promoting efficient water resource management in various fields.

Fig 22: NEUTRON PROBES

AMPLITUDE DOMAIN REFLECTOMETRY(ADR)

Amplitude Domain Reflectometry (ADR) sensors are used for analyzing moisture content in the soil.ADR sensors employ the principle of measuring the amplitude of electrical signals to assess soil moisture levels accurately.These sensors work by transmitting electrical signals into the soil and analyzing the amplitude of the reflected signals.The amplitude of the reflected signals is influenced by the dielectric properties of the soil, which change with varying moisture content.

ADR sensors provide a non-destructive and efficient method for monitoring soil moisture, making them valuable in agriculture and environmental research.Farmers utilize ADR sensors to optimize irrigation practices, prevent water stress in crops, and improve water use efficiency.ADR technology allows continuous monitoring of soil moisture dynamics, enabling timely interventions for irrigation management.These sensors are suitable for a wide range of soil types and can be deployed at different depths to capture moisture variations throughout the soil profile.

ADR sensors are often integrated into automated irrigation systems and soil moisture networks for real-time monitoring and decision-making. They provide reliable and accurate data, aiding in water conservation efforts and sustainable agriculture practices.Overall, ADR sensors play a vital role in analyzing soil moisture content, optimizing irrigation strategies, and promoting efficient water resource management in diverse applications.

Fig 23: ADR SENSOR

TENSIOMETERS

Tensiometer sensors are commonly used for analyzing moisture content in the soil. Tensiometer sensors measure soil moisture by assessing the soil's tension or suction potential.These sensors consist of a porous ceramic cup, a tube, and a pressure gauge or transducer.Tensiometer sensors work by inserting the ceramic cup into the soil and measuring the pressure required to extract moisture from the cup.

The pressure reading indicates the soil moisture tension, which correlates with the soil moisture content.Tensiometer sensors are particularly useful for measuring soil moisture in the range where plants can extract water effectively.They find extensive application in agriculture, horticulture, and landscaping to optimize irrigation practices and prevent under or overwatering.

Tensiometer sensors provide real-time measurements, enabling farmers to make informed decisions regarding irrigation scheduling.They are valuable tools for maintaining optimal soil moisture levels, promoting healthy plant growth, and preventing water stress.Tensiometer sensors are versatile and can be used in various soil types, including sandy, loamy, and clay soils.Overall, tensiometer sensors play a crucial role in analyzing soil moisture content, facilitating precise irrigation management, and conserving water resources.

Fig 24: TENSIOMETER

CAPACITIVE SOIL MOISTURE SENSORS

Capacitive soil moisture sensors are electronic devices used to measure the moisture content in soil. These sensors operate on the principle of changes in capacitance, which is the ability to store an electrical charge, based on the moisture level in the soil. Here's an overview of capacitive soil moisture sensors:

Working Principle: Capacitive soil moisture sensors consist of two or more electrodes that form a capacitor. When the sensor is inserted into the soil, the moisture content in the soil affects the dielectric constant, which is a measure of a material's ability to store electrical energy. As the soil moisture increases, the dielectric constant changes, leading to a change in capacitance.

Construction: Capacitive soil moisture sensors typically consist of a probe with embedded electrodes, an integrated circuit, and a protective casing. The electrodes are usually made of conductive material and are spaced apart to form a capacitor. The integrated circuit processes the capacitance measurements and provides an output signal that correlates to the moisture level.

Measurement Technique: Capacitive soil moisture sensors measure the capacitance between the electrodes. This is usually done by applying an oscillating electrical signal to the sensor and measuring the response. The measured capacitance is then converted into a moisture reading using calibration curves or algorithms.

Calibration: To obtain accurate moisture readings, capacitive soil moisture sensors require calibration. Calibration involves correlating the measured capacitance values with actual moisture levels in the soil. This is typically done by taking readings at different moisture levels and creating a calibration curve or equation for accurate moisture estimation.

Sensitivity and Accuracy: Capacitive soil moisture sensors are known for their high sensitivity to changes in soil moisture. They can detect small variations in moisture levels, making them suitable for precise irrigation control and research applications. However, the accuracy of these sensors can be affected by factors such as soil composition, temperature, and sensor calibration.

Installation and Placement: Capacitive soil moisture sensors are inserted into the soil at the desired depth to measure moisture levels at specific locations. Proper placement is important to ensure representative readings and avoid interference from factors such as surface water or roots. Sensor manufacturers usually provide guidelines for the optimal installation depth.

Advantages: Capacitive soil moisture sensors offer several advantages. They are non-destructive, allowing for continuous monitoring without disturbing the soil structure. These sensors can be used in a wide range of soil types and are suitable for both indoor and outdoor applications. Capacitive sensors also tend to consume less power compared to other types of soil moisture sensors.

Limitations: Capacitive soil moisture sensors have certain limitations to consider. They are influenced by factors such as salinity, soil composition, and temperature, which can affect their accuracy. Additionally, these sensors may require periodic recalibration to maintain measurement accuracy over time.

Applications: Capacitive soil moisture sensors are widely used in agriculture, horticulture, landscaping, and environmental monitoring. They help optimize irrigation practices, prevent overwatering or underwatering, and enable efficient water management. Capacitive sensors are also used in scientific research, greenhouse control systems, and smart agriculture technologies.

Integration with IoT: Capacitive soil moisture sensors can be integrated into Internet of Things (IoT) systems for remote monitoring and control. By connecting these sensors to IoT platforms, users can access real-time moisture data, receive alerts, and automate irrigation processes based on predefined thresholds.

In summary, capacitive soil moisture sensors provide a reliable and non-destructive method of measuring soil moisture content. Their high sensitivity, versatility, and integration potential with IoT systems make them valuable tools for efficient water management and improved plant health in various agricultural and environmental applications.

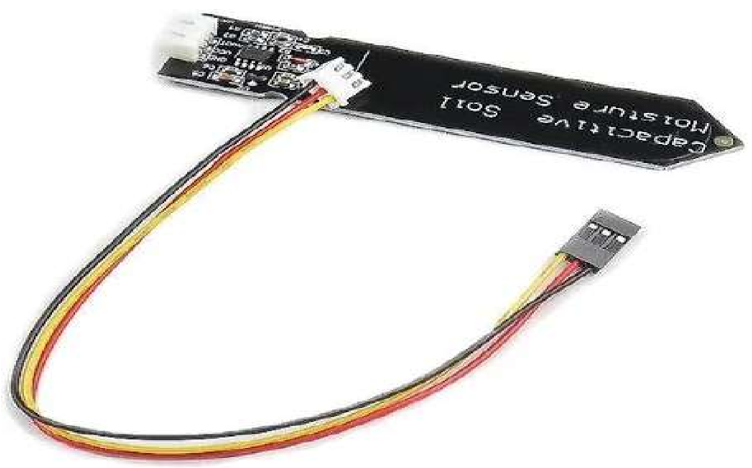

Fig 25: CAPACITIVE SOIL MOISTURE SENSOR

6.1.1 RESISTIVE SOIL MOISTURE SENSOR

Resistive soil moisture sensors are commonly used devices for measuring the moisture content in soil. These sensors operate on the principle of changes in electrical resistance based on the moisture level in the soil. Here's an overview of resistive soil moisture sensors:

Working Principle: Resistive soil moisture sensors consist of two or more electrodes, typically made of conductive materials such as metal or carbon. When inserted into the soil, the moisture content affects the electrical resistance between the electrodes. As the soil moisture increases, the conductivity of the soil increases, leading to a decrease in electrical resistance.

Construction: Resistive soil moisture sensors are typically constructed using two metal or carbon electrodes. The electrodes are spaced apart, and the region between them comes into contact with the soil. The resistance across the electrodes changes as the soil moisture level changes.

Measurement Technique: Resistive soil moisture sensors measure the electrical resistance between the electrodes. This is usually done by applying a known voltage or current across the electrodes and measuring the resulting electrical resistance using an analog-to-digital converter (ADC) or a resistance measurement circuit.

Calibration: To obtain accurate moisture readings, resistive soil moisture sensors require calibration. Calibration involves correlating the measured resistance values with actual moisture levels in the soil. This is typically done by taking readings at different moisture levels and creating a calibration curve or equation for accurate moisture estimation.

Sensitivity and Accuracy: Resistive soil moisture sensors are generally sensitive to changes in soil moisture. They can provide reliable readings and detect variations in moisture content. However, the accuracy of these sensors can be influenced by factors such as soil composition, temperature, and sensor calibration.

Installation and Placement: Resistive soil moisture sensors are inserted into the soil at the desired depth to measure moisture levels at specific locations. Proper placement is important to ensure representative readings and avoid interference from factors such as surface water or roots. Sensor manufacturers usually provide guidelines for the optimal installation depth.

Advantages: Resistive soil moisture sensors offer several advantages. They are relatively low-cost and simple to use compared to other types of soil moisture sensors. Resistive sensors can be used in a wide range of soil types and are suitable for both indoor and outdoor applications. These sensors can provide real-time moisture data and assist in optimizing irrigation practices.

Limitations: Resistive soil moisture sensors have certain limitations to consider. They are affected by factors such as salinity, soil composition, and temperature, which can impact their accuracy. Additionally, these sensors may require periodic recalibration to maintain measurement accuracy over time. They can also be prone to corrosion and degradation if not properly protected.

Applications: Resistive soil moisture sensors find applications in agriculture, horticulture, landscaping, and environmental monitoring. They are used to monitor and control irrigation processes, prevent overwatering or underwatering, and aid in water conservation efforts. Resistive sensors are also utilized in research projects, greenhouse control systems, and smart agriculture technologies.

Integration with IoT: Resistive soil moisture sensors can be integrated into Internet of Things (IoT) systems for remote monitoring and control. By connecting these sensors to IoT platforms, users can access real-time moisture data, receive alerts, and automate irrigation processes based on predefined thresholds.

In summary, resistive soil moisture sensors provide a cost-effective and practical solution for measuring soil moisture content. Their sensitivity, versatility, and potential integration with IoT systems make them valuable tools for efficient water management, plant health monitoring, and agricultural applications.

6.2 COMPARISON OF SENSORS

Sensor	Method	Advantage	
Fiber Optics	-Measures the change of the intensity of the light travel existing the probe to soil and entering back to the probe from soil	-Takes into consideration whether predictions	- expensive - very new technology
Tensiometers	- The built in vacuum gauge inside the plastic tube measures the pressure -The pressure changes by the water pulled out of the soil -Measured in centimeter: higher reading means less moisture and lower reading means Hi moisture	- easy to read the data - easy to operate - fast measurement - low power consumption	- &45-80(vary by the length,6-48” of the probe) - needs routine maintenance - cannot use during winter
Electrical Resistance blocks:Granular matrix	-Similar method to gypsum blocks	- better version of gypsum blocks -high accuracy - easy to operate - low cost(&25 - &50) - wide range of soil moisture - long duration(5-7 years) - low power consumption	- lower Accuracy compared to dielectric sensor - slow
Gypsum Blocks	-Two electrodes inside the Porus material such as gypsum measures the resistance itself -The water from the soil moves into the gypsum decreases the resistance and water	-Low cost - accurate in clay soil - easy to operate - low power consumption	- duration is around 1 to 2 years - low accuracy in Sandy soils - less repeatability

	pulled from the gypsum increases the resistance -Low resistance means higher moisture level and vice versa		
Electrical Conductivity Probes	-Measure the current of electricity between two probes(direct contact with soil) -More moisture have better the conductivity and vice versa	- high accuracy in clay soil - low cost	- very sensitive to the spacing of the groups and soil type - less repeatability
Heat Dissipation	-Ceramic medium of sensor measure heat dissipated by the soil -Higher dissipation has higher moisture level and vice versa	- independent of soil type or salinity influences	- high power consumption
Dielectric: Capacitance	-Two electrodes of dielectric have direct contact with soil and high oscillating frequency is applied to the electrodes and measures resonant frequency -The resonant frequency vary by moisture level of soil -Large change in frequency have higher moisture level and vice versa	- high accuracy - good for research use - read soil volumetric water content directly - low maintenance	- expensive - not practical for controlling irrigation system
Dielectric:TDR	-Measurement of time travel along the length of the probe rod by electromagnetic pulse -More travel time in higher moisture level and vice versa	- high accuracy - good for research use - read soil volumetric water content directly - low maintenance	- expensive - not practical for controlling irrigation system -Very complex

6.3 VOLTAGE AND ACCURACY

6.3.1 VOLTAGE

The voltage requirements for sensors can vary depending on their specific design, application, and manufacturer. However, I can provide you with some general information regarding the voltage ranges typically used for the sensors mentioned:

TDR Sensor (Time Domain Reflectometry): TDR sensors are commonly used to measure moisture content in soil. They operate by sending electromagnetic pulses through the soil and measuring the time it takes for the pulses to reflect back. The voltage requirements for TDR sensors typically range from 5 volts to 24 volts, with 12 volts being a common voltage level.

FDR Sensor (Frequency Domain Reflectometry): FDR sensors are also used for measuring soil moisture content. They work by analyzing the frequency response of the soil-water system. FDR sensors typically require a power supply voltage ranging from 12 volts to 24 volts.

Gypsum Sensor: Gypsum sensors, or gypsum blocks, are often used for monitoring soil moisture levels. These sensors consist of gypsum material with embedded electrodes. The voltage requirements for gypsum sensors are usually in the range of 1.5 volts to 9 volts, with 3 volts being a common voltage level.

Neutron Probe: Neutron probes are used for soil moisture measurements based on the neutron moderation principle. These probes typically use a small radioactive source to emit fast neutrons into the soil and detect the slow neutrons that are produced through interaction with soil moisture. Neutron probes usually require a high-voltage power supply in the range of several hundred volts to a few kilovolts, depending on the specific probe model.

It's important to note that these voltage ranges are general guidelines, and the actual voltage requirements may vary depending on the specific sensor model or manufacturer. Always consult the manufacturer's documentation or specifications for accurate voltage information for a particular sensor.

6.3.2 ACCURACY

The accuracy of soil moisture sensors can vary depending on various factors, including sensor technology, calibration, environmental conditions, and the specific manufacturer. Here are some general guidelines regarding the accuracy of the sensors mentioned:

TDR Sensors (Time Domain Reflectometry): TDR sensors are known for providing accurate soil moisture measurements. When properly calibrated, TDR sensors can achieve an accuracy of around ±2-3% volumetric water content (VWC) under ideal conditions. However, it's important to note that the accuracy may vary depending on soil type, salinity levels, and sensor calibration.

FDR Sensors (Frequency Domain Reflectometry): FDR sensors also offer good accuracy for soil moisture measurements. Similar to TDR sensors, the accuracy of FDR sensors can be around ±2-3% VWC, provided they are well calibrated and used in suitable soil conditions. However, as with any sensor, variations can occur based on specific factors and calibration methods.

Gypsum Blocks (Electrical Resistance Blocks): Gypsum blocks are relatively inexpensive and widely used for soil moisture measurements. The accuracy of gypsum blocks can range from ±3-5% VWC under optimal conditions. However, gypsum blocks may be affected by soil salinity, temperature, and other factors, which can introduce some degree of error in measurements.

Neutron Probes: Neutron probes are highly accurate soil moisture measurement devices. They can achieve an accuracy of around ±1-3% VWC. However, neutron probes are more complex and require careful calibration and handling due to the involvement of radioactive sources. Environmental factors and soil heterogeneity can also impact the accuracy of neutron probe measurements.

It's worth mentioning that these accuracy ranges are general estimates and can vary depending on specific sensor models, calibration techniques, and environmental conditions. It is essential to refer to the manufacturer's specifications and guidelines for accurate information on the accuracy of a particular sensor. Additionally, regular sensor maintenance, calibration checks, and proper installation techniques can help optimize the accuracy of soil moisture measurements.

Chapter 7

Conclusion & Future Work

The multi-crop irrigation system developed in this study demonstrates the potential of IoT technology to enhance the efficiency and effectiveness of irrigation systems. The system's ability to regulate moisture levels and maintain optimal growing conditions for various crops can lead to significant improvements in crop yield and water usage.We could direct the water to other crops according to soil moisture sensor values.Also, farmers could remotely monitor the status of irrigation through the wifi module.

Finally, we may draw the conclusion that automating irrigation using IoT technology will make it simple. The proposed system fixes all the issues with the ex1stmg system, such as the fact that existing systems can only transmit sensor signals over a limited distance of 100 meters, whereas we can use a nodemcu to increase that distance to more than 500 meters. Additionally, existing systems were designed to irrigate a single crop, but we designed this system to irrigate multiple crops based on the specifications. The suggested method, which can irrigate numerous crops depending on crop needs, will be put into place to solve the current issue. We employed nodemcu in this system, which will transmit sensor readings from distances more than 500 m. Therefore, by implementing the suggested technique, we can help farmers save time and reduce water waste. It also decreases labor requirements while improving crop growth efficiency.

In practice, resistive moisture sensors can not be used because of its less coverage area.So,real time usage sensors are also listed and compared.The voltage consumption and accuracy of the real time sensors are also described.

With further research and development, the system can be scaled up for use in larger agricultural settings, leading to a more sustainable and productive agriculture industry.

Appendices

Appendix 1

ANALOG TO DIGITAL CONVERSION

Analog-to-Digital Converters (ADCs) transform an analog voltage to a binary number (a series of 1's and 0's), and then eventually to a digital number (base 10) for reading on a meter, monitor, or chart. The number of binary digits (bits) that represents the digital number determines the ADC resolution. However, the digital number is only an approximation of the true value of the analog voltage at a particular instant because the voltage can only be represented (digitally) in discrete steps. How closely the digital number approximates the analog value also depends on the ADC resolution. A mathematical relationship conveniently shows how the number of bits an ADC handles determines its specific theoretical resolution: An n-bit ADC has a resolution of one part in 2^n. For example, a 12-bit ADC has a resolution of one part in 4,096, where 2^12 = 4,096. Thus, a 12-bit ADC with a maximum input of 10 VDC can resolve the measurement into 10 VDC/4096 = 0.00244 VDC = 2.44 mV. Similarly, for the same 0 to 10 VDC range, a 16-bit ADC resolution is 10/2^16 = 10/65,536 = 0.153 mV. The resolution is usually specified with respect to the full-range reading of the ADC, not with respect to the measured value at any particular instant.

Voltage-to-frequency ADCs convert the analog input voltage to a pulse train with the frequency proportional to the amplitude of the input. (See Figure 2.02.) The pulses are counted over a fixed period to determine the frequency, and the pulse counter output, in turn, represents the digital voltage. Voltage-to-frequency converters inherently have a high noise rejection characteristic, because the input signal is effectively integrated over the counting interval. Voltage-to-frequency conversion is commonly used to convert slow and noisy signals. Voltage-to-frequency ADCs are also widely used for remote sensing in noisy environments. The input voltage is converted to a frequency at the remote location and the digital pulse train is transmitted over a pair of wires to the counter. This eliminates noise that can be introduced in the transmission lines of an analog signal over a relatively long distance.

Appendix 2

INTERNET OF THINGS

The Internet of Things (IoT) is a revolutionary concept that has rapidly transformed the way we interact with technology and the world around us. In simple terms, IoT refers to a vast network of interconnected physical devices, vehicles, buildings, and other objects embedded with sensors, software, and network connectivity, enabling them to collect and exchange data. This interconnectedness allows for seamless communication, automation, and data-driven decision-making, leading to increased efficiency, productivity, and convenience across various industries and aspects of our daily lives.

At its core, IoT is about bridging the gap between the digital and physical worlds, enabling previously unconnected objects to become smart, responsive, and capable of autonomous decision-making. The proliferation of IoT has been made possible due to the advancements in technology, including miniaturization of sensors, the availability of high-speed internet, and the development of powerful yet energy-efficient processors.

One of the key aspects of IoT is the ability of devices to sense and gather data from their environment. Sensors play a vital role in IoT, capturing information such as temperature, humidity, light, motion, pressure, and much more. These sensors provide real-time data that can be analyzed and acted upon, enabling businesses and individuals to make informed decisions and optimize processes.

IoT has found applications across numerous sectors, including healthcare, agriculture, transportation, manufacturing, energy, and smart cities. In healthcare, IoT devices can monitor patient vital signs, track medication adherence, and enable remote patient monitoring, improving healthcare delivery and patient outcomes. In agriculture, IoT sensors can measure soil moisture, temperature, and crop growth, allowing farmers to optimize irrigation, conserve water, and increase crop yields. In transportation, IoT enables smart traffic management, vehicle-to-vehicle communication, and autonomous driving, leading to safer and more efficient transportation systems.

In manufacturing, IoT has given rise to the concept of Industry 4.0, where machines, equipment, and systems are connected and communicate with each other, enabling predictive maintenance, real-time monitoring, and smart production. Energy management has also been revolutionized by IoT, allowing for efficient power grid management, smart metering, and intelligent energy consumption in homes and buildings. Smart cities leverage IoT to enhance urban services, including waste management, public transportation, lighting, and infrastructure maintenance, leading to improved quality of life for citizens.

The data generated by IoT devices is a valuable asset that can be used to gain insights, optimize operations, and drive innovation. However, managing and analyzing massive volumes of data can be challenging. This is where cloud computing and big data analytics come into play. IoT platforms and cloud services provide the infrastructure and tools to store, process, and analyze data in a scalable and cost-effective manner. Machine learning and artificial intelligence techniques are applied to IoT data to uncover patterns, detect anomalies, and generate actionable intelligence.

Despite the numerous benefits and opportunities offered by IoT, there are also challenges and concerns that need to be addressed. Security and privacy are major considerations in the IoT ecosystem. With the vast number of interconnected devices and the exchange of sensitive data, ensuring the confidentiality, integrity, and availability of information becomes crucial. Strong encryption, authentication mechanisms, and robust security protocols are necessary to protect IoT systems from cyber threats.

Interoperability and standardization are also important aspects of IoT. As IoT devices come from different manufacturers and operate on various platforms, ensuring seamless communication and compatibility between devices becomes essential. Standards and protocols such as MQTT, CoAP, and OPC-UA enable interoperability and facilitate the exchange of data between devices, regardless of their underlying technologies.

Furthermore, the exponential growth of IoT devices raises concerns about the impact on the environment and sustainability. The energy consumption of IoT devices, the disposal of electronic waste, and the carbon footprint associated with manufacturing and operating these devices need to be carefully managed.

In conclusion, the Internet of Things has ushered in a new era of connectivity and intelligence, transforming industries, businesses, and our everyday lives. The ability to gather, analyze, and act upon real-time data from a vast array of interconnected devices opens up unprecedented possibilities for innovation, efficiency, and convenience. However, addressing challenges such as security, privacy, interoperability, and sustainability is crucial for the continued success and responsible deployment of IoT. As technology continues to evolve, IoT is poised to become even more pervasive, creating a world where everything is connected and working harmoniously to improve our lives.

Appendix 3

C/C++

C/C++ programming is widely used in Arduino Uno for developing code that controls the board's functionality and interacts with external components. Arduino uses a simplified version of the C++ language, which inherits many features from the C programming language. Here's an overview of C/C++ programming in Arduino Uno:

1. Structure: Arduino code follows a specific structure with two essential functions: `setup()` and `loop()`. The `setup()` function is called once when the board starts or resets, and it is typically used to initialize variables, configure pin modes, and set up communication interfaces. The `loop()` function is the main body of the code and is executed repeatedly until the board loses power. This function contains the instructions that define the board's behavior during its operation.

2. Variables: C/C++ provides various data types for defining variables, including integers (`int`), floating-point numbers (`float`), characters (`char`), booleans (`bool`), and arrays. These variables can store and manipulate data, enabling control of inputs and outputs from sensors, actuators, and other peripherals connected to the Arduino board.

3. Functions: C/C++ allows the creation of user-defined functions, which are blocks of code that perform specific tasks. Functions provide modularity, allowing programmers to break down complex tasks into smaller, manageable parts. Arduino code can include both predefined functions provided by the Arduino library and custom functions created by the programmer.

4. Control structures: C/C++ offers several control structures, including conditional statements (if-else, switch-case), loops (for, while), and jump statements (break, continue, return). These structures enable programmers to make decisions, repeat actions, and control program flow based on specific conditions.

5. Libraries: Arduino provides a rich set of libraries that extend the capabilities of the Arduino board. These libraries encapsulate complex functionality into easy-to-use functions, enabling interaction with sensors, actuators, displays, communication protocols, and more. Libraries simplify coding and reduce the complexity of low-level hardware programming.

Advantages of C/C++ languages in Arduino programming:

Efficiency: C/C++ languages are known for their efficiency and close-to-hardware programming capabilities. Arduino Uno, with its limited resources and processing power, benefits from the performance optimization provided by C/C++.

Portability: C/C++ programs are highly portable, allowing code written for Arduino Uno to be easily adapted to other microcontrollers or platforms with minimal modifications. This flexibility enables code reuse and compatibility across different hardware.

Extensive Community and Resources: C/C++ is widely used in the programming community, and Arduino has a large and active community of developers. This means that there are abundant resources, tutorials, and libraries available to help beginners get started and experienced programmers enhance their projects.

Integration with Existing Code: C/C++ is a versatile language that can easily integrate with existing codebases written in C or C++. This compatibility allows developers to leverage existing algorithms, libraries, and software components in their Arduino projects.

Low-Level Access: C/C++ provides low-level access to the hardware, allowing programmers to directly manipulate registers, work with interrupts, and optimize code for specific requirements. This level of control is beneficial in applications where precise timing, efficiency, and direct hardware interaction are crucial.

Overall, C/C++ programming in Arduino Uno offers a powerful and flexible platform for building a wide range of embedded systems and IoT applications. It combines the efficiency and control of low-level programming with the simplicity and ease of use provided by the Arduino framework, making it accessible to both beginners and experienced developers.

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