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Water Pump Wireless Monitoring and Control System

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Abstract*: This project presents the development of a wireless monitoring and control system for a water pump, utilizing the Raspberry Pi PicoW microcontroller along with various sensors and a relay module. The system incorporates an Ultrasonic Sensor for water level detection, a DHT11 sensor for monitoring temperature and humidity, 5V Submersible Water Pump, and a Soil Moisture Sensor for assessing soil moisture levels. The primary objective is to achieve full automation of the water pump system, enabling users to remotely monitor and control it from any location. Through the integration of these components and wireless connectivity, users can effectively manage water resources, optimize irrigation processes, and respond promptly to changing environmental conditions. This project not only enhances convenience for users but also contributes to efficient water usage and conservation efforts.*

Keywords: Wireless Monitoring, DHT11, Relay, Wireless Remote Control, Water Pump Control System, Ultrasonic water level indicator.

I. INTRODUCTION

In recent years, the global demand for efficient and sustainable water management solutions has escalated significantly, driven by a growing awareness of environmental concerns and the need to conserve precious resources. The emergence of IoT (Internet of Things) technology has presented unprecedented opportunities to tackle these pressing challenges by revolutionizing conventional systems with smart, interconnected solutions. Against this backdrop, this research paper introduces an innovative Water Pump Wireless Monitoring and Control System, a pioneering endeavor aimed at revolutionizing water management practices.

This cutting-edge system represents a fusion of advanced hardware and software components, strategically integrated to automate the operation of water pumps and empower users with remote control capabilities. At its heart lies the Raspberry Pi Pico W microcontroller, a versatile computing platform that orchestrates the seamless interaction between the various sensors and actuators. The inclusion of key sensors such as the Ultrasonic, DHT11, and Soil Moisture sensor enables the system to gather critical data on water levels, environmental conditions, and soil moisture content in real-time. This data is then processed and transmitted wirelessly, leveraging the power of connectivity to provide users with actionable insights and precise control over their water management infrastructure.

Through the integration of these cutting-edge technologies, the main goal of this project is to improve water resource management by offering unparalleled levels of monitoring, control, and optimization. By providing users with real-time access to crucial information and the ability to remotely regulate water pump operations, the system aims to minimize waste, maximize efficiency, and promote sustainability. Furthermore, this paper delves into the intricate design and implementation details of the proposed system, shedding light on its potential applications across various sectors including agriculture, urban water supply, and industrial processes. Ultimately, this research endeavour seeks to underscore the transformative impact of IoT-driven solutions in shaping a more resilient, efficient, and sustainable water management ecosystem.

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II. METHODOLOGY

Hardware Requirement Specification

The project primarily requires hardware components to integrate Raspberry Pi PicoW microcontroller along with various sensors and a relay module. The system incorporates an Ultrasonic Sensor for water level detection, a DHT11 sensor for monitoring temperature and humidity, 5V Submersible Water Pump, and a Soil Moisture Sensor for assessing soil moisture levels. The following is the list of hardware components that are interconnected to bring this project to fruition:

Raspberry Pi Pico W:- It is a wireless-enabled microcontroller board offering enhanced connectivity and versatility for embedded projects. With SRAM of 264KB and 2MB of QSPI Flash, it provides ample resources for running complex applications and storing data. Its built-in Wi-Fi and Bluetooth connectivity enable seamless wireless communication, allowing to enable distant supervision and management of the water pump system. GPIO pins onRaspberry Pi Pico W facilitate easy interfacing with sensors and actuators, making it an ideal choice for building IoT projects. In the Water Pump Wireless Monitoring and Control System, this microcontroller serves as the brain, orchestrating the operation of other components and facilitating data exchange between the system and users.

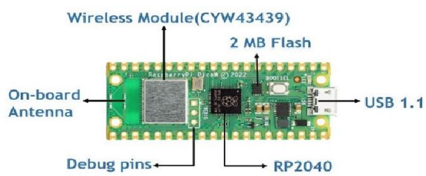

Fig. 1. Raspberry Pi Pico W

Ultrasonic Sensor:- The Ultrasonic Sensor is a key component in the water pump system, responsible for accurately measuring water levels in tanks or reservoirs. Operating at 5V, it generates ultrasonic pulses and calculates the duration required for the pulses to return following their collision with an object. Subsequently, this information is utilized to determine the distance to the water surface, providing real-time information on water levels. The sensor's detection range, which can extend to several meters depending on the model, ensures precise monitoring even in large-scale applications. By interfacing the Ultrasonic Sensor with the microcontroller, it automatically adapt pump operations based on water level readings, optimizing water usage and preventing overflow or dry-running scenarios.

Fig. 2.Ultrasonic Sensor

DHT11Sensor:- It plays an indispensable role in guaranteeing the effective and secure functioning of the water pump system by continuously monitoring the environmental conditions. Its ability to operate within a voltage range of 3.3V - 5V ensures compatibility with a broad spectrum of microcontrollers, including the Raspberry Pi Pico W. By accurately measuring ambient temperature and humidity levels, the DHT11 sensor provides valuable insights into the surrounding conditions, enabling the system to respond effectively to changes in the environment. Operating within temperature ranging from 0°C - 50°C and humidity levels from 20% to 90%, the sensor offers sufficient coverage for monitoring most indoor and outdoor environments, making it suitable for diverse applications. Integrating the DHT11 sensor with the microcontroller allows it to dynamically adapt pump operations based on real-time temperature and humidity readings, ensuring optimal performance and preventing damage due to extreme conditions. This proactive approach not only enhances the efficiency of the water pump system but also contributes to its longevity and reliability, ultimately promoting sustainable water management practices.

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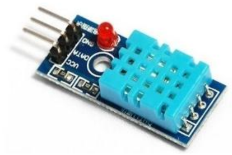

Fig. 3.DHT11 Sensor

Soil Moisture(SM) Sensor:- Itserves an essential function in enhancing irrigation practice by furnishing real-time information. Operating within a voltage range of 3.3V to 5V, it gauges the moisture level in the soil, helping users determine the optimal timing and duration of watering sessions. With an adjustable detection range typically spanning from 0% to 100%, the Soil Moisture Sensor offers flexibility to accommodate different soil types and moisture requirements. By interfacing this sensor with the microcontroller, it can intelligently regulate pump operations based on soil moisture readings, preventing overwatering, or underwatering and promoting healthy plant growth.

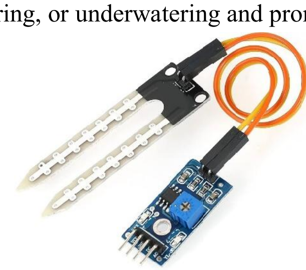

Fig. 4. Soil Moisture Sensor

Relay Module:- The Relay Module serves as a crucial interface between the Raspberry Pi Pico W and the 5V Submersible Water Pump, enabling remote control and automation of pump operations. Operating at 5V, it serve as a toggle. With the ability to handle loads up to 10A at 250V AC or 30V DC, the relay module offers sufficient capacity to support the operation of the water pump. By integrating the relay module with the microcontroller, it can implement sophisticated control algorithms, ensuring efficient water management and enhancing user convenience.

Fig. 5. Relay Module

5V Submersible Water Pump: -The 5V Submersible Water Pump is the physical mechanism responsible for transferring water from a source, such as a tank or reservoir, to the desired location. Operating at a voltage of 5V DC, this pump is designed to function efficiently in various water-related applications. With a maximum flow rate and lift height dependent on the specific model, it offers flexibility to accommodate different project requirements. Submersible by nature, this pump is typically waterproof and can be fully submerged in water without risking damage to its internal components. The 5V Submersible Water Pump acts as the primary mechanism for water distribution and irrigation. Controlled by the Raspberry Pi Pico W through the Relay Module, it enables automated and remote-controlled pumping operations based on sensor readings or user commands. By harnessing the power of this pump, the system can efficiently manage water resources, optimize irrigation schedules, and ensure consistent water supply to plants or desired locations, contributing to improved efficiency and sustainability in water management practices.

Fig. 6. 5V Submersible Water Pump

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Software Requirement Specification:

ThonnyIDE: - In our project, we employed the Thonny IDE software to code for our system. The Thonny Integrated Development Environment (IDE) serves as a comprehensive software tool for Python programming, providing developers with a streamlined platform for code editing, debugging, and project management. Additionally, Thonny offers an interactive Python shell for executing code snippets and experimenting with programming concepts in a sandbox environment, empowering users to explore Python's capabilities in real-time.With built-in support for virtual environments, Thonny enables users to isolate project dependencies and manage project-specific Python environments effectively. Integration with the Raspberry Pi Pico W development ecosystem allows users to write, debug, and upload MicroPython firmware to the microcontroller seamlessly. Thonny's documentation, community forums, and online resources provide valuable support for users, ensuring a smooth and productive development experience. Looking ahead, Thonny IDE continues to evolve with future enhancements focused on performance improvements, enhanced debugging features, and support for emerging technologies, reinforcing its position as a leading choice for Python development and Raspberry Pi Pico W integration.

Realtime Database: - It is an integral component of the Firebase platform, is a cloud-based database offered by Google. It allows developers to store and sync data between users in real-time across multiple clients, such as web, Android, and iOS apps. Firebase Realtime Database uses JSON as its data format, allowing for easy integration with web and mobile applications.

Key features of Firebase Realtime Database include:

- *Real-time Data Sync*: Modification to the database are promptly synchronizedin real-time, enabling seamless collaboration and updates across devices.
- *Data Security*: Firebase offers built-in security features to protect data stored in the Realtime Database. Developers can define access rules and permissions at the database, collection, or document level to control who can read or write data.
- *Scalability*: Firebase Realtime Database is designed to scale automatically to accommodate growing data volumes and user loads. This ensures that applications can handle spikes in traffic and maintain performance under heavy usage.
- *Analytics and Monitoring*: Firebase provides analytics and monitoring tools to track database usage, monitor performance, and gain insights into user behaviour,helping developers optimize their applications.

Android Studio IDE: - Android Studio IDE serves as the primary development environment for Android application development, leveraging a range of technologies to streamline the development process. With its integration of Firebase Database, developers can seamlessly incorporate real-time data storage and synchronization capabilities into their Android applications, enabling efficient data management and collaboration. Android Studio is optimized for the Android operating system, providing developers with a robust platform for designing, coding, testing, and deploying applications tailored specifically for Android devices. Kotlin, a modern programming language fully supported by Android Studio, offers concise syntax, null safety, and interoperability with Java, enhancing developer productivity and application performance. Additionally, XML (Extensible Markup Language) is utilized for designing user interfaces (UI) in Android Studio, allowing developers to create visually appealing and responsive layouts for their applications. By harnessing the power of these technologies within Android Studio, developers can create feature-rich Android applications with ease, empowering them to innovate and deliver exceptional user experiences.

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System Block Diagram

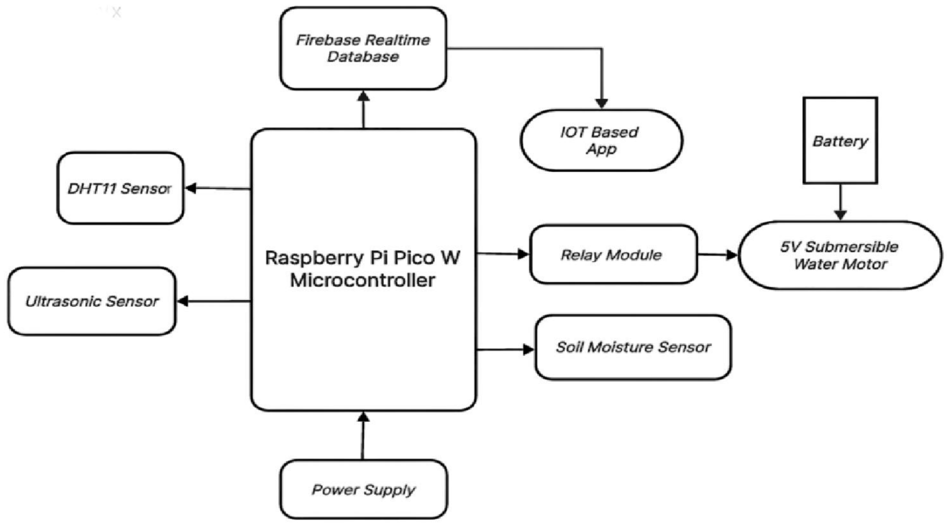

Fig. 7. System Block Diagram

III. IMPLEMENTATION

Working of the system

The system showcases the versatility of the Water Pump Wireless Monitoring and Control System by demonstrating its functionality through two distinct applications. The first application focuses on addressing the issue of water overflow from the overhead tank in a society setting. Here, we employ the system to automate the process of refilling the overhead tank from the underground tank, ensuring a consistent water supply while preventing the risk of overflow. The second application, on the other hand, targets home gardening by utilizing the system to automate the watering of plants based on soil moisture levels. Through these two applications, we aim to highlight the adaptability and efficiency of the system in addressing different water management needs, ranging from societal water distribution to individual plant care.

In the first application, focused on preventing the overflow of water from the overhead tank in the society, the system operates in a proactive manner to ensure efficient water management. The Ultrasonic Sensor serves as the primary component for monitoring thetank. As the level of water decreases below a predetermined threshold, the sensor detects this change and sends the information to the microcontroller. Upon receiving the signal, the microcontroller triggers the Relay Module to activate the 5V Submersible Water Pump, which then transfers water from the underground tank to the overhead tank. This process continues until the overhead tank reaches a predefined capacity, typically 100%.

At this point, the system transmits message notification on the application, indicating that the tank is nearing full capacity. The user can then access the mobile app and manually turn off the motor to prevent overflow. Alternatively, if the user does not respond promptly, the system automatically shuts off the motor to avoid any potential damage or water wastage. This proactive approach ensures that the water supply is maintained at optimal levels without the risk of overflow, providing peace of mind to the society residents and promoting efficient water usage.

In the second application, aimed at watering plants at home based on soil moisture levels, it utilizes the SM to track the soil's moisture content.As the soil moisture level decreases below a pre-established limit, indicating that the plants require watering, the sensor sends this information to the microcontroller. Upon receiving the signal, the microcontroller activates the Relay Module to turn on the 5V Submersible Water Pump, which then irrigates the soil until the moisture level reaches the desired threshold.

Once the soil moisture level is sufficient, the system transmits analert messageon the app, informing that soil moisture level has been restored. The user can then access the mobile app and manually turn off the motor to avoid overwatering. Alternatively, if the user does not respond, the system automatically shuts off the motor to prevent excessive water

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usage. This ensures that the plants get sufficient water while reducing water wastage to a minimum, fostering healthy plant growth, and conserving resources.

Circuit Diagram

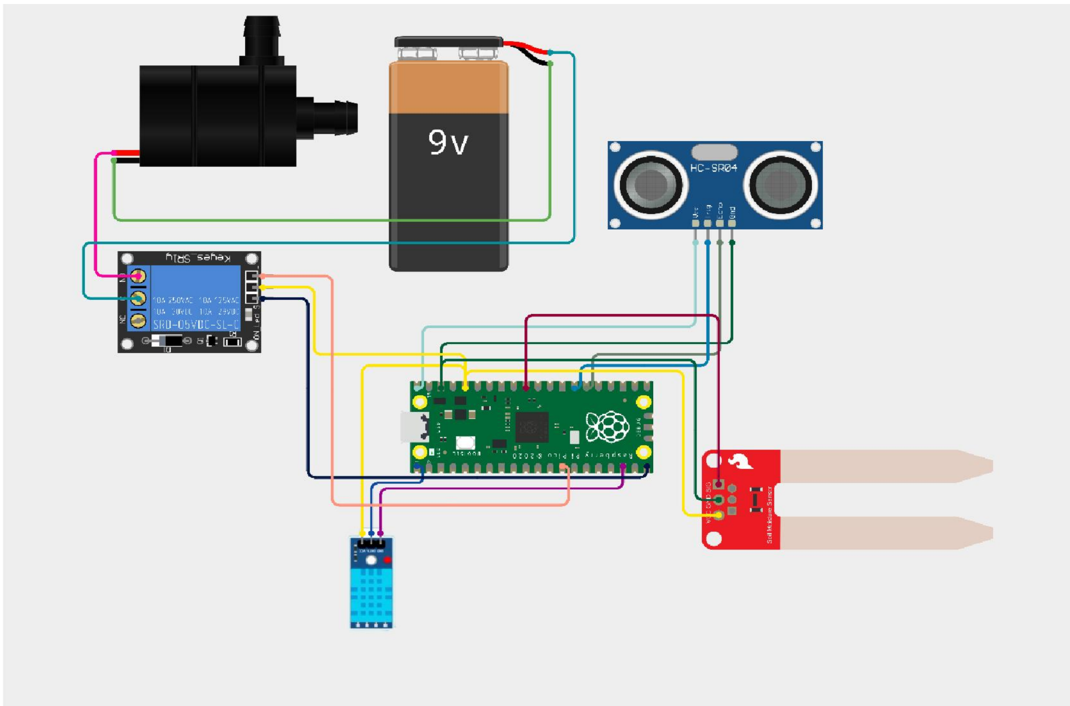

Fig. 8. Circuit Diagram of the proposed system

IV. ADVANTAGES

- Efficient water usage optimization.
- Remote monitoring and control capability.
- Proactive measures to prevent overflow or overwatering.
- Versatile and adaptable for various applications.
- Intuitive user interface for enhanced user experience.
- Promotes sustainability through smart water management.

V. RESULT AND DISCUSSION

The Water Pump Wireless Monitoring and Control System demonstrates remarkable versatility and effectiveness in two distinct applications: society water management and home gardening.In the society water management application, the system addresses the common issue of water overflow from overhead tanks by automating the refilling process from an underground tank. Using an Ultrasonic Sensor to monitor water levelsthe system engages a Submersible Pump when water levels fall below a specified threshold, ensuring consistent supply without risk of overflow. Alerts to a mobile app prompt user intervention to prevent overflow, with automatic shutdown as a failsafe measure. This proactive approach optimizes water usage and provides peace of mind to residents.

In the home gardening application, the system utilizes a Soil Moisture Sensor to regulate plant watering based on moisture content in the soil. When the moisture content falls below a predetermined threshold, the system triggers the water pump to irrigate until the desired moisture level is reached. Similar to the society application, alerts prompt user intervention to prevent overwatering, with automatic shutdown if needed. This promotes healthy plant growth while conserving water resources.

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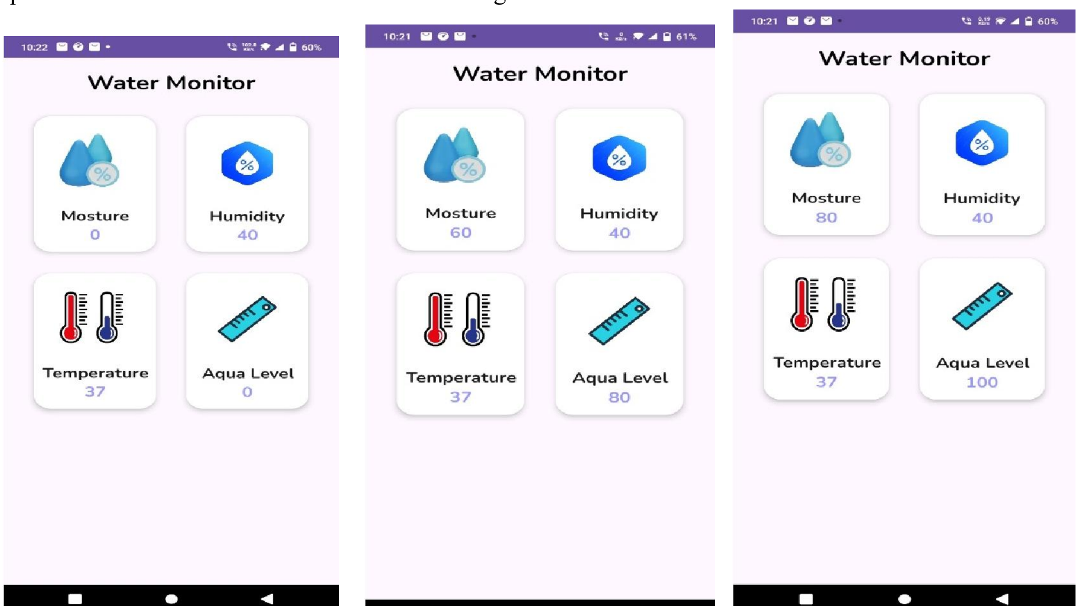
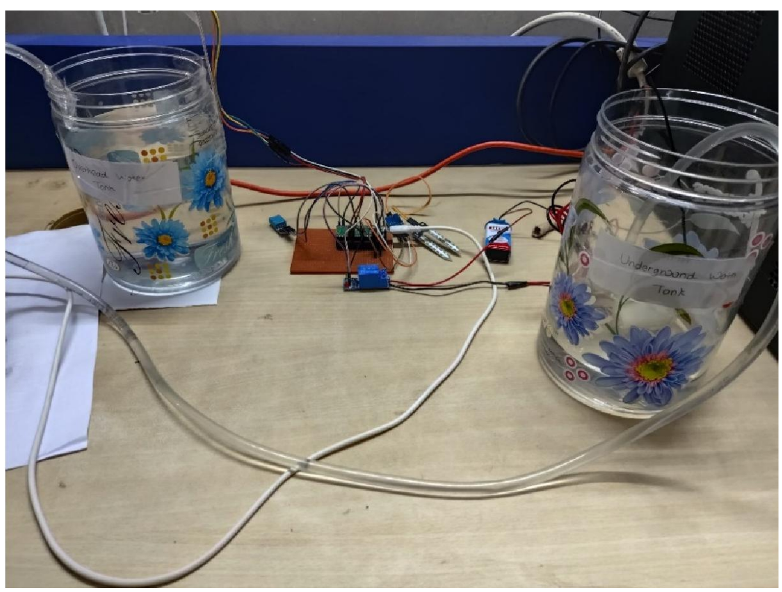
In summary, the project demonstrates the adaptability and efficiency of the Water Pump Wireless Monitoring and Control System in addressing various water management needs, from large-scale societal distribution to individual plant care. By combining automation with user intervention, the system ensures optimal water usage while safeguarding against potential issues such as overflow or overwatering.



(a) (b) (c)



(d)

Fig. 10Representation of the project

Fig 10(a) shows the data initially at stationary state. Fig (b) shows the data after some interval of time. Fig(c) shows the data at final stage and Fig(d) project system representation of one of the applications on preventing the overflow of water from the overhead tank in the society.

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VI. CONCLUSION

In the present study, we have thoroughly examined the utilization of the Water Pump Wireless Monitoring and Control System, representing a significant advancement in water management technology, and offering innovative solutions for efficient water distribution and conservation. Through the demonstration of two distinct applications, the system has showcased its versatility and adaptability in addressing diverse water management needs. By automating the process of water distribution and irrigation, the system ensures optimal water usage while preventing the risk of overflow or overwatering. Real-time monitoring of water levels and soil moisture levels allows for precise control of pump operations, promoting sustainability and resource conservation. The integration of remote monitoring and control capabilities via a user-friendly mobile app enhances accessibility and user engagement, empowering users to manage water resources effectively from anywhere, at any time.

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