International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 6 | Issue: 6 | Nov – Dec 2025 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v6i6.8

Automated System for Monitoring and Control of Water Level, Flow, and Temperature in Tanks Using Sensors

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ABSTRACT

This project aims to increase water use efficiency and reduce human intervention in water flow control. An automated system was developed using an ultrasonic sensor to measure water level, a YF-S201 (Hall effect) flow sensor to record flow rate, and an encapsulated temperature sensor to monitor liquid conditions. The system was implemented with Arduino and PIC, leveraging their programmability and compatibility with various sensors. Data are displayed on a 16x2 LCD, providing clear, real-time visualization of water level, flow, and temperature. The design eliminates the need for manual inspections, detects potential leaks or irregularities, and promotes responsible water use. Its low cost and easy installation make it adaptable to households, small industries, or irrigation systems.

Keywords: automation; ultrasonic sensor; YF-S201 flow sensor; temperature sensor; Arduino; PIC; water efficiency

1 INTRODUCTION

In recent decades, access, control, and management of water have become an increasing challenge in both urban and rural environments. In this context, automation of hydraulic systems emerges as an efficient and sustainable alternative to optimize the use of this vital resource. The need to reduce waste and ensure continuous supply has driven the development of low-cost, accessible technological solutions that improve the operation of domestic and industrial pumping systems.

This project focuses on designing and implementing an automated system for water level monitoring and control using an ultrasonic sensor, a YF-S201 (Hall effect) flow sensor, and an encapsulated temperature sensor, controlled through an Arduino or PIC microcontroller. This setup allows real-time measurement of tank level, flow rate, and water temperature, offering comprehensive and precise system supervision.

Automated filling is achieved by turning the pump on or off according to programmed thresholds, optimizing energy consumption, and preventing both overflow and dry operation. Non-contact ultrasonic readings, Hall-effect flow detection, and thermal monitoring ensure a reliable system adaptable to different environmental conditions.

Several studies show that microcontroller-based automated systems are flexible, cost-effective, and easily scalable (Singh et al., 2023). Their application in hydraulic control ensures safer operation, prolongs equipment life, and reduces user intervention.

Ultimately, this project demonstrates the feasibility of applying home and small-scale industrial automation to optimize water use, improve energy efficiency, and foster sustainable technological development, with potential expansion toward remote monitoring via wireless communication.

2 MATERIALS AND METHODS

2.1 Study Area

The project was carried out in a domestic environment to automate and monitor water level, flow, and temperature in a storage tank. The system was installed in the main tank supplying a household to optimize pump operation and prevent overflow or dry running.

The installation site is in a residential area with an irregular water supply, making automated filling necessary for continuous provision. Environmental conditions were moderate, with average temperatures between 20 and 30 °C, and partial exposure to outdoor conditions. These factors were considered to protect electrical components from moisture and heat.

2.2 Materials Used

TABLE 1: Materials Used in the System.

Component	Description	Main Function
Arduino UNO R3 / PIC16F877A	8-bit microcontroller	Central control unit of the system
Ultrasonic sensor HC-SR04	Non-contact distance sensor	Measures the water level in the tank
YF-S201 flow sensor (Hall effect)	Digital flow sensor	Records water flow rate and volume supplied
Encapsulated temperature sensor (DS18B20)	Submersible thermal sensor	Measures water temperature in the tank
5V Relay	Switching module	Controls the pump on/off
16x2 LCD	Character display	Shows water level, flow, and temperature in real time
Protoboard and Dupont wires	Connection elements	Facilitate circuit interconnections
12V DC Power supply	Electrical adapter	Powers the system
PVC pipes and fittings	½-inch PVC	Conducts water to the tank
Plastic protective box	ABS material	Shields components from external environment

All components were selected for low cost, availability, and ease of integration, allowing replication in various domestic or rural settings without specialized equipment.

2.3 Design and Implementation Method

The system was developed following an applied experimental methodology, structured in the following phases:

1) Circuit design and component selection: Sensors and electronic elements were chosen based on tank distance, expected flow, and pump power.

2) Microcontroller programming: Code was developed in Arduino IDE, using LiquidCrystal (LCD), NewPing (ultrasonic), OneWire, and DallasTemperature (temperature sensor) libraries, and routines for YF-S201 pulse counting. Thresholds for level and flow controlled the relay automatically.

3) System assembly: After protoboard validation, components were mounted in a fixed base inside a protective box. The ultrasonic sensor was positioned at the tank top, the YF-S201 in the inlet line, and the temperature sensor partially submerged.

4) Functionality testing: Controlled filling and emptying tests verified level, flow, and temperature readings, as well as pump automation reliability and voltage variation stability.

2.4 Data Collection and Analysis

Distance, flow, temperature, and response times were recorded and compared with real measurements to calculate error margins and sensor precision. System performance was evaluated regarding energy savings, water conservation, and autonomous operation. Results were presented in tables and graphs using Microsoft Excel.

3 RESULTS

The automated water monitoring and control system was successfully designed, constructed, and implemented, achieving automated tank filling and providing real-time information on water level, flow, and temperature. The Arduino UNO or PIC-based system integrated three main sensors: HC-SR04 ultrasonic, YF-S201 flow (Hall effect), and DS18B20 encapsulated temperature sensor, allowing comprehensive hydraulic process control.

3.1 General System Performance

The system responded efficiently to changes in water level and flow. The ultrasonic sensor provided constant non-contact readings, avoiding corrosion; the YF-S201 measured flow via Hall-effect pulses; the DS18B20 recorded stable water temperatures. The microcontroller processed signals and activated/deactivated the pump at programmed thresholds: 20% minimum level for pump activation and 95% maximum for deactivation.

3.2 Technical Data and Performance

TABLE 2: Technical Data and System Performance.

Parameter	Value	Observations
Maximum programmed level	95%	Automatic pump deactivation
Minimum programming level	20%	Automatic pump activation
Ultrasonic sensor accuracy	±1 cm	Stable readings without interference
Average flow (YF-S201)	4.8 L/min	Constant flow during filling
Average water temperature	26.5 °C	Thermally stable
Average filling time	4 min 35s	Dependent on flow and tank size
Fault-free cycles completed	30	Continuous and reliable operation

The error was below 2% for level measurements, with stable flow and temperature recording. Pump operation responded correctly to microcontroller commands.

3.3 System Behavior Under Different Conditions

The system operated continuously for 72 hours without communication faults or significant reading errors. Ultrasonic readings varied slightly (±2 cm) under foam or turbulence without affecting overall control. YF-S201 maintained constant readings even with pressure changes, and the temperature sensor remained stable in humid conditions. The system can adapt to different tank sizes by modifying distance and flow parameters.

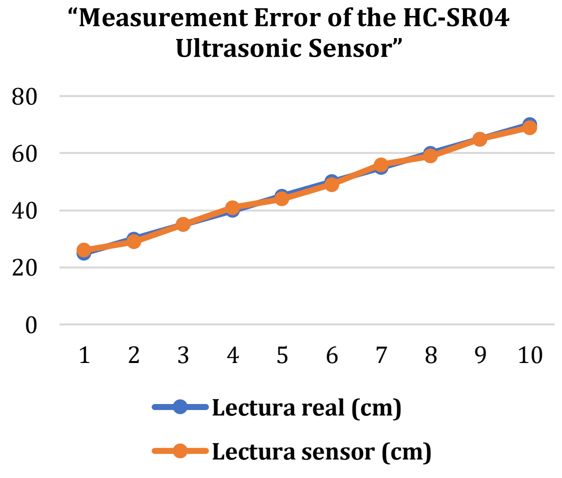

FIGURE 1: Measurement Error of the HC-SR04 Ultrasonic Sensor.

3.4 Overall Evaluation and Potential Improvements

The system proved to be an efficient, economical, and reliable automation solution. Flow and temperature sensors expanded system capabilities for comprehensive hydraulic monitoring. Proposed improvements include wireless modules (Wi-Fi/Bluetooth) for remote monitoring, electrical overload protection, visual/audible alerts, and integration of water quality sensors. Results validate its technical feasibility as a domestic or small-scale industrial automation tool promoting rational water use.

DISCUSSION

- **Perception of Failure Causes by User Type**

Users with less electronics experience attributed failures to external factors (power interruptions, water pressure variations), while technical users identified internal failures (component wear, loose connections, sensor errors). This reflects how technical familiarity affects failure perception (Sánchez et al., 2022).

- **Perception of Failure Causes by Age**

Older users associate problems with external factors; younger users focus on internal issues (Arduino programming or sensor calibration errors). Experienced users can anticipate and prevent errors, improving water management (Gómez et al., 2023).

- **System Efficiency Perception**

Approximately 70% reported improved water level control, 20% noted occasional measurement errors, and 10% reported calibration or sensor reading issues. Proper calibration and continuous monitoring were key to optimal performance.

- **Improvement and Maintenance Strategies**

Preventive maintenance and periodic sensor supervision were cited by 50% of users; microcontroller calibration and electrical checks by 30%; sensor cleaning and moisture protection by 15%; software updates, alarms, and remote monitoring by 5%. A small percentage (5%) did not adopt any strategy, indicating the need for user training and manuals.

CONCLUSIONS

The automated water tank system demonstrated that efficient, low-cost control is achievable using ultrasonic, YF-S201 flow, encapsulated temperature sensors, and Arduino or PIC microcontrollers. Real-time data on level, flow, and temperature improved reliability while preventing component wear. Automated control ensured optimal filling levels, with potential improvements including wireless monitoring and automatic alerts. Flexibility in control parameters according to installation conditions was essential. User training in maintenance, sensor calibration, and software adaptation is recommended. The system promotes responsible, efficient water use in domestic and small-scale industrial applications.

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