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GSM DTMF Based Smart Irrigation System Working on Renewable Energy

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Abstract

The GSM DTMF-based Smart Irrigation System integrates renewable energy sources to enhance agricultural water management and sustainability. This system enables remote control of three-phase motor pumps via mobile phones, using Dual-Tone Multi-Frequency (DTMF) signalling through GSM networks. This innovation is particularly beneficial for farmers in regions like India, where unpredictable weather and frequent power outages complicate traditional irrigation methods. By using solar power or other renewable sources, the system ensures continuous operation even during power failures, promoting reliable irrigation practices.The system's core components include a microcontroller interfaced with a GSM module, soil moisture sensors, and a renewable energy power supply. The soil moisture sensors monitor the field's water levels in real-time and communicate with the microcontroller, which processes the data and triggers the motor pump when irrigation is needed. The use of DTMF technology allows farmers to operate their irrigation systems remotely without requiring internet access, thereby reducing dependence on unstable local electricity grids. This feature is essential for regions with limited connectivity, ensuring farmers have consistent access to their irrigation systems.

INTRODUCTION

In today's environmentally conscious landscape, efficient water management in gardening and agriculture is crucial. This project introduces an innovative IoT-based garden watering system that automates irrigation and analyzes water consumption for optimal resource use. Traditional gardening often leads to excessive water use, prompting the need for a systematic approach.

The GSM DTMF-Based Smart Irrigation System offers a solution by allowing farmers to remotely control irrigation pumps via mobile phone technology, even in areas with limited internet connectivity. Powered by renewable energy sources like solar panels, this system promotes

sustainable agriculture by optimizing water usage and reducing energy costs.

Equipped with soil moisture and water flow sensors, the system ensures precise watering based on real-time data, preventing waste and enhancing water conservation. A user-friendly interface allows for easy remote management of watering schedules. Additionally, safety features like over-current protection and dry-run prevention safeguard the equipment.

Overall, this project modernizes traditional agriculture by integrating mobile technology and renewable energy, improving crop yields, conserving water, and supporting farmers' livelihoods in diverse settings.

LITERATURE SURVEY

Meena et al. (2020)[1] propose an IoT-based automated irrigation system aimed at addressing water scarcity and improving agricultural efficiency in India. The system employs an Arduino microcontroller to automate the monitoring and control of irrigation based on parameters such as temperature, humidity, and soil moisture. It utilizes sensors to collect real-time data, which is then used to turn the motor on or off and notify the user via GSM messages, enabling remote monitoring and control through SMS. An LCD display provides on-site status updates, allowing farmers to keep track of field conditions regardless of their location.

Anitha et al. (2020)[2] present an Internet of Things (IoT)-based smart irrigation system designed to improve water management in agriculture, particularly in regions like India, where water scarcity is a pressing issue. The system utilizes soil moisture sensors to monitor real-time soil dampness and controls water delivery to crops automatically. By employing microcontrollers and GPRS modules, data from sensors are transmitted online, allowing for remote monitoring and intelligent decision-making based on field conditions. The integration of additional sensors, such as temperature and humidity sensors, enhances the system's ability to maintain optimal soil moisture levels, minimizing water waste and ensuring the health of crops.

Ghodake et al. (2024) [3] discuss the use of Dual-Tone Multi-Frequency (DTMF) technology as an effective approach for automating irrigation control, particularly in remote agricultural areas. By utilizing DTMF signals sent over telephone networks, farmers can remotely operate water pumps, thereby reducing labor demands and enhancing convenience. The integration of DTMF with GSM modules and microcontrollers extends the system's functionality, enabling remote control via mobile networks and real-time notifications. Studies show that DTMF-based systems offer benefits such as improved water management, reduced operational costs, and greater accessibility for regions with limited infrastructure, making them a practical alternative for small to medium-sized farms.

OBJECTIVES

The objective of the **GSM DTMF-Based Smart Irrigation System Working on Renewable Energy** is to develop a reliable, efficient, and sustainable solution for agricultural water management that addresses the challenges of traditional irrigation practices. The system aims to achieve the following specific objectives:

1. **Enable Remote Control of Irrigation Pumps**: Allow farmers to operate and manage irrigation pumps remotely using GSM and DTMF technology through their mobile phones, providing flexibility and convenience in irrigation scheduling without requiring physical presence in the field.
2. **Automate Irrigation Based on Soil Moisture Levels**: Integrate soil moisture sensors to continuously monitor the moisture content in the soil and automate the activation and deactivation of irrigation pumps. This ensures optimal water usage and prevents both over-irrigation and under-irrigation, promoting healthier crop growth.
3. **Utilize Renewable Energy Sources**: Power the irrigation system using renewable energy sources, such as solar panels, to ensure uninterrupted operation even in areas with unreliable electricity supply. This reduces dependency on non-renewable energy, lowers operational costs, and supports environmentally sustainable agricultural practices.
4. **Improve Water Resource Management**: Enhance the efficiency of water usage by implementing a precise and targeted irrigation strategy based on real-time field data, thereby reducing water wastage and conserving valuable water resources.
5. **Enhance Crop Yields and Reduce Labor Costs**: By automating irrigation and enabling remote control, reduce the manual labor required for irrigation management, allowing farmers to focus on other critical farming activities. This, in turn, contributes to increased crop yields and overall farm productivity.
6. **Ensure System Reliability and Safety**: Incorporate safety features such as over-current protection and dry-run prevention to protect the irrigation system components and ensure reliable operation under various environmental conditions.

7. **Promote Sustainable Agricultural Practices**: Support sustainable agriculture by optimizing water use, reducing energy consumption, and minimizing the environmental impact of farming activities, thereby contributing to long-term agricultural sustainability and food security.

PROPOSED METHODOLOGY

This system is a combination of hardware and software components. The hardware part consists of different sensors like soil moisture sensor, temperature sensor, relays, pumps, etc whereas the software part consists of web-based application connected to the Arduino board and other hardware components using Internet of Things (IoT). The application consists of signals and a database in which readings are displayed from sensors and are inserted using the hardware. This research tries to automate the process of irrigation on the farmland by monitoring the soil water level of the soil relative to the plant being cultivated and the adaptively sprinkling water to simulate the effect of rainfall

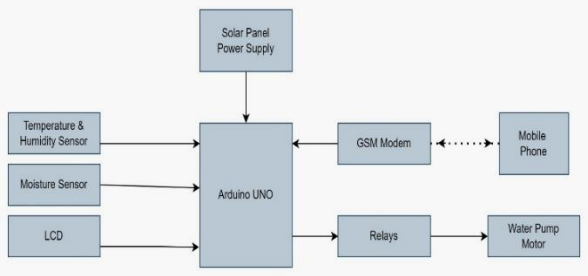


Fig 1: Proposed System

The methodology for GSM DTMF Based smart Irrigation Working On Renewable Energy involves integrating hardware and software components to automate and optimize irrigation processes. The system uses an Arduino Uno microcontroller as the core processing unit, interfacing with sensors such as the DHT11 for temperature and humidity, and a soil moisture sensor to collect environmental data. This data is continuously monitored, and when the soil moisture level drops below a set threshold, the system automatically activates the water pump via a relay module, ensuring timely irrigation. The user can also choose manual mode, where the water pump is controlled through GSM-based commands by making phone calls, triggering the pump to turn on or off. SMS notifications provide updates on the pump's status, moisture levels, temperature, and humidity. An LCD display further enhances the system by displaying real-time data, allowing users to visually monitor field conditions. This dual-mode operation, combined with reliable GSM communication, ensures flexible and efficient irrigation management even in remote areas without internet connectivity.

GSM Module: The GSM module receives commands sent via DTMF tones from the user's mobile phone. These tones are generated by pressing keys on the phone, each corresponding to a specific command for the irrigation system.

DTMF Decoder: This device decodes the DTMF tones received through the GSM module and converts them into digital signals. These signals are then sent to the microcontroller for further processing.

Microcontroller: The microcontroller is programmed to interpret the digital signals from the DTMF decoder and execute the corresponding commands. It controls the operation of the irrigation pumps based on user input and soil moisture data.

Soil Moisture Sensors: These sensors continuously monitor the moisture levels in the soil and provide real-time data to the microcontroller. When the moisture level falls below a predefined threshold, the microcontroller can automatically activate the irrigation pump.

Renewable Energy Source: Solar panels or other renewable energy sources provide power to the entire system, ensuring continuous operation even during power outages.

Pump Control Unit: The pump control unit receives signals from the microcontroller to turn the irrigation pump on or off. It includes safety features like over-current protection and dry-run prevention to prevent equipment damage.

Sensor Integration: Connect the soil moisture sensor and DHT11 temperature and humidity sensor to the Arduino Uno for environmental monitoring.

Pump Control: Use a relay module to control the water pump based on input from the microcontroller.

Automatic Mode Operation: The microcontroller activates the pump when soil moisture falls below a certain threshold.

Manual Mode Operation: Users control the pump by calling the GSM module's SIM card number; the system starts/stops the pump based on the number of calls.

LCD Display: Real-time sensor data and pump status are displayed.

GSM Communication: Send SMS notifications to the registered mobile phone with pump status and environmental data.

Hardware Components

Arduino Microcontroller Board : The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various

projects. Arduino.cc developed the **Arduino UNO board.**

I2C 16X2 LCD MODULE: The I2C 16×2 Arduino LCD Screen is using an I2C communication interface. It is able to display 16×2 characters on 2 lines, white characters on blue background.This display overcomes the drawback of LCD 1602 Parallel LCD Display in which you'll waste about 8 Pins on your Arduino for the display to get working.

Temperature and Humidity Sensors: DHT11 Module features a temperature & humidity sensor complex with a calibrated digital signal output. The exclusive digital-signal-acquisition technique and temperature & humidity sensing technology ensure high reliability and excellent long-term stability. This sensor includes an NTC for temperature measurement and a resistive-type humidity measurement component for humidity measurement.

Soil Moisture Sensor: Soil water content has important effects on many fundamental biophysical processes. It influences seed germination, plant growth and nutrition, microbial degradation of soil organic matter, conversion of nutrients in the root zone, and water transfer at the land-air interface.

GSM Modem: SIM900A Modem is built with Dual Band GSM based SIM900A modem from SIMCOM. It works on frequencies 900MHz. SIM900A can search these two bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 1200-115200 through AT command. SIM900A is an ultra compact and wireless module.

Water Pump: DC 12V Pneumatic Diaphragm Water Pump Motor R365 pump is a low cost and lightweight water pump. It is ideal for non-submersible pumps for a variety of liquid and air movement applications. As it provides enough pressure, used with nozzles to make the spray systems..

Water Level Sensor Float Switch: A float switch is a device used to sense the level of liquid within a tank, it may actuate a pump, an indicator, an alarm, or other devices.

Software Components

Arduino Programming Software Arduino IDE: The Arduino IDE is an open-source software, which is used to write and upload code to the Arduino boards. The IDE application is suitable for different operating systems such as Windows, Mac OS X, and Linux. It supports the programming languages C and C++. Here, IDE stands for Integrated Development Environment.

In the Arduino IDE, the code crafted for your project is referred to as a "sketch," which you can seamlessly upload to your Genuino or Arduino board for execution. The sketch is saved with the extension '.ino.'

Embedded C/C++: For writing control algorithms.

GSM Library for Arduino: To facilitate GSM communication.

RESULT AND DISCUSSION

The GSM DTMF-based Smart Irrigation System operates in two distinct modes—Manual-Automatic Mode and Remote-Control Mode ensuring flexibility and efficiency in managing irrigation based on user needs and environmental conditions.

A. Manual-Automatic Mode :

This mode leverages automation for irrigation based on real-time soil moisture levels and water tank status:Automatic Pump Operation: The system monitors soil moisture levels using sensors. If the moisture level falls below the predefined threshold, the system automatically activates the water pump to irrigate the fields.

Low Water Alert: If the soil moisture level is low but the water tank is empty, the system sends an SMS alert to the owner, notifying them about the empty tank to ensure timely refilling and uninterrupted irrigation.

B. Remote Control Mode: This mode provides remote access to irrigation pumps through GSM-based DTMF signalling, ensuring control even in areas with limited internet connectivity:

Motor Pump Control via Call: The owner initiates a call to the system's GSM module. Upon receiving the call, the system starts the motor pump and immediately sends an SMS to the owner confirming the pump's activation.

The system automatically stops the motor pump after a preset duration, following which it sends another SMS to notify the owner that the pump has been turned off.

Tank Status Alert: If the owner makes a call to start the motor pump but the water tank is empty, the system sends an SMS alert informing the owner of the tank's status.

These two modes provide a robust combination of automation and remote control, enhancing user convenience, optimizing water usage, and ensuring consistent irrigation practices even in challenging environments.

The performance analysis of the GSM DTMF-based Smart Irrigation System highlights its efficiency, reliability, and adaptability in

addressing key agricultural challenges. The system successfully demonstrated its capability to operate in both manual-automatic and remote-control modes, ensuring optimal irrigation management under varying conditions.

Automated Operation Efficiency: The system effectively monitored soil moisture levels and triggered the water pump when the moisture content dropped below the threshold. This ensured timely irrigation without requiring manual intervention. In cases where the water tank was empty, SMS notifications were promptly sent to the owner, allowing them to refill the tank and prevent irrigation interruptions.

Remote Control Flexibility: Remote operation of the motor pump through GSM-based DTMF signalling provided farmers with enhanced convenience, particularly in areas with limited internet connectivity. The system reliably initiated and stopped the motor pump based on phone calls, and the SMS confirmation for each action added a layer of transparency and control for the user.

Energy Sustainability : The integration of renewable energy sources, such as solar panels, ensured the system's operation during power outages, significantly reducing dependence on conventional electricity grids. This feature was particularly beneficial in regions with unreliable power supplies, making the system a sustainable choice for agricultural irrigation.

Water Conservation: The system's ability to detect soil moisture levels and regulate irrigation accordingly minimized water wastage. This automated water management approach supported sustainable farming practices and contributed to resource conservation.

Challenges Addressed

The system proved effective in mitigating challenges such as unreliable power supply, manual irrigation inefficiencies, and water wastage. Its dual-mode operation offered flexibility to adapt to different farming needs, empowering farmers with better control over irrigation practices.

Overall, the GSM DTMF-based Smart Irrigation System demonstrated significant potential to enhance agricultural productivity, conserve resources, and promote sustainability in farming operations. The results validate the system's practicality and efficiency, aligning with the growing demand for smart and sustainable agricultural solutions.

Fig (i): GSM DTMF Based Smart Irrigation System Working On Renewable Energy

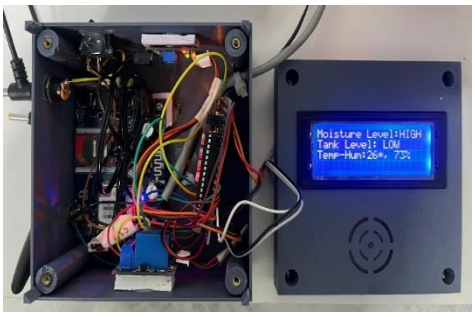
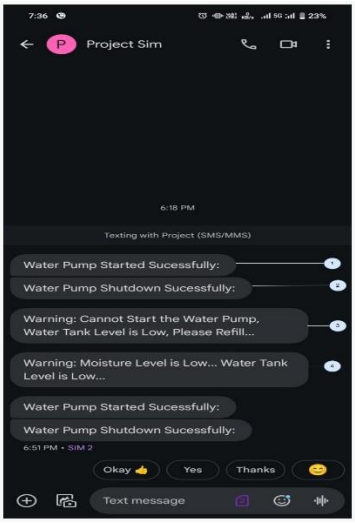


Fig (ii): Hardware with Encloser



Fig(iii): Register Contact SMS Notification

CONCLUSIONS

The GSM DTMF Based smart Irrigation Working On Renewable Energy offers a practical and innovative solution for modern agriculture, especially in regions where water management and network connectivity are significant challenges. By combining automated irrigation with manual remote control, the system optimizes water use, improves labour efficiency, and supports sustainable farming practices. Through real-time monitoring and status updates via SMS, it empowers farmers with the information needed to make informed decisions, thereby enhancing agricultural productivity and resource conservation. The GSM DTMF-based Smart Irrigation System offers a transformative

approach to agricultural water management by addressing key limitations of traditional methods. By integrating renewable energy sources, the system ensures uninterrupted operation, even in areas with frequent power outages. Its use of GSM-based communication and DTMF technology enables farmers to remotely control irrigation pumps without the need for internet connectivity, making it highly suitable for rural regions.

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