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Designing Cost-Effective SMS based Irrigation System using GSM Module

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Abstract:- This paper describes the development and application of an SMS-based, affordable, and easily understandable irrigation control system for agricultural purposes. The system leverages the processing power of a Raspberry Pi Pico microcontroller and the remote communication capabilities of a GSM module to create a robust and versatile solution. By incorporating a suite of sensors for soil moisture, temperature, and humidity, the system automates irrigation cycles based on user-defined thresholds and real-time sensor data. This data-driven approach ensures optimal water usage, minimizing labor requirements and promoting sustainable farming practices by reducing water waste. Additionally, the system transmits SMS alerts for critical situations such as high temperature, low moisture, or pump malfunctions, enabling timely intervention to prevent crop stress or equipment failure. Users can remotely control the pump and receive status updates through SMS commands, providing a convenient interface for managing irrigation tasks from anywhere with cellular reception. This innovative system contributes to the field of smart agriculture by demonstrating how readily available technology can be effectively used to improve water management efficiency, minimize labor requirements, and ultimately increase agricultural productivity.

Keywords:- *GSM, Raspberry Pi Pico, SMS, Sensors.*

I. INTRODUCTION

In the agricultural landscapes of India, where life revolves around the cycle of sowing and harvesting, inconsistent and unpredictable rainfall patterns pose a significant challenge for farmers aiming to achieve optimal crop yield. Insufficient or Inadequate rainfall threatens agricultural yield and productivity, making efficient irrigation systems a necessity. While traditional methods are effective, they often fall short in the face of unpredictable weather, leading to potential crop losses and reduced yields. Furthermore, the acute demand for intelligent irrigation systems is highlighted by the growth in energy costs and the depletion of water supplies. Existing irrigation practices, such as surface irrigation, sub-surface irrigation, and sprinkler systems and many other, are beneficial but require a refined approach to ensure precise and correct water supply to crops. In many regions, the absence of systematic irrigation systems tailored to fit natural conditions worse the challenges faced by farmers, impacting both their livelihoods and the nation's agricultural economy.

This innovative project attempts to guide in a new era of agricultural innovation across rural India by harnessing the capabilities of the Raspberry Pi Pico microcontroller. Renowned for its compact dimensions, affordability, and adaptability, the Raspberry Pi Pico emerges as the typical platform for the creation of an intelligent irrigation system assured to redefine farming practices. Through the seamless integration of cutting-edge technology with traditional agricultural methods, this attempt promises to optimize resource utilization, enhance crop yields, and support the flexibility of the farming communities in the face of evolving environmental challenges. This initiative not only aims to address the immediate challenges faced by farmers but also encourages a culture of innovation and sustainability, laying the groundwork for a brighter, more prosperous future for rural India. By empowering farmers with tools to remotely monitor and manage irrigation systems, the project aims to mitigate risks associated with climate variability and resource scarcity, ultimately promoting elasticity and economic stability in agricultural communities.

The aim of this study is to change, enhance, and set up an advanced irrigation system that utilizes the GSM module and Raspberry Pi Pico microprocessor, while also using many sensors, including soil moisture and DHT11, to improve its performance. These sensors will be utilized by this system to obtain precise data on farm water demands, weather conditions, and soil moisture levels. Using the aforementioned data, the equipment will use the farmer's SMS commands to autonomously regulate irrigation. This will make sure that crops are always given the right quantity of water at appropriate times, regardless of whether the farmer isn't present at the farm. In addition, it will notify farmers as soon as there is an accident in the agricultural area. Through a simple-to-use interface, farmers will be able to remotely manage irrigation practices and the preferences, boosting efficiency, minimizing expenses for labor, and decreasing the waste of water.

Therefore, goal of this project is to create an environment friendly and strong future for Indian agriculture. The intelligent irrigation system developed will not only mitigate and reduce the risks posed by inconsistent and unpredictable rainfall but also optimize water usage by reducing the wastage, improve crop yields, and contribute to the economic prosperity of farming communities. By empowering farmers with technology-driven solutions, this project aims to transform the landscape of Indian agriculture towards greater efficiency and sustainability. This effort

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represents a significant step towards integrating technology into agriculture, paving the way for new era of smart farming.

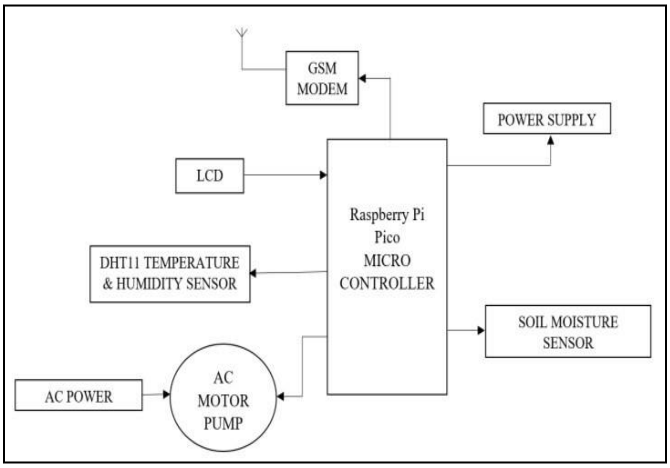

Fig 1 System Block Diagram

II. COMPONENTS

A. Soil Moisture Sensor

Because soil moisture sensors deliver precise measures of soil moisture content, they have become vital for agrarian and environmental monitoring. These sensors function by detecting changes in physical parameters, such as electrical conductivity or dielectric constant, and converting them into electrical signals. They can then use the aforementioned data to figure out the soil's relative water content, delivering useful information for managing the availability of water, improving irrigation techniques, and preserving crop health.

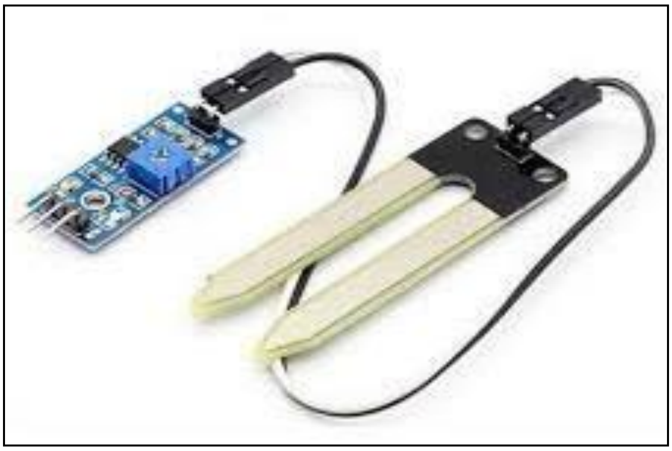
Fig 2 Soil Mositure Sensor

B. Raspberry Pi Pico

The Raspberry Pi Foundation's dedication to pioneering and top-notch microcontroller technology is illustrated by the Raspberry Pi Pico, which is supplied with power by its own custom established RP2040 microprocessor chip. With its dual-core ARM Cortex-M0+ processor clocked at speeds of up to 133MHz, the Pico offers remarkable performance capabilities, enabling seamless execution of complex tasks in diverse embedded applications. In addition to its impressive processing power, the Raspberry Pi Pico features 26 GPIO pins, providing extensive connectivity options for interfacing with sensors, actuators, and peripheral devices. This versatile GPIO configuration allows for the implementation of various projects, from simple sensor monitoring systems to sophisticated automation solutions.

Fig 3 Raspberry Pi Pico

C. GSM Module

GSM, standing for Global System for Mobile Communication, adheres to the research standards set by GSM 802.11. Incorporated into our project infrastructure, the GSM Sim 900 serves as a pivotal digital transmission and reception tool crafted for open-air cellular mobile communication. Its essential role lies in facilitating smooth communication between users and the system, thereby enabling robust long-distance control and monitoring functionalities crucial for project effectiveness. Additionally, the GSM technology employed in our project ensures reliable and efficient communication channels, enhancing overall project performance and user experience.


Fig 4 GSM Module

D. LCD Display

The LCD 16×2 is renowned for its robustness and widespread utilization across industries. Its capability to display 16 characters per line across 2 lines ensures readability and precision in conveying information. Apart from textual data, it seamlessly incorporates basic graphical elements, adding visual richness to its output. Its compact size and flexible functionality make it a preferred choice for diverse applications, ranging from consumer electronics to industrial automation and beyond.


Fig 5 LCD Display

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E. DHT11 Temperature & Humidity Sensor

The DHT11 Temperature & Humidity Sensor gives consistent temperature and humidity measurements through the use of a standardized digital information result. Because of its sophisticated engineering, which promises perpetual stability and consistency, it is capable of being used for a variety of activities. When integrated with microcontrollers, it offers rapid response times and cost-effective performance, making it an ideal choice for projects requiring precise environmental monitoring and control. Additionally, its compact design and low power consumption further enhance its versatility and usability in various settings.

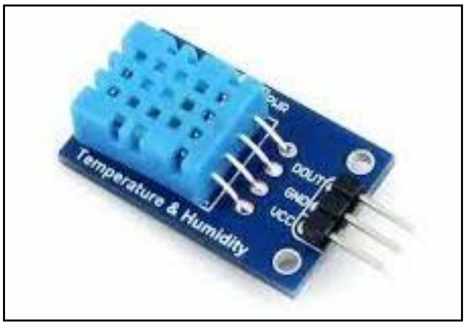

Fig 6 DHT11 Temperature & Humidity Sensor

F. Submersible Pump

Usually referred to an electric submersible pump, this type of pump is a versatile instrument engineered to be used entirely while submerged in water. Its hermetically sealed motor, directly integrated into the pump's body, ensures efficient performance. With an operating voltage range of AC 165-220V at 50Hz and a power consumption of 14 watts, it is suitable for various applications. Featuring a maximum lifting height of 1.25 meters, the submersible pump efficiently converts rotary energy into kinetic energy and subsequently into pressure energy, enabling the effective transport of water to the surface.

Fig 7 Submersible Pump

G. Relay Module

The relay functions as an electrically operated device, utilizing an electromagnet to mechanically control the opening and closing of its contacts. It plays a crucial part in our endeavor by handling how the water pump functions, guaranteeing an efficient and balanced stream of water whenever needed. Its activation by an electrical signal allows for precise control over when the pump is turned on or off, optimizing energy usage. Furthermore, integrating the relay enhances safety by providing isolation between the control circuitry and the high-power components of the pump, thereby reducing the risk of electrical hazards.

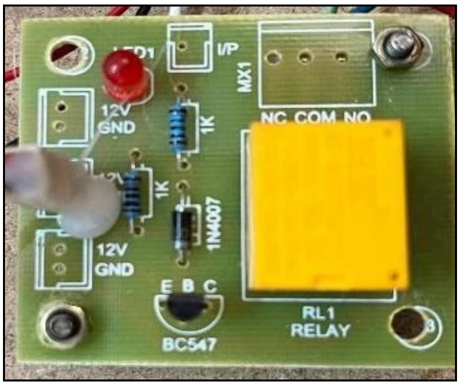

Fig 8 Relay Module

H. 12V Adapter

The 12V adapter, also known as a 12-volt power supply, plays a critical role in converting AC mains power into a stable DC voltage of 12 volts. This essential electrical device serves as a power source for various electronic devices and appliances that rely on a 12-volt supply to operate efficiently. Its widespread use spans across numerous applications, making it indispensable in modern electronics and technology.

Fig 9 12V Adapter

Table 1 Specifications of Designed System

No	Component	Specification
1	Soil Moisture Sensor	1 sensor
2	Raspberry Pi Pico	133MHz Wi-Fi & Bluetooth
3	GSM Module	9V, Requires SIM Card
4	LCD Display	16X2
5	DHT11	1 sensor
6	Submersible Pump	12V DC
7	Relay Module	12V

III. LITERATURE SURVEY

In 2013, a study conducted by Sachin Prabhakar Bandewar and Aditi V. Vedalankar aimed at automating irrigation processes using AVR ATmega8535 microcontrollers and GSM modules. Their research focused on providing timely water distribution while offering protection against common faults in agricultural irrigation systems. Additionally, the study explored future possibilities such as web-based applications for remote control, further enhancing irrigation efficiency.

In 2014, using ARM technology, Divya Kokalla and D.M.K. Chaitanya explored an intriguing, inexpensive irrigating system that worked on a cellular phone. Their research addressed water distribution challenges in rural areas with inadequate power supply by leveraging ARM microcontrollers and GSM modems. By optimizing water distribution based on climatic conditions and real-time data, the study offered an affordable solution for efficient irrigation management.

Another study conducted in 2017 by K.G. Sunil Kumar investigated the performance of an electric motor management for irrigation purposes in agriculture utilizing a system with embedded functionality that used the technology of GSM. His studies were aimed at reducing motor exhaustion, dry run, and singular phasing three significant factors which impact irrigation systems. By utilizing GSM networks for remote control and monitoring, the study proposed a solution to enhance motor efficiency and prevent damage, thus improving agricultural irrigation practices.

IV. WORKING & IMPLEMENTATION

Undertaking this project made necessary for a comprehensive understanding of the challenges in agricultural irrigation in rural India. This preliminary investigation served as the foundation upon which our project's architecture was carefully crafted. Deliberations on factors such as affordability, scalability, and efficacy involved in the selection of the Raspberry Pi Pico microcontroller as the cornerstone of our hardware setup. Understanding the complexities of local farming practices and the constraints faced by rural communities further informed our design decisions, ensuring that the developed solution aligns closely with the needs and realities of its intended users.

The selection of the Raspberry Pi Pico microcontroller emerged from its versatility, cost-effectiveness, and robust performance. After evaluating various microcontroller options, including Arduino and ESP8266, we opted for the Raspberry Pi Pico due to its extensive community support, ample GPIO pins, and compatibility with a wide range of sensors and modules. Additionally, the availability of C++ as a programming language offered a user-friendly interface for rapid prototyping and development.

Interfacing the sensors with the Raspberry Pi Pico microcontroller was a crucial aspect of the project implementation. In order to provide instantaneous data on conditions in the environment and crop moisture levels, the hardware infrastructure in combination the DHT11, which is a temperature as well as humidity sensor in together with the sensor for soil moisture. While the soil moisture sensor uses conductivity to figure out the amount of moisture in the soil, the sensor called DHT11 uses a capacitive humidity sensor to detect moisture and a thermal sensor for tracking temperature and humidity. By interfacing these sensors with the Raspberry Pi Pico, it was able to acquire accurate and reliable data essential for making informed irrigation decisions. Upon acquiring sensor data, the Raspberry Pi Pico microcontroller executed algorithms to determine irrigation requirements based on predefined code that was fed into it. These algorithms leveraged the collected data to remotely control the irrigation process, ensuring crops received the optimal amount of water at the right time by the SMS commands. Additionally, the system displayed critical information such as temperature, humidity, and pump status on an LCD display for user convenience and monitoring.

Incorporating GSM technology into our irrigation system marked a significant leap forward in enhancing its functionality and accessibility. GSM modules were interfaced with the Raspberry Pi Pico to facilitate seamless data transmission via SMS, facilitated remote communication and control capabilities, allowing farmers to monitor field conditions and adjust irrigation settings via SMS commands. This integration not only provided real-time insights into the irrigation process but also empowered farmers with the flexibility to manage their fields remotely, regardless of geographic location with cellular network coverage. The widespread nature of GSM networks provided farmers with a cost-effective and accessible means of remote monitoring and control. This not only enhanced the efficiency of agricultural irrigation but also empowered farmers with greater autonomy and decision-making capabilities.

Interfacing the GSM modules with the Raspberry Pi Pico involved configuring serial communication settings and implementing protocols for sending and receiving SMS messages. The Raspberry Pi Pico and GSM modules were capable to establish serial communication with the help of the Universal Asynchronous Receiver-Transmitter (UART) protocol, with specific baud rates and communication parameters set to ensure compatibility and reliability. By adhering to these protocols, the project ensured the establishment of a robust communication channel for transmitting sensor data and receiving commands from users was made possible. This meticulous attention to communication protocol not only facilitated seamless interaction between the system components but also enhanced the reliability and responsiveness of the overall irrigation system.

GSM modules operate based on AT commands, a standardized set of instructions used to control and communicate with GSM devices. AT commands were utilized to send and receive SMS messages, query network information, and manage communication settings. By leveraging these commands, we were able to establish a robust communication interface between the Raspberry Pi Pico and

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GSM modules, enabling seamless data exchange and remote control functionalities. This streamlined communication protocol laid the foundation for efficient interaction between the irrigation system and end- users, enhancing user experience and system usability.

One of the primary AT commands utilized in our project was "AT+CMGS," which is responsible for sending SMS messages. This command initiates the SMS sending process and specifies the recipient's phone number to which the message should be delivered. By incorporating this command into our system, we enabled the transmission of alert messages to designated mobile numbers in response to various environmental conditions or system events. For example, upon detecting high temperatures or excessive humidity levels in the field, our system would trigger the execution of specific code segments responsible for sending alert messages. These segments would include the "AT+CMGS" command followed by the recipient's phone number and the message content detailing the detected condition. By leveraging this command, we ensured timely communication of critical information to farmers, enabling them to take appropriate action to mitigate potential risks to their crops.

Another crucial AT command employed in our project was "AT+CMGF," which sets the SMS text mode. By configuring the GSM module to operate in text mode, we facilitated the sending and receiving of SMS messages using plain text rather than PDU (Protocol Data Unit) mode. This choice simplified the message formatting process and enhanced the readability of SMS messages sent by our system, improving user experience and system usability. Additionally, we utilized the "AT+CNMI" command to configure new message indications. This command specifies how newly received SMS messages should be handled by the GSM module. By setting parameters such as message format and indication mode, we ensured that incoming SMS messages were promptly processed and made available for retrieval by the microcontroller. This seamless integration between the GSM module and the microcontroller enabled efficient communication and real-time interaction with end-users.

The integration of relay modules served a crucial role in our project, providing a means of controlling the water pump and ensuring user safety. Relay modules act as electromagnetic switches, allowing low-power microcontrollers like the Raspberry Pi Pico to control high-power devices such as water pumps. By utilizing relay modules, it was made possible to achieve isolation between the microcontroller and the high-voltage components, reducing the risk of electrical hazards and ensuring reliable operation of the irrigation system. This robust safety measure not only safeguards the equipment but also minimizes the potential for accidents, enhancing the overall reliability and usability of the system.

User interaction with the irrigation system was facilitated through SMS commands, allowing farmers to monitor field conditions and control irrigation operations remotely. SMS commands such as "*ON#" and "*OFF#" were used to activate and deactivate the water pump, while queries for temperature, humidity, and soil moisture levels elicited informative responses from the system. Once a valid pump control command was identified, the microcontroller would execute the corresponding action, either activating or deactivating the water pump accordingly. To provide feedback to users regarding the status of the pump operation, the system would update the LCD display to reflect the current pump state (e.g., "ON" or "OFF"). Additionally, the microcontroller would send an acknowledgment SMS message confirming the successful execution of the pump control command, ensuring clear communication with users. By implementing this custom command recognition system, we empowered users to control the water pump remotely using simple SMS commands, such as "*ON#" or "*OFF#". To response which the farmers will get as “Pump_ON” when the pump is activated to ON and “Pump_OFF” when the pump is shut OFF to their registered mobile numbers. And the farmer will be able know the status of the sensor values and the state of pump by sending the SMS command “*S#”. The inclusion of ‘*’ and ‘#’ before and after the actual command is to ensure the encryption. The farmer will also get the alerts when the water level in the soil is high or low indicating the farmer to take action in regard to the present condition in the agricultural land. This intuitive interface eliminated the need for complex user interactions and provided farmers with a convenient means of managing irrigation operations from anywhere.

This natural interface empowered farmers with real-time insights into their fields' conditions, enabling informed decision-making and timely interventions. The implementation of alerts and responses in our project was crucial for ensuring timely notifications and interventions in case of anomalies or critical events. By monitoring sensor data and system status in real-time, the Raspberry Pi Pico microcontroller was programmed to trigger SMS alerts in response to predefined thresholds or fault conditions. Alerts such as high temperature, low humidity, or pump malfunction were promptly communicated to users, enabling proactive measures to mitigate risks and ensure optimal crop health. This proactive approach not only enhances crop management but also contributes to overall farm productivity and sustainability.

In summary, the integration of these components into our irrigation system proved pivotal in enabling seamless communication and remote control capabilities. Leveraging these mechanisms, we established a robust communication link between the microcontroller and the GSM module, enabling the transmission of SMS messages and the implementation of custom command recognition logic. This approach not only enhanced the functionality of our irrigation system but also improved user experience and accessibility, ultimately contributing to the project's success in revolutionizing agricultural practices in rural India.

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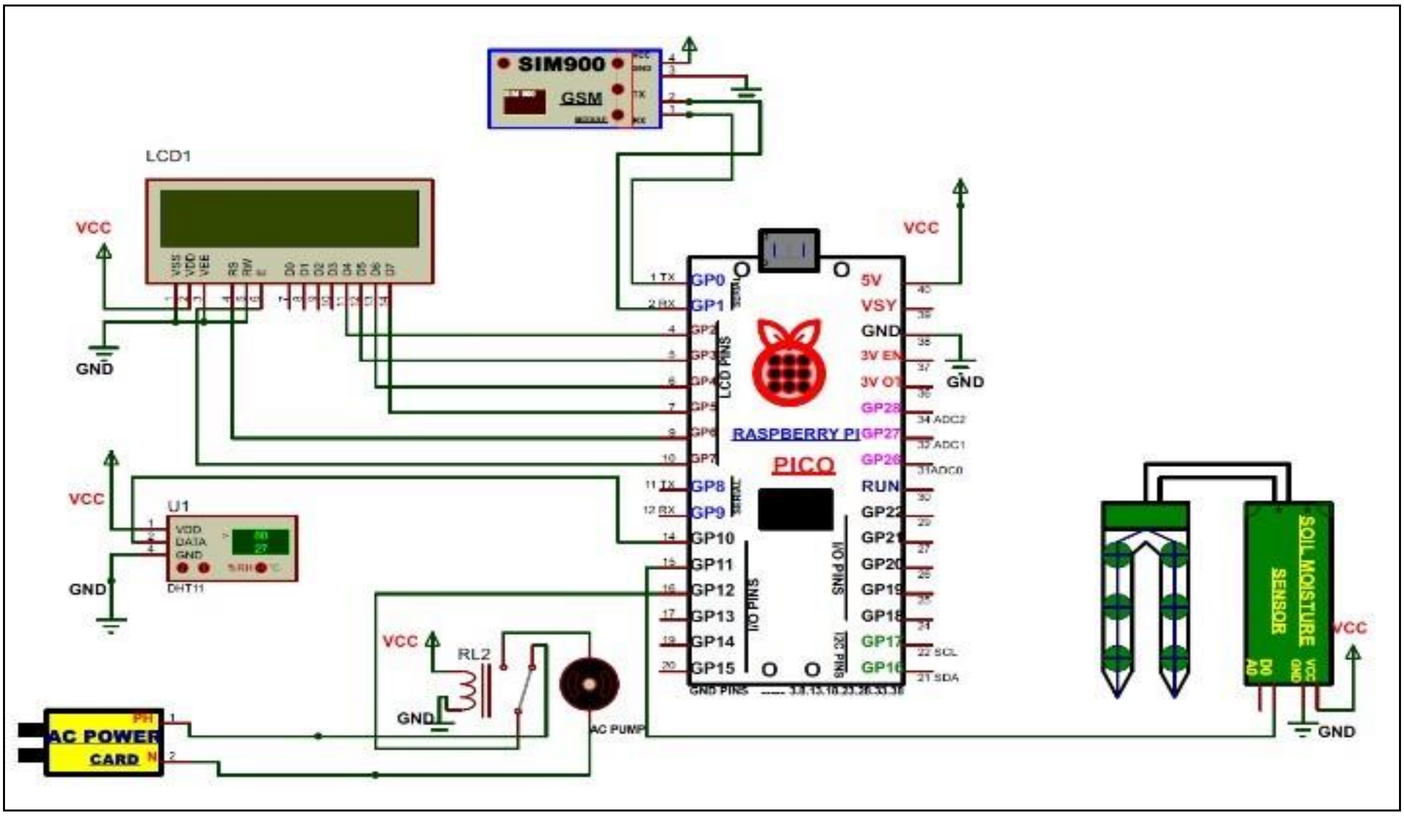

Fig 10 Circuit Diagram of Designing Cost-Effective SMS based Irrigation System using GSM Module

Fig 11 Designing Cost-Effective SMS based Irrigation System using GSM Module

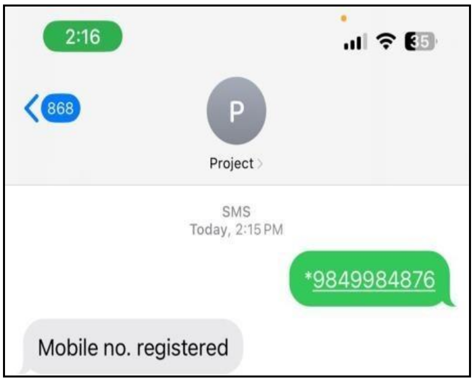

Fig 13 Reply Message to Mobile Showing that Mobile Number is Registered

V. RESULTS

➢ *Mobile Number Registration*

Fig 12 LCD Display Showing to Send Mobile Number to Register

➢ *Motor ON & OFF*

Fig 14 LCD Display Showing the Pump-ON

Fig 15 LCD Display Showing the Pump-OFF

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- *Status*

The Commands that are to be sent are:

- *ON# - For turning the pump ON
- *OFF# - For turning the pump OFF
- *S# - For knowing the status of sensors and pump

Fig 16 Mobile Screenshot Showing the Reply Messages for Commands *ON#, *OFF#, *S#

- *Moisture Dry*

Fig 17 Alert Sent to Indicate that Water Level is Low / Soil is Dry

- *Moisture Wet*

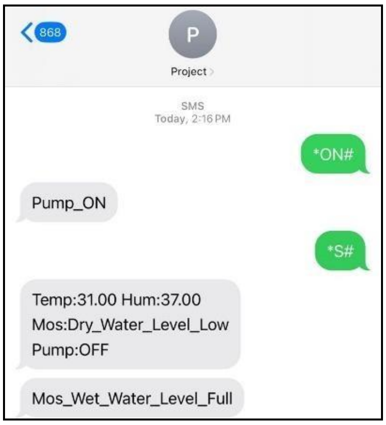

Fig 18 Alert Sent to Indicate that Water Level is Full / Soil is Wet

VI. FUTURE WORK

Future work will focus on refining the system based on field testing and user feedback, potentially including the integration of additional sensors such as those for measuring sunlight intensity, pH levels, and soil nutrient content for more comprehensive environmental monitoring, leveraging machine learning algorithms for anticipatory decision-making and for the analysis of historical sensor data and the prediction of future irrigation requirements with greater accuracy. Concurrently, the development of a dedicated mobile application tailored to interface seamlessly with the system would offer enhanced accessibility and user convenience. This mobile platform could empower users to remotely monitor sensor data, adjust irrigation parameters, and receive real-time alerts directly on their smartphones. Also integration of IoT technologies will enable real-time data sharing and remote monitoring. Finally, the implementation of robust data analytics and reporting tools would facilitate informed decision-making by discerning trends in sensor data and offering actionable insights for the continual refinement of irrigation strategies.

VII. CONCLUSION

In conclusion, our project represents a significant advancement in agricultural technology, particularly in the realm of irrigation management. By utilizing the Raspberry Pi Pico microcontroller and GSM technology, the system offers a cost-effective yet powerful solution to the longstanding challenges faced by farmers in optimizing water usage and enhancing crop yields. Furthermore, the incorporation of remote administration and continuous oversight capabilities allows farmers greater influence over their watering practices, which maximizes efficiency and improves the utilization of resources.

The successful incorporation of hardware components such as the sensor for monitoring heat as well as humidity (DHT11), and also to measure the water content in the agrarian land, and GSM Module demonstrates the project's effectiveness in real-time data acquisition and communication. These components work in harmony to continuously monitor environmental conditions and soil moisture levels, providing farmers with valuable insights into their fields' hydration status. Moreover, the intelligent control logic embedded within the system enables remote decision-making regarding irrigation schedules and water distribution. By analyzing sensor data, the system makes sure that crops are given the exact quantity of nourishments of water, thereby maximizing agricultural productivity while conserving water resources.

One of the key strengths of the project lies in its user-friendly interface and remote accessibility. Farmers can easily interact with the system using simple SMS commands, allowing for seamless monitoring and control from anywhere with cellular network coverage. This remote functionality not only enhances convenience but also empowers farmers with greater flexibility and control over their irrigation operations.

In summary, the "Designing Cost-Effective SMS-Based Irrigation System" project represents a promising step towards sustainable and efficient agriculture. By harnessing the power of technology to address fundamental agricultural challenges, we can create the conditions for a future where producing food is not only more economically feasible yet also more sustainably conscious and socially equitable.

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