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Design and Build a Water Level Monitoring System in IoT-Based Reservoirs

Sujono[1], Mohammad Hufaif Ibri Al Fahhiz[2]
[1]Informatics, KH.A. Wahab Hasbullah University
[2]Informatics, KH.A. Wahab Hasbullah University
Email: sujono@unwaha.com, faizbmx098@gmail.com

ABSTRACT
In modern life, the use of water tanks has become a common solution for storing water to meet the needs of households, industries, and public facilities. In traditional systems, water capacity monitoring is usually done manually using visual methods or simple floats. This research aims to ensure optimal water availability in the tank and improve the efficiency of tank monitoring. With this system, users can obtain real-time data on water capacity in the tank, either through electronic devices or integration with Internet of Things (IoT) technology for remote monitoring. This makes it easier for users to monitor without having to be at the tank location. This system is also equipped with an automation feature, which allows automatic water pump control based on the water capacity detected by the sensor. Test results show that this system works accurately and efficiently in monitoring and controlling water. With the application of IoT technology, this system can improve water management efficiency, reduce human error, and support sustainability initiatives in the use of water resources.

Keywords : IoT, water level monitoring, automation, water reservoir management.

INTRODUCTION

In traditional systems, water level monitoring is usually done manually using visual methods or simple buoys. However, this method has several drawbacks, such as the risk of human error, for example errors in reading water levels or negligence in conducting routine monitoring. Although automatic buoys are now available, this tool still has some drawbacks, such as limitations in obtaining real-time data and access to information that can only be done at the reservoir location, so monitoring still requires more time and effort. Therefore, innovative solutions are needed that are able to monitor and control the management of water reservoirs more efficiently and integrally (Darmanto, Lamsadi, and Asrul 2025).

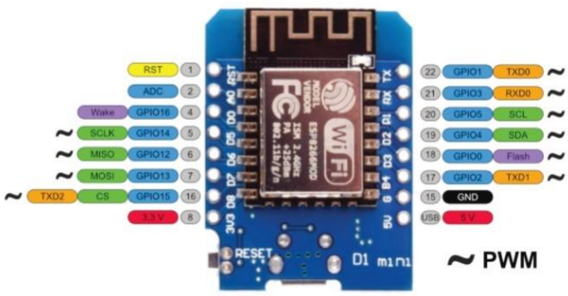
The implementation of a water level monitoring system in IoT-based reservoirs aims to ensure optimal water availability in reservoirs and increase efficiency in reservoir monitoring (Darmanto et al. 2025). With this system, users can obtain real-time data on the water level in the reservoir, either through electronic devices directly or through integration with Internet of Things (IoT) technology. The system has been connected to the Telegram-based IoT platform, thus enabling practical remote monitoring and control through the Telegram app on the user's device. This makes it easier for users to monitor without having to be at the reservoir location.

The system is also equipped with an automation feature, which allows automatic control of the water pump based on the water level detected by the HC-SR04 ultrasonic sensor. When the water in the reservoir is below the minimum limit, the system will automatically activate the pump to fill the water. On the other hand, if the water reaches the maximum limit, the pump will be turned off automatically to prevent overflow and avoid waste. In addition, this system also supports manual control through the Telegram platform, where users can turn the pump on or off remotely by simply sending commands through the Telegram application (Febriyanto et al. 2021). Therefore, research on the Design and Construction of Water Level Monitoring Systems in IoT-Based Reservoirs is becoming increasingly relevant to answer the challenges in managing water reservoirs in today's digital era.

THEORETICAL STUDIES

1. Research Methods Used
   a. Data Collection
   Data is a source or basic material that is very valuable in the process of producing information. Therefore, data collection needs to be done carefully so that the data obtained is useful and of quality. In this study, the author applies several data collection methods that are tailored to the needs of the study, including observation, namely data collection techniques that are carried out by directly observing objects or phenomena that are the focus of the research; and literature studies, namely One of the methods of data collection is carried out by tracing various sources of written information. This method includes the activity of searching, reading, and analyzing documents related to the research topic.
   b. Method Prototype
   According to Sommerville Ian, a *prototype* is an early version of the software system used to demonstrate concepts, design experiments, and find more problems and possible solutions (Nugraha and Syarif 2018). To build a system that suits the needs of users, the prototype method is carried out through several systematic stages. These stages include:
      1. Communication
      2. Planning Appropriately
      3. Accurate Modeling of Planning
      4. Prototype Formation
      5. System/Software Submission to Users & Feedback
   c. Use of Tools and Materials
   The tools and materials used in the manufacture of this tool, are as follows:
   - Laptop/PC
   - Wemos D1 Mini
   - Sensor Ultrasonik HC-SR04
   - Mounting Bracket Sensor Ultrasonik HC-SR04
   - Relay module 5V 2 Channel
   - LCD 16x2 I2C
   - Frame LCD 16x2 I2C
   - Mini Water Pump 5V
   - Step Down LM-2596
   - IC 7805
   - 5mm LED Lights
   - Resistor 1k
   - Elco
   - GX16 4-pin Aviation Connector
   - Adaptor 12V 5A
   - DC Power Jack Female
   - Breadboard
   - Cable Micro USB
   - Cable AWG22
   - Cable LAN
   - Cable Jumper
   - PCB
   - Plastic Box (Project Box) X5
   - Selang Waterpass
   - 4 Inch Paralon Pipe + Cap
   - Triplek 15 mm (35×35 cm)
   - Push ON, Push OFF Switch

2. Literature review
   a. Wemos D1 Mini
   Wemos D1 Mini is an ESP266-based mini wifi board that is known to be economical and reliable. ESP8266 this can connect devices *microcontroller* Like Arduino with internet via wifi. This Wemos D1 Mini can create mini projects without using arduino as the microcontroller, because the Wemos D1 Mini module can work alone or *stand-alone* to process each byte *code* or *coding* who entered. (Abrianto, Sari, and Irmayani 2021)



Picture 1. Wemos D1 Mini

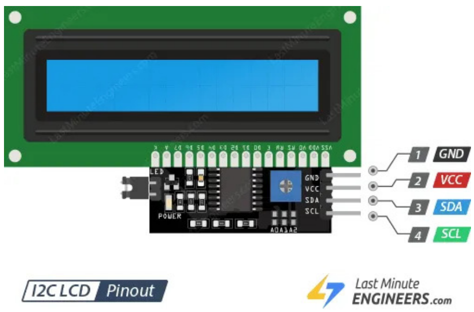
   b. Sensor ultrasonik HC-SR04

The HC-SR04 ultrasonic sensor is an ultrasonic sensor that can be used to measure the distance between the barrier and the sensor. The measurement range ranges from 2 cm to 400 cm. This sensor has 4 pins, namely VCC as the sensor's positive voltage source, the Trigger pin used to generate the ultrasonic signal, the Echo pin used to detect the ultrasonic reflection signal, and the Gnd pin as the sensor's negative voltage source. (Missa, Lapono, and Wahid 2018)

Picture 2. Sensor ultrasonik HC-SR04

c. LCD I2C

I2C LCD is an LCD Module (*Liquid Crystal Display)* which is controlled in synchronous serial using the I2C/IIC protocol *(Inter Integrated Circuit)* or TWI *(Two Wire Interface)*. Normally, LCD modules are controlled in parallel for both the data path and its control. This LCD can function to display something in the form of text or numbers that have been programmed from the microcontroller. (Veronika Simbar and Syahrin in Deswar and Pradana 2021).



Picture 3. LCD I2C

d. Module relay

The relay module is one of the devices that operates on the electromagnetic principle to move the contactor to move the ON to OFF position or vice versa by utilizing electrical power. The event of closing and opening of this contactor occurs due to the magnetic induction effect arising from the electric induction coil. The most fundamental difference between the relay and the switch is when moving from the ON to OFF position. The relay moves automatically with electric current, while the switch is done manually. (Omega et al. 2023).

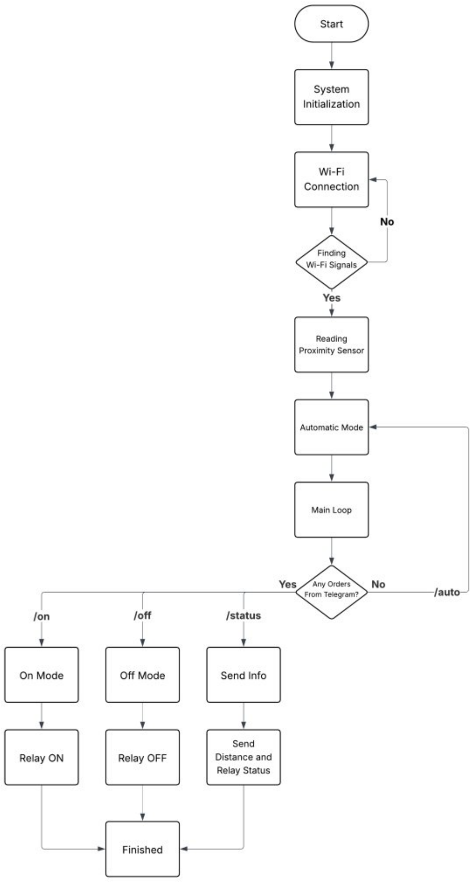
Picture 4. Relay module

e. Mini Water Pump

A mini water pump is a device used to suck and remove water from one place to another, it can be from a low place to a higher place or even parallel. The working principle of this water pump is that it can convert the mechanical energy of the motor into energy to attract and encourage the flow of water. (Djaksana and Gunawan 2021)

Picture 5. Mini Water Pump

3. Flowchart

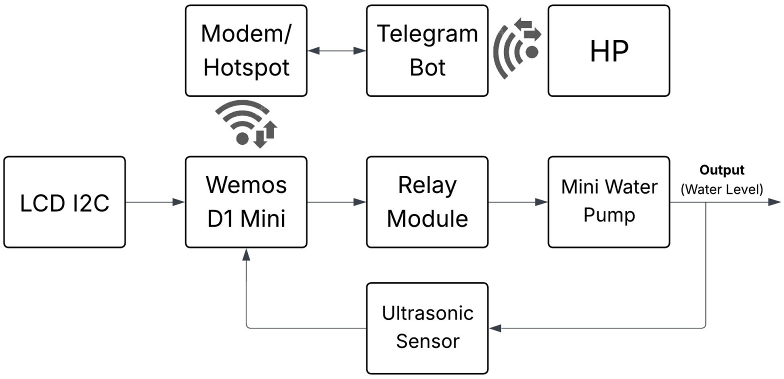


Picture 6. Alur Flowchart

The flowchart above describes the automated system workflow that can be controlled through Telegram commands in a structured manner. This diagram illustrates how the system works automatically after initialization, and then continuously monitors whether there are any commands from Telegram. If the command is received, the system executes as commands such as turning the relay on or off, as well as sending status and distance information. If there are no commands, the system remains running in automatic mode.

4. System Chart

This water level monitoring and control system consists of several main components, namely Wemos D1 Mini, Ultrasonic Sensor, Relay Module, Mini Water Pump, I2C LCD, Modem/Hotspot, and Telegram Bot. The relationships between the components are shown in the following block diagram, which illustrates the workflow of the system from water level measurement to automatic or manual control of the pump via Telegram.



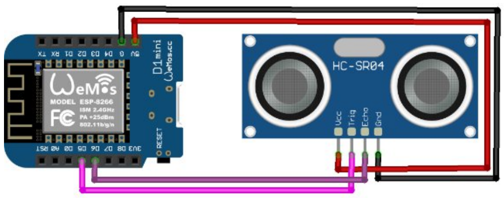
Picture 7. System Flow Chart

Explanation of the block diagram above:

1. Ultrasonic Sensor (HC-SR04): Measures the distance of the water surface by reflecting ultrasonic waves, then transmits the data to the Wemos D1 Mini.
2. Wemos D1 Mini: A central microcontroller that processes sensor data, sets up relays and pumps, displays info on LCDs, and communicates with Telegram bots via Wi-Fi.
3. I2C LCD: Displays the water level and pump status in real-time with two-pin communication (SDA & SCL), in sync with the data sent to Telegram.
4. Relay Module: Acts as an electronic switch to turn on/off the pump based on water level or commands from Telegram.
5. Mini Water Pump: A small pump that is active when the water is below the limit, controlled by a relay either automatically or manually via Telegram.
6. Output (Water Level): Shows the system result in the form of water level which is automatically controlled through sensors and pumps.
7. Modem/Hotspot: Provides an internet connection for the Wemos D1 Mini to access Telegram Bot.
8. Telegram bot: An interface that allows remote control and monitoring of the system through text commands.
9. HP (Smartphone): Used by users to access Telegram bots and control the system from anywhere.

5. Tool Design

- Ultrasonic Sensor Design

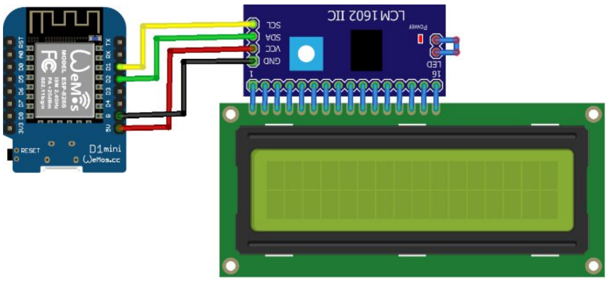


Picture 8. Ultrasonic Sensor Design

Table 1. Ultrasonic Sensor Network Pins

Sensor Ultrasonik	Wemos
GND	GND
Echo	D6
Trig	D5
VCC	5V

- I2C LCD Designing

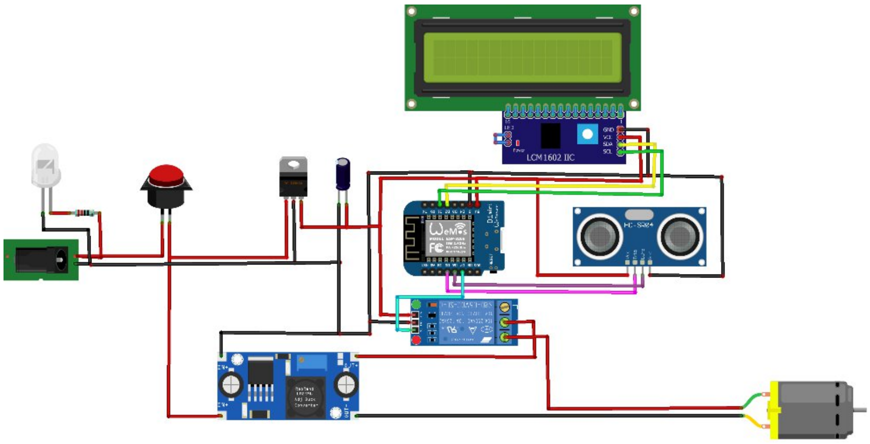


Picture 9. I2C LCD Designing

Table 2. I2C LCD Network Pin

LCD	Breadboard
GND	GND
VCC	5V
SDA	D2
SCL	D1

- Overall Component Planning



Picture 10. Overall Planning

Table 3. Overall Network Pins

Sensor Ultrasonik	Module Relay	LCD I2C	Wemos	Mini Water Pump	Step Down LM2596
GND			GND		
Echo			D6		
Trig			D5		
VCC			5V		
		GND	GND		
		VCC	5V		
		SDA	D2		
		SCL	D1		
	IN		D7		
	GND		GND		
	VCC		5V		
				(-)	OUT-
	WITH				OUT+
	NO			(+)	
			GND		IN-
			5V		IN+

RESULTS AND DISCUSSION

Testing is carried out to ensure the performance of the automatic water pump control system. Tests include ultrasonic sensors, relays, I2C LCDs, and mini water pumps, as well as system response to commands from programs embedded in the Wemos D1 Mini.

The steps in testing this system are as follows:

1. Connecting all components such as ultrasonic sensors, I2C LCDs, relay modules, and mini water pumps to the Wemos D1 Mini according to the pre-designed circuit.
2. Perform testing of the HC-SR04 ultrasonic sensor by placing it above the surface of the water to detect the distance in the water level in real-time.
3. Ensure that the 16x2 I2C LCD can display sensor reading data in the form of water distance and pump status directly and accurately.
4. Observe the response of the relay module when receiving commands from the Wemos D1 Mini, either automatically (based on water level) or manually from Telegram.
5. Test the mini water pump by making sure the pump is on when the water distance is below the threshold and off when the water reaches the upper limit.
6. Ensure the entire system works in sync, either automatically or through Telegram's manual controls, as well as displaying information in real-time on LCDs and bots.

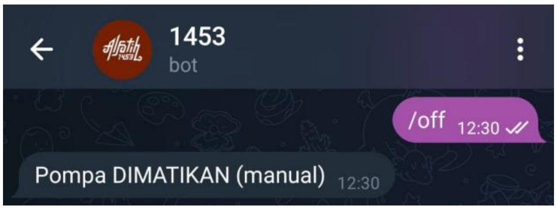
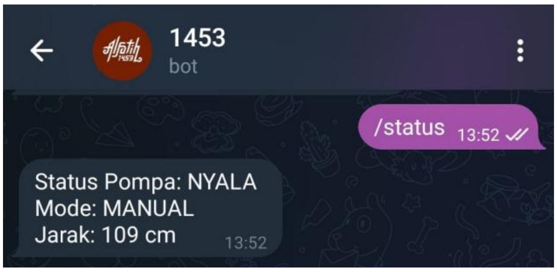
Picture 11. Final Results

Information:

- The image above shows a prototype of a water level monitoring system in an IoT-based reservoir.
- In the lower center, the main control unit consists of a black box containing an electronic circuit, equipped with a 16x2 LCD as an information display medium and a push button for manual input.
- On the front left, there is a 12V adapter as the main power source to power the system.
- At the back are two mini reservoirs (gray in color) that are used as water reservoir simulations, complete with pipes and hoses for the filling process and water level measurement.
- Several cables and connectors connect sensors, pumps, and control units, signifying the system has been modular and functionally assembled.
- Inside the control black box are the Wemos D1 Mini microcontroller, relays, and other electronic circuits as the brains of the system that receive data from ultrasonic sensors as well as send commands to the pump and Telegram Bot.

Table 4. Telegram Bot Testing

Command	Response	Output/Next State	Test Results
/on		The system goes into manual mode where the water pump is operated directly by the user. The pump is activated without paying attention to the sensor readings.	Succeed

off		The system is in manual mode where the water pump is turned off directly by the user. The relay is disabled even if the water is below the threshold.	Succeed
/auto		The system is in automatic mode where the decision to turn the pump on or off is made based on data from the ultrasonic sensor.	Succeed
/status		The system is in a state of preparing information to be sent to Telegram, in the form of the results of the distance measurement from the ultrasonic sensor, the current mode (automatic/manual), and the pump status (ON or OFF).	Succeed

CONCLUSION

This research successfully designed a prototype of an Internet of Things (IoT)-based water level monitoring system in a water tank using Wemos D1 Mini, HC-SR04 ultrasonic sensor, and relay module, which is connected to the Telegram application as a remote control and monitoring medium. This system is able to display water level information in real-time and control the mini water pump both automatically and manually. In automatic mode, the system will turn the mini water pump on and off based on the water level data obtained from the sensor. While in manual mode, users can control the mini water pump through text commands on Telegram. Based on the test results, the system is able to work accurately and efficiently in the process of monitoring and controlling the prototype water tank and has the potential to reduce the risk of human error in water management.

SUGGESTION

For future system development, it is recommended that this prototype be equipped with a power backup such as a battery or UPS to ensure continued operation during power outages. Adding additional parameters such as temperature, water quality, or flow rate could expand the system's application scope to agricultural or industrial settings. Furthermore, developing a web-based graphical interface or dedicated mobile application could provide a more accurate monitoring information. Adding an automatic notification system could also improve reliability, such as warnings if the water is running low or the mini water pump is inactive. Finally, developing a system to support multi-tank management would be an added advantage for large-scale or communal applications.

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