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A DESIGN OF AN AUTOMATED FERTIGATION SYSTEM USING IOT

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Abstract

At present, farmers still use traditional styles of husbandry operation leading to inputs wastages and low production due to inaccurate types and amount of fertilizers applied to the field which depends upon soil analysis and plant yield. The process of determining the type of fertilizers according to the soil analysis results takes a long time The implementation of the Automatic Fertigation System using IoT contributes to sustainable agriculture by minimizing resource wastage, reducing environmental impact, and improving overall crop health and productivity. This study outlines the system architecture, sensor integration, data analytics, and the practical implications of deploying such a system in agricultural settings. The results demonstrate the potential for IoT-based automatic fertigation to revolutionize precision agriculture practices, offering efficient and environmentally conscious solutions for modern farming.

Keywords:
Arduino UNO, Soil Moisture Sensor, DHT11 Sensor, PH Sensor, EC Sensor, Node MCU.

I. Introduction

In recent times, there has been a myriad of research into Precision Agriculture (PA). This is because it allows for the management of small- to very large- scale crop production while using smaller traditional inputs (land, fertilizers, pesticides, water, and herbicides). The main objective of Automatic fertigation using IoT technology is to revolutionize modern agriculture, offering growers unprecedented levels of precision, efficiency, and sustainability in crop production. One such technological innovation that holds immense promise for modern agriculture is the integration of Internet of Things (IoT) technology into fertigation systems. Fertigation, the precise application of water and nutrients through irrigation systems, plays a critical role in ensuring optimal plant growth and yield. By harnessing the power of IoT, automatic fertigation systems offer real-time monitoring, intelligent decision-making, and automated control of the fertigation process, revolutionizing traditional farming practices. The integration of IoT technology into fertigation systems promises to address these challenges by providing farmers with unprecedented levels of precision, efficiency, and control over the irrigation and fertilization process. IoT-enabled sensors deployed in the field can continuously monitor soil moisture levels, nutrient concentrations, temperature, humidity, and other environmental parameters in real-time.

II. Literature Review

- A literature survey on automatic fertigation using IoT would involve gathering and reviewing existing research, studies, and publications related to the integration of IoT technology into fertigation systems. Here's a structured approach to conducting a literature survey on this topic.
- Begin by identifying keywords related to automatic fertigation and IoT, such as "automatic fertigation," "smart agriculture," "Internet of Things," "sensor networks," "precision agriculture," and "fertigation control systems."
- Utilize academic databases such as PubMed, IEEE Xplore, ScienceDirect, Google Scholar, and ResearchGate to search for relevant articles, conference his structured approach.

2.1 Comparison between various existing methods

This table highlights the differences between the methods in terms of accuracy, real-time monitoring capabilities and data collection. Each method has its strengths and limitations, and the choice of method depends on the specific requirements and objectives of the fertigation system

Method	Accuracy	Real-Time Monitoring	Data
Raman and nuclear magnetic resonance studies.	Provides accurate data on orientational relaxation times of nitrate ion.	Does not involve real-time monitoring.	Data collected through experiments and analysis.
Laboratory calibration of soil moisture sensors.	Accuracy depends on the calibration process and sensor Performance.	Provides real-time monitoring of the soil moisture levels.	Data collected from sensor readings and calibration.
Automated Fertigation System using IoT.	Accuracy depends on sensor calibration.	Offers real-time monitoring of fertigation parameters.	Data collected from sensors, IoT devices.

III.Methodology

The methodology for automatic fertigation involves a systematic approach to designing, implementing, and managing a precision irrigation system that delivers water and nutrients to plants based on their specific requirements. Here's a step-by-step methodology for implementing automatic fertigation:

3.1 Assessment of Crop Requirements:

- Identify the specific nutrient requirements and growth stages of the crops being cultivated.
- Consider factors such as crop type, variety, planting density, and environmental conditions.

3.2 Soil Analysis:

- Conduct soil testing to determine soil properties, nutrient levels, pH, and moisture content.
- Soil analysis helps optimize nutrient application and irrigation scheduling based on soil characteristics.

3.3 Selection of Fertigation System Components:

- Choose appropriate fertigation equipment, including pumps, injectors, valves, sensors, and controllers.
- Select irrigation methods such as drip irrigation, sprinkler systems, or hydroponics, based on crop type and field conditions.

3.4 Installation of Fertigation System:

- Install irrigation infrastructure, including pipelines, emitters, and valves, to deliver water and nutrients to the plants' root zone.
- Set up fertigation equipment, such as fertilizer injectors, mixing tanks, and filtration systems, to deliver precise nutrient solutions.

3.5 Integration of Sensors and Controllers:

- Integrate soil moisture sensors, weather stations, and other environmental sensors to monitor soil moisture levels, temperature, humidity, and other relevant parameters.
- Connect sensors to a central controller or IoT platform for real-time data collection and analysis.

3.6 Programming and Calibration:

- Program the fertigation system controller to regulate irrigation and nutrient application based on sensor data, crop requirements, and predefined schedules.
- Calibrate pumps, injectors, and controllers to ensure accurate delivery of water and nutrients according to the desired ratios and concentrations.

3.7 Nutrient Management:

- Prepare nutrient solutions by mixing fertilizers, micronutrients, and other additives in appropriate concentrations.
- Monitor nutrient levels in the fertigation system and adjust nutrient formulations as needed to maintain optimal plant nutrition.

3.8 Irrigation Scheduling:

- Develop irrigation schedules based on crop water requirements, soil moisture levels, and environmental conditions.
- Use data from soil moisture sensors and weather forecasts to optimize irrigation timing and duration.

3.9 Monitoring and Maintenance:

- Regularly monitor the performance of the fertigation system, including irrigation uniformity, nutrient delivery, and system operation.
- Conduct routine maintenance tasks such as cleaning filters, checking for leaks, and replacing worn components to ensure system reliability.

3.10 Data Analysis and Optimization:

- Analyze data collected from sensors, controllers, and crop monitoring to identify patterns, trends, and areas for improvement.
- Continuously optimize fertigation schedules, nutrient formulations, and irrigation practices based on data-driven insights and feedback from crop performance.

By following this methodology, growers can implement an effective automatic fertigation system that optimizes water and nutrient management, improves crop productivity, and enhances resource efficiency in agricultural production.

IV.Block Diagram Description

- In this project, we monitor soil pH, electrical conductivity (EC), moisture, and temperature/humidity using various sensors, including a DHT11 for temperature and humidity. A pH sensor checks soil acidity or alkalinity, with corrective actions taken if levels are out of range, and the current pH value displayed on an LCD.
- The system adjusts irrigation and nutrient supply via relay-controlled pumps based on continuous monitoring of soil moisture, pH, and EC sensors. Data is wirelessly transmitted using Zigbee to an IoT server, allowing remote management of soil conditions to promote optimal plant growth.

4.1 Block Diagram (TX):

In automatic fertigation systems using IoT, a transmitter kit plays a crucial role in collecting and transmitting data from various sensors and devices to a central control system or cloud platform. Here's how the transmitter kit typically works in such a system.

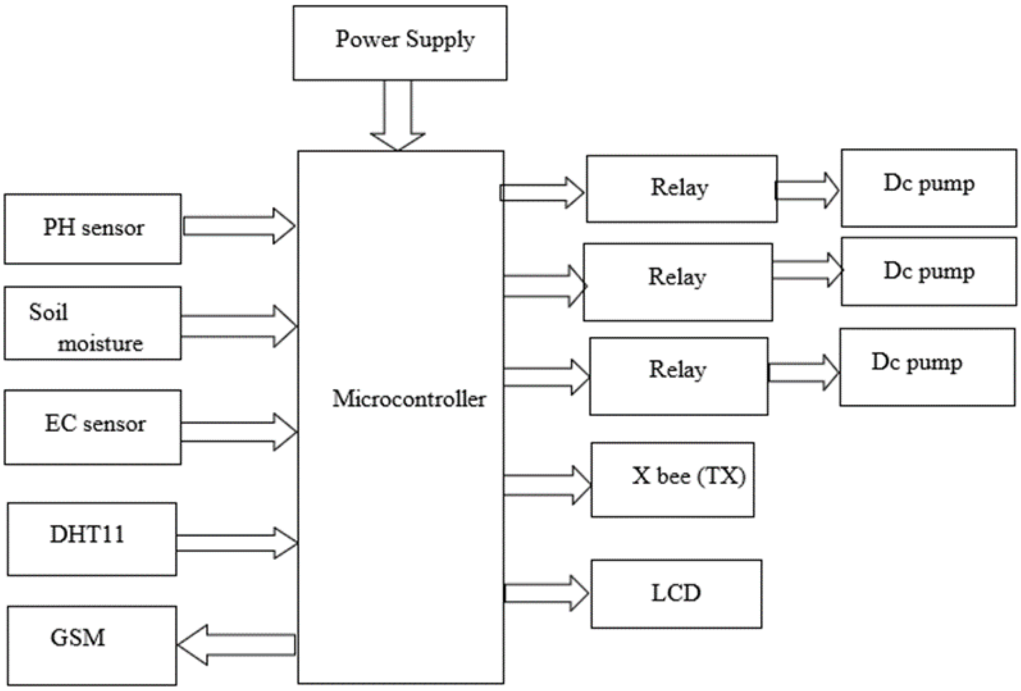

Fig.1 Block diagram of Transmitter kit

4.2 Block Diagram (RX):

In an automatic fertigation system using IoT (Internet of Things), the receiver kit plays a crucial role in receiving and processing data from various sensors and control commands from the central management system.

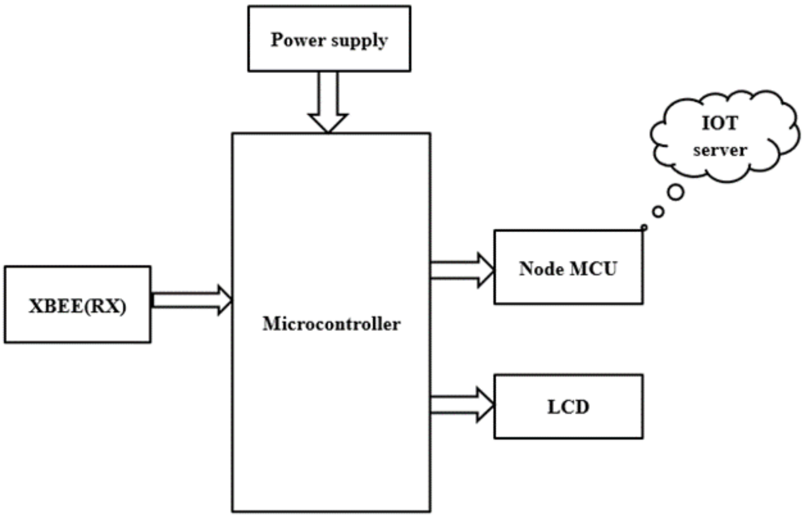

Fig.2 Block Diagram of Receiver kit

V. Hardware Components

A. Arduino Uno

The brain of the system, responsible for controlling various components based on input received. To enable remote monitoring and control, you'll need an IoT module such as ESP8266 or ESP32, which allows the Arduino to connect to the internet. Develop a user interface (web or mobile) to monitor the

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status of the system and manually control it if needed. This interface should display real-time sensor data and allow users to adjust settings remotely.

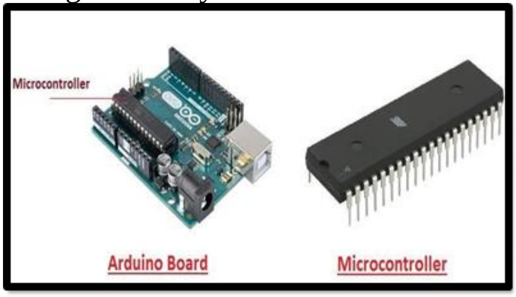

Fig. 3 Arduino Uno

B. Soil Moisture Sensor

Connect the soil moisture sensor to your Arduino Uno according to its specifications. Typically, this involves connecting power, ground, and signal wires. Ensure the sensor is properly inserted into the soil in the location where you want to monitor moisture levels. Implement logic to determine when irrigation is needed based on the moisture readings. You can set thresholds to trigger watering when soil moisture falls below a certain level.

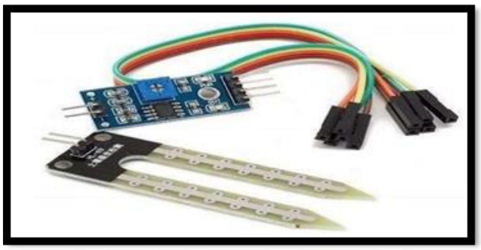

Fig. 4 Soil Moisture Sensor

C. DHT11 Sensor (Temperature/Humidity)

Integrating a DHT11 sensor into an automatic fertigation system using IoT allows you to monitor both temperature and humidity levels, which are crucial factors for plant growth. Here's how you can implement it. The DHT11 sensor is a basic and affordable sensor that can measure temperature and humidity. Ensure it's suitable for your application and compatible with your Arduino and IoT module. Connect the DHT11 sensor to your Arduino Uno according to its datasheet. Usually, it requires a single data pin connection

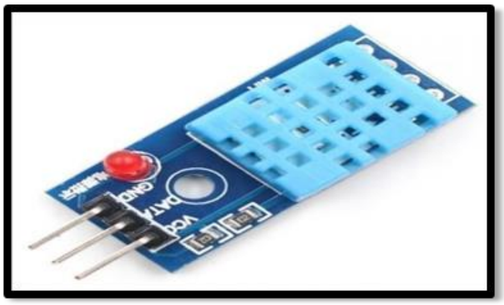

Fig. 5 DHT11 Sensor

D. EC Sensor

Integrating an EC (Electrical Conductivity) sensor into an automatic fertigation system using IoT can provide valuable information about the nutrient concentration in the soil or nutrient solution. Here's a guide on how to implement it. Set up your IoT application on the chosen platform to receive data from the Arduino. Configure rules or triggers on the IoT platform to initiate actions (such as adjusting nutrient levels or activating the irrigation system) based on the received EC data.

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Fig. 6 EC Sensor

E. pH Sensor

Integrating a pH sensor into an automatic fertigation system using IoT enables you to monitor the pH level of the soil or nutrient solution, crucial for maintaining optimal growing conditions for plants. Here's a guide on how to implement it. Choose a pH sensor suitable for your application. pH sensors come in various types, including analog and digital, and may require different calibration procedures. Ensure the sensor is compatible with your Arduino Uno and IoT module. Connect the pH sensor to your Arduino Uno according to its datasheet

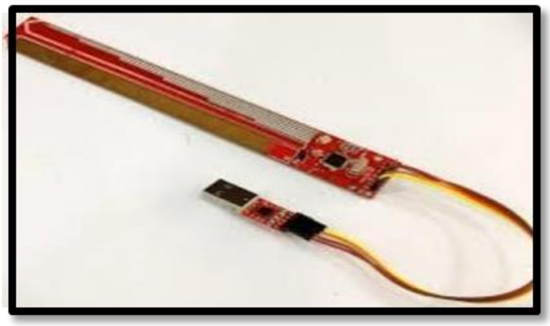

Fig. 7 pH Sensor

F. GSM Module

Connect the GSM module to your Arduino Uno according to its datasheet or provided instructions. This typically involves connecting power, ground, RX, and TX pins. Insert a SIM card into the GSM module and ensure it is properly activated and has sufficient credit for sending messages or making calls. Implement functions to send SMS messages, make calls, and receive commands from text messages. Integrate the GSM functionality with your existing automatic fertigation logic. For example, you can send SMS commands to trigger irrigation or request status updates from the system

Fig. 8 GSM Module

VI.Working

- In a fertigation system that's automated, there are two main parts that work together: the transmitter kit and the receiver kit. Think of them like a pair of walkie-talkies. The transmitter sends messages wirelessly to the receiver, which is usually close to the irrigation or fertigation equipment in the field.
- The transmitter kit has sensors like a moisture sensor, temperature gauge, and others. These sensors measure things like how wet the soil is, the level of nutrients, pH levels (how acidic or basic the soil is), and temperature. Based on these measurements, the transmitter sends instructions to the receiver, telling it what to do. For example, it might say to adjust how much water or fertilizer is being sent to the plants.
- The receiver kit listens for the messages from the transmitter and then acts on them. It controls things like valves or pumps to change how much water or fertilizer is being given to the crops. This helps make sure that the plants are getting just the right amount of what they need, which helps them grow well and saves resources.
- Overall, the transmitter and receiver kits in an automatic fertigation system work together like a wireless walkie-talkie system. They talk to each other in real-time, helping farmers keep an eye on and control the irrigation and fertilization of their crops more efficiently

VII. Software Used

- Arduino IDE where IDE stands for Integrated Development Environment – An official software introduced by Arduino.cc, that is mainly used for writing, compiling and uploading the code in the Arduino Device. Almost all Arduino modules are compatible with this software that is an open source and is readily available to install and start compiling the code on the go.
- It is an official Arduino software, making code compilation too easy that even a common person with no prior technical knowledge can get their feet wet with the learning process.

Applications

- Crop production optimization
- Water Conservation
- Fertilizer Efficiency
- Remote Monitoring and control
- Precision Agriculture
- Greenhouse Farming
- Commercial Agriculture

Advantages And Disadvantages

- Precision Fertilization
- Water Conservation
- Resource Efficiency
- Remote Monitoring and Control
- Complex to install
- Risk of Over fertilization or Under fertilization

VIII. Hardware Result

The implementation of an automatic fertigation system using IOT technology resulted in improved crop yield water conservation and fertilizer efficiency. Real–time monitoring and control allowed for remote management. While data insights facilitated precise nutrient delivery. The system’s automation reduced labor costs and promoted environmental sustainability by optimizing resource usage and minimizing pollution. By harnessing the power of data–driven automation and smart decision–making, farmers can optimize crop production while promoting sustainability and efficiency in their operations. IOT based fertigation systems are scalable and can be adapted to different types of crops, soil.

Conditions agricultural settings. They can also integrate with other smart farming technologies for a solution.

8.1 Comparison Table For Rice & Sugarcane With Various Fertilizers

Here's a comparison table for rice and sugarcane crops with NPK, micronutrient, and organic fertilizers, including pH level, EC value, and moisture level:

Crop	Fertilizer Type	PH Level	EC Value	Moisture Level (%)
Rice	NPK Fertilizer	5.5-6.5	1.0-1.5	60-70
	Micronutrient	5.5-6.5	1.0-1.3	60-70
	Organic	5.5-6.5	1.0-1.4	65-75
Sugarcane	NPK Fertilizer	6.0-7.0	1.2-1.6	70-80
	Micronutrient	6.0-7.0	1.2-1.5	70-80
	Organic	6.0-7.0	1.2-1.7	75-85

Selection of Best Fertilizers for The Crops

- Based on the pH level, EC value, and moisture level, the best fertilizer for rice would be Organic Fertilizer cause it typically provide a balanced nutrient supply while also improving soil structure and microbial activity, which is beneficial for rice cultivation. Additionally, the pH, EC, and moisture levels associated with organic fertilizers align well with the optimal conditions for growing rice.
- Based on the pH level, EC value, and moisture level, the best fertilizer for sugarcane would be Micronutrient fertilizer cause it provides essential trace elements required for plant growth and development, which are crucial for sugarcane cultivation. Additionally, the pH, EC, and moisture levels associated with micronutrient fertilizers align well with the optimal conditions for growing sugarcane.

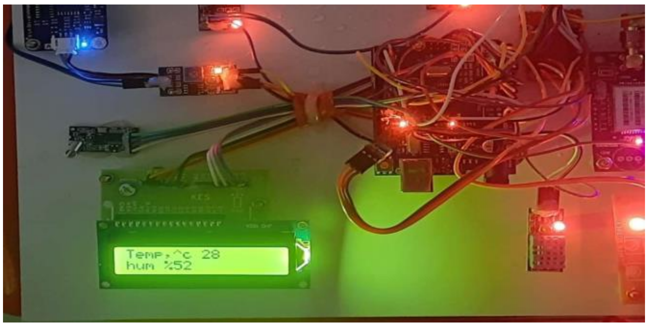

Fig a. Temperature & Humidity of the surrounding

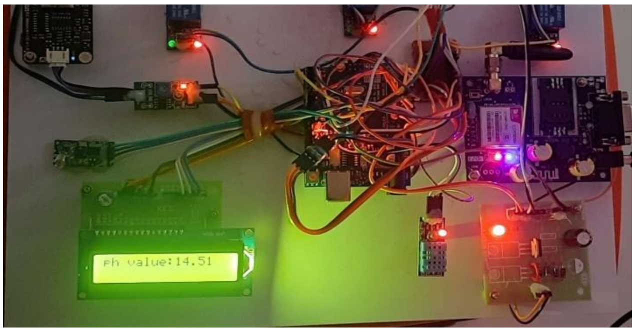

Fig b. pH value of the soil

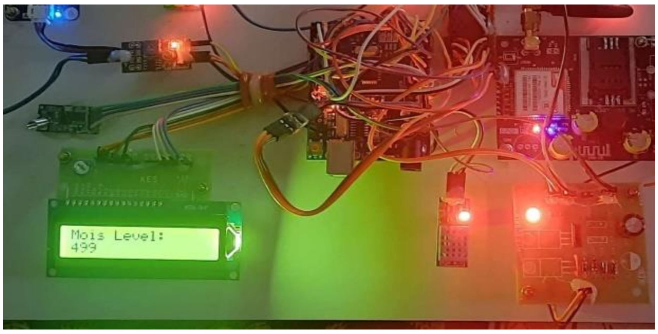

Fig c. Moisture level of the soil

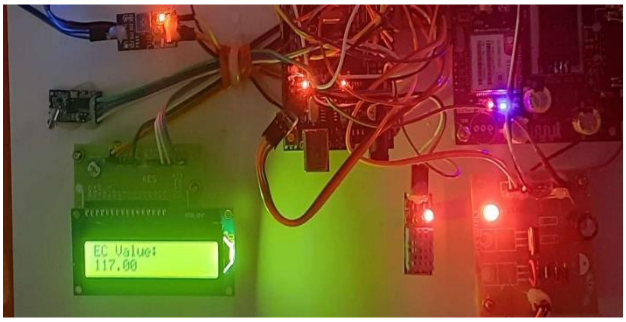

Fig d. EC value of the conductivity of the soil

IX.Conclusion

The integration of Internet of Things (IoT) technology into automatic fertigation systems represents a significant advancement in precision agriculture. Through the deployment of IoT devices, sensors, and cloud- based analytics, automatic fertigation systems offer real-time monitoring, intelligent decision-making, and automated control of the fertilization and irrigation processes. The implementation of automatic fertigation using IoT holds several key benefits for agricultural practices. Firstly, it enables precise and tailored nutrient delivery to crops, ensuring optimal growth and yield. By continuously monitoring soil moisture, nutrient levels, and environmental conditions, the system can dynamically adjust fertilizer dosages and irrigation schedules to meet the specific needs of each crop. By comparing three fertilizers, it's proven that NPK fertilizer is the best. Because its pH value is 6.5, which is sufficient for the crop, and its EC value is 240 mS/m, which helps to increase the crop yield and finally increases the production.

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