Project Report: Arduino-Based Water Level Monitoring for a Horizontal Cylindrical Tank

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Tools Used: Arduino, Eagle CAD, C++, Trigonometry.

Abstract

This project presents the design and implementation of a real-time water level monitoring system for a horizontally laid cylindrical tank using an Arduino-based setup. A 3296 multi-turn potentiometer was used to simulate a 0–5 V analog water level sensor. The system employs mathematical modeling based on circular segment geometry to accurately compute water volume. LEDs provide visual feedback on critical thresholds (Empty, Refill, Full), and a custom PCB was designed and fabricated using Eagle CAD to host the circuit. While the project was designed to include an LCD display for live volume readout, the Serial Monitor was used in its place for testing and verification purposes.

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1. Introduction

Horizontally laid cylindrical water tanks are commonly used in residential and industrial setups due to space efficiency. However, monitoring the water level in such tanks requires non-linear volume calculations. The objective of this project was to develop an accurate and cost-effective solution using an Arduino microcontroller and custom PCB hardware. Mathematical formulas for circular segment area were applied to translate analog voltage levels to water height, then to volume, and finally into practical thresholds for tank management. An LCD was intended to display live water volume, but due to hardware limitations during development, the Serial Monitor was used as a substitute.

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2. System Overview

Key Components:

- Arduino Uno
- 3296 multi-turn potentiometer (simulates sensor voltage 0–5 V)
- Red, Yellow, and Green LEDs
- Resistors (220Ω typical)
- 16x2 LCD Display (intended component)
- Custom-designed PCB (Eagle CAD)

System Functionality:

1. Analog voltage (0–5 V) is read from the potentiometer.
2. Voltage is mapped to water height (0 to tank diameter).
3. Height is used to calculate segment area and then volume.
4. Volume is displayed on Serial Monitor (in place of LCD).
5. LEDs turn on based on volume thresholds.

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3. Mathematical Modeling

Tank Geometry: Horizontally oriented cylindrical tank

- Radius R=1.0
- Length L=2.0
- Maximum water height H=2.0 (i.e., tank diameter)

Equations Used:

1. **Sensor Voltage to Height:**

sensor_voltage = (sensorValue * 5.0) / 1023.0

water_level, x = (sensor_voltage / 5.0) * H

2. **Central Angle of Segment (in radians):**

$$\theta = 2*\mathrm{acos}\left\{(R-x)/R\right\}$$

3. **Segment Area:**

$$A = \tfrac{1}{2} R^2 \left\{ \theta - \mathrm{Sin}(\theta) \right\}$$

4. **Tank Volume:**

$$V = A \times L$$

5. **Convert to Litres:**

$$V_{litres} = V_{m^3} \times 1000$$

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4. Arduino Code Implementation

// See Arduino folder for complete sketch

The Arduino code reads analog voltage, performs calculations for water height and volume, and switches LEDs based on predefined thresholds. It was designed to also support LCD display via I2C using the LiquidCrystal_I2C library, but during testing, output was observed via Serial Monitor.

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5. Circuit Design

The circuit was designed in Eagle CAD and includes:

- Analog input (A0) from the 3296 potentiometer
- Digital outputs to Red (D2), Yellow (D3), and Green (D4) LEDs
- Power and ground rails
- Output pins prepared for 16x2 LCD display (optional)

Refer to the schematic file in the repository for component layout.

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6. PCB Design & Fabrication

The schematic was converted into a PCB using Eagle's board editor. The board includes:

- Clear silkscreen labels (in layout, not applied physically)
- Proper trace separation

- Pads for all headers and external connections

Due to the scope of the project and available resources, only the PCB routing was completed, and the drill holes were created. No components were soldered or mounted on the board. The fabricated PCB was used for demonstration purposes of design and basic layout without final population or electrical testing.

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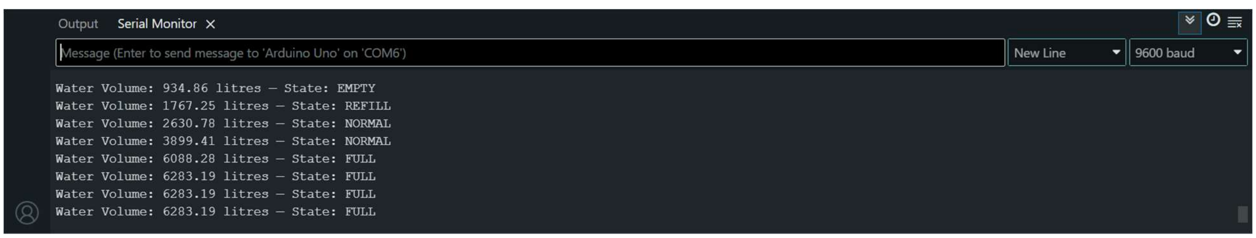
7. Testing & Results

Observed Outcomes:

- Serial Monitor displayed water volume in litres in real time.
- Voltage scaling matched height and volume accurately.
- LED indicators responded to correct threshold levels:
    - Red: volume ≤ 1000 L (Empty)
    - Yellow: 1000 L < volume < 2000 L (Refill)
    - Green: volume ≥ 4500 L (Full)



Test Method: Sensor input was simulated using the potentiometer across full scale. Output was monitored through Serial Monitor. LCD display functionality was not tested due to hardware constraints but was provisioned in the design.

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8. Challenges & Solutions

Challenge	Solution
Low sensitivity of 3296 trimpot	Carefully tuned multi-turn adjustment with serial feedback

Challenge	Solution
Complex volume formula	Applied circular segment geometry with code comments
LCD display unavailable	Used Serial Monitor to verify output and logic
PCB design learning curve	Followed Eagle tutorials and tested netlist and design rules

9. Conclusion

The project achieved its intended goal of simulating a reliable and mathematically accurate water level monitoring system for a horizontal cylindrical tank. Through a combination of embedded systems programming, trigonometry, and PCB design, the system demonstrates practical engineering integration. While LCD support was included in the design, testing was carried out via Serial Monitor due to temporary hardware limitations.

10. Appendices

- Arduino Code (See /Arduino folder)
- PCB Schematic & Board Files (See /Schematics folder)
- Test Images and Serial Output Screenshots (See /Images folder)
- Math Workings (See /Math folder)

References

- Arduino Reference Documentation: https://www.arduino.cc/reference/en/
- Eagle CAD Tutorials: https://www.autodesk.com/products/eagle/blog/
- Volume of Horizontal Cylindrical Segment: Engineering Toolbox
- Trigonometric and Sector Area Calculations (Khan Academy, Math StackExchange)