

Automatic Dual-Tank Water Pump Control Using Arduino Uno R4 and Ultrasonic Sensors

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Received: July 23rd, 2026. Revised: August 31st, 2026. Accepted: September 3rd, 2026

Available online: September 9th, 2026. Published: September 9th, 2026.

Abstract— This study developed and evaluated an Arduino Uno R4 Minima-based automatic pump control system for managing water distribution between two storage tanks using three HC-SR04 ultrasonic sensors, two 12 V DC pumps, four solenoid valves, a relay module, and a 20×4 LCD monitoring interface. A quantitative Research and Development approach was employed to design, integrate, and experimentally test the system under controlled laboratory conditions. The ultrasonic sensors continuously monitored water levels in the two storage tanks and the main reservoir, while the microcontroller controlled-pump and solenoid valve operation according to predefined water-level conditions. The system was evaluated under seven operating scenarios involving dual-pump, single-pump, alternating, standby, and no-water conditions. The HC-SR04 sensors achieved an average measurement error of 1.78% and an average accuracy of 98.22%. All seven system operating scenarios were successfully executed according to the designed control logic. The main technical contribution of the proposed system is the integration of two pumps, multiple solenoid valves, and real-time water-level monitoring to enable flexible automatic distribution between two storage tanks. The results indicate that the developed prototype can reliably perform automatic pump and valve control under controlled experimental conditions, while further testing is required to assess long-term reliability, hydraulic performance, energy consumption, and field-scale applicability.

Keywords: Arduino Uno R4; automatic pump control; ultrasonic sensor; dual-tank control; embedded control system.

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I. INTRODUCTION

Water is essential for human existence and is employed in numerous tasks like bathing, laundry, cooking, and drinking across domestic, industrial, and public domains (Missa, Jacob, & Keon, 2025). The consistent availability and flow of water are vital for the ongoing viability of these functions. A key element of a water distribution network is the pump, which serves to transport water from its source to either a storage reservoir or directly to where it is needed. Typically, pump operation relies on traditional ON/OFF techniques utilizing switches or mechanical floats. This approach has drawbacks in adapting to gradual fluctuations in water levels, leading to frequent switching and possibly hastening the deterioration of pump parts (Ulum, Lutfi, & Faizin, 2022).

In addition, water supply networks that utilize multiple pumps often do not possess an effective load-sharing method. Consequently, one pump might function more vigorously compared to the others, which can lead to diminished reliability and a shorter lifespan for the system. As water usage rises, running several pumps at the same time necessitates a management approach that can autonomously determine actions based on monitored water levels (Mulyana, Rozi, & Bahar, 2025). Thus, a regulatory

framework is necessary that can flexibly manage pump activity as water tank conditions evolve.

Improvements in microcontroller technology have made it possible to create automation systems that are more adaptable and affordable. A commonly utilized platform in embedded systems is the Arduino Uno due to its low cost, user-friendly programming, and compatibility with a range of sensors and electronic components (Saputra & Surapati, 2024). By using the Arduino Uno as the primary control unit, a pump management system can be developed to respond dynamically to fluctuations in water levels. Furthermore, incorporating a solenoid valve enables the control of water distribution routes by automatically opening and closing the valve based on specified requirements.

Real-time surveillance of system status is a crucial part of ensuring the stability of water distribution. Data about water levels, pump conditions, and the operational status of the system, which can be observed directly, will aid in the processes of monitoring and maintenance. To assist with this, ultrasonic sensors were chosen as the water-level sensors since they can collect data without needing to touch the water surface, exhibit minimal wear, and deliver continuous and quick information on water levels.

Numerous investigations into the automation systems for water pumps have been undertaken in the past. One research effort at PT. Padasa Enam Utama employed a control system based on sensors that regulated just one pump (Ramadhani, Amin, & Dalimunthe, 2025). Another research project developed a pump house system utilizing a Programmable Logic Controller (PLC), featuring controls based on buttons and rotary encoders to manage two pumps (Ernawati, 2018). Additionally, a different study utilized a water-level sensor linked directly to a transistor and a relay, functioning as an automatic control system for the pump (Fathurahman & Wardhana, 2024). Nevertheless, most of these investigations tend to concentrate on the operation of a single pump or have yet to incorporate a water distribution system that can autonomously adjust the functioning of two pumps and two valves depending on the status of several storage tanks.

Considering these challenges, this research created and developed an automatic control system utilizing Arduino Uno to manage two pumps and two solenoid valves in two water storage reservoirs. The control system employs ultrasonic sensors to measure water levels and decide whether the pumps should operate alternately or simultaneously based on the levels detected. Moreover, the system features a monitoring interface that shows the status and condition of the tanks in real time. The aim of implementing this system is to enhance the consistency of water distribution, minimize potential losses caused by overflowing water, and facilitate the advancement of intelligent and sustainable infrastructure in alignment with Sustainable Development Goal (SDG) 9 focusing on constructing resilient, innovative, and sustainable infrastructure (Mozef & Maharani, 2024; UN General Assembly, 2015).

II. METHOD

Research and Development using a quantitative approach was the method employed in this study (Sugiyono, 2018). The device designed consists of a control system for two pumps to fill two storage tanks, as well as solenoid valves to regulate the flow of water to its destination. The concept of the device designed in this study is a simulation system for controlling water pumps using an Arduino Uno microcontroller (Petru, Tivlea, & Popa, 2023). This system is designed to control two water pumps that will operate two 12 V DC pump loads. Control is based on water level conditions detected by an ultrasonic sensor, which serves as the system's input (Hanan, Sunarno, & Yulianti, 2016).

Ultrasonic sensors are used to detect three water level conditions, low, medium, and high, based on predetermined distances (Wahyuni, Sentana, Muhardi, & Irawan, 2021). This information is then processed by an Arduino Uno microcontroller according to rules defined by the designer. Based on the results of this processing, the system determines the output condition, which involves operating the pumps either alternately or simultaneously (SHODIQIN & KURNIAWAN, 2020).

When the water level in one of the tanks is low, the system will activate both pumps simultaneously to increase the water flow rate. When the water level is moderate, the pumps will supply water to the tanks, with solenoid valves directing the water to each tank's respective line. When the water level is high, both pumps will shut off.

This system uses an Arduino Uno microcontroller as the control center, which reads input from an ultrasonic sensor, processes the data, and controls the output via a relay connected to a pump load, simulating a pump, and a solenoid valve used to shut off the water flow according to specified conditions (Amin, 2018). With this design, the control system operates automatically and can determine pump operation based on detected conditions.

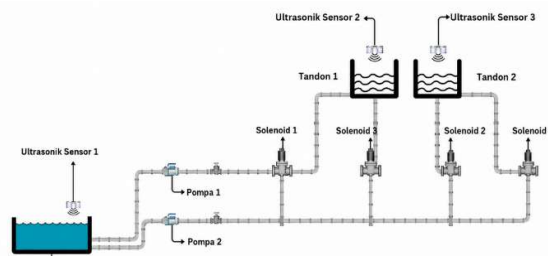


Figure 1. Concept Design Illustration

A. Flowchart System

A flowchart is a diagram used to illustrate the sequence of processes, data flow, and decision-making logic within a system. Flowcharts are created using standard symbols that represent specific functions, making it easier to visually understand a system's workflow. With flowcharts, the processes of system analysis, design, implementation, and maintenance can be carried out more easily because the relationships between processes are clearly visible.

In the design of an automatic water pump control system, a flowchart is used to illustrate the sequence of how the system operates, from reading the ultrasonic sensor, processing the water level data, making decisions to activate the pump and solenoid valve, to displaying the information on the LCD.

Flowcharts also help explain the control logic applied to the system before it is implemented as a program. The system flowchart is shown in Figure 2.

The study consisted of several stages, which are described as follows:

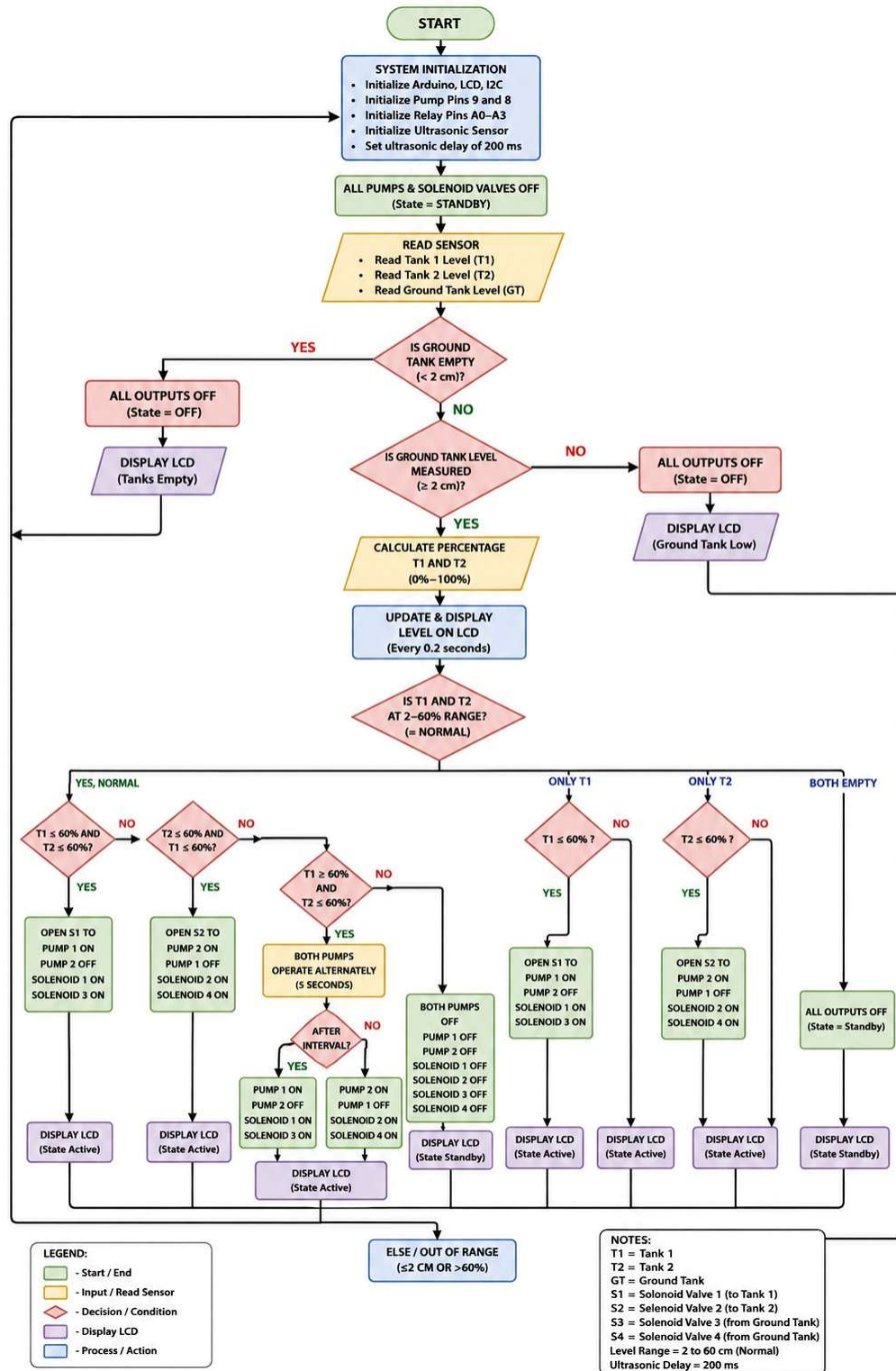


Figure 2. System Flowchart

B. Component Type Selection

This control system for the pump is made up of multiple elements that are combined into one cohesive system.

Table 1. Component

No	Component Name	Function	Specifications	Formula
1.	Sensor Ultrasonik HC-SR04	Measures water level by detecting the distance to the water surface using ultrasonic waves.	Three HC-SR04 sensors; two for Tank 1 and Tank 2, one for the bottom tank; operating frequency 40 kHz.	Ultrasonic distance measurement formula (Arunglabi, Allu, & Patandianan, 2026): $d = \frac{v \times t}{2}$ d = distance between the sensor and the object (m or cm) v = speed of sound in air (m/s) t = travel time of the ultrasonic pulse (s)
2.	Arduino Uno Minima R4	Main controller for sensor reading and actuator control.	Renesas RA4M1, 32-bit ARM Cortex-M4, 48 MHz, programmable using Arduino IDE (C++). (Saputra et al., 2025).	
3.	Liquid Crystal Display (LCD) 20×4 I2C	Displays water level, system status, pump status, and valve status.	20 columns × 4 rows, I2C interface, low power consumption.	
4.	12 V DC Pump	Pumps water from the source tank to the destination tank.	DC 12 V water pump.	Flow rate equation (Agustina et al., 2024): $Q = \frac{V}{t}$ Q = volumetric flow rate (L/s or m ³ /s) V = volume of fluid (L or m ³) t = time (s)
5.	Solenoid valve DC 12 V	Controls water flow automatically by opening or closing the pipeline.	DC 12 V electromagnetic valve.	
6.	Relay	Electrically switch pumps and solenoid valves.	5 V control input; switching capacity up to 250 VAC/10 A or 125 VAC/15 A (Yulianto, 2023).	
7.	Check Valve	Prevents reverse water flow.	Cartridge-type one-way valve.	
8.	Power Supply Unit (PSU)	Converts AC mains voltage to regulated DC voltage for the system.	5 V 5 A PSU and 12 V 10 A PSU.	Electrical power equation (Halim, Arsyad, & Purworaharjo, 2023): $P = V \times I$ P = electrical power (W) V = voltage (V) I = electric current (A)

The elements comprise the HC-SR04 ultrasonic detector, Arduino Uno R4 Minima, 20×4 I2C liquid crystal display, 12 V direct current pump, 12 V direct current solenoid valve, relay module, chkeek valve, and the power supply unit (PSU).

C. Subsystem Design Implementation

The implementation of the subsystem design in this research includes a water level sensing subsystem, a processing unit, a pump controller, a solenoid valve subsystem, a display interface, and a power supply unit, all combined into a system that automatically manages water filling for two storage tanks. This system aims to oversee water availability, regulate the distribution process, and safeguard the pump from running without water (Guo, Wang, Taha, & Summers, 2020; Karar, Al-Rasheed, Al-Rasheed, & Reyad, 2020).

The subsystem for measuring water levels utilizes three HC-SR04 ultrasonic sensors, which are positioned on Tank 1, Tank 2, and the primary reservoir tank (Pradana, Pratiwi, & Arifin, 2024; Samosir & Hidayat, 2026). The sensors situated on Tank 1 and Tank 2 serve to gauge the levels of water and translate these readings into percentage representations of water volume. Meanwhile, the sensor located on the primary reservoir acts as a protective feature to monitor the presence of water at the main source. The data collected from these measurements are sent in real-time to the microcontroller to contribute as input for controlling the system. The control part of the system employs an Arduino Uno as its primary controller, tasked with handling sensor information, assessing the system's operational states, and managing the actuators, specifically the pumps and solenoid valves, via a relay module. Additionally, the system features a 20×4 I2C LCD which shows details about water levels, the status of the pumps, and the conditions of the solenoid valves, thus enabling users to monitor the system effectively (Gati & Lias, 2022).

The actuator subsystem is made up of a pair of DC pumps and four solenoid valves that manage the flow of water from the primary reservoir to Tank 1 and Tank 2. The activation of the pumps and solenoid valves is governed by the control logic encoded in the Arduino Uno, which enables the automatic filling process to function, either in an alternating manner or at the same time, based on the specific needs of each tank (Karar et al., 2020). Each subsystem is powered by the PSU module, which supplies 5 VDC to the Arduino Uno, sensors, LCD, and relay modules, as well as 12 VDC for the pumps and solenoid valves. The combination of all subsystems creates a self-operating pump control system that can monitor water levels in real time, automatically fill up, and

safeguard against conditions of insufficient water with consistent functionality (Casado, Cisqueila, & López, 2018; Rahman, Andrizal, Herizon, & Anggara, 2025).

D. Software Design Implementation

The software in this study uses input data collected from three HC-SR04 ultrasonic sensors. The data collected is handled by the Arduino Uno microcontroller and then used as output signals to manage the relay module. This helps in controlling the system based on specific conditions like low water level, medium water level, high water level, and when the main reservoir is empty with no water available.

III. RESULTS

A. Testing and Analysis of the Ultrasonic Sensor Module

The ultrasonic sensor module was checked to find out how well it can measure the distance from the water surface to the sensor. The test was done by checking the real distance measured with a reference tool against the distance picked up by the HC-SR04 ultrasonic sensor. The deviation, percentage error, and sensor precision were calculated based on the measurement results. This testing process is meant to check if the sensor can give correct distance information, so it can be relied upon as the main source for controlling the automatic water pump system. The results from the ultrasonic sensor tests are shown in table 2.

Based on the test results, the HC-SR04 ultrasonic sensor achieved an average error of 1.78% and an average accuracy of 98.22%. These results indicate that the sensor can measure water level distances with high accuracy and can therefore be reliably used as the primary sensing component in the automatic water pump control system.

$$\text{Error \%} = \frac{(x \text{ measured} - x \text{ actual})}{x \text{ actual}}$$

Table 2. Ultrasonic Sensor Testing Results

Actual Distance (cm)	Measured Distance (cm)	Difference (cm)	Error	Accuracy
5	5,1	0.1	0,020	98%
7	6,9	0.1	0,014	98,6%
12	12,3	0.3	0,025	97,5%
17	17,2	0.2	0,012	98,8%
Mean			1,78%	98,22%

B. Testing and Analysis of the Processing Module

The processing module was tested to verify that it operated properly and executed the programmed control functions correctly. The test was carried out by connecting the processing module to a relay module, which served as the output device controlled by the microcontroller. The microcontroller was programmed to switch the relay on for 2 seconds and off for 2 seconds repeatedly. The test results are presented in table 3.

Table 3. Relay-Based Processing Module Test Results

Input	Output
High	Relay turns on for 2 seconds
Low	Relay remains off for 2 seconds

C. Testing and Analysis of the Actuator Module

The actuator module was tested to ensure that all actuators operated according to the programmed conditions. The actuator subsystem in this system consists of DC pumps and solenoid valves that perform functions such as turning the pumps on and off and opening or closing the solenoid valves.

Table 4. Actuator Module Test Results

No	Tank 1 Condition	Tank 2 Condition	Pump 1	Pump 2	Active Solenoid Valve(s)	Operating Mode
1	100%	40%	ON	ON	S2 - S4	Dual T2
2	100%	70%	OFF	ON	S4	Single T2
3	40%	100%	ON	ON	S1 - S3	Dual T1
4	70%	100%	ON	OFF	S1	Single T1
5	100%	100%	OFF	OFF	-	Stand by
6	40%	35 %	Alternating ON/OFF	Alternating ON/OFF	Alternating	Toggle Mode

Based on the test results, the actuator subsystem operated according to the designed control logic. When one tank reached a full condition and the other tank had a water level less than or equal to 60%, the system activated both pumps simultaneously and opened the solenoid valves directing water to the tank that required filling. This operating condition was intended to accelerate the filling process until the water level reached 60%. After the water level exceeded 60%, the system automatically deactivated one of the pumps, and the filling process continued using only a single pump until the tank became full. This strategy was implemented to reduce electrical power consumption and extend the service life of the pumps.

When both tanks had water levels below 60%, the system operated in toggle mode by activating the actuators alternately every 2 seconds. This mechanism was intended to maintain balanced water

distribution between the two tanks and prevent excessive differences in water levels. Furthermore, the protection system functioned properly. When the sensor in the main reservoir detected that the water level had fallen below the predetermined minimum threshold, all pumps and solenoid valves were automatically deactivated. This mechanism prevents the pumps from operating without water supply, thereby avoiding potential pump damage.

Based on these results, it can be concluded that the actuator subsystem, consisting of the pumps and solenoid valves, operated according to the system requirements and effectively supported the automatic water-filling process for the two storage tanks in a safe and reliable manner.

D. Testing and Analysis of the Power Supply Module

The power supply module was tested under two operating conditions: when the system was active and when the system was inactive. The tests were conducted for both the 5 V and 12 V power supply units to verify that the output voltages complied with their specified values. The test results are shown in Figures 3 and 4, while the measured data are presented in Tables 5 and 6. Based on the measurement results, both power supply units produced stable output voltages under active and inactive operating conditions. The 5 V power supply consistently generated an output of approximately 5.6 V, while the 12 V power supply produced an output ranging from 12.3 V to 12.6 V. These results indicate that the power supply modules can provide sufficient and stable electrical power for all system components.



Figure 3. 5 V Power Supply (PSU) Test Result



Figure 4. 12 V Power Supply (PSU) Test Result

E. System Testing and Analysis

The overall system testing was conducted to evaluate the performance of the automatic pump control system for two water storage tanks after all subsystems had been integrated. The test involved the

HC-SR04 ultrasonic sensors as water level detectors, the Arduino Uno R4 Minima as the processing module, the 12 V DC pumps and solenoid valves as actuators, and the 20×4 LCD as the monitoring interface. The tests were carried out by simulating various water-level conditions in Tank 1, Tank 2, and the main reservoir. The data acquired from the sensors were processed by the microcontroller to determine the operating conditions of the pumps and solenoid valves according to the designed control logic.

Table 5. 5 V Power Supply (PSU) Test Results

Trial	Input Voltage (VAC)	DC Output Voltage (V)	
		System Inactive	System Active
1	220	5.6	5.6
2	217	5.6	5.6
3	220	5.6	5.6
4	220	5.6	5.6
5	218	5.6	5.6

Table 6. 12 V Power Supply (PSU) Test Results

Trial	Input Voltage (VAC)	DC Output Voltage (V)	
		System Inactive	System Active
1	220	12.5	12.5
2	219	12.5	12.3
3	220	12.5	12.5
4	218	12.6	12.4
5	220	12.6	12.5

Table 7. System Testing and Analysis Results

No	Tank 1	Tank 2	Ground Tank	System Response	Result
1	100%	30%	Water Available	Dual T2	Passed
2	100%	70%	Water Available	Single T2	Passed
3	30%	100%	Water Available	Dual T1	Passed
4	70%	100%	Water Available	Single T1	Passed
5	40%	35%	Water Available	Alternating Toggle Mode	Passed
6	100%	100%	Water Available	Standby	Passed
7	50%	40%	No Water	All OFF	Passed

IV. DISCUSSION

Based on the experimental results, the proposed automatic pump control system operated according to the designed control algorithm. All testing scenarios were completed successfully with a 100% success rate, while the HC-SR04 ultrasonic sensor achieved an average accuracy of 98.22% with an average measurement error of 1.78%. These results indicate that the sensor provides stable and reliable water-level measurements, allowing the controller to make consistent operating decisions.

These findings are consistent with the study entitled "Automatic Water Pump System at PT. Padasa Enam Utama" (Ramadhani et al., 2025), which also employed an ultrasonic sensor and a logic control approach for automatic pump operation. The previous study demonstrated that the ultrasonic sensor could reliably detect water-level changes to control the pump automatically. Similarly, the proposed system achieved reliable water-level detection while extending the control strategy to two storage tanks with multiple operating modes without compromising system performance.

Compared with the study "Automatic Pump House System Using a Programmable Logic Controller (PLC)" (Ernawati, 2018), the results of this research also demonstrate comparable automatic control performance. The PLC-based system successfully controlled pump operation according to sensor inputs, whereas the proposed system achieved the same objective using an Arduino Uno R4 Minima. This finding indicates that a microcontroller-based implementation can provide control performance comparable to a PLC for small and medium scale automatic water pump applications.

The obtained results are also in agreement with the study "Automatic Water Pump Control System Based on Transistors, Relays, and Water Level Sensors" (Fathurahman & Wardhana, 2024), which demonstrated successful automatic pump activation and deactivation according to water-level conditions. However, the proposed system utilizes a non-contact ultrasonic sensor instead of a conductive water-level sensor, providing more flexible level measurement while reducing the risk of sensor corrosion. Furthermore, the programmable microcontroller enables more advanced control functions without requiring hardware modifications.

Overall, the experimental results confirm that the proposed system performs consistently with previous studies while offering additional functionality. The successful execution of all testing scenarios, together with the high sensor accuracy and reliable control performance, demonstrates that the developed system is suitable for automatic dual-tank water distribution applications.

V. CONCLUSION

Based on the design and experimental testing, the Arduino Uno R4 Minima-based automatic water distribution system was successfully developed and integrated using three HC-SR04 ultrasonic sensors, two 12 V DC pumps, four solenoid valves, a relay module, and a 20×4 LCD monitoring interface. The HC-SR04 ultrasonic sensors demonstrated reliable water-level measurement, with an average error of

1.78% and an average accuracy of 98.22%. The integrated system successfully completed all seven tested operating scenarios, including dual-pump operation, single-pump operation for each tank, alternating operation, standby condition, and pump deactivation when no water was available in the main reservoir. The results confirm that the proposed control logic can operate the pumps and solenoid valves according to the tested water-level conditions. The low-water test in the main reservoir also showed that the system could automatically deactivate the actuators when the water supply was unavailable, providing protection under the tested condition. However, the evaluation was conducted under controlled experimental conditions and did not measure energy consumption, long-term reliability, hydraulic performance, or field-scale operation. Therefore, claims regarding energy efficiency, extended pump lifetime, fail-safe performance, and broader application suitability should be considered preliminary. Future development should include quantitative power and flow-rate measurements, longer-duration testing, more comprehensive fault-condition testing, improved sensor accuracy, data logging and IoT integration, automatic alarms or notifications, backup power, and evaluation under more diverse operating conditions.

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